CORVINUS UNIVERSITY OF BUDAPEST

A MATURITY MODEL FOR IMPLEMENTATION AND APPLICATION OF ENTERPRISE RESOURCE PLANNING SYSTEMS AND ERP UTILIZATION TO INDUSTRY 4.0

DOCTORAL DISSERTATION

Supervisor: Katalin Ternai Ph.D.

Muhamet Gërvalla

Budapest
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DEPARTMENT OF INFORMATION SYSTEMS

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DOCTORAL SCHOOL OF BUSINESS INFORMATICS

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ABSTRACT

The implementation and application of Enterprise Resource Planning (ERP) support the organizations in managing their resources, processes, and to integrate all the business processes into a single unified platform. ERP system application increases the information flow between the departments or business units worldwide, as well as collaboration with partners, suppliers, and customers. On the other hand, Industry 4.0, as a new technological concept, aims to support organizations to complete digitalization and automation of their processes and functions, specifically in the manufacturing Industry. This study analyzes the evolution of ERP systems and the current trends of their implementation and application, also the organization's readiness for further digitalization. Many studies confirm that organizations are struggling in the implementation and application of ERP systems. In support of the evaluation of the maturity of implementation and application of ERP systems, three maturity models are identified during this study, but they lack defining the complete process which supports the organization to check their maturity level of ERP systems by themselves. The study analyzes the impact of different factors that affect the successful implementation and application of an ERP system. In addition, this study has investigated whether strategic use of IT positively affects the ERP selection, implementation, and application process, as well as if appropriate ERP selection has a positive effect on the implementation and application and the role of ERP implementation on the ERP application. Also, the impact of the application on Business Performance. Based on the undertaken study, a new maturity model to measure the implementation and application of an ERP system is proposed. The proposed ERP Maturity Model (ERPMM) will support organizations to understand their organization status related to the ERP system implementation and application. A prototype that applies the proposed maturity model is developed in support of the organization for self-evaluation. Primary data was used to analyze if the ERP application can be used to predict the readiness of the organizations for Industry 4.0. Furthermore, the study presents an analysis of the integration of ERP and Industry 4.0 and does ERP application support the organization to check if they are ready for further digitalization, specifically for Industry 4.0 technologies.

Keywords: ERP system, implementation, application, maturity model, Industry 4.0, new technologies, digitalization,

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"And do not walk upon the earth exultantly. Indeed, you will never tear the earth [apart], and you will never reach the mountains in height." (Quran, Al-Isra, 37-38)

1. INTRODUCTION

Doing business in the era of globalization, by providing services and products for customers in most industries is becoming more complex and more internationalized, which means that managing and using information efficiently is very important for the success of modern organizations. Managing all operations in a company requires information systems that can integrate data deriving from managerial level to production and must be available for use at any time and accurately. Many organizations are using solutions that information technology provides, such as Enterprise Resources Planning (ERP) systems. These systems support organization to manage their resources, processes and integrate all the various operations to increase the flow of information within the company as well as collaboration with partners, suppliers, and customers. ERP systems assist an organization in many areas starting from increasing better information sharing between departments, improving workflow, better supply chain management, integration of data, processes, and technology in real-time across internal and external value chains (Mabert et al., 2003; Shang & Seddon, 2002; Thomas F. Gattiker, 2005). Furthermore, they declare that these systems support the standardization of various business practices, improve order management, and accurate accounting information of inventory management.

On the other hand, industrial production started with the first generation, where machines were used for mechanized production by using water and steam. The second generation began with mass production by using electricity. The third generation came as a result of the usage of computers and electronics to automate manufacturing processes.

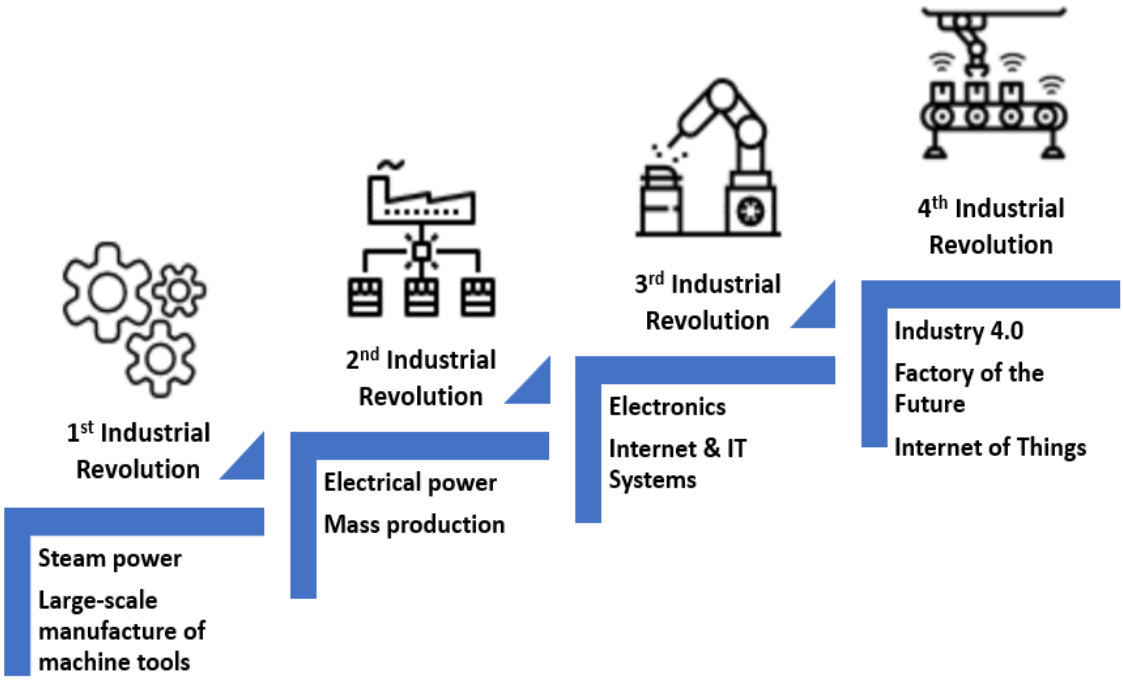

Figure 1 Industrial revolution adopted from Haddara et al. (Haddara & Elragal, 2015)

Moreover, now, we have the 4th generation or Industry 4.0, which is in the beginning phase. This generation enables computers and automation connectivity by using IoT devices, starting from suppliers, distributors, manufacturing facilities, a stage when robots and machines have begun to replace human workers and also collaborate with them (Forbes, 2016; Haddara & Elragal, 2015).

This study analyzes the evolution of ERP systems and the current trends of ERP systems implementation and application by identifying the current challenges of ERP systems implementation and application and the challenges to integrate the ERP system and Industry 4.0. The Webster and Watson approach was used for the literature review to understand the current state of the art of ERP systems and Industry 4.0 (Webster & Watson, 2002). The literature is collected from electronic databases from the field of Information Systems, Computer Sciences, and Business Management, as well as the industry opinions and reports are considered because of their expertise, which has a vital role in the undertaken study. The applied approach intended to identify the problem statement and to define the aim and objectives of the research. Based on the aim and objectives of the study, research questions and hypotheses have been generated.

Based on the undertaken study, it is proposed a new maturity model (ERPMM) to measure the maturity of implementation and application of the ERP system in the organization. The quantitative methodology was applied to check the reliability and

validity of the proposed model. The proposed model (ERPMM) to measure the maturity of ERP system implementation and application will support organizations in generating a clear picture of their organization status related to the ERP system implementation and application. In this way, they can evaluate the benefits of implementation and application of an ERP system, and whether they should do something in the way they are applying the ERP system. The study also analyzes the impact of different factors that affect a successful ERP system implementation and application.

Moreover, it has been examined if the strategic use of IT positively affects the ERP selection, implementation, and application process, as well as if appropriate ERP selection has a positive effect on the ERP implementation and application. The study analyzed the relationship between different stages of ERP implementation and application. The results of the study reveal that the ERP application has a positive impact on business performance. Based on the proposed maturity model, it has been developed a prototype that supports the organizations to evaluate its status of ERP system implementation and application. On the other hand, the study presents an analysis of the integration of ERP and Industry 4.0, which is done based on secondary data. Whereas, primary data was used to analyze if the ERP application can be used to predict the readiness of the organization for Industry 4.0. Thus, this study presents the challenges of integration of current ERP systems with Industry 4.0.

1.1 Problem statement

Nowadays, to create a competitive advantage, organizations must be effective and efficient in managing and delivering their services and products. This can be achieved through the digitalization of business processes, more specifically, with the help of ERP systems. An ERP implementation requires to have standardized processes for all the functions of the organization. In the context of ERP systems, these processes are supported by IT resources. According to a survey in 2018, Panorama Consulting Solutions shows that the main reasons why organizations implement ERP systems are to improve business performance by 64%, to position the company for growth, and to reduce working capital by 57% (Panorama Consulting Solutions, 2018). Based on the same survey, 42% of the organizations declared that they had success in the implementation of the ERP system, 30% still do not know and, 28% failed in the implementation process. The implementation and application of ERP systems is a long process that has to go

through several phases to achieve the implementation and application of ERP system maturity.

During the implementation and application of an ERP system, there are many Critical Success Factors (CSF) that need to be analyzed to have success in the implementation and application of ERP systems. Some of them are: the support of management in changing business processes, ERP project management, to define business requirements, to determine the costs and duration of ERP implementation, and other CSFs (Ehie & Madsen, 2005; Ngai et al., 2008; Ram et al., 2013; Somers & Nelson, 2001; Umble et al., 2003).

Based on the literature review, currently, the majority of the maturity models are not clearly defined and cannot support the organization directly to evaluate its ERP system implementation and application by themselves. This study investigates the factors that have an impact on the implementation and application of ERP systems and the relationship of different stages of its implementation and application in support of developing a new maturity model to help the organization in the process of evaluation of the ERP system and its impact on the business performance. Initially, the study aims to present an overview of the maturity situation of ERP systems implementation and application in Kosovo based on quantitative research. The data which will be collected from the organizations in Kosovo will be used to validate the new ERP system maturity model. Also, Industry 4.0, as a new concept in the field of information technology, presents several opportunities for integration of ERP systems and Industry 4.0. Furthermore, the study aims to identify the impact of Industry 4.0 on the ERP systems approach and if ERP application can be used to predict the readiness of the organizations for Industry 4.0.

1.2 Aims and objectives

The overall aim of this thesis is to analyze challenges, as well as to identify crucial elements of ERP systems implementation and application. Based on the undertaken study, a new maturity model for the implementation and application of ERP system will be developed. Data gathering in support of the development of the maturity model will be done on different industries in Kosovo, such as manufacturing, retail, ICT, professional

and financial services, public sector, education, healthcare, etc. At the same time, the research will try to understand the relationship between different stages of implementation and application of the ERP systems, business performance, and Industry 4.0.

Objectives to be met after the completion of this research are:

- To create a theoretical background of ERP lifecycle and models to measure the maturity level of ERP systems implementation and application;
- To create a maturity model for ERP systems implementation and application;
- To determine the relationship between different stages of implementation and application of ERP systems;
- To assess the effect of ERP application on business performance;
- To develop a prototype to measure the ERP maturity;
- To create a theoretical background of Industry 4.0;
- To define the challenges to integrate ERP and Industry 4.0.

1.3 Research questions

This thesis will gather data and analyze them to answer the following research questions:

1. What is the relationship between ERP selection, ERP implementation and ERP application with the organization's IT Strategy?
2. What is the impact of ERP selection on ERP implementation and ERP application?
3. Does the ERP implementation have an impact on the ERP application?
4. Is there any significant evidence that ERP application has a positive impact on organization performance?
5. What is the impact of Industry 4.0 on the ERP systems approach?

1.4 Research hypotheses

This research will test the following hypotheses to achieve the objectives of the thesis:

Table 1 Research hypotheses

H1 Main Hypothesis	Strategic use of IT significantly and positively affects ERP Implementation
H1.1 Sub-Hypothesis	Strategic use of IT significantly and positively affects ERP Selection
H1.2 Sub-Hypothesis	Strategic use of IT significantly and positively affects ERP Application
H2 Main Hypothesis	Appropriate ERP Selection has a positive impact on ERP Application
H2.1 Sub-Hypothesis	Appropriate ERP Selection has positive impact on ERP Implementation
H3 Main Hypothesis	ERP Implementation has a significant and positive impact on ERP Application
H3.1 Sub-Hypothesis	ERP Application has a positive impact on Performance Indicators
H4 Main Hypothesis	ERP Application can support organization to evaluate their readiness for Industry 4.0

1.5 Thesis structure

In order to achieve the aim and objectives of the study, this thesis is organized in eight chapters. A short description for each of the chapters is described below:

- Chapter 1: presents an introduction to the thesis and a short overview of the main concepts which are studied during the research. The problem statement is defined to understand the relevance to study this topic, and based on that, the aim and objectives of the thesis are identified, followed by research questions and hypotheses are generated;
- Chapter 2 – presents the previous studies related to the research topic, with a focus on ERP systems evolution, ERP implementation and application lifecycle, and other ERP system points that are important to be investigated in order to generate

the necessary knowledge for further steps. Also, the IT governance frameworks, maturity models in general and current ERP maturity models are presented;

- Chapter 3 – introduces a detailed approach that was applied to achieve the aim and objectives of the thesis, starting by definition of research design, research plan, questionnaire development and testing, selection of the research methods, and sample size determination. Furthermore, the field survey and field interviews details are presented;
- Chapter 4 – presents the proposed maturity model, which is developed and validated based on this study. The description of each construct of the model with the detailed items and weigh, and the maturity level classification are presented;
- Chapter 5 – presents the statistical approach and all the statistical analysis that supported to check the reliability and validation of the model.
- Chapter 6 – the results of the hypotheses testing of the thesis are presented. For each hypothesis, the testing results that supported or not the hypotheses of the studies are discussed. Also, the answer to the research questions of the study are presented in this chapter;
- Chapter 7 – the developed prototype is presented and described, including the presentation of the client-side, server-side, and ER diagram for the database;
- Chapter 8- the discussion and conclusion of the research and the contribution of the study are presented. Also, the future recommendation for the area of the research topic is proposed.

1.6 Summary

The introduction to the research topic is presented. Initially, it describes the concepts which are analyzed in this thesis. Starting with an overall definition of the ERP systems and their role in the organization and the industrial generation with a focus in Industry 4.0. Also, the problem statement, aims and objectives of this study are defined. Furthermore, the research questions and hypotheses are presented, including a short description for each chapter of the thesis.

2. LITERATURE REVIEW

2.1 Definition of ERP

Leon defines ERP as "the techniques and concepts for integrated management of businesses as a whole from the viewpoint of the effective use of management resources to improve the efficiency of enterprise management" (Leon, 2008). He declares that ERP concepts are supported by ERP packages, integrated software packages, which can cover all the business functions. In his book, he defines "ERP software is a mirror image of the major business processes of an organization, such as customer order fulfillment and manufacturing. " (Leon, 2008).

According to Monk et al., ERP systems are core software programs that can support enterprise information sharing in every business process ranging from entering data into the system and generating information or reports that can help in planning through a single database (Monk & Bret J. Wagner, 2013). ERP systems support the efficient functioning of business processes by integrating sales, marketing, production, logistics, accounting, and human resources tasks, as well as interconnection and coordination with customers and suppliers (Monk & Bret J. Wagner, 2013).

Wallace and Kremzar, in their book, state that ERP is not software, and an ERP is not only concerned with resource planning but also with other business processes (Wallace & Kremzar, 2001). These authors present the evolution of ERP in four steps where ERP is now seen as an enterprise-wide set of tools that helps enterprises in three main directions in forecasting, planning, and scheduling as well as in specific business processes, like linking customers to suppliers on a supply chain, assisting in the process of decision-making and coordinating various business activities of sales, purchasing, marketing, logistics, finance, operations management, product development and human resource management (Wallace & Kremzar, 2001).

According to Aberdeen Group, the ERP system offers complete, mature business applications, providing the necessary infrastructure that can help in operational and transactional system records (Aberdeen Group, 2008). They view ERP as a strategic move

in standardizing and automating business processes across the enterprise and state that implementation of ERP can be viewed as added value for them (Aberdeen Group, 2008).

Gartner defined ERP "as the ability to deliver an integrated suite of business applications. ERP tools share a common process and data model, covering broad and deep operational end-to-end processes, such as those found in finance, human resources (HR), distribution, manufacturing, service and supply chain" (Gartner, 2013). According to Gartner, ERP systems can be applied in many industries, and they help companies in different areas. However, Gartner declared that the implementation and application of such systems are often complicated and the costs are not always easy to justify (Gartner, 2013).

According to SAP, ERP systems integrate all the core business processes into a single system, starting with finance, HR, manufacturing, supply chain, services, procurement, and other processes (SAP, 2018). These systems can assist in having better information sharing between departments in real-time and can provide a clear view over the operation inside enterprises by using ERP system data, which can give insight and help in the decision-making process to manage the enterprise performance in a real-time (SAP, 2018).

Somers and Nelson, on an earlier study, defined ERP system as IT innovation, which aims to enhance organizational performance by integrating all the departments and functions of an enterprise into a single computer system (Somers & Nelson, 2001).

2.1.1 ERP evolution

The usage of the technology started in the 1960s where most of the companies were focused on production, and the need to apply inventory management systems emerged. During this time, most of the companies were focused on the application of a centralized computing system for inventory management by using inventory control packages (Rashid et al., 2002). Table 2 presents the evolution of ERP systems.

Table 2 Evolution of ERP

Year	Type	Objectives
2010s	Cloud ERP	Usage of resources such as ERP systems from a distance with the usage of the internet to enable the availability, scalability, and flexibility of computer resources in support to offer a single platform for resource management of the enterprises.
2000s	Enterprise Resource Planning II (ERP II)	New integrated modules; Application of e-business; Usage of the Internet for communication between ERP modules in different locations;
1990s	Enterprise Resource Planning (ERP)	A single system for enterprise management; Better information sharing; Improve interaction between departments; Improve order management; Reduce costs, etc.
1980s	Manufacturing Resources Planning (MRP II)	Finance Management; Human resources management; Resource Allocation; Accuracy of results; Optimized operation and processes; Availability of information compared to MRP.
1970s	Material Requirements Planning (MRP)	Planning necessary products and parts; Management of stock-out situation; Order management.
1960s	Inventory Control Packages	Inventory management;

Forecast future inventory demand based on the products on the stock.

Material Requirements Planning (MRP) - The ERP life began with the Material Requirements Planning (MRP), which was applied by the manufacturing organizations to automate production and inventory management.
According to Rashid et al., MRP systems supported the master production schedule by planning the necessary products and parts based on the bill of materials and helped in the prioritization of the production sector (Rashid et al., 2002).
MRP helped the companies manage the stock-out situation, purchasing inappropriate materials, etc., by having a clear overview of the products the companies produced, such as raw materials and stock management.

Manufacturing Resource Planning (MRP II) - In the 1980s, MRP evolved in Manufacturing Resource Planning (MRP II). MRP II systems aim was to optimize the manufacturing operations and processes by integrating the materials with production requirements (Basoglu et al., 2007). Into MRP II system were included financial accounting, financial management, distribution management, demand management, human resource, and engineering (Basoglu et al., 2007; Rashid et al., 2002; Umble et al., 2003).

According to Ganesh et al., MRP II was a new concept composed of three components: planning skills, data integrity, and computing resources of different organization departments to ensure efficient usage of resources (Ganesh et al., 2014). The integration of different modules into a single system supported companies to optimize and prevent unwanted situations and also could help as a simulation in production and planning.

Enterprise Resource Planning (ERP) - With the application and success of MRP II, the need to improve and expand these systems appeared. By the 1990s, Enterprise Resource Planning (ERP) was the new version of MRP II with new features. ERP enabled organizations to integrate all resource planning into a single system for the enterprises, starting from product design, warehouse management, material planning, human resources, finance, project management, production planning, sales and distribution, controlling, operations and logistics management (Umble et al., 2003).

The implementation of ERP resulted in increased productivity of the organizations and helped them create competitive advantages. According to Sumner, the incentives of organizations to implement ERP system are the following: legacy systems replacement; simplification and standardization of systems; gain of strategic advantage; improved interactions with suppliers and customers; ease of upgrading systems; link to global activities; restructuring company organization and pressure to keep up with competitors (Sumner, 2014). Also, in the same book, performance outcomes of ERP system implementation and application are presented.

Table 3 ERP performance outcomes adopted by Sumner (Sumner, 2014).

ERP Performance Outcomes
Quickened information response time
Increased interaction across the enterprise
Improved order management/order cycle
Decreased financial close cycle
Improved interaction with customers
Improved on-time delivery
Reduced direct operating costs
Lowered inventory levels

Table 3 presents many performance outcomes organizations benefits after the implementation. Nowadays, there are different ERP system vendors, and the most known are SAP, Oracle, Microsoft, Epicor, Infor, and Open Source ERP or Customized ERP systems based on the organization's needs. Integration of all organization functions made possible faster information sharing across the departments, improved communication with clients and suppliers, better decision making, and reporting, which has a direct impact on the effectiveness and efficiency of organizations. While in the aspect of inventory management, the delivery time was faster than the previous versions; order management was more accurate; operation costs were decreased, which led to decreased financial costs.

Enterprise Resource Planning (ERP II) - By the 2000s, the new name "Extended ERPs" was coined, or ERP II systems. Into this version was integrated new modules such

as Decision Supporting Systems (DSS), Customer Relationship Management (CRM), Knowledge Management (KM), Supply Chain Management (SCM), Business Intelligence (BI), Data Warehousing (DW) and Data Mining (DM) with e-business also, the internet was used for the first time for communication between different stakeholders (Caserio & Trucco, 2018). In this new model, e-commerce not only refers to buying and selling, but is also about enhanced productivity, reaching new customers, and sharing knowledge across institutions for competitive advantage (Thomas & Prusak, 1998).

Cloud ERP - While the technologies advanced with fast steps, a new innovative technological approach called Cloud Computing appeared. This new approach enabled the usage of the internet for accessing and using IT resources from a distance. According to Abd Elmonem et al., Cloud Computing provides the organization an environment with low cost that enables availability, scalability, and flexibility of computer resources (Abd Elmonem et al., 2016).

Cloud Computing offers three types of operation: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), which are described in detail in Chapter 2 on Industry 4.0 section (Wang & Xu, 2013). The application of Cloud Computing allowed the upgrade of ERP to Cloud ERP to offer services in a cloud environment provided via the SaaS (Caserio & Trucco, 2018). Cloud-based ERP does not require to install or configure any software on the user side. It can be accessed by a web browser over the internet (Abd Elmonem et al., 2016).

According to Caserio et al. the main challenges of Cloud ERP are data security (server is managed and controlled by the Cloud ERP Vendor) and integration (integration of different application that organization have into Cloud ERP because of the diversity of technologies applied by the vendor or the organization) (Caserio & Trucco, 2018).

2.1.2 ERP architecture

At the beginning of MRP and MRP II, the software packages were available only in mainframe computer platforms (Leon, 2008). In this way, the usage of the true potential of these systems was limited. Later on, with the introduction of ERP, the client/server environment was available, where a considered number of clients could use services from

a single server at the same time. The client is considered the application of laptops, computers, or other technologies that enables to request a service or share resources with the server. On the other hand, the server is a connection point that hosts applications and provides services for many clients. ERP applies a three-tier architecture: presentation layer, application layer, and database layer (Rashid et al., 2002). According to him, below are presented a short description for each layer:

- Presentation layer: Graphical User Interfaces (GUI) or WEB interfaces to access the system used by the user to pass or get the information from the application layer;
- Application layer: Serves as a mediate layer for the presentation layer and database server, all the logical operation and functions are processed here. Also, it serves as a workload distribution;
- Database server: Data repository, data are managed in this layer with the permission to read and write. The operation is managed by Structured Query Language (SQL).

2.1.3 ERP project life cycle

Based on the literature review, researchers have different approaches related to the ERP project life cycle. In his study, Ross has identified five stages of ERP implementation; according to him, the ERP implementation stages are design, implementation, stabilization, continuous improvement, and transformation (Ross, 1999). Dey et al., in their paper, managing the enterprise resource planning project, stated that ERP implementation needs three phases: planning, implementation, and hand-over, evaluation, and operations (Dey et al., 2010). Another study by Zhang et al., reported that the process of ERP implementation mainly includes four stages: pre-preparation stage, implementation preparation stage, test operation, and customization stage, and new system operation stage. (Zhang et al., 2006). Furthermore, Chen et al., in their paper, used a four-stage implementation model, which includes: initiation, contagion, control, and integration (Law et al., 2010).

An earlier study done by Esteves and Pastor, they proposed a framework about ERP lifecycle, which consists of the following stages: adoption decision, acquisition,

implementation, use and maintenance, evolution, and retirement phase (Esteves & Pastor, 2001). Another implementation methodology is described in the paper of Sun et al. were based on literature review they highlighted five stages that are mostly used when enterprises implement ERP, such as Organizational readiness assessment, ERP selection, implementation, final preparation and live-run (Sun et al., 2015).

Table 4 Number of stages according to different researchers

Author	Nr. of stages	Stages
Jeanne W. Ross	5	1. Design 2. Implementation 3. Stabilization 4. Continuous Improvement 5. Transformation
Dey, Clegg, & Bennett	3	1. Planning 2. Implementation 3. Hand-over, evaluation and operations
Zhang, Guo, Liu, & Choi	4	1. Pre-preparation stage 2. Implementation preparation stage 3. Test operation and customization stage 4. New system operation stage
Law, Chen, & Wu	4	1. Initiation 2. Contagion 3. Control 4. Integration
Esteves & Pastor	6	1. Adoption decision 2. Acquisition 3. Implementation 4. Use and maintenance 5. Evolution 6. Retirement phase

Sun, Ni, & Lam	5	1. Organizational readiness assessment 2. ERP selection 3. Implementation 4. Final preparation 5. Live-run

According to this study, the number of stages in the framework proposed by different researchers varies from three to six presented in Table 4. However, after analyzing all the stages in the content, it is viewed that almost all the stages have similar activities, except that they are positioned in different implementation and application stages.

The most significant difference identified during this research is in the Esteves & Pastor framework, in the sixth stage, the retirement stage (Esteves & Pastor, 2001). They defined this stage as the point where enterprises decide if the ERP system becomes inadequate to the business needs because of changes in the strategic approach, lost trust in the ERP vendor, implementation partner, or experience in implementation. This stage is closely related to the critical success factor and key performance indicators of the implementation and application of ERP systems.

On the other hand, another critical stage mentioned in Ross's framework is the transformation stage (Ross, 1999). Although this paper is written earlier, Ross has somehow predicted the future of ERP systems, and nowadays, this is an important topic. Below is a quote from his paper:

"We will focus more on combinations of products and services to address customer needs. Over the last 50-60 years we sold what we wanted to make. In the future, we will provide the products and services that customers need, relying, when necessary, on external sourcing. This means we will be increasingly connected with our suppliers, partners, and customers. (Business Vice President)".

According to Esteves & Pastor's framework, below is presented an overview of the six stages of ERP lifecycle (Esteves & Pastor, 2001):

- Adoption decision - In this phase, managers should be able to understand if their organization needs the application of an ERP system to address the current challenges and to improve their organization performance. Activities in this phase include analyzing the impact of ERP adoption in the whole organization, the definition of system requirements and definition of goals and objectives;
- Acquisition - In this phase, the organization must select the best ERP systems that fit on their business processes to eliminate or minimize the need for ERP system customization and analyses the return of investment compared to the selected ERP vendor. Involving a consulting company that will support organizations in the future ERP lifecycle is very important, mostly in the implementation stage. Also, other factors of ERP system such as functionality, price, training, and maintenance should be analyzed and defined in this stage;
- Implementation - This phase deals with the process of harmonizing and customizing ERP packages with the business processes to meet the need of the organization. In most of the cases, a consultant will support the organization with the methodologies, best practices, and training;
- Use and maintenance - This phase supports the organization on the application level. The system must be maintained because malfunction has to be corrected at the same time; the on-going processes on the system must be optimized. Also, new general systems requirements have to be implemented. This shall ensure the functionality, usability, and adequacy of the system to fulfill the organization goals and objectives;
- Evolution - This phase consists of the ability of the organization to integrate new capabilities into the ERP system. It shall include new innovative solution on planning and scheduling, supply chain management, customer relationship management, data warehouses, big data analytics, integrating communication channels with partners, electronic services;
- Retirement phase - In this phase, organizations can identify or evaluate that the ERP system becomes inadequate for their organization's needs. Managers should decide if they must change the ERP system with new technologies or information systems to fulfill the organization's goals and objectives.

ERP implementation is a project of system engineering or practice of system science, which is related to organizational transformation, IT, and business process management

(Dey et al., 2010; Ross, 1999; Zhang et al., 2006). It can lead to a new business organization environment by impacting the increased performance in processes, strategic vendor alliances, and constant change, with a focus to create a dynamic organization to increase the competitiveness.

2.1.4 ERP critical success factors

The implementation and application of an ERP system is a long process, which itself includes a large number of activities, in different stages of implementation and application ERP system life cycle (Dey et al., 2010; Esteves & Pastor, 2001; Law et al., 2010; Ross, 1999; Zhang et al., 2006). The success of the implementation and application of an ERP system is correlated with a large number of factors that will be presented below, based on different researchers.

Somers and Nelson proposed a list of 22 Critical Success Factors (CSF) that has an impact on the implementation and application of ERP systems (Somers & Nelson, 2001). Their focus was on the IT implementation, business processes, project management, and different case studies of ERP implementation in more than 110 companies. Another study from Sun et al. created an initial list of CSFs from the literature and selected a few of them using expert opinions, then analyzing them. They classified CSFs based on their relevance to the ERP system implementation stages (Sun et al., 2015). Umble et al. in their study, in addition to other factors identified by other researchers, identifies as crucial points in the implementation of ERP systems, whether the organization has long-term objectives for implementing such a system, and what are the expectations and benefits of implementation of an ERP system (Umble et al., 2003). Also, there are other studies, which identified many CSFs related to the implementation and application of ERP systems. Table 5 presents CSFs identified by the literature review as well as the reference of the researchers.

Table 5 ERP implementation and application CSFs identified by researchers

CSFs	References
Top management support	(Ehie & Madsen, 2005; Ngai et al., 2008; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003)

Effective communication	(Ngai et al., 2008; Ram et al., 2013; Sun et al., 2015)
Clear understanding of strategic goals	(Ngai et al., 2008; Ram et al., 2013; Umble et al., 2003)
Project management	(Ehie & Madsen, 2005; Ngai et al., 2008; Ram et al., 2013; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003)
User training	(Ehie & Madsen, 2005; Ram et al., 2013; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003)
Expectations and performance measures	(Ngai et al., 2008; Somers & Nelson, 2001; Umble et al., 2003)
ERP Vendor/customer partnerships	(Baki & Çakar, 2005; Ngai et al., 2008; Ram et al., 2013; Sun et al., 2015)
Use of Consultants	(Baki & Çakar, 2005; Ehie & Madsen, 2005; Ram et al., 2013; Somers & Nelson, 2001)
ERP Customization/packages	(Baki & Çakar, 2005; Ngai et al., 2008; Somers & Nelson, 2001)
Business process reengineering	(Ehie & Madsen, 2005; Ngai et al., 2008; Ram et al., 2013; Somers & Nelson, 2001)
Implementation cost	(Baki & Çakar, 2005; Ehie & Madsen, 2005; Somers & Nelson, 2001; Sun et al., 2015)
Implementation timeline	(Baki & Çakar, 2005; Ram et al., 2013; Sun et al., 2015)
ERP Implementation team	(Ngai et al., 2008; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003)
Change management	(Ngai et al., 2008; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003)
Defining goals and objectives	(Somers & Nelson, 2001; Sun et al., 2015)
Ongoing vendor support	(Baki & Çakar, 2005; Somers & Nelson, 2001; Sun et al., 2015)
Data management	(ICA, 2015; Ngai et al., 2008; Somers & Nelson, 2001)
ERP implementation methodology	(Ngai et al., 2008; Ram et al., 2013)

The literature review presents that there are a large number of CSFs. In the table above, are selected CSFs that have been mostly mentioned by various researchers. It is identified that Top Management Support has a very high impact on the success of implementing an ERP system. Also, Project Management during the lifecycle of implementing an ERP system has been considered by many researchers as an essential CSF.

2.1.5 ERP selection

One of the critical aspects during the ERP implementation and application is selecting the ERP vendor that offers the ERP system, which can fulfill the organization's requirements. During the ERP selection decision, according to Panorama Consulting, the organization should be focused what are the functions they will need for the next five years, what are the business goals, which is related with their IT strategy or digital strategy of the organization (Panorama Consulting Group, 2020b). There are many studies which have identified that the adequate selection of the ERP systems is a crucial concern which is related to ERP Customization or selection of the packages which has an impact on the success of the ERP implementation and application (Aloini et al., 2012; Baki & Çakar, 2005; Ngai et al., 2008; Somers & Nelson, 2001). According to Aloini et al., wrong selection of an ERP vendor and packages will lead to a mismatch between the package, business processes, and strategies, and to eliminate the vendor and packages should be evaluated in functionality, technology, support, and costs (Aloini et al., 2012). Based on the earlier studies, another factor that has an impact on the ERP implementation and application success rate is the selection of the adequate ERP vendor and the partnership between the ERP vendor and the organization that implements the ERP system (Baki & Çakar, 2005; Ngai et al., 2008; Ram et al., 2013; Sun et al., 2015). Otherwise, inadequate ERP vendor selection, which is not in line with the strategic goal of the business, is a dangerous pitfall that impacts the success of ERP selection and implementation (Aloini et al., 2012; Haddara, 2014). At the same time, the use of consultants and involvement of both management and user representatives in the evaluation process has an impact on the success of ERP implementation and application (Aloini et al., 2012; Baki & Çakar, 2005; Ehie & Madsen, 2005; Ram et al., 2013; Somers & Nelson, 2001).

According to Aloini et al., the software and hardware required for the implementation of the selected ERP system are an essential technical point that must be analyzed during the ERP selection process (Aloini et al., 2012). Considering that top management support is one of the critical factors that have the highest impact on the ERP implementation and application based on previous studies, it is evident that they should be very supportive on the ERP vendor selection process (Ehie & Madsen, 2005; Ngai et al., 2008; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003). An article published by Panorama Consulting Group has identified 6 ERP selection criteria for evaluation of ERP systems,

specifically for those organization who wants to upgrade their ERP system. These criteria are presented below (Panorama Consulting Group, 2020):

- Deployment Option – organizations should carefully evaluate the transition from on-premise to on cloud, specifically those who are categorized in Tier I due to the limiting factors. On the other side, ERP vendors may stop to develop or support organizations that have implemented ERP on-premises. A careful analysis should be on this point regarding the deployment of an ERP system on the organization;
- Scalability – even that some ERP vendors target large organizations, it is hard to find which is the best formula for an organization to decide which ERP vendor will fulfill their requirements. In case the number of customers, users, transactions, and volume of data increases, it means that the software should be able to process them in a real-time environment that will increase the organization costs. In this case, the system scalability it is vital to support the organization growth, and at the same time, it can be expensive;
- Technical fit – it is essential that an ERP vendor understands the organizational culture on the aspect of business processes. Where the organization presents them step by step in order to map the ERP system requirements. Based on the organization-specific requirements, the ERP vendor demos their system, even that they may have already integrated and offered functions for the industry the organization operates. On the other hand, not always ERP vendors can address all the business requirements, the organization must focus on the requirements with the highest priorities which could be customized on the software;
- References – finding if the ERP vendor has implemented ERP systems in the same industry is another vital issue, which may support the organization in the selection process. The organization must be able to investigate if the ERP vendors understand the industrial norm where their organization operates, do they implemented before the functions that the organization needs, does previous organization where they implemented ERP system achieved the desired results;
- Return on investment – during ERP selection, if the focus is on return on investment (ROI) rather than the total cost of ownership and if the ERP system is customized based on optimized processes, the ERP implementation and application will support the organization much more to increase the business benefits, a good example that may help to quantify the benefits of ERP

implementation and application is by developing a business case or even run a pre-implementation pilot;

- Product viability – analyze and understand what are the plans of ERP vendor for their ERP system on the future, do they want to invest and upgrade their product, will they give support after the implementation for a long term or they may switch their business objectives. It may be very costly for the organization who has implemented this ERP system if they need further customization on the future if the ERP vendor stops supporting a particular product that the organization has implemented (Panorama Consulting Group, 2020).

It is evident that during the ERP selection, it is essential to analyze the portfolio of the vendor in terms of technical and financial capacities, what is the solution that the vendor can offer, will this solution support the organization to increase the performance. Also, it is important to analyze the infrastructure that the ERP vendor requires to implement the ERP system on the organization, where depending on the deployment option, the number of business units, numbers of users will affect the ability of the organization to invest in such investment.

2.1.6 ERP implementation

Depending on the organization, the implementation of ERP systems requires a feasibility study to determine which is the best solution to implement an ERP system. The decision for implementation of an ERP system is related to the strategy of the organization and the determination of the goals and objectives the organization aims to achieve with the ERP system implementation. According to previous studies, the definition of goals and objectives, expectation and performance measurements for ERP system implementation are some of the factors that must be carefully identified and planned in order to reduce or eliminate the negative impact on the ERP system implementation phase (Ngai et al., 2008; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003). The success of ERP system implementation is also related to project planning and management. Project planning and management such as the definition of project costs, implementation timeline, project management on overall can determine the success of ERP system implementation (Baki & Çakar, 2005; Ehie & Madsen, 2005; Ngai et al., 2008; Ram et al., 2013; Somers & Nelson, 2001; Sun et al., 2015; Umble et al., 2003). The external ERP consultant

engagement is a critical point during the ERP implementation, also the implementation team expertise that can bridge the gap between the existing workflow and new ERP business practice by appropriate change management in the organization results on the success of ERP implementation where it is known that before the implementation it is required that the organization define well the business processes (Baki & Çakar, 2005; Ehie & Madsen, 2005; Marić, 2018; Ngai et al., 2008; Ram et al., 2013; Sun et al., 2015; Umble et al., 2003). ERP systems users as an important stakeholder on the organization and in the project must be trained during ERP implementation, as this is considered that user training is a key factor that may impact the success rate of ERP implementation and application on the organization (Ram et al., 2013; Sun et al., 2015; Umble et al., 2003).

During the implementation of the ERP system, there are three main aspects: people, processes, and technology that must be analyzed to choose which ERP system implementation strategy fits for the specific organization. Different ERP system implementation strategies are identified, but most of them are derived from the following: Big Bang, Phased, Parallel, Pilot, and Hybrid (Khanna & Arneja, 2012; Leon, 2008; Panorama Consulting Solutions, 2019; Wallace & Kremzar, 2001). Based on the cited sources, below is e description for each of the mentioned ERP implementation strategies.

- Big Bang strategy – this approach allows the transition from an old to a new ERP system at once. The organization starts to apply the new system at the same time on all the departments and business units. Because of the risk of this strategy, it finds more applications in organizations that may have one or two business units. On the other hand, there is no need to create new interfaces that are used during the transition from the old to the new system, and it enables centralized data management at the same time on all business units, which has a positive effect on reporting and analyzing the data. Careful planning and execution may result in success in implementation. Otherwise, it may fail;
- Phased strategy – this strategy enables the organization to choose between phasing by module or business unit implementation. The implementation is done based on chronological order or step by step approach, starting with an autonomous module or business unit while the integration is done later on when all the modules are installed on all business units. This strategy has a positive effect on end-user acceptance, where they have more time to learn the adaptation of the new system.

On the other hand, the implementation costs may be higher compared to the Big Bang approach. Also, it is necessary to use interfaces to bridge the gap between the old and new ERP systems until the complete implementation;

- Parallel strategy – this implementation strategy enables the application of the legacy system and a new ERP system parallelly for a specific time frame. The time length of the parallel operation of both systems could be from day to day, up to years, depending on the size of the organization. In this way, the organization can compare the output of the new system compared to the old one, and the risk of switching to the new ERP system will be lower compared to other strategies. In case of an error in the new system, the organization could react without effecting the process flow. Users could learn by a new system while operating the new system. On the other hand, more effort is required because the data must be entered in both systems, which require more labor force. The parallel strategy is used until the organization evaluates that the output from the new system is correct;
- Pilot strategy – this strategy enables the installation of the system on the specific area of the organization to have a clear overview of the processes of ERP implementation. In this way, organizations will understand the benefits, obstacles, and challenges of migrating to a new system are. This strategy helps the organizations decide whether it is worth moving to a new ERP system. Using this strategy, the organization will have a low risk and cost compared to other strategies, while the time of implementation could be more intensive;
- Hybrid strategy – based on the organization's culture and complexity, this strategy allows the combination of different implementation strategies in order to get the best of the ERP implementation process. It is essential that during the planning to be identified, all the implementation strategies and to decide which is the suitable combination that fits the specific organization in order to meet their unique needs. Based on the organization, in some cases, this strategy may be the appropriate one, which results in effective and efficient ERP implementation. Having a clear picture over the complete process of implementation is not easy to be captured because of the combination of the different strategies, which in the worst case, has an impact on the time and cost of the implementation.

According to Khanna et al., the implementation strategy must be selected according to the specific needs of the industry that the organization operates (Khanna & Arneja, 2012).

Considering the mentioned studies, the organization should carefully identify the aim and objective to implement and ERP systems, which must also be aligned with the organization's business strategy. Also, it must be defined as the key performance indicators in order to evaluate if the implementation and application of the ERP system achieved the planned aims and objectives. Selecting the appropriate strategy for ERP implementation is very important for the organization because the success of ERP implementation is closely related to it. Studies emphasize the expertise of consultants it is necessary during the implementation, where they can support the organization in the definition of requirements, business processes reengineering, and to support the organization in the integration of the new system on their organization for a successful ERP implementation and application.

2.1.7 Benefits of ERP application

The need for an organization to increase their business performance is related to the improvement of business processes. ERP system implementation and application support organizations to achieve their goals and objectives to increase the performance of the organization at the same time helps them to become more competitive with their competitors. According to Sumner, the benefits of ERP application can have an impact on different areas such as: moving from stand-alone systems to integrated systems; supporting the coordination across business functions; managing data into a single database; unified maintenance where changes are affected on all the systems in the same time; single interface; real-time information which supports the decision-making process; standardized business processes (Sumner, 2014).

According to Sadrzadehrafiei et al., based on a study in the dry food packages industry, benefits of ERP application can be categorized based on the business functions (Sadrzadehrafiei et al., 2013). They emphasized that the benefits of ERP application are in three areas(Sadrzadehrafiei et al., 2013):

- Strategic area - Improve supplier performance; Generate product differentiation; Finance information accuracy and faster decision-making capability; Improve employee performance management; Improve the interaction with customers; Better customer satisfaction;
- Tactical area - Tying the suppliers to the ERP system; Improve the interaction between business units; Improve cash management; Improve the performance of the industry; Improve the customer services; Better customer responsiveness;
- Operational area - Real-time data access across multiple sites; Improve order management/order cycle; Decrease financial close cycle; General information integration; Real-time data access across multiple sites; Improve on-time delivery.

Monk et al., in their book, states that the application of an ERP system as an integrated information system enables the organization to create efficient business processes that result in a reduction of the costs (Monk & Bret J. Wagner, 2013). Also, they declare, ERP vendors nowadays allow integration of business units on a global level, which removes the obstacles of currency exchange rates, languages, and culture. They emphasize that the ERP system integrates people and data into a single unified system, which indirectly has an impact on the number of workforce engagement; at the same time, management has a clear picture of the business units where they can analyze and react to improve the business processes.

Table 6 Benefits of ERP application

Benefits of ERP Application	**References**
Integrated system, single database	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Sadrzadehrafiei et al., 2013; Sumner, 2014)
Consistent real-time information (e.g. about customers, vendors)	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Rivard & Smith, 2010; Sadrzadehrafiei et al., 2013; Sumner, 2014)
Decision-making process	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Sadrzadehrafiei et al., 2013; Sumner, 2014)

Improved inventory management	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Sumner, 2014)
Reduced costs	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018)
Improved operation management	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018)
Manufacturing lead time and production capacity	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Sadrzadehrafiei et al., 2013)
Improved customer services	(Leon, 2008; Monk & Bret J. Wagner, 2013; Panorama Consulting Solutions, 2018; Sadrzadehrafiei et al., 2013)
Increased number of customers or sales	(Monk & Bret J. Wagner, 2013)
Increased employee performance	(Sadrzadehrafiei et al., 2013)
Improved on-time delivery	(Leon, 2008; Panorama Consulting Solutions, 2018; Sadrzadehrafiei et al., 2013)

Another approach to ERP benefits is presented in Leon's book, where he categorizes the benefits of ERP as tangible and intangible (Leon, 2008). According to his book, the main benefits of ERP application are Information Integration; Reduction of lead-time; On-time shipment; Cycle time reduction; Better customer satisfaction; Improved supplier performance; Increased flexibility; Reduced quality costs; Improved resource utilization; Better analysis and planning capabilities; Improved information accuracy and decision making; Use of the latest technology (Leon, 2008).

Panorama Consulting Solutions presented a list of the benefits of ERP implementation based on a survey they did in 2018. According to this report, 80% of the companies declared the ERP application resulted with the availability of information, 55% with improved data reliability, 46% increased interaction/integration of business operation/processes followed by improved productivity and efficiency and improved lead time and inventory management by 44%. Based on the same report, another essential benefit was better decision making by 38%, followed with other benefits such as reduction of operation costs/labor costs, improved interaction with customers, and improved interaction with customers.

Based on the literature, there are many areas where successful ERP implementation and application has a positive impact. Table 6 presents some of the most mentioned benefits by previous studies that are achieved with the successful ERP implementation and application. Identification of these benefits supported the development of a maturity model for the ERP application benefits and business performance.

2.2 Business processes

The application and implementation of ERP systems are depended on the organization's business processes. Business processes have an essential role in designing the ERP system for a specific organization. The business process is a collection of sequential activities that takes input and produce an output that generates value for: an external customer who can be someone who buys products or services, or an internal customer such as a colleague from another department inside the organization (Anand et al., 2013; Monk & Bret J. Wagner, 2013).

According to Von Rosing et al., a business process is a set of defined activities or tasks which have a consistent behavior that gives as an output a specific product or service (Von Rosing et al., 2014). Business processes can be classified on 1. Operational processes – activities on the level of the organization value chain, and 2. Managerial processes – activities on administration, coordination, communication, and controlling of resources (Anand et al., 2013; Mooney et al., 1995; Zölzer, 2008).

Business Process Reengineering (BPR) is a process innovation that supports the alignment of IT resources with the organization's business strategy to increase the business value (Mooney et al., 1995). They declare that business process reengineering enables designing processes that support organizations in the successful application of IT resources to automate the activities.

According to Sumner, the elements of Business Process Reengineering are 1. Business Processes – the organization should not focus on automation of actual processes but should focus on designing new business processes; 2. Integration – Integration of business processes; 3. Technology – application of technology to redesign the business processes;

4. Cross-functional coordination – designing new business processes in the context of cross-department communication; 5. Timing – improving process continuity; 6. Objective – implementing strategies with a focus on market-driven to increase the competitiveness of the organization (Sumner, 2014). The success of Business Process Reengineering is dependent on five dimensions, starting with clear project scope, support of top-level management, resource allocation, project management, and change management (Jurisch et al., 2012). Table 7 present the factors that have an impact on the success of Business Process Reengineering (BPR).

Table 7 BPR success factor adopted from Jurisch et al. (Jurisch et al., 2012)

BPR dimension	Stages
Project Scope	1. Realistic expectations 2. Clear vision and goals
Top-level management commitment	1. BRR know-how 2. IT: Use, role and adoption of IT
Project Management	1. Process Analysis 2. Implementation map/concept 3. Flexible and adaptive methodology 4. Plan execution 5. Continuous control 6. Handling of barriers and risks
Change Management	1. Organizational readiness for change 2. Motivation/resistance to change 3. Training/new skills 4. Cooperation and communication

According to Weske et al., Business Process Management (BPM) react by different systems such as Workflow Management (WFM), Case Handling (CH), Enterprise Application Integration (EAI), Enterprise Resource Planning (ERP), Customer Relation Management (CRM), etc. (Weske et al., 2004). They define BPM as follows: "A generic software system that is driven by explicit process designs to enact and manage operational business processes" (Weske et al., 2004). According to Van De Aalst, Business Process

Management is the evolution of workflow waves (Van Der Aalst, 2004). In the context of operational processes, he defines BPM as: "Supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information" (Van Der Aalst, 2004).

The scope of business processes covers all the departments or functional areas of an organization. Depending on the organization profile, the functional area can be marketing and sales, accounting, human resource management, material management, production and planning, procurement, marketing, and sales. Each of the mentioned function has one or more business processes. While on the other hand, business reengineering enables the re-designing of business processes to allow the organization to increase competitiveness, reduce costs, increase the effectiveness and efficiency of operations, and better satisfaction of the customers. Business Process Management is an ongoing activity inside an organization that aims to improve the organization's performance by analyzing, modeling, monitoring, and improving the processes with the support of business process reengineering.

The implementation and application of the ERP systems are closely related to the business processes of the organization, and all the business processes must be defined clearly in order to have success in ERP system implementation and application. Depending on the organization, it is necessary to do the business process reengineering before the implementation and application of the ERP system.

2.3 Maturity models

A maturity model analyses and evaluates the current state of an organization processes and enables the classification of business maturity into different levels. After the evaluation, they support organizations with actions they should take to improve their business performance.

According to Von Scheel et al., the maturity model is a structured collection of elements that support organization to assess they capabilities to identify the necessary actions to improve their organization sustainability (Von Scheel et al., 2014). Based on the same

study, they declare that the first maturity model was developed by Richard and L. Nolan, in 1973 with the purpose to evaluate the IT organizations. Von Scheel et al. declare that measuring the maturity level of business process management helps the organization to set a baseline where their organization stands in relation with business processes and after the evaluation, how they can react to improve and further development of their business processes (Von Scheel et al., 2014). Below are presented Capability Maturity Model Integration (CMMI) and ERP maturity models.

2.3.1 Capability Maturity Model Integration (CMMI)

The first version of the Capability Maturity Model (CMM) was developed in 1995 and was designed for software organizations to analyze the software development process (SEI, 2010). CMM aims to improve the business processes in an organization and serves as a framework to describe the evolution of processes from ad hoc to mature processes (SEI, 2010).

According to Greiner, in the beginning, the CMM was applied as a tool to evaluate software development for government contractors (Greiner, 2007). According to Paul et al., CMM provides a guide to achieve the maturity of processes by providing and recommending best practices on the process of development and maintenance of software (Paulk et al., 2011). Paul et al., in their paper, they declare that CMM can be used by four levels of organization: 1. Assessment teams; 2. Evaluation teams; 3. Upper management; 4. Technical staff and process improvement groups which will help the organization identify strengths and weaknesses, identify risks in the contractor selection process and monitoring them, identify activities to start a software process improvement and define the improving processes in their organization. CMM applies five levels to evaluate the maturity of the processes were each of the levels is measured based on five Key Process Areas (KPA) such as 1. goals, 2. commitment, 3. ability, 4. measurement and 5. verification (Greiner, 2007; Paulk et al., 2011).

Figure 2 presents the five levels of software process maturity. According to Paulk et al., organizations categorized on the first level apply ad hoc or chaotic processes, so they need to establish the basic business processes; while where maturity level is 2 to 5, they must focus on achieving higher level of maturity by creating standard processes and

procedures, on the same time continually improving their business processes based on best practices.

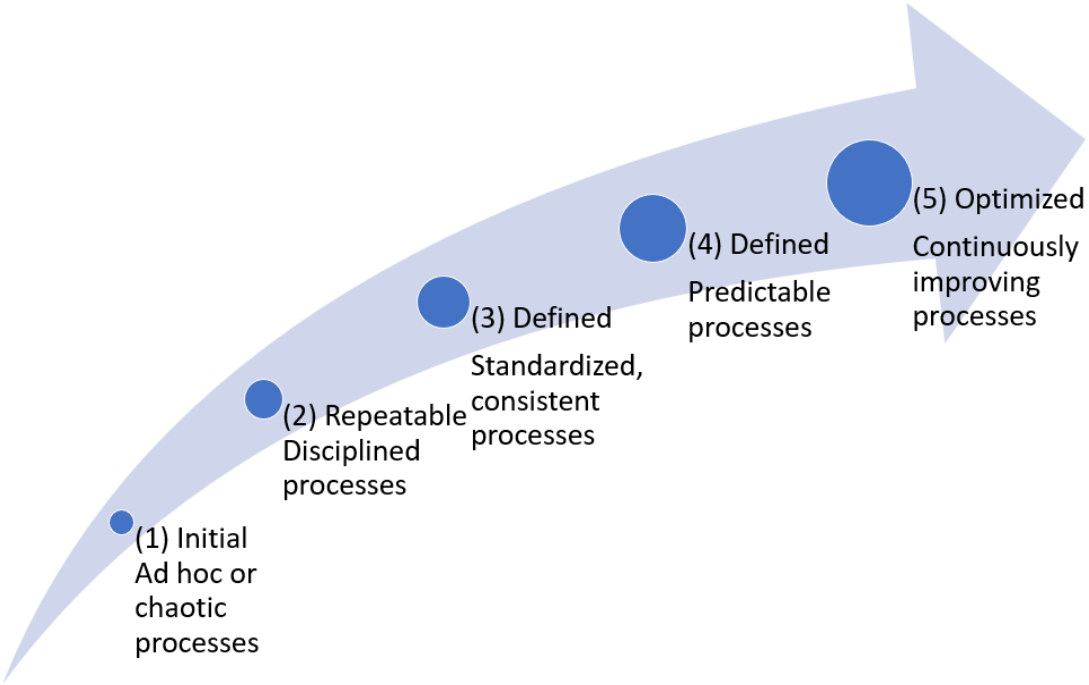

Figure 2 Five levels of Process Maturity adopted from Paulk et al. (Paulk et al., 2011)

Below are presented the five levels of CMM presented by Greiner and Paulk et al. (Paulk et al., 2011):

- Initial – the organization started to apply new processes for software development, but they lack in providing a stable environment. The processes in this level are classified as ad hoc or chaotic;
- Repeatable – application of new processes is established, and the organization has control over the processes. It has managed to create a basic process management environment. The process is repeated based on previous similar projects;
- Defined – the organization created standardized processes for developing and maintaining products and services in the level of managers and technical staff. The standardization of business processes supports them on better visibility on the ongoing projects;
- Managed – the organization managed to set in place quantitative methods to measure the performance of business processes and for project management; These assessments allow them to create criteria in managing processes;

- Optimized – the organization is focused continually to improve and optimize the business process performance by applying new innovative processes and the latest technological trends.

Capability Maturity Model Integration (CMMI) is the upgraded version of CMM. Both of them were developed by the same institute (SEI, 2010). According to Wendler, CMMI is a framework that supports organizations in product and service development with the best practices (Wendler, 2012). The application of CMMI enables the organization to achieve the business goals by integrating the organization's business processes into a single framework to have a better view on the whole organization levels and to improve their business performance (Greiner, 2007; SEI, 2010).

2.4 IT governance

Nowadays, the usage of IT is a critical point to improve business governance practices, which means that managing and using IT services is very important for the success of businesses. IT Governance supports enterprises to effectively manage IT resources by different frameworks (National Computing Centre, 2005). IT Governance support companies to manage and control IT-related projects, starting with prioritization and justification of IT investments, controlling, budgeting, and authorization levels (Moeller, 2013). According to Moeller, IT Governance is the process of aligning IT investments with the business processes and governmental laws and rules, including professional standards, and it manages and controls IT services.

IT Service Management focus is mainly concerned with the operational excellence of IT related services, whereas IT Governance focuses on enabling, controlling, and assisting the decision making at the strategic level.

IT Governance is an integral part of the enterprise governance in defining leadership, organizational structures and processes to achieve the planned objectives and to increase the sustainability of enterprises, with the focus to improve the management and control the information technology (IT Governance Institute, 2004; National Computing Centre, 2005). IT Governance covers five key areas for IT management and control, such as IT and Business Strategy Alignment, Value Delivery, Risk Management, Resource Management and Performance Measurement (IT Governance Institute, 2004).

There are different frameworks related to IT Governance, such as ITIL, COBIT, CMMI, COSO, and these are the best-practice approaches to regulatory and corporate governance compliance where each of them on their own has specific strengths (Calder, 2008).

2.4.1 IT Infrastructure Library (ITIL)

ITIL describes the best practices and approaches in IT Service Management, starting from strategy generation to the continual service improvements. ITIL was published in the 1980s, by the Central Computer Telecommunications Agency (now Office of Government Commerce). The first version of ITIL has 31 associated books covering all aspects of IT services. In the year 2000, was published the second version of ITIL as a set of revised books that become universally accepted for adequate IT service provision and in 2007, ITIL V2 was enhanced and consolidated to the third version of ITIL, which covers IT service lifecycle.

The current version of ITIL (ITIL V3) introduces a framework for IT Service Management lifecycle and highlights outcomes that must be achieved to successfully implement and manage IT services (ItSMF, 2011). ITIL V3 is a library that contains a set of five books and 26 different processes inside different phases of its lifecycle that describes the processes that need to be implemented in an organization and provides a systematic approach in the area of IT Governance, management, operations and control of IT services. Each of the five ITIL books gives the best practices for providing IT services efficiently and effectively. ITIL V3 framework contains five phases: 1. Service Strategy; 2. Service Design; 3. Service Transition; 4. Service Operation; 5. Continual Service Improvement (ItSMF, 2011).

- **Service Strategy phase -** This phase can help IT planning by five key processes: Strategy Management for IT Services, Service Portfolio Management, Business Relationship Management, Financial Management, and Demand Management, to map the current situation of the enterprises. It helps identify the IT services that are needed by the organizations to understand how these services should be delivered, to define the customers, develop the offer, identify strategic assets, quantifying the value of service, financial forecast for the services and to analyze

how changes in the business environment would affect the IT services. The outcomes are the detailed description of the IT service that is delivered to customers, IT planning to achieve institution objectives, financial budget, and performance plan (ItSMF, 2011). Moeller, suggest that companies initially should assess their service strategy by answering themselves the questions below about their IT services (Moeller, 2013):

- Which of our IT services or service offerings are the most distinctive?
- Which of our services are the most profitable for the overall enterprise?
- Which of our customers and stakeholders are the most satisfied?
- Which areas or services are potential problem points or areas for dissatisfaction?
- Which of our activities are the most different and effective?

- **Service Design phase -** Service design phase includes eight processes: Design Coordination, Service Catalogue Management, Service Level Management, Supplier Management, IT Service Continuity Management, Information Security Management, Availability Management, and Capacity Management. Service design phase ensures that all IT units can deliver quality services, meet all the enterprise requirements by the alignment of IT and business needs, improve IT Governance, improve quality of service, improve consistency between IT units, and easier implementation of new services (ItSMF, 2011). According to Moeller, there are five key aspects of service design: 1. Design of each IT service offered; 2. Design of the service management systems and tools; 3. Design of IT architectures and management systems; 4. Design of processes needed to install, operate, and improve IT services and processes; and 5. Design of measurement methods and metrics (Moeller, 2013). He classified activities into three categories planning, improving and measuring actions, with a focus on service delivery capacity management. These depend on multiple inputs, including requirements regarding the availability of the business; information on reliability, maintainability, recoverability, and serviceability; and information from the other processes, incidents, problems, and achieved service levels (Moeller, 2013);

- **Service Transition phase -** This phase helps control and manage the risk of IT service failure by using contingency plans to manage the risk when new services are transitioned to a new operation level of service. It ensures that all changes comply with institution requirements to improve the consistency and quality of new service implementation (ItSMF, 2011). This phase includes seven processes: Change Management, Release and Deployment Management, Service Validation and Testing, Change Evaluation, Service Asset and Configuration Management, Knowledge Management, and Transition Planning and Support. According to Moeller, this phase helps in utilized standardized methods and procedures to ensure safe change management and to minimize the impact of changes in service delivery quality (Moeller, 2013);

- **Service Transition phase -** This phase contributes to performing the day-to-day operation of the processes that manage the IT services. This can be achieved by the application of five processes: Event Management, Incident Management, Problem Management, and Request Fulfilment. It is also where performance indicators for the services are gathered and reported, and value is realized (ItSMF, 2011). Moeller divided this phase into these categories: Service Operation Event and Incident Management and Service Operation Problem Management;

- **Continual Service Improvement phase** - Continual service improvement phase is responsible for identifying and evaluating institution needs and implementing improvements to IT services to support institutional goals (ItSMF, 2011). This phase helps improve the process efficiency and effectiveness by these activities lifecycle: Service Strategy, Service Design, Service Transition, and Service Operation.

ITIL helps companies in organizing the IT service activities inside the organization to improve the quality of IT services delivered from a business and customer perspective (ItSMF, 2011). According to Moeller, ITIL is a framework designed to support IT functions and outlines the best practices that are crucial for IT Governance, starting from checklists, tasks, procedures, and responsibilities (Moeller, 2013). He identified some of the advantages of ITIL framework application: increased user and customer satisfaction with the IT services provided; improved service availability, directly leading to

potentially increased business profits and revenue; financial savings from reduced rework, lost time, improved resource management and usage; improved time to market for the IT aspects of new products and services; improved decision making and optimized risk for all IT-related processes.

The latest version published in 2019 is ITIL 4, where the key components are the ITIL Service Value System (SVS) focused on the establishment of IT service management practices to support the organization on customer experience, value streams, and the digital transformation of the organizations (Axelos, 2019). According to Axelos, core components of ITIL 4 are ITIL service value, ITIL practices, ITIL guiding principles, and continual improvement. To consider the core components that ITIL 4 offers, it is outlined in the four-dimensional model of service management (Axelos, 2019):

- Organization and people;
- Information and technology;
- Partners and suppliers;
- Value streams and processes.

ITIL implementation offers and requires a culture change, and institutions should prepare employees and management of institutions how ITIL implementation will help them in the working environment. According to Parvizi et al., they emphasize that COBIT and ITIL can link the bridge between the operational and head managers of the organization (Parvizi et al., 2013).

2.4.2 COBIT 5

COBIT 5 is a comprehensive framework that supports an organization to achieve the goals and objectives which focus on effective governance and management of IT resources (ISACA, 2012). According to ISACA, information is key for all organizations, and technology plays a vital role in it. As a framework, COBIT is more oriented as a controlling method that is focused on risk management. The aim of COBIT is: to meet stakeholder's needs; cover enterprise end-to-end; apply a single integrated framework, and enable a holistic approach and separate governance from management (ISACA, 2012). Based on ISACA, the application of COBIT support organization on value

creation, user satisfaction, compliance with different standards, better alignment of business needs, and IT objectives (ISACA, 2012). COBIT 5, can be used to identify risks and eliminates them (Tsai et al., 2016). According to ISACA, below is presented a short description of its five principles:

- Meeting Stakeholders Needs – COBIT 5 helps transform stakeholder's needs in specific objectives on all the levels of the organization to fulfill the stakeholder's overall goal and requirements in support of IT and Business Alignment;
- Enterprise End to End Coverage – support on the integration of governance of the organization with the IT governance, while it sees IT not only as an IT function but as an organization asset. This principle is supported by identifying the governance enablers and governance scope, which are followed by the description of the roles, activities, and relationship between them;
- Applying a Single Integrated Framework – enables the organization to integrate different frameworks and standards. COBIT is used as a framework integrator as called COBIT 5 Knowledge Base by mapping current situation and giving content filtering based on COBIT 5 family to provide up-to-date guidance and good practices for management and governance of IT resources;
- Enabling a Holistic Approach – here are applied seven categories where are described as the factor that leads to the achievement of organization objectives. Starting by identifying policies and frameworks, processes, organizational structure, culture, information, service and infrastructure, people skills, and competences;
- Separating Governance from the Management – the aim of this principle is to make a clear distinction between management and governance. Management is responsible for making possible the achievement of governance objectives by planning, building, running, and monitoring organization activities, while governance is responsible for evaluating, direct and monitor performance to make sure that stakeholder's needs are being met.

According to Tsai et al., implementation of ERP systems under the COBIT 5 architecture has a positive impact on information quality, business value through internal control and IT governance (Tsai et al., 2016). Also, they declare that applying COBIT during the ERP implementation will support organizations to review the processes, remove unnecessary

activities and business process re-engineering to reach the organization's goal to increase the business value (Tsai et al., 2016). Another research declares that COBIT is an IT governance tool that identifies risks and manages the risk that could potentially have an impact on ERP implementation (Parvizi et al., 2013). The application of COBIT supports organizations on different levels, such as: aligning IT with the business strategy, resource allocation, and risk management.

2.5 ERP as IT and Information System

Information systems empower the organizations to increase their competitive advantages by integrating information technology and business processes, which can be reached with the implementation and application of ERP systems that support organizations to improve their performance. In order to make sure that the ERP system will have a positive impact on the future, special care should be on the ERP evolution in coordination with all the stakeholders to eliminate the chance of disintegration.

A successful application of information systems across the enterprise and using the software to apply the best practices on business process management will affect an overall improvement of the organization, specifically after the implementation and application of ERP systems (Bourgeois, 2014). Furthermore, Bourgeios, declares that organization functions, which include finance, accounting, and quality control are depended on Information Technology (IT), and ERP systems are an example that represents the role of IT in these functions on the organizations (Bourgeois, 2014). Perunović et al., have taken two companies as a case study on their research, where these companies declared that IT applications are integrated and synchronized into ERP system in support of business processes, an ERP system is a backbone of the software element of IT in their company (Perunović et al., 2012). Klaus, in his book, declares that suitable ERP strategy and appropriate software systems are linked with the IT infrastructure of the organization, which is closely related to the standardization of the business processes and internal and external master data for a successful ERP implementation (Gronwald, 2020). Lecerf and Omrani on their study, declare that there is a relationship between innovation and IT adoption, while the implementation of ERP systems, they relate it with IT investment in the organization that can support SMEs to increase the export performance and to achieve better global competitiveness, which leads to a better global business environment (Lecerf

& Omrani, 2020). Another study which was done by Aloini et al. declares that the reason why companies implement ERP system is to get the benefits that IT offers, such as a shared database that support the integration of the company into a unified system with the consistency of data which removes the need for separate computer systems, people and data integration, open architecture, and also in business processes (Aloini et al., 2012).

On the other hand, ERP systems are classified as an enterprise-wide information system that supports the organization to coordinate resources, information, and activities and empower the organization in the aspect of enterprise integration, business process re-engineering, standardized systems and processes, global information system infrastructure, etc. (Nawaz & Channakeshavalu, 2013). Also, they declare that the ERP system provides an organization with a company-wide information system that covers all the business processes in a real-time environment to improve customer service. According to Samara, ERP system evolution it is not just a vendor issue, he emphasized that all the stakeholders such as firms, vendors, consultants, etc., should be involved in this process, in order to be well-coordinated to make sure that information system integration could be improved with the ERP system application; otherwise, information system disintegration could occur (Samara, 2015). Karimi et al., in their study, identified that information system resources are crucial in creating the ERP capabilities in an organization that has an impact on the positive outcome of the business processes (Karimi et al., 2007). At the same time, they declare that there is a need to focus on the synergies among information system resources, ERP system capabilities, and the value of IT at a process level and not only in IT infrastructure resources investment (Karimi et al., 2007).

ERP system can be used as an information system tool that supports the organization to collect and save the data for a period of time and use these data by Big Data analytics solutions such MapReduce, Hadoop, Alpine Mines, or even usage of ERP Vendors solution such as SAP offer for his ERP systems. The application of Big Data analytics will empower the organization in four dimensions: optimize business operation, identify business risk, predict new business opportunities, and comply with laws or regulatory requirements (EMC, 2015). According to EMC, the Big Data analytics lifecycle has 6 phases: 1. Discovery, 2. Preparation, 3. Model Planning, 4. Model Building, Communicate results, and 6. Operationalize (EMC, 2015). In this scenario of Big Data

lifecycle, ERP systems can support the organization as a repository database on the discovery phase where is necessary to check for historical data of the organization in terms of sales, projects, people, technology, time, and other factors which are generated with the usage of ERP as an information system for business process management.

In the current wave of globalization, the need for the digitalization of the organizations requires a complete transformation of their business processes to improve their products and services in order to satisfy the needs of customers, partners, and all the stakeholders. To achieve a successful digital transformation, there is a need to apply the adequate tools and information systems which will support them to fulfill the requirements of the market and to be very accurate on what the organization does and at the same time to have real-time data from the business processes and operations.

2.5.1 ERP maturity models

The maturity of ERP application is related to the project lifecycle of ERP implementation and application and the performance outcomes of the organization after the implementation and application of the ERP system. Also, it is required that the business strategy must be aligned with IT strategy, where the aim and objectives of the organization what they want to achieve after the implementation and application of the ERP system. In order to measure if the implementation and application achieved the planned aim and objectives, it is necessary to create key performance indicators that will support the organization in this process. On the other hand, application of assessment tools by applying the ERP maturity model supports organization on the evaluation process in order to identify the weakness in the implementation or application process compared to the key performance indicators or the business performance overall or to understand the maturity level about the ERP implementation and application. The application of maturity models will support the organization in understanding where they stand in relation to the ERP application, and in this way, they can continually improve and optimize the application of ERP systems to increase the performance of the organization. According to the literature review, three maturity models to measure the maturity of ERP system implementation and application are identified. These three models are described below.

- Holland and Light proposed a framework to measure the maturity of the ERP system (Holland & Light, 2001). Their model is classified into five theoretical areas, the ERP implementation process: 1. strategic use of IT, 2. organization sophistication, 3. penetration of the ERP system, 4. vision and 5. drivers and lessons. Based on these five areas, they developed a three-stage model to evaluate the ERP system maturity cycle. The first stage presents the management of existing systems and planning activities related to the implementation of the new ERP system. The second stage introduces the impact of applying the ERP system to business processes and the organization of the enterprise after ERP system implementation. The third stage involves the strategic use of the ERP system using innovative business processes and IT initiatives that extend ERP transaction data to support new functionalities and capabilities in areas such as supply chain management.
- ERP Maturity Model (EMM), was proposed by Parthasarathy & Ramachandran to measure the usage of ERP maturity in enterprises. Their maturity model has three levels: 1. Legacy System level, where ad-hoc and manual processes are used to manage ERP projects; 2. Designed level, presents that improvements are identified, and requirements engineering method is used; 3. Improved level, presents that business goals are achieved, business process re-engineering is improved, and continuous business improvement is identified (Parthasarathy & Ramachandran, 2008).
- Scanzo proposed a maturity model for ERP implementation, the proposed model applied the top-down approach where his model focus on: Complexity of ERP implementation such as a Project (implementation strategy, dimension, impact) and Organization Context (culture, ICT governance, structure, technology, financial); and the Capacity of the organization on ERP implementation Process (skills, resources, methods) and Risk Management Process (skill, resource methods); to plan, control and manage of processes which will support the organization on the determination of factors that affects the implementation and application of ERP system. While the maturity of ERP implementation is presented on five Clusters with the actions that the organization should follow to increase the success of ERP implementation and application (Scanzo, 2011).

2.6 Definition of Industry 4.0

Industry 4.0 is the fourth industrial revolution which presents the transformation and application of new and innovative technologies in the manufacturing sector. This concept uses the internet to connect factories in many fields. Below are presented some different definitions according to different researchers.

According to the German Federal Ministry of Education and Research, the term Industry 4.0 had existed since 2011 when a strategic manufacturing roadmap was developed to promote the digitalization of manufacturing. Industry 4.0 is also called ‘smart industry', ‘intelligent industry', ‘smart factory', or ‘smart manufacturing' (Business Insider, 2016).

Hartmut Rauen’s explanation regarding Industry 4.0 is as follows, "The implementation starts with small steps here and there, and there won't be a big bang that is going to introduce Industry 4.0. On the contrary, it will come step by step. But if we look back in ten years we will see that the world has changed significantly." (Hartmut Rauen, Deputy Executive Director Mechanical Engineering Industry Association (VDMA), 2012).

Based on Shafiq et al., "Industrie 4.0 is the integration of complex physical machinery and devices with networked sensors and software, used to predict, control and plan for better business and societal outcomes" (Shafiq et al., 2015).

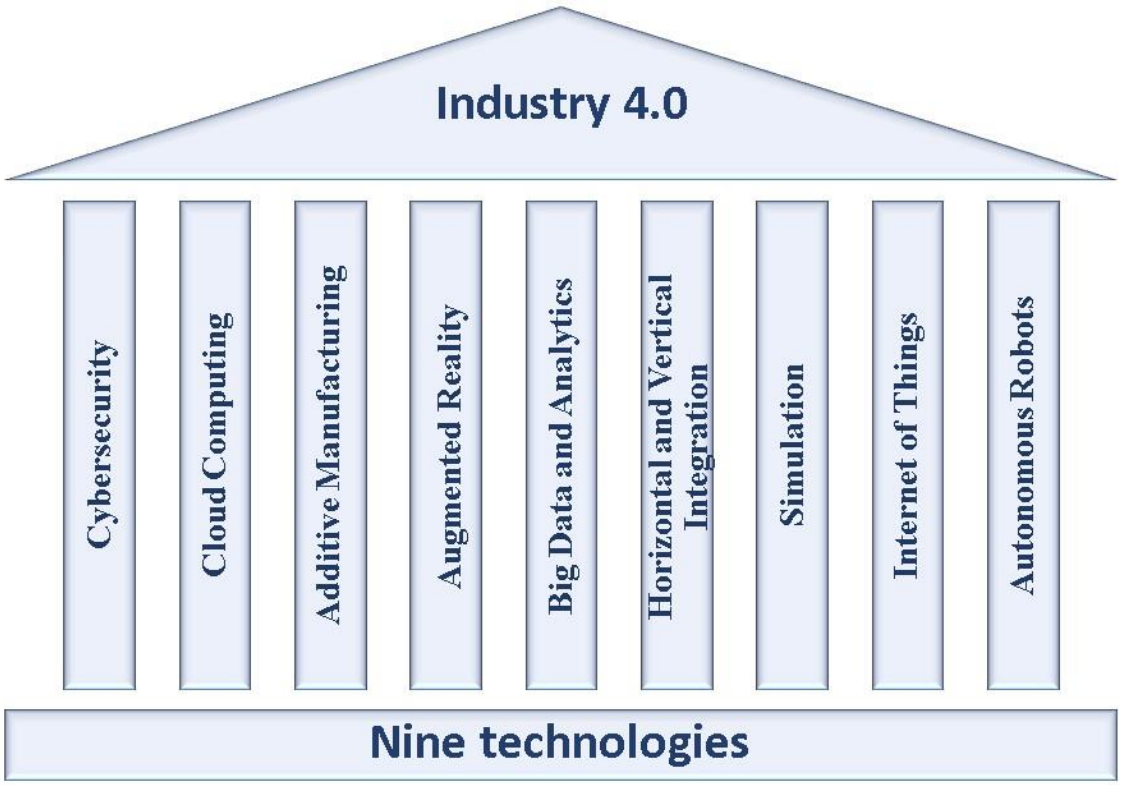

Figure 3 Industry 4.0 technologies

Industry 4.0, as a new concept, to fulfill the modern manufacturing requirements, applies nine technologies, which are presented in Figure 3 (Rüßmann et al., 2015). These technologies allow more flexibility in production and real-time monitoring, controlling, and reaction based on real-time situations and requirements. There are four drivers why the organization must focus on the implementation of Industry 4.0: organizational, technological, innovation, and operational (Santos et al., 2017).

Industry 4.0 aims to reduce the complexity of operation in manufacturing to increase the efficiency and effectiveness by application of real-time data and information which are interconnected by IoT sensors to reduce costs in the long-term for companies (Santos et al., 2017). Below are presented the technologies of Industry 4.0.

2.6.1 Cybersecurity

Cybersecurity is a crucial point in Industry 4.0 because of the increased number of devices that are interconnected. Industry 4.0 requires unified standards and communication protocols. Many devices are used in Industry 4.0, starting from machine controllers,

sensors, manufacturing lines, and other industrial systems so that the cybersecurity threats will increase dramatically (Rüßmann et al., 2015). It is essential to ensure that all communication equipment's and protocols are secured to protect critical systems from cybersecurity threats. The impact of Cybersecurity is very high because of the numbers of objects which are interconnected between each other by applying Cyber-Physical Systems.

Shafiq et al. define Cyber-Physical System (CPS) as the established global network which is implemented in global networks for business, which is combined from physical and digital worlds that includes: warehousing systems, machinery, and production facilities (Shafiq et al., 2015). According to Shafiq et al., CPS on the manufacturing industries is referred to as Cyber-Physical Production Systems (CPPSs), and it "comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently" (Shafiq et al., 2015).

Monostori and Váncza definition of CPS is: "Cyber-physical systems are assembled of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, networked data accessing and data-processing services available typically on the Internet" (Váncza & Monostori, 2017).

According to Gandhi from SAP, CPS can adapt to dynamic requirements and therefore are self-optimizing. That helps in automation and decentralization of processes in collaboration networks, with machines, products, objects, warehousing systems, and production facilities (Gandhi, 2015).

2.6.2 Cloud computing

Cloud computing is defined as an Internet-based service or IT infrastructure, starting from applications delivered as a service or hardware and software in the data centers provided by a service provider that is always available (Armbrust et al., 2010).

Cloud computing is divided into three categories(W. Wu et al., 2011). Software as a Service (SaaS) is a model of software where a provider licenses an application that is delivered over the internet. SaaS providers host applications on their web servers and simplifies the utilization of a large number of software applications remotely, elastically, and seamlessly (Wang & Xu, 2013); Platform as a Service (PaaS): A software development framework and components all delivered on the network. A PaaS model packages a computing platform including an operating system, programming language execution environment, database, and the webserver. A PaaS client can develop and run its applications at the software layer (Wang & Xu, 2013); Infrastructure as a Service (IaaS): An integrated environment of computing resources, storage, and network fabric delivered over the network. Offered as an on-demand, pay for usage model (Wang & Xu, 2013).

According to Zhong et al., the application of Cloud Computing offers greater flexibility, cost reduction, elasticity, better resource allocation that enables the organization to increase its competitiveness (Zhong et al., 2017). Cloud Computing allows gathering the data from multiple manufacturing into a single database in Cloud by connecting machines, data, and people that results in better asset performance management and operation optimization (Zhong et al., 2017).

2.6.3 Additive manufacturing

Additive Manufacturing is a technology that enables companies to produce a prototype, individual components, and 3-D printing. "With Industry 4.0, additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs. High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand" (Rüßmann et al., 2015).

According to José Horst et al., Additive Manufacturing plays an essential role in Industry 4.0, by supporting decentralized production processes and allowing rapid prototyping, which has an impact on time and costs, and efficiencies of the processes (José Horst & De Almeida Vieira, 2018).

2.6.4 Augmented reality

Augmented Reality (AR) can be defined as the ability to combine the physical, real-world environment information by adding virtual information that is generated by computers (Carmigniani et al., 2011; H. K. Wu et al., 2013). Yang defines AR as the technology of the future, who can develop "next generation, reality-based interface" (Yang, 2011). Augmented Reality has many advantages compared to Virtual Reality. The main advantage of AR is the ability to integrate the virtual environment and real-world interaction (Yang, 2011).

By using the Augmented Reality, users can increase the capability of finishing tasks by using virtual information from different sources directly to his work environment like the live-video streaming, or just getting the instruction how to operate with different kinds of equipment's event if the technician is not an expert in that particular part of the equipment which is presented in SAP and Vuzix cooperation (SAP&Vuzix, 2014). The Architecture of the Augmented Reality System is a process that has four steps: scene capture, scene identification for choosing the accurate information for boosting it, scene processing, and visualization of the augmented scene (Alkhamisi & Monowar, 2013).

Augmented Reality based systems nowadays are used in different aspects in a real-time situation, starting from warehouses, maintenance instructions, etc. which help the users of this technology to improve decision making and work procedures (Rüßmann et al., 2015).

2.6.5 Big data and analytics

Big data represents an extensive data set of structured and unstructured data that is hard to be processed and manipulated by using traditional tools. According to EMC, data structures can be classified into four types (EMC, 2015):

- Structured Data – data which are classified based on the data type, format and structure;
- Semi-structured data – textual data files such as XML data files which are defined by an XML schema;

- Quasi-structured data – textual data erratic data formats that requires tools to be formatted;
- Unstructured data – data that does not have an inherent structure which is stored in different types of files (EMC, 2015).

Big data can help companies analyze the past, present and predict the future, by using an analytical application to generate value from the available data, based on the five V's of Big Data: Volume, Variety, Velocity, Veracity and Volume (Hadi et al., 2015; IBM, 2016; Viceconti et al., 2015). Below are presented some facts from an IBM article and description for each of the five V's (Hadi et al., 2015):

- Volume (Scale of data) – The quantity of data collected by the organization and can be used to increase the knowledge for a specific or overall objective. 90% of today's data has been created in the last years. Every day we create 2.5 quintillion bytes of data;
- Velocity (Speed of data) - Data processing for a period of time that supports an immediate response to increasing efficiency. Every 60 seconds there are 72 hours of footage uploaded to YouTube, 216000 Instagram posts, or 204000 emails sent. 50T GB/sec is the estimated rate of global Internet traffic in 2018;
- Variety (Diversity of data) - Refers to the type of data that can be structured data, semi-structured data, quasi-structured and unstructured data. 80% of data is video, images, and documents and 90% of them are unstructured (tweets, photos, etc.);
- Veracity (Certainty of data) - Represents the scale of trust on the collected data in order to make a decision, 1 in 3 business leaders do not trust the information they use to make decisions;
- Value – This refers to the added-value that the processes/analyses of the collected data can bring to the organization, which is closely related to the volume and variety of data.

In a current competitive environment, for the organization in order to understand the market trends, customer's preferences, unknown correlations, and other business information, they need to apply business analytics tools (Zhong et al., 2017). Business analytics and big data support the organization to understand its position about the market and, on the other hand, to forecast and plan the future. This technology has an impact on

increasing customer satisfaction based on customer relationship management (CRM) system data, increase the productivity and competitiveness of the organization by analyzing the data from the processes and machines (Zhong et al., 2017). According to Hadi et al., in the new era of digitalization of government services, Big Data support on policy and decision making to increase the collaboration between the governments, citizens, and businesses (Hadi et al., 2015).

2.6.6 Horizontal and vertical integration

Vertical integration focuses on the connection of different levels in company with the help of IT systems, especially in production management, manufacturing, and low-level Programmable Logic Controller (PLC) systems like machine controllers, sensors, etc. that exists within the company in order to increase the flexibility and performance in planning and management (ICA, 2015). Integration of Vertical networking with the Cyber-Physical Production Systems (CPPSs) support organization plant to react based on the stock level or the faults on the system inside smart factories, also they are not focused only in the autonomous organization of production management but also on maintenance management (Deloitte, 2015).

Horizontal integration implies the connection between all the components of the value chain, starting from internal company logistics, production, sales and services, to external partners, suppliers, customers, energy suppliers, etc. to create a value chain as autonomously acting participants (ICA, 2015). The horizontal integration enables the organization to develop a new business model concerning cooperation between customers and partners, based on the principle of optimized real-time networks that support the transparency, and flexibility to react on problems and faults and better global optimization (Deloitte, 2015).

Application of Horizontal and Vertical integration enables the companies to create new values in their organization by applying smart factories, which can increase the flexibility of an organization, better communication with all stakeholders, autonomous organization and maintenance management, and organization performance in general.

2.6.7 Simulation

A simulation is a tool for predicting and evaluating the performance of analytically intractable systems. By integration of sensing, computing, and control, Jie Xu et al. defines that simulation optimization helps companies in the decision-making process, which provides the “smart brain” required to drastically improve the efficiency of industrial systems (Xu et al., 2016).
According to Rodič, the organization will be forced to implement Industry 4.0 because of their competitors and partners (Rodič, 2017). He emphasis that implementation of Industry 4.0 will support organizations on new modern simulation modeling, to diversify the manufacturing process based on the online automated modeling and database integration.

With the use of future simulations, companies are enabled to simulate the real-world situation in a virtual model, which can help companies to enable testing and optimization of products, places, etc. in the virtual world before the physical set-up.

2.6.8 Internet of things

Bacsárdi & Gludovátz, declare that there are many reasons to apply the Internet of Things (IoT) in the Industrial field: "now: the companies can reduce the cost of operation, and prevent the failure or stoppage of the production line in the future, the companies gain extra profit via service-oriented production system and the managers’ needs will be satisfied for easier decision making" (Bacsárdi & Gludovátz, 2017).

According to Zhong et al., the application of the Internet of Things offers advanced connectivity of different physical objects, systems and services that support data transfer, sharing, and communication between objects (Zhong et al., 2017). They declare that IoT can be applied to different industries to achieve the control and automate of objects to create smart objects.
The application of the Internet of Things devices can contribute to the data reading and transferring to the central databases. At the same time, these types of equipment allow the automation of the data entry, which helps in the reduction of data entry errors and data processing time.

2.6.9 Autonomous robots

In the past, the application of robots has found a place in manufacturing industries to solve complex problems (Rüßmann et al., 2015). According to Rüßmann et al., nowadays the robots are evolving positively; they will support organizations to become more flexible, autonomous, and cooperative that leads to an entirely new way of working, such as communication between robots or working together with humans' side by side and learn from them.

According to Fitzgerald and Quasney, the Autonomous Robots are devices that can vary in size, functionality, mobility, or the automation abilities, that can perform tasks without or with minimal intervention or interaction with humans, and they can learn from them or their environment in support of decision making or task performing (Fitzgerald & Quasney, 2018). They declare that Autonomous Robots in the future will be developed based on five principles: artificial intelligence, navigation, cost reductions, sensor and response capabilities, regulatory reform and public policy. Fitzgerald and Quasney state that the benefits of the autonomous system will add value to the supply chain, with the following potential benefits (Fitzgerald & Quasney, 2018):

- Increase efficiency and productivity;
- Reduce error, re-work, and risk rates;
- Improve safety for employees in high-risk work environments;
- Perform lower value, mundane tasks so humans can work collaboratively to focus on more strategic efforts that cannot be automated;
- Enhance revenue by improving perfect order fulfillment rates, delivery speed, and, ultimately, customer satisfaction (Fitzgerald & Quasney, 2018).

2.7 Summary

This chapter presents a detailed literature review of the research topic. Initially, the definitions of ERP systems are presented, followed by the evolution of these systems. Each phase of ERP evolution, including the changes that happened during these phases, are described. In order to analyze the implementation and application of the ERP system as a process, the ERP project lifecycle is studied. Specifically, with a focus on the

identification of critical success factors that has an impact on this process. Many researchers have proposed different frameworks of ERP implementation and application. One of them, Esteves and Pastor frameworks, differs on the six-stage, as they call the retirement stage (Esteves & Pastor, 2001). This is somehow related to the achievement of ERP maturity and the need of the organization to go further in the digitalization in order to fulfill the organization's requirements. This chapter presents critical success factors that have an impact on the implementation and application of ERP systems, with a focus on analyzing the ERP selection, implementation, and benefits of the application. Furthermore, the relationship between the business processes and implementation and application of ERP systems is analyzed considering the frameworks that support IT governance. Also, previous maturity models in general and specifically for ERP systems are analyzed and presented. The previous models are very complex to be used by the organization also, with the new rapid technological changes, it was necessary to be developed an ERP maturity model that supports organizations on the current wave of technology. On the other hand, the definition and technologies of Industry 4.0 are well analyzed. This chapter enabled to create the basis in support of the research topic.

3 METHODOLOGY

The quality of this research depends on several aspects, such as the research combination of literature along with the field survey and the selection of the appropriate research methodology. This research has determined the statement of the problem, aims and objectives, the research questions and hypotheses, methodology selection, and application of the best methods that suit and provide the current state of ERP systems and Industry 4.0. The objectives of this thesis are to identify if the strategic use of IT has an impact on the process of ERP vendor selection, implementation and application, as well as to study what is the relationship between different stages of implementation and application of ERP system and business performance. At the same time, the study aims to analyze if ERP application can be used to predict the readiness of an organization for Industry 4.0. In order to achieve the best results and fulfill the aim and objectives of the study, the best practices are used in close cooperation with the thesis mentor.

Below are the steps that are followed closely to layout the design, development, and implementation methodology for the completion of the study.

- Identification of the research undertaking;
- Literature review;
- Problem statement;
- Definition of the research aims and objectives;
- Definition of the research methodology;
- Development of the research methods and research instruments;
- Design of the questionnaire;
- Data gathering through the survey;
- Verification of data reliability and validity;
- Data processing and analysis;
- Results assessment and analyzes;
- Conclusions, contributions, and research recommendations.

3.1 Research design

After the literature is reviewed, it is deemed necessary to develop and design the central research questions. Ensuring the research is on the right track, it is considered essential to be harmonized with the literature on existing frameworks about the ERP systems to deliver unbiased results. Below are further details for the work methodology and thorough process in developing the research questions that would be entirely appropriate related to the design of the study that will be described below about the development of the questionnaire and model. The research questions are tailored to provide a clear understanding of the ERP system implementation and application in Kosovo, to validate and check the reliability of the proposed model for ERP system implementation and application.

It is understood that the intention of this research is to develop a maturity model for implementation and application of ERP systems, and at the same time to see if there is any relationship between the ERP application with the readiness of the organizations for the Industry 4.0 and the impact of Industry 4.0 to the ERP approach. The selection of Kosovo has been seen as an opportunity because of the data collection. Table 8 presents the research questions of the study and the source of the data.

Table 8 Research questions of the study.

Nr.	Research questions	Source
RQ1	What is the relationship between ERP selection, ERP implementation and ERP application with the organization's IT Strategy?	Primary data
RQ2	What is the impact of ERP selection on ERP implementation and application?	Primary data
RQ3	Does the ERP implementation have an impact on the ERP Application?	Primary data
RQ4	Is there any significant evidence that ERP application has a positive impact on organization performance?	Primary data

RQ5	What is the impact of Industry 4.0 on the ERP systems approach?	Secondary data

While the research hypotheses of the study are:

Table 9 Research hypotheses

H1 Main Hypothesis	Strategic use of IT significantly and positively affects ERP Implementation
H1.1 Sub-Hypothesis	Strategic use of IT significantly and positively affects ERP Selection
H1.2 Sub-Hypothesis	Strategic use of IT significantly and positively affects ERP Application
H2 Main Hypothesis	Appropriate ERP Selection has a positive impact on ERP Application
H2.1 Sub-Hypothesis	Appropriate ERP Selection has positive impact on ERP Implementation
H3 Main Hypothesis	ERP Implementation has a significant and positive impact on ERP Application
H3.1 Sub-Hypothesis	ERP Application has a positive impact on Performance Indicators
H4 Main Hypothesis	ERP Application can support organization to evaluate their readiness for Industry 4.0

3.2 Research plan

This study starts by analyzing and organizing existing research through secondary data (published papers, from academia, industry, and other data sources) to review and understand the current situation on the ERP systems in general. During the literature review, the focus was on identifying the factors that have an impact on the implementation and application of ERP systems, strategic use of IT, and the actual models of measuring the maturity of ERP systems. The Webster and Watson approach for literature review served as an appropriate approach for gaining comprehensive insights (Webster & Watson, 2002). The literature was collected from electronic databases, like

ScienceDirect, EBSCO, SpringerLink, and other databases with the focus on Information Systems, Computer Sciences, and Business Management. Besides academic scholar publishing, the study has also taken opinions from the industry side where often reports play an essential role in enriching the knowledge that comes from the industry know-how that cannot be ignored even though the study is purely academically based. On the other hand, to answer the research questions and hypotheses, it was necessary to undertake primary research in Kosovo organizations related to the maturity of ERP systems and their awareness about the Industry 4.0 to achieve the aim and objectives of this thesis. Primary data collection is done by using a questionnaire and quantitative research methodology.

The questionnaire is developed according to the Dillman approach. He declares that there are three types of data variables: opinion variable (what enterprises think), behavior (what people did in the past, do now or will do in the future), and attribute (characteristics such as age, gender, education, income, etc.) (Dillman, 2007). The questions in the questionnaire will try to answers the research questions and validate the research hypotheses.

According to Dillman, data collection from questionnaires is classified into two options: Self-administered (internet-mediated questionnaires, mail questionnaires) or Interviewer-administered (structured interviewers where the data are collected face to face) (Dillman, 2007). In this study, both of the options are used to collect the data. Data analysis is done in the R software.

Often during the field surveys of organizations, a significant concern is how to obtain the willingness of the companies/individuals to participate in the study. In our case, ERP system implementation and application, the whole number of organizations in a specific sector is always hard to fully define for many reasons such as their respective location, lack of readiness to participate in the survey, data confidentiality, competition, and many other reasons. The questionnaire has been tailored specifically for this survey and available in both languages, Albanian and English, bearing in mind that the questionnaire has been approved by the thesis mentor. To ease the process further, the questionnaire is created using Google forms and sent to organizations through a link (also a word/excel

has been developed for companies that operate in a traditional format). The questions are expected to take approximately an average of 16 to 20 minutes.

3.3 Questionnaire development

The questionnaire design mainly has been based on the three identified maturity models and frameworks of ERP lifecycle earlier done by different researchers in existing articles; however, their scope and extensibility are limited; therefore, it was necessary to create a modified framework including research questions. Most of the questions are taken from existing maturity models such as those proposed by Holland and Light, specifically for the Strategic use of IT; Parthasarathy & Ramachandran; Scanzo, also some critical factors are converted into question based on the previous studies and the impact they have on specific phase during the decision for ERP implementation and during the implementation and application phases (Holland & Light, 2001; Parthasarathy & Ramachandran, 2008; Scanzo, 2011). Also, questions based on the ERP industry reports are generated. The determination of stages of ERP implementation and application is done based on the identified ERP lifecycle as they are described in the literature review, while the main focus was on Esteves and Pastor ERP lifecycle implementation and application stages (Esteves & Pastor, 2001). The questionnaire consisted of appropriate questions related to ERP systems implementation and application, and Industry 4.0. Existing frameworks have been reviewed based on literature to draw the best applicable approach. Because the questionnaire is developed from the beginning, it is required to check the reliability of the questionnaire, presented the Questionnaire Reliability sub-chapter. The questionnaire contains seven sections with questions: General Questions, Strategic use of IT, ERP Selection, ERP Implementation, ERP Application, Performance Indicators, and Industry 4.0.

Initially, the weight of the questions are equal, and after the data gathering and evaluation based on the methods mentioned in the section where the maturity model has been proposed, the weight of each item of the model was recalculated. The organization is asked to provide a self-evaluation of their current ERP implementation and application. During the questionnaire analyses and design, several factors were considered and available as to what model to utilize. Likert scale type model that was developed in the principle of measuring attitudes about a specific topic and if participants agreed with them

(McLeod, 2008). These are scales of agreement or disagreement in a linear form where organizations interviewed can strongly disagree to strongly agree. The choices are offered on five scales, seven or even nine, but must always bear a neutral point meaning nor agreeing or disagreeing (McLeod, 2008).

The Likert scale model has been extensively used by many researchers, more specifically applied to measure character and personality traits (Likert, 1932). Due to a rigorous research approach by measuring and delivering specific results, Likert created a procedure offering attitudinal scales that included such as below (Likert, 1932):

1 – Strongly approve
2 – Approve
3 – Undecided
4 - Disapprove
5 - Strongly disapprove

Furthermore, five Likert type scale model utilized:

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Table 10 Likert scale questionnaire

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	1	**2**	**3**	**4**	5
Question?	☐	☐	☐	☐	☐

While in section seven, Industry 4.0 questions, because of the nature of the field, the response option was as follows:

Table 11 Industry 4.0 response options

	Not planned at all 1	Partially planned 2	Planned in the next 3 years 3	Fully planned 4	Present already 5
Question?	☐	☐	☐	☐	☐

In this case, it is considered that this scale offers significant advantages, not only answering yes/no but giving a significant degree of opinion expression, and quantitative data is received and analyzed (McLeod, 2008).

The questionnaire design dates from 2018; however, intensive work has been coordinated with the thesis mentor beginning of 2019. Nevertheless, the research framework has been drafted and approved back in 2018.

3.4 Questionnaire reliability

At the initial stage, the preliminary reliability test was conducted using a pilot sample (n=19 participants). The results are reported in Table 12.

Table 12 Reliability analysis results

Constructs	Number of items included in the scale	Cronbach's alpha	Scale mean scores	Scale SD
Strategic use of IT	8	0.78	3.89	0.52
ERP Selection	8	0.73	3.96	0.49
ERP Implementation	8	0.82	3.84	0.56
ERP Application	8	0.71	4.10	0.36
Performance Indicators	8	0.76	3.84	0.42
Industry 4.0	13	0.77	1.89	0.56

As shown in Table 12, all the values of Cronbach's Alfa, ranged from 0.71 (latent construct "ERP Application") to 0.82 ("ERP Implementation"), exceeding the level 0.70

recommended by Nunnally (Nunnally & Bernstein, 1978). Thus, the internal consistency of all used constructs measured by Cronbach's alphas is acceptable.

Further, item-total (correlation between an item and a subscale), item-rest (correlation between item and subscale with the item dropped), and inter-item (average), among items within the subscale) correlation was investigated in Table 13. Table 13 indicates six problematic items (2.6 An external ERP consultant is involved in the evaluation team, 4.4 Communication between the departments is digitalized and efficient, 4.5 Easier job for employees, 4.8 The organization has successfully adopted business changes and their supporting processes (people, IT, culture, etc.), 5.6 Organization achieved the goals to create new innovative product/services, 5.8 Availability of information and better decision-making, 6.2 Robots) with correlation with the rest of the items < 0.30 and average inter-item correlation lower acceptable level 0.15 proposed by Clark and Watson (Clark & Watson, 1995). The decision about these items will be made when further data are collected, based on Chronbach's Alphas are acceptable, and inter-item correlation is lower but near 0.15.

Table 13 Item-total and item-rest correlation within the constructs

Items	n	Item-total correlation	Item-rest correlation	Average inter-item correlation	Item score	
					mean	sd
1.0 Strategic use of IT						
1.1 IT and Business strategy are aligned and the organization has clearly defined goals and objectives	19	0.69	0.61	0.42	4.16	0.50
1.2 Top management support exist in strategic investment projects	19	0.50	0.36	0.27	4.16	0.69
1.3 Feasibility study is done for technical and human resources and infrastructure	19	0.67	0.54	0.36	3.74	0.81

1.4 Cross-department cooperation is smooth and effective	19	0.59	0.37	0.21	3.84	1.12
1.5 Employees are proactively involved in digitalization and they support the business changes	19	0.72	0.56	0.34	3.53	1.07
1.6 The organization has a clear vision of ERP implementation	19	0.74	0.63	0.39	4.00	0.82
1.7 Cost-benefit analysis is part of ERP implementation and application	19	0.58	0.46	0.36	4.00	0.67
1.8 Organization is prepared for Change management and Business Process Reengineering	19	0.65	0.53	0.39	3.68	0.75
2.0 ERP Selection						
2.1 Top management firmly support the evaluation team in the ERP selection process	19	0.68	0.56	0.36	4.00	0.75
2.2 The ERP vendor and implementation partner have a strong portfolio in terms of technical and financial capacities	19	0.76	0.63	0.39	3.84	0.90
2.3 The vendor and implementation partner have a suitable solution that results in organization benefit	19	0.47	0.32	0.22	3.95	0.71

2.4 The vendor and implementation partner understand the organization culture and industrial norm	19	0.53	0.36	0.24	3.89	0.81
2.5 The evaluation team involves both management and user representatives	19	0.63	0.51	0.33	3.89	0.66
2.6 An external ERP consultant is involved in the evaluation team	19	0.47	**0.18**	**0.12**	3.58	1.22
2.7 The hardware and infrastructure are at an affordable cost to ensure functional system performance	19	0.75	0.60	0.36	3.89	0.94
2.8 Organization has run a pre-implementation pilot	19	0.59	0.50	0.31	4.63	0.50
3.0 ERP Implementation						
3.1 The scope and objectives are clearly identified by the implementation team	19	0.22	**0.06**	**0.03**	4.16	0.69
3.2 The project is implemented on time	19	0.87	0.78	0.51	3.74	1.15
3.3 The organization is well trained to accept the changes for the best practices for a new ERP system	19	0.77	0.67	0.44	3.58	0.84
3.4 The implementation partner can bridge the gap between the existing workflow and new ERP	19	0.59	0.47	0.30	3.79	0.71

business practice by appropriate change management in the organization						
3.5 Employee's user training during ERP implementation is effective	19	0.75	0.66	0.43	3.84	0.76
3.6 External ERP consultant engagement resulted with success on implementation	19	0.71	0.57	0.37	3.58	0.96
3.7 The project is implemented on budget	19	0.65	0.52	0.33	4.05	0.85
3.8 Implementation strategy has been appropriate	19	0.72	0.64	0.41	3.95	0.62
4.0 ERP Application						
4.1 The organization achieved the goals and objectives to implement and apply the ERP system	19	0.51	0.35	0.22	4.26	0.56
4.2 The organization reduced manufacturing or service offering lead times	19	0.54	0.36	0.20	4.21	0.63
4.3 Processes are automated and functional	19	0.71	0.60	0.32	4.21	0.54
4.4 Communication between the departments is digitalized and efficient	19	0.41	**0.18**	**0.12**	4.16	0.69
4.5 Easier job for employees	19	0.44	**0.25**	**0.13**	4.53	0.61

4.6 Departments are integrated into a single ERP system	19	0.92	0.86	0.45	3.95	0.71
4.7 The organization reduced operating/labor costs	19	0.67	0.46	0.27	3.74	0.81
4.8 The organization has successfully adopted business changes and their supporting processes (people, IT, culture, etc.)	19	0.34	**0.19**	**0.11**	3.74	0.45
5.0 Performance Indicators						
5.1 ERP implementation and application of ERP resulted in Increased profit	19	0.67	0.52	0.32	3.47	0.70
5.2 Improved delivery time of product/services	19	0.61	0.50	0.30	4.05	0.52
5.3 Reduced administrative workload	19	0.78	0.67	0.39	4.11	0.74
5.4 Improved interaction between department, customers, and suppliers	19	0.75	0.61	0.36	3.79	0.85
5.5 Business success in terms of sales and market share	19	0.46	0.30	0.16	3.47	0.61
5.6 Organization achieved the goals to create new innovative product/services	19	0.35	**0.15**	**0.11**	3.58	0.69
5.7 Reduced costs	19	0.83	0.73	0.43	3.74	0.73
5.8 Availability of information and better decision-making	19	0.38	**0.24**	**0.14**	4.47	0.51

6.0 Industry 4.0						
6.1 Does the organization have an Industry 4.0 strategy	19	0.73	0.66	0.37	1.84	0.96
6.2 Robots	19	0.32	**0.25**	0.17	1.32	0.58
6.3 Internet of Things	19	0.78	0.72	0.39	1.74	0.87
6.4 Sensors	19	0.55	0.41	0.22	2.11	1.24
6.5 Predictive Analytics and Maintenance	19	0.54	0.42	0.24	2.05	1.08
6.6 Autonomous Systems (vehicles, warehouses, drones)	19	0.41	0.27	0.16	1.68	1.11
6.7 Simulation	19	0.57	0.50	0.29	1.47	0.70
6.8 Cloud Computing, Cloud Systems	19	0.66	0.51	0.25	2.84	1.54
6.9 Virtual Reality or Augmented Reality	19	0.06	**-0.08**	**-0.04**	1.42	1.02
6.10 Machine Learning	19	0.38	0.28	0.16	1.58	0.77
6.11 Big Data and Business Analytics	19	0.55	0.40	0.19	2.74	1.37
6.12 Artificial Intelligence	19	0.62	0.51	0.24	1.68	1.06
6.13 Machine to Machine Communications	19	0.65	0.52	0.24	2.05	1.39

Based on Table 13, two items (3.1 The scope and objectives are clearly identified by the implementation team and 6.9 Virtual Reality or Augmented Reality) should be excluded from the final questionnaire. The first item 3.1 The scope and objectives which are clearly identified by the implementation team, have a low inter-item correlation (0.03). The second item, 6.9 Virtual Reality or Augmented Reality, is negatively correlated with the rest of the items. So, these items are inconsistent with the rest of the items from the corresponding subscales. For a better understanding of the relationship between the items, the mentioned item will be not removed until all the data are gathered and the final analysis is done.

Finally, the average score for each construct was calculated as the mean of the item scores within each subscale. Figure 4 displays correlation coefficients among all constructs.

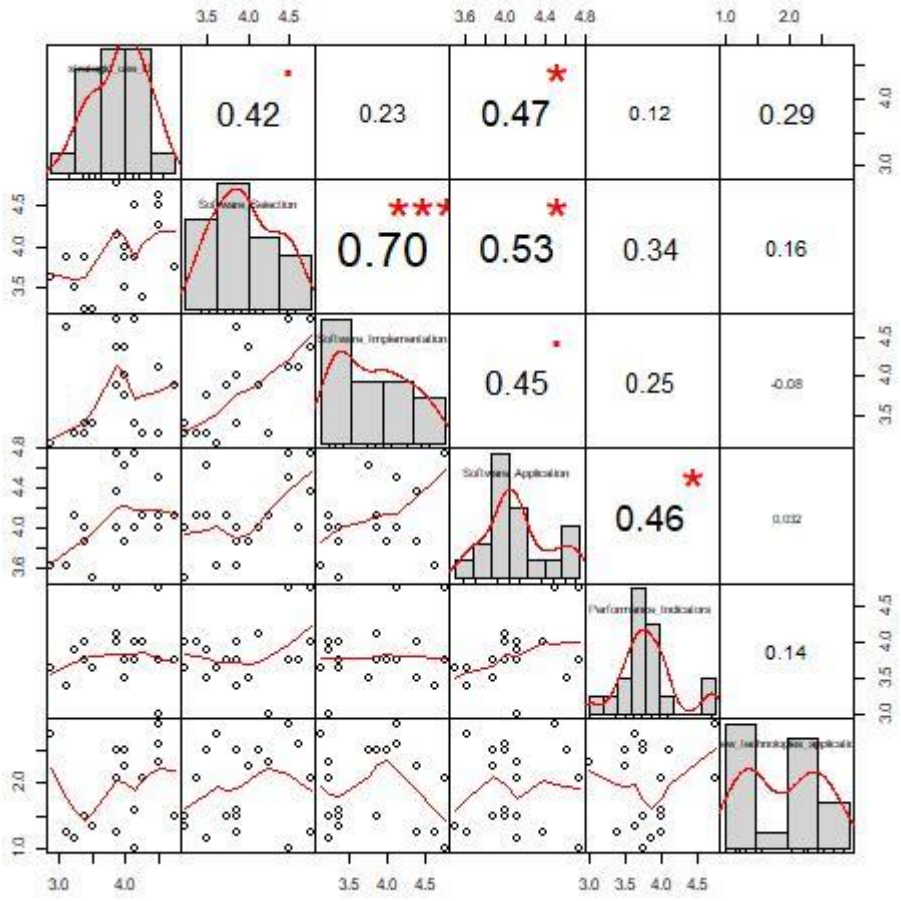

Figure 4 Correlation among constructs (preliminary results)

As shown in Figure 4, all correlation coefficients are lower than threshold 0.85, indicating no significant overlap between the constructs Awang, supporting discriminant validity (Awang, 2014).

3.5 Field survey

Selecting an area is always a challenge due to many practical reasons, such as access to companies as well as measuring current trends of development. The selection of the Kosovo region has been seen as an excellent opportunity for this specific study because of the diversity of the organizations also the development phases that the organizations reached last 20 years, and the technological changes they have faced during this time,

including migrating to ERP systems. Because some organizations are limited in the scale of knowledge in terms of ERP systems, a careful approach has been carried out in selecting organizations that fit well with the application, knowledge, and respective benefits that ERP systems offer.

3.6 Sample size determination

Sample size determination is essential when applying the quantitative method. The confidence level in terms of acceptance is usually at around 90%, 95%, and 99%. The margin of errors or widely accepted terminology confidence interval may range from 1% to 8%, but also may be the researcher's decision on many factors influencing the study or inability to obtain the response/feedback from the targeted audience. For the real numbers of the organizations that apply ERP systems are not fully known, however, based on the contact with the companies who implement ERP systems in Kosovo, it is estimated that there are between 170 – 200 organizations that are fully functional on ERP system implementation and application. The number of new business ventures of opening business and closing usually happens very fast as mainly they are small-sized industry and primarily family-based. The bottom line, since the exact numbers cannot be determined precisely, this can be summarized as N = 176 (number of population size). Due to many limits in the confidence level has been taken as 90% and the confidence interval (margin of error) as 6%. The questionnaire has been sent to the 148 companies, and only 91 respondents have answered, therefore, meeting the criteria and categorized as per the above explanation.

3.7 Field Interviews

The study targeted various management levels at the companies (General Manager, Owner, or Board Member, Top Level Management, IT Manager or CIO, IT Specialist, etc.). Table 14 presents the distribution of positions of the interviewees.

Table 14 Position of the interviewee

Position of the interviewee	Respondents	Percentage
Top Level Management	34	37.36 %
IT Manager or CIO	20	21.98 %
IT Specialist	15	16.48 %
Other	13	14.29 %
General Manager, Owner, or Board Member	9	9.89 %

For the questionnaire, the format has been tailored to meet the study objectives and its purpose. At first, the questionnaire required to answer necessary company information such as location, number of workers, industry category, the position of the interviewee, and company name to ensure the valid organization is part of the survey and finally avoid any duplication of efforts.

3.8 Choosing the method to conduct the research

The methods selected for this study are thought to be a combination of quantitative and qualitative methods. Choosing one vs. another certainly have their benefits; however, in this case, it is best thought to have a combination of methods that will provide more insights from the field and literature review. As the study progressed through framework analysis and in-depth literature review, the questions were detailed, so a quantitative survey was a necessity. The variables were structured in a manner that they can be tested with the statistical methods; therefore, the questionnaire design, development, scaling will meet the target lot number size and give reliable results. The questionnaire design was sent forward to the organizations in a suitable format; they were called and consulted via phone, personal e-mail, personal contacts, personal site visits, etc. As stated above, many challenges were encountered during the survey as some of the companies did not respond; therefore, it required several times and contacts to be made.

In Kosovo, the organization structure is around 80% small size and family-owned with the focus for local consumption products and with a limited focus on exports due to their size capacities. The intention was to approach only the industries that meet the standards and capacities of organizations that have ERP systems or have the ability to expand their ERP systems. It is considered that regardless of the company size, even small companies can still apply technological tools such as ERP systems and may fully enjoy the advantage they offer; however, the cost of an ERP system is often an issue for small-size companies.

Table 15 Number of workers

Number of employees	Number of employees	Percentage
50 - 249	31	34.07 %
10 - 49	29	31.87 %
250 and more	27	29.67 %
1 - 9	4	4.40 %

Percentages do not always equal 100% due to rounding.

The classification of the organizations is done in four levels, presented in Table 15. Considering that ERP systems find more applications in organizations with a larger number of employees, then over 63% of the surveys are from such organizations, respectively 34.07% with 50 - 249 employees and 29.67% with 250 and more employees. Then, the rest of the respondents, respectively, 31.87% with 10-49 employees and 4.4% with less than nine employees. The goal has been to have a better representation of the situation of implementation and application of ERP in all levels of the organizations.

Table 16 Type of Industry

Industry	Number of Organizations	Percentage
Wholesale & Distribution	29	31.87 %
Manufacturing	19	20.88 %
Retail	13	14.29 %
ICT	10	10.99 %
Professional & Financial Services	7	7.69 %
Public Sector	5	5.49 %
Education	3	3.30 %

Healthcare	3	3.30 %
Other	2	2.20 %

Percentages do not always equal 100% due to rounding.

The classification of organizations is based on the literature review; the preliminary list is generated based on research done by Panorama Consulting (Panorama Consulting Solutions, 2019). At the same time, local companies that have implemented ERP systems in Kosovo have also been contacted to verify if they have implemented and applied ERP systems in such industries in Kosovo, according to the preliminary list. After analyzing the classification of industries in the report of Panorama Consulting and their verification with local companies that implement such systems, the final list presented in Table 16 is generated.

The industries that have responded most positively to the survey are Wholesale & Distribution - 31.87%, Manufacturing - 20.88%, Retail - 14.29%, and ICT - 10.29%. Although it has been attempted to do the survey more in the manufacturing sector, the percentage of organizations in this industry that participated in the survey has also been dictated by the willingness of organizations to participate in the research.

3.9 Summary

This chapter presents in detail the research approach that was applied during this thesis. For the creation of a literature review, Webster and Watson were identified as the appropriate approach (Webster & Watson, 2002). A questionnaire is developed to collect the data from organizations in support of model validation. To design and develop the questionnaire, the Dillman approach was applied (Dillman, 2007). In order to check the questionnaire's reliability, initially, it was sent to 19 organizations, and based on them, the questionnaire is analyzed and approved for further investigation of the problem. Also, in this chapter, details regarding the sample size determination, field interviews details, classification of the organization is presented. Furthermore, the applied research methods are presented.

4 ERPMM: THE PROPOSED MATURITY MODEL FOR ERP SYSTEMS

Maturity models support the organization to analyze and evaluate the organization's business processes in support of identifying gaps and where the organization stands with their maturity level for a specific objective. Three maturity models developed by previous researchers to measure the ERP maturity level are identified. Because technology is changing rapidly, also ERP vendors are adopting ERP systems based on the organization's requirements, it was necessary to develop a new ERP maturity model with a new approach about the current state of ERP systems implementation and application process in support of the organizations. Based on the literature review, the initial theoretical maturity model for ERP systems were created. A questionnaire was developed to check the validation and reliability of the model. The questions are generated from existing identified maturity models (Holland and Light, Parthasarathy & Ramachandran; Scanzo) also by identifying other critical factors at specific stages that influence the implementation and application of ERP systems that were mentioned by different researchers and referenced on Literature Review chapter (Holland & Light, 2001; Parthasarathy & Ramachandran, 2008; Scanzo, 2011). At the same time, reports from the industry helped in the generation of new questions based on the new technological changes that have occurred recently. The initial model is constructed based on some of the ERP system lifecycle stages proposed by Esteves and Pastor (Esteves & Pastor, 2001). In order to validate the model, data were collected from 91 organizations that have implemented and are applying ERP systems.

After data collection and analysis, the following methods have been applied to examine the reliability and validity of the model: Average Variance Extracted - AVE, Cronbach's alpha, Composite Reliability, and Loading to evaluate if the model can be accepted. Chapter 5 presents the detailed results of all the analyzes done to validate the model and its reliability. Thus, the final model contained 35 variables.

The proposed model to measure the maturity of ERP systems (ERPMM) implementation and application has been developed in full harmony with the literature review that has been done in this study through the use of secondary data. The model to measure the

maturity of ERP systems implementation and application (ERPMM) consists of 5 constructs, as shown in Figure 5. The model constructs are:

1. Strategic use of IT;
2. ERP Selection;
3. ERP Implementation;
4. ERP Application;
5. Performance Indicators.

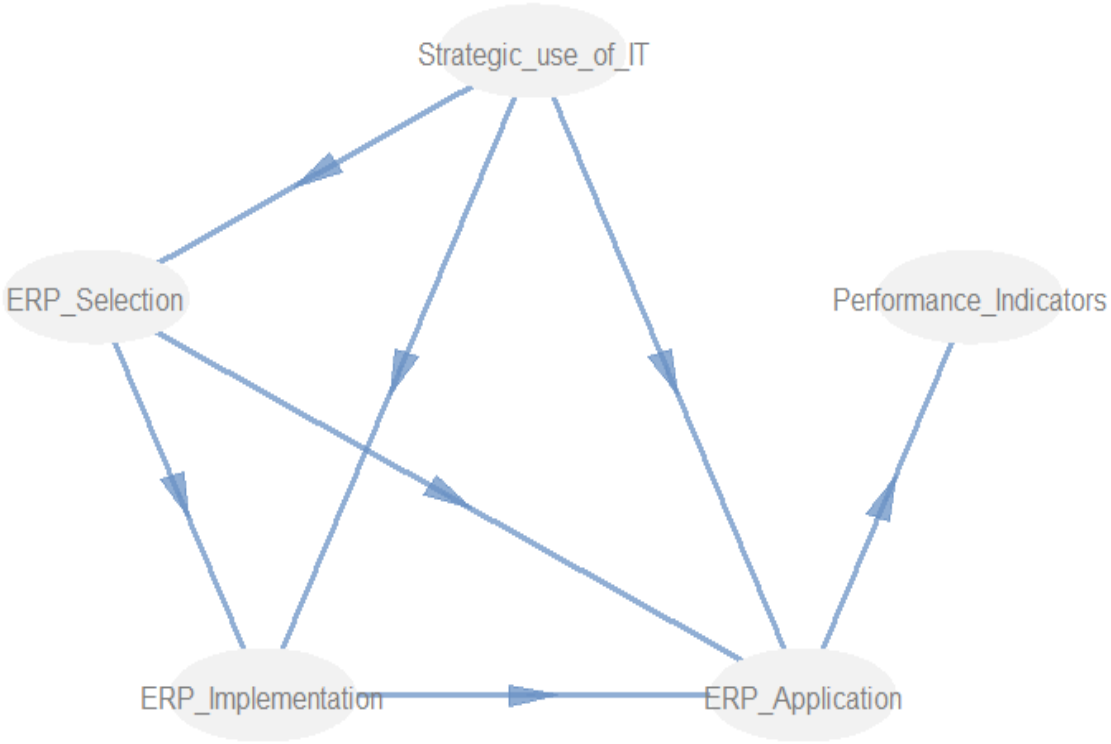

Figure 5 Proposed ERP maturity model - ERPMM

In Table 17, is presented the model constructs with the specific variables for each of the constructs of the model.

Table 17 Model constructs

Constructs	***Variable***
Strategic use of IT	Top management support exist in strategic investment projects Feasibility study is done for technical and human resources and infrastructure; Cross-department cooperation is smooth and effective; Employees are proactively involved in digitalization and they support the business changes; The organization has a clear vision of ERP implementation; Cost-benefit analysis is part of ERP implementation and application; Organization is prepared for Change management and Business Process Reengineering.
ERP Selection	Top management firmly support the evaluation team in the ERP selection process; The ERP vendor and implementation partner have a strong portfolio in terms of technical and financial capacities; The vendor and implementation partner have a suitable solution that results in organization benefit; The vendor and implementation partner understand the organization culture and industrial norm; The evaluation team involves both management and user representatives; The hardware and infrastructure are at an affordable cost to ensure functional system performance.
ERP Implementation	The scope and objectives are clearly identified by the implementation team; The project is implemented on time; The organization is well trained to accept the changes for the best practices for a new ERP system; The implementation partner can bridge the gap between the existing; workflow and new ERP business practice by appropriate change management in the organization; Employee's user training during ERP implementation is effective The project is implemented on budget; Implementation strategy has been appropriate.

ERP Application	The organization achieved the goals and objectives to implement and apply the ERP system; The organization reduced manufacturing or service offering lead times; Processes are automated and functional; Communication between the departments is digitalized and efficient Easier job for employees; Departments are integrated into a single ERP system; The organization has successfully adopted business changes and their supporting processes (people, IT, culture, etc.).
Performance Indicators	ERP implementation and application of ERP resulted in Increased profit; Improved delivery time of product/services; Reduced administrative workload; Improved interaction between department, customers, and suppliers; Business success in terms of sales and market share; Organization achieved the goals to create new innovative product/services; Reduced costs; Availability of information and better decision-making.

During the literature review, there could not be found a simple and commonly accepted way how to calculate the importance of the constructs. The standardized loadings from Table 23 were used to determine the weight for each item and construct in total. Initially, the weight of the five constructs was calculated based on the sum of all items in the specific constructs.

Table 18 Weight of the constructs of the proposed model

Construct	Weight of construct
Strategic use of IT	19.11 %
ERP Selection	20.35 %
ERP Implementation	20.43 %
ERP Application	20.29 %
Performance Indicators	19.82 %

Based on Table 23, below are presented the weight for each item of the constructs.

4.1 Strategic use of IT construct

The variables in Figure 6 presents the factors that are related to the impact of strategic use of IT on the process of measuring the maturity of the ERP implementation and application based on the developed model of this study.

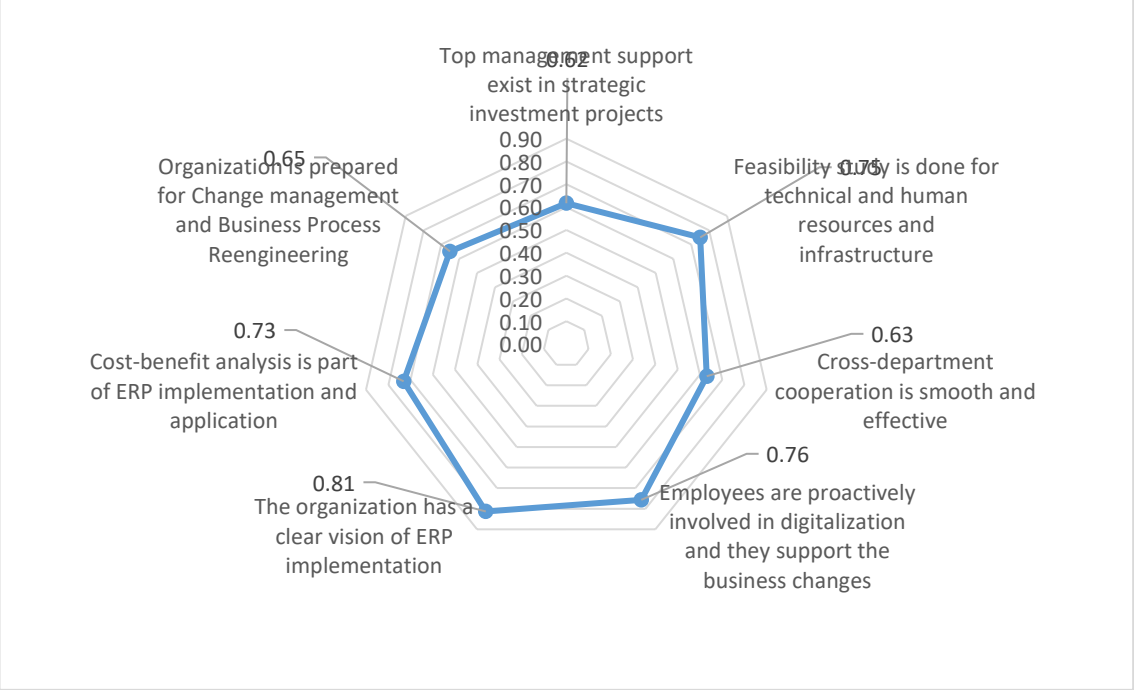

Figure 6 Strategic use of IT items weights

The most important factor of Strategic use of IT is the definition of the organization's vision about ERP system implementation and application. Approximately the same weight with a small difference is between the factor if the organization has done a feasibility study in order to understand that the organization is capable of providing enough technical and human resources and infrastructure in the process of ERP implementation and application and involvement of employees in the process of digitalization and their support on the business process changes. Cost-benefit analysis is considered as the fourth factor based on the analysis. Based on the calculated weight, it is approximately on the same level of importance as the readiness of the organizations for change management and business process reengineering. While cross-department cooperation is listed as the sixth factor of the Strategic use of IT. Even though during the literature review, one of the main factors which has a significant impact on the success of ERP implementation and application is identified top management support, in this study,

compared with other factors on the same construct it is listed as the last factor based on the importance in the context of top management support on strategic investment projects.

4.2 ERP selection construct

The final version of the developed construct ERP selection contains six factors after the statistical analysis.

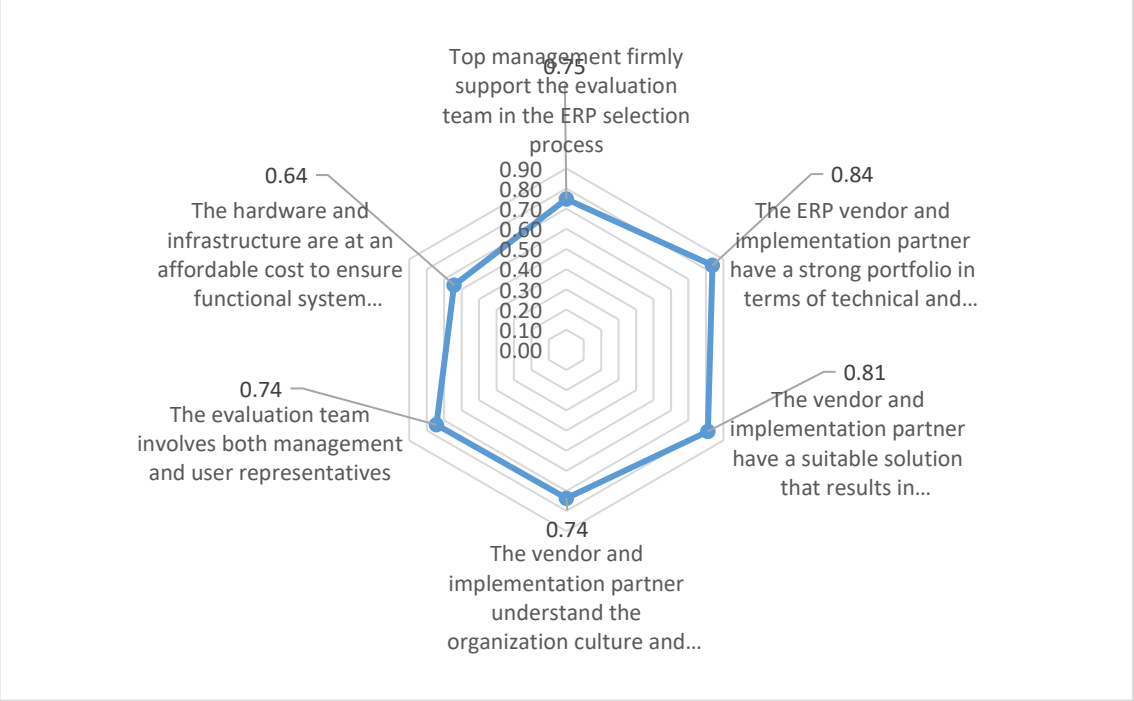

Figure 7 ERP Selection items weights

The highest important factor of this construct is the experience, and the technical and financial capabilities of the ERP vendor and implementation partner, followed by the ERP solution which is offered to the organization who wants to implement and apply the ERP system. While two other factors, the support of top management of the evaluation team on the process of ERP selection and involvement of management and user representatives, have the same weight on the ERP selection construct. Also, based on the study and the calculated weight of the factors, it is considered that it is essential that the ERP vendor and implementation partner should understand the organization's culture and industrial norm. Compared with the other factor of the construct of ERP selection, the cost of hardware and infrastructure have the lowest impact.

4.3 ERP implementation construct

The study shows that the highest important factor in the ERP implementation process is choosing the appropriate implementation strategy, followed by the definition of the implementation timeline factor.

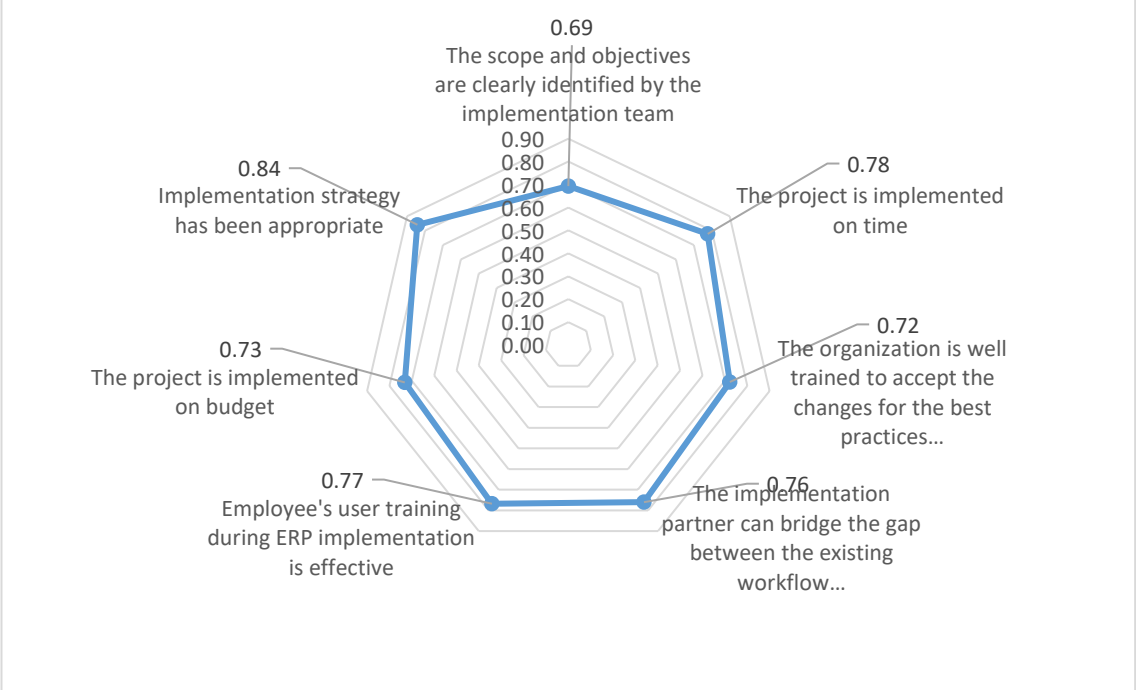

Figure 8 ERP Implementation items weights

User training during the implementation of ERP system and the ability of the implementation partner to bridge the gap between the existing workflow before and after the ERP system implementation and application by choosing the appropriate change management are weighted on the same level with a bit more importance of the user training. The implementation of the project on the planned budget is listed as the fifth factor of ERP implementation. While preparing the organization for the new ERP system and definition of the goals and objectives by the implementation team are listed as the sixth and seventh factors based on the calculated weight on the ERP implementation process.

4.4 ERP application construct

On the ERP application, factors presented in Figure 9, the most crucial factor is process automation and functionality.

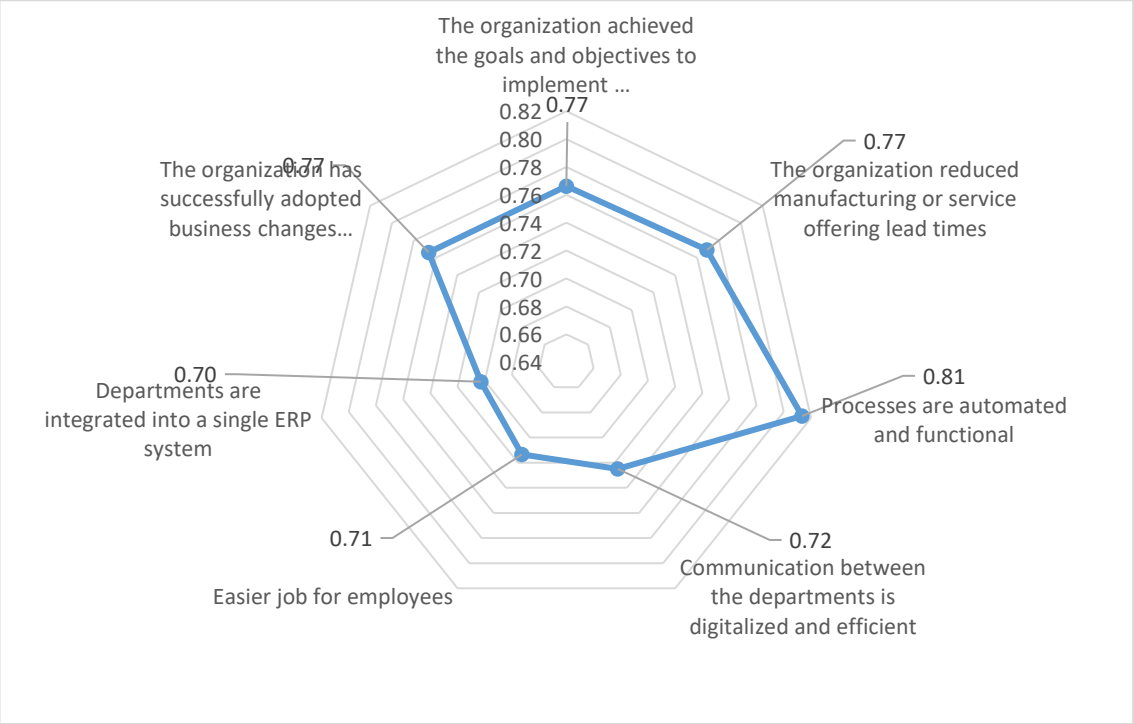

Figure 9 ERP Application items weights

While the organization aims to achieve the planned goals and objectives to implement and apply the ERP system, reduce the manufacturing or service offering lead time and ability of the organization to successfully adopt business changes and their supporting processes are listed on the same level with the same weight. Also, on the ERP application, with lower importance than the previously mentioned factors are listed the impact of ERP application on the workload for the employees, the integration of department into a single ERP system, and digitalization of communication between the departments and increased efficiency between departments.

4.5 Performance indicators construct

Based on the literature review, there are eight key factors that are identified that are necessary to evaluate the importance of ERP implementation and application on the business performance.

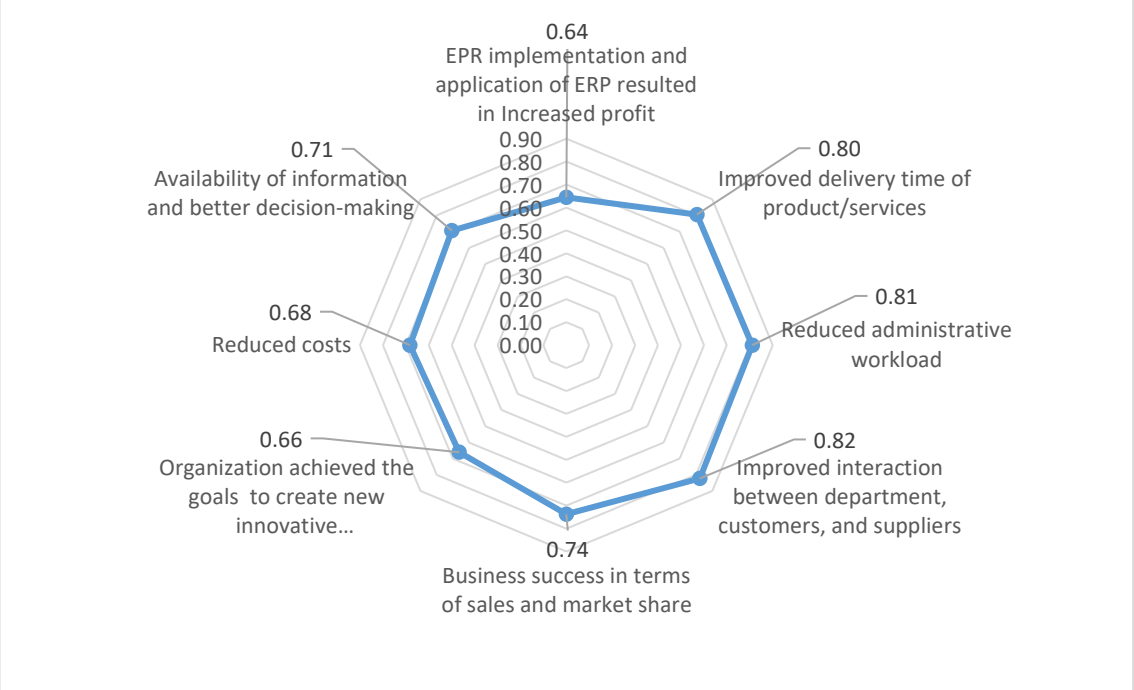

Figure 10 Performance Indicators items weights

Figure 10 shows the indicators and their respective weight based on this study. It is seen that the highest important factor is the ability of ERP application on business performance in the context of improving the interaction between departments, customers, and suppliers. With a small difference, are listed two other factors the improvement of the delivery time of the products and services and the impact of ERP application on reducing the administrative workload. Based on the weight presented in Figure 10, other important factors of business performance are calculated, the success of business in terms of increasing the sales and market shares and the availability of information and better decision making. At the same time, other factors, the cost reduction, and the aim to create innovative products/services that are listed in the sixth and seventh places. The last factor of business indicators is the impact of the ERP application to increase the profit of the organization.

4.6 Maturity levels of ERPMM

Taking into consideration the calculated weight for each of the items of the constructs, it is seen that the weight of them varies from 0.62 to 0.84. As it is mentioned, the weight of each of the items is calculated based on the loading factor presented in chapter five.

With the application of the presented maturity model – ERPMM and the calculated weight for each of the items of the constructs of the model, now it is manageable to determine the maturity of the ERP implementation and application of the organization. In order to determine the classification of ERP maturity, the CMMI approach with a five-level classification will be applied.

Table 19 Five levels of proposed ERP Maturity Model

Maturity Level	Classification	Evaluation
Level I	1-20	Non-Compliant
Level II	21-40	Substantially-Compliant
Level III	41-60	Partially-Compliant
Level IV	61-80	Compliant
Level V	81-100	Fully-Compliant

Non-Compliant: the organization did not achieve the essential criteria for the implementation and application of the ERP system. There are many critical issues that the organization faced during this process;
Substantially-Compliant: the organization lacks on the implementation and application of ERP systems, even that there is a minimal positive impact on this process.
Partially-Compliant: the organization started to identify the impact in some aspect of implementation and application of ERP system even that what was achieved it is not enough;
Compliant: the implementation and application of ERP system resulted in the integration of organization functions and positive feedback on all levels where the ERP is applied. The organization achieved to create a stable system in support of the organization stability;

Fully-Compliant: the organization acts entirely in accordance with the initial strategic plan for implementation and application of the ERP system, furthermore the organization is ready for further digitalization or new technologies implementation and application.

The above-identified levels will support the organization on the evaluation maturity level of implementation and application of ERP systems in their organization.

4.7 Summary

The proposed maturity model ERPMM is presented. All the items of the model, also the weight of constructs and items which are used for the assessment of the ERP maturity model, are described. The classification level of ERP maturity is presented. Based on the proposed ERP maturity model, the organization can be classified on five levels: Non-Compliant, Substantially-Compliant, Partially-Compliant, Compliant, Fully-Compliant. Each of the ERPMM classification levels are presented and described.

5 RESULTS OF MATURITY MODEL VALIDATION

The undertaken study analyzed the current state of the art of ERP systems implementation and application. It also analyzed the relationship of ERP systems with the Industry 4.0 approach. Based on the aims and objectives of the thesis and the problem statement, the research questions and hypotheses are generated and presented in chapter one of the thesis also; the detailed applied methodology is described in the Methodology chapter. Initially, by investigating and gathering the literature review, it was developed a new theoretical maturity model to measure the maturity of ERP systems implementation and application and the role of ERP application to predict the readiness of organizations about the Industry 4.0. Based on the developed maturity model, a questionnaire is generated for the purpose of data collection in support of model validation.

The study is done based on a quantitative methodology. There were 91 responders collected from organizations that already have implemented and are applying ERP systems. Various management levels in the organizations took part in the study. The research was undertaken in different industries such as Wholesale & Distribution, Manufacturing, Retail ICT, Professional & Financial Services, Public Sector, Education, Healthcare, Others. Also, the size of the organization was classified by the number of employees, where 34.07% of responders where from organizations with 50 – 249 employees, 31.87% with 10 – 49, 29.67% with 250 and more employees while the rest of the organization are classified with 1 - 9 employees.

Table 20 Selected ERP vendor

ERP Vendor	Number of Organizations	Percentage
Microsoft	37	40.66 %
Open Source	6	6.59 %
Oracle	6	6.59 %
SAP	3	3.30 %
Infor	1	1.10 %
Other	38	41.76 %

Based on the study, in Kosovo, the most implemented ERP vendor is Microsoft Dynamic with 40.66%, while in the second place are Open Source ERP vendors with 6.59%, and in the same position stands Oracle with 6.59%. SAP is implemented only on 3.3% of the organizations, followed by Infor with 1.1%. The rest of the organizations, 41.76%, declares that they implemented other ERP vendors.

Table 21 Deployment option

Deployment option	Number of Organizations	Percentage
Cloud ERP	20	21.98
On-Premises	52	57.14
SaaS - Software as a Service	19	20.88

Based on Table 21, it is seen that most of the organizations with 57.14% have chosen to implement their ERP system On-Premises, while 21.98% of the organizations declared that they have Cloud ERP deployment option, and 20.88% of the organizations is using SaaS – Software as a Service as a deployment way.

For the purpose of examination of the reliability and validity of the model, the following analysis has been done: Average Variance Extracted - AVE, Cronbach's alpha, Composite Reliability, and Loading. The final version of the model has 35 variables and five constructs. Below are presented the analysis for the model evaluation.

5.1 Model reliability and validation

Considering the objective of the research to develop a model to measure the maturity of implementation and application of ERP systems, the following analysis has been done to test the significance of the impact latent construct “Strategic use of IT” on latent constructs “ERP Selection”, “ERP Implementation” and “ERP Application”; the impact of “ERP Selection” on latent constructs “ERP Implementation” and “ERP Application”, the impact of “ERP Implementation” on latent construct “ERP Application”; as well as the impact of “ERP Application” on latent construct “Performance Indicators”. Structural Equation Modeling was used as SEM allows "to measure any combination of relationships by examining a series of dependent relationships simultaneously while considering potential errors of measurement among all variables" (Work et al., 2014).

The two-stage approach for data analysis using SEM proposed by Gerbing and Anderson was applied (Gerbing & Anderson, 1988). At the first stage, a measurement model was estimated using Confirmatory Factor Analysis (CFA), presented in Table 22.

Table 22 Loading for the initial model

Item	Construct	Loading	Removed
1.1 IT and Business strategy are aligned and the organization has clearly defined goals and objectives	Strategic use of IT	0.579089	YES
1.2 Top management support exist in strategic investment projects	Strategic use of IT	0.645408	NO
1.3 Feasibility study is done for technical and human resources and infrastructure	Strategic use of IT	0.749034	NO
1.4 Cross-department cooperation is smooth and effective	Strategic use of IT	0.620645	NO
1.5 Employees are proactively involved in digitalization and they support the business changes	Strategic use of IT	0.727667	NO
1.6 The organization has a clear vision of ERP implementation	Strategic use of IT	0.780399	NO
1.7 Cost-benefit analysis is part of ERP implementation and application	Strategic use of IT	0.738303	NO
1.8 Organization is prepared for Change management and Business Process Reengineering	Strategic use of IT	0.665153	NO
2.1 Top management firmly support the evaluation team in the ERP selection process	ERP Selection	0.751316	NO
2.2 The ERP vendor and implementation partner have a strong portfolio in terms of technical and financial capacities	ERP Selection	0.805787	NO
2.3 The vendor and implementation partner have a suitable solution that results in organization benefit	ERP Selection	0.788795	NO
2.4 The vendor and implementation partner understand the organization culture and industrial norm	ERP Selection	0.73124	NO

2.5 The evaluation team involves both management and user representatives	ERP Selection	0.746343	NO
2.6 An external ERP consultant is involved in the evaluation team	ERP Selection	0.356552	YES
2.7 The hardware and infrastructure are at an affordable cost to ensure functional system performance	ERP Selection	0.634905	NO
2.8 Organization has run a pre-implementation pilot	ERP Selection	0.565952	YES
3.1 The scope and objectives are clearly identified by the implementation team	ERP Implementation	0.686166	NO
3.2 The project is implemented on time	ERP Implementation	0.784892	NO
3.3 The organization is well trained to accept the changes for the best practices for a new ERP system	ERP Implementation	0.697557	NO
3.4 The implementation partner can bridge the gap between the existing workflow and new ERP business practice by appropriate change management in the organization	ERP Implementation	0.753799	NO
3.5 Employee's user training during ERP implementation is effective	ERP Implementation	0.759116	NO
3.6 External ERP consultant engagement resulted with success on implementation	ERP Implementation	0.467527	YES
3.7 The project is implemented on budget	ERP Implementation	0.745345	NO
3.8 Implementation strategy has been appropriate	ERP Implementation	0.830956	NO
4.1 The organization achieved the goals and objectives to implement and apply the ERP system	ERP Application	0.74797	NO
4.2 The organization reduced manufacturing or service offering lead times	ERP Application	0.762035	NO
4.3 Processes are automated and functional	ERP Application	0.802104	NO
4.4 Communication between the departments is digitalized and efficient	ERP Application	0.705991	NO
4.5 Easier job for employees	ERP Application	0.715672	NO

4.6 Departments are integrated into a single ERP system	ERP Application	0.701435	NO
4.7 The organization reduced operating/labor costs	ERP Application	0.482861	YES
4.8 The organization has successfully adopted business changes and their supporting processes (people, IT, culture, etc.)	ERP Application	0.778513	NO
5.1 ERP implementation and application of ERP resulted in Increased profit	Performance Indicators	0.648486	NO
5.2 Improved delivery time of product/services	Performance Indicators	0.800748	NO
5.3 Reduced administrative workload	Performance Indicators	0.811706	NO
5.4 Improved interaction between department, customers, and suppliers	Performance Indicators	0.822393	NO
5.5 Business success in terms of sales and market share	Performance Indicators	0.735955	NO
5.6 Organization achieved the goals to create new innovative product/services	Performance Indicators	0.659785	NO
5.7 Reduced costs	Performance Indicators	0.687211	NO
5.8 Availability of information and better decision-making	Performance Indicators	0.705137	NO

Also, the reliability and validity of the latent factors used in the model were investigated at the given stage.

At the second, Structural Equation Modeling (SEM) was used to test the significance of the relationships of variables “Strategic use of IT” on latent constructs “ERP Selection”, “ERP Implementation” and “ERP Application”; the impact of “ERP Selection” on latent constructs “ERP Implementation” and “ERP Application”, the impact of “ERP Implementation” on latent construct “ERP Application”; as well as the impact of “ERP Application” on latent construct “Performance Indicators”.

A total of 91 respondents answered the questionnaire. At the first step measurement model was estimated using all 40 items. Considering a relatively small sample size PLS

approach was applied (using plspm package of R). The goodness of fit index of the model (GoF index) was 0.53 that was between 0.45 to 0.9 that is considered as a range of GoF index for a true model (Evermann & Tate, 2010). To improve the model, according to Awang items that have loading < 0.6 presented in Table 22 are considered as "problematic" items. These items are one item ("IT and Business strategy are aligned and the organization has clearly defined goals and objectives") from construct Strategic use of IT, two items ("An external ERP consultant is involved in the evaluation team" and "Organization has run a pre-implementation pilot") from construct "ERP Selection", one item ("External ERP consultant engagement resulted with success on implementation") from construct "ERP Implementation" and one item ("The organization reduced operating/labor costs") from construct "ERP Application" (Awang, 2014). Therefore, these items were removed one-by-one as proposed by Awang (Awang, 2014). Thus, the final model includes 35 items and five latent variables, as shown in Table 23. Descriptive statistics for latent variables are reported in Table 24.

Table 23 The final measurement model with estimated loadings and validity and reliability statistics

Constructs and Items	**Standardized loadings**	**Cronbach's alpha**	**Composite reliability**	**AVE**	**R squared**
Strategic use of IT		**0.84**	**0.88**	**0.50**	
1.2 Top management support exist in strategic investment projects	0.62				
1.3 Feasibility study is done for technical and human resources and infrastructure	0.75				
1.4 Cross-department cooperation is smooth and effective	0.63				
1.5 Employees are proactively involved in digitalization and they support the business changes	0.76				

1.6 The organization has a clear vision of ERP implementation	0.81				
1.7 Cost-benefit analysis is part of ERP implementation and application	0.73				
1.8 Organization is prepared for Change management and Business Process Reengineering	0.65				
ERP Selection		**0.85**	**0.89**	**0.57**	**0.33**
2.1 Top management firmly support the evaluation team in the ERP selection process	0.75				
2.2 The ERP vendor and implementation partner have a strong portfolio in terms of technical and financial capacities	0.84				
2.3 The vendor and implementation partner have a suitable solution that results in organization benefit	0.81				
2.4 The vendor and implementation partner understand the organization culture and industrial norm	0.74				
2.5 The evaluation team involves both management and user representatives	0.74				
2.7 The hardware and infrastructure are at an affordable cost to ensure	0.64				

functional system performance					
ERP Implementation		**0.88**	**0.90**	**0.57**	**0.66**
3.1 The scope and objectives are clearly identified by the implementation team	0.69				
3.2 The project is implemented on time	0.78				
3.3 The organization is well trained to accept the changes for the best practices for a new ERP system	0.72				
3.4 The implementation partner can bridge the gap between the existing workflow and new ERP business practice by appropriate change management in the organization	0.76				
3.5 Employee's user training during ERP implementation is effective	0.77				
3.7 The project is implemented on budget	0.73				
3.8 Implementation strategy has been appropriate	0.84				
ERP Application		**0.87**	**0.90**	**0.57**	**0.63**
4.1 The organization achieved the goals and objectives to implement and apply the ERP system	0.77				

4.2 The organization reduced manufacturing or service offering lead times	0.77				
4.3 Processes are automated and functional	0.81				
4.4 Communication between the departments is digitalized and efficient	0.72				
4.5 Easier job for employees	0.71				
4.6 Departments are integrated into a single ERP system	0.70				
4.8 The organization has successfully adopted business changes and their supporting processes (people, IT, culture, etc.)	0.77				
Performance Indicators		**0.88**	**0.90**	**0.54**	**0.54**
5.1 ERP implementation and application of ERP resulted in Increased profit	0.64				
5.2 Improved delivery time of product/services	0.80				
5.3 Reduced administrative workload	0.81				
5.4 Improved interaction between department, customers, and suppliers	0.82				
5.5 Business success in terms of sales and market share	0.74				
5.6 Organization achieved the goals to create new innovative product/services	0.66				
5.7 Reduced costs	0.68				

5.8 Availability of information and better decision-making	0.71	

Table 24 Descriptive statistics of the latent construct

		95% Confidence interval		Standard			
Variable	Mean	low	high	deviation	Max value	Min value	N
Strategic use IT	4.22	4.10	4.33	0.55	5.00	2.75	91
ERP Selection	4.17	4.06	4.28	0.54	5.00	2.88	91
ERP Implementation	4.16	4.04	4.28	0.60	5.00	2.63	91
ERP Application	4.31	4.21	4.42	0.53	5.00	2.75	91
Performance Indicators	4.20	4.09	4.31	0.55	5.00	3.00	91

According to Table 23, all loadings have values larger than 0.6, indicating that the model has no "problematic items" (Joseph J. F. et al., 2010). Also, 26 of 35 items have loading values larger than 0.7, indicating that the model has 74.28% of "ideal items" Thus, there is evidence to consider all items as acceptable supporting the convergent validity of the model. The reliability of the constructs was investigated using Cronbach's α and composite reliability statistics ω. All the values of Cronbach's α ranged from 0.84 (Strategic_use_of_IT) to 0.88 (Performance Indicators and ERP Implementation), exceeding the level 0.70 recommended by Nunnally (Nunnally & Bernstein, 1978). Thus, the internal consistency of all the latent constructs is acceptable. Also, all values of ω for both samples are more significant than the threshold 0.70 proposed by Fornell and Larcker as an acceptable level (Fornell & Larcker, 1981). Thus, all values of ω support construct reliability of the model for all latent variables (Joseph J. F. et al., 2010).

The Average Variance Extracted (AVE) was estimated to explore the convergent validity of the model. As shown in Table 23, all constructs have AVE values that exceed the acceptable level 0.5 suggested by Joseph et al. (Joseph J. F. et al., 2010). Thus the model reported in Table 23 indicates an acceptable level of convergent validity.

Then, discriminant validity was tested. Discriminant validity investigated the correlation matrix. As shown in Table 25, all correlation coefficients between constructs were smaller

than the threshold 0.85, indicating no significant overlap between the constructs (Awang, 2014).

Table 25 Correlation matrix

	(1)	(2)	(3)	(4)	(5)
Strategic use of IT	1	0.57	0.56	0.65	0.52
ERP Selection	0.57	1	0.81	0.74	0.61
ERP Implementation	0.56	0.81	1	0.7	0.59
ERP Application	0.65	0.74	0.7	1	0.74
Performance Indicators	0.52	0.61	0.59	0.74	1

Thus, the model indicates acceptable discriminant validity. The goodness of fit index of the final model (GoF index) is 0.55 that meets the range of 0.45 to 0.9 for the true model (Evermann & Tate, 2010). Considering that AVE, Cronbach's alpha, composite reliability, and loading values indicated a good fit, the model fit in general can be considered as acceptable.

Modern data science methods and algorithms were tested in order to validate the model. The following methods were applied: regression trees, logistic regression, and k-fold cross validation were tested. Based on the previous studies, a small dataset can impact giving not an accurate result of the model. Also, experts from data science techniques were consulted and confirmed that in order to get reliable results, the data set size must be larger. Considering that modern data science methods and algorithms require large data set to give reliable results after analyzing, in the future, after the database population, data science methods should be used for further investigation of the model.

5.2 Summary

In the beginning, there are presented the distribution of the ERP vendors which the organizations participated in this study have implemented. Also, the selected deployment option is presented where the most selected is On-Premises with 57.14%, followed by

Cloud ERP and SaaS. This chapter presents all the analyses that are performed in order to validate the proposed ERP maturity model. Considering the results of applied methods for model validation, the model is accepted.

6 RESEARCH QUESTIONS AND HYPOTHESES TESTING

In order to achieve the aim and objectives of the study, to test the hypotheses and to answer the research questions of the study, the path analysis was conducted. During the hypotheses testing, if the corresponding loading is positive and significantly differs from zero, then the corresponding hypothesis is supported. Considering that PLS is a non-parametric method, bootstrapping (500 replications) was applied to calculate standard errors of the path loadings. According to Ravand and Baghaei, the parameter evaluations received within the PLS method, which are more than twice larger than their standard errors, could be considered as significantly different from zero at the significance level 0.05 (Hamdollah & Baghaei, 2016).

The graphical presentation of the model with loadings is displayed in Figure 13.

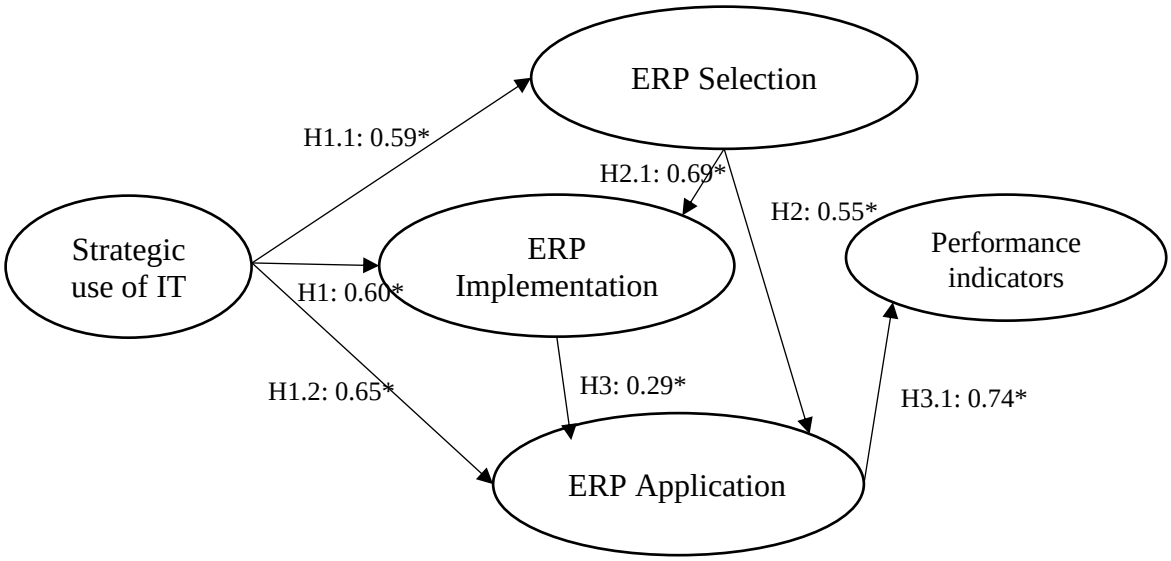

Figure 11 Graphical presentation of the model with the factor loadings

6.1 Hypotheses testing

Below is a description and results for each of the hypotheses of the study and answers to the research question of this thesis.

Main Hypothesis H1 - Strategic use of IT significantly and positively affects ERP Implementation

After the theoretical development of the model, the construct of Strategic use of IT contained eight items. During the validation of the model, one of the items, "IT and Business strategy are aligned and the organization has clearly defined goals and objectives" had loading lower than 0.6, which is considered as "problematic item", and it is removed from the construct. On the other hand, the ERP Implementation construct had eight items, and after validation, one of them "External ERP consultant engagement resulted with success on implementation" had loading lower than 0.6 and were removed from the final construct.

Table 26 H1 - Strategic use of IT significantly and positively affects ERP Implementation hypothesis testing results

Path (Hypothesis)	Standardized path coefficient	95% Bootstrap CI	
		lower	upper
H1: Strategic use of IT -> ERP Implementation	0.60*	0.45	0.72

* - significant at the level 0.05

The final construct of Strategic use of IT and ERP Implementation was used to test the H1 hypothesis. According to the analysis presented in Table 26, the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05. Considering this, at the significance level 0.05, Strategic use of IT significantly and positively affects ERP, which confirms that H1 is accepted.

Sub-Hypothesis H1.1 - Strategic use of IT significantly and positively affects ERP Selection

To identify if the strategic use of IT on the organization affects the ERP Selection, the H1.1 hypothesis was generated. As it is described on the model validation, one of eight items "IT and Business strategy are aligned and the organization has clearly defined goals and objectives" of Strategic use of IT had lower than 0.6 and were removed from the final construct, while on the ERP Selection construct two of eight items "An external ERP consultant is involved in the evaluation team and "Organization has run a pre-implementation pilot" were removed from the final construct. Table 27 presents the results of H1.1 hypothesis testing.

Table 27 H1.1 - Strategic use of IT significantly and positively affects ERP Selection hypothesis testing results

	Standardized path	95% Bootstrap CI	
Path (Hypothesis)	coefficient	lower	upper
H1.1: Strategic use of IT -> ERP Selection	0.59*	0.45	0.70

* - significant at the level 0.05

H1.1 - Strategic use of IT significantly and positively affects the ERP Selection hypothesis is accepted regarding that the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05.

Sub-Hypothesis H1.2 - Strategic use of IT significantly and positively affects ERP Application

Based on the results presented in Table 28, H1.2 - Strategic use of IT significantly and positively affects ERP Application is accepted, considering that the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05.

Table 28 H1.2 - Strategic use of IT significantly and positively affects ERP Application hypothesis testing results

	Standardized path	95% Bootstrap CI	
Path (Hypothesis)	coefficient	lower	upper

H1.2: Strategic use of IT -> ERP Application	0.65*	0.55	0.77

* - significant at the level 0.05

The final construct of Strategic use of IT contains seven items after one item was removed during the model validation, on the other hand, the final construct of ERP application contains seven items because one the items "The organization reduced operating/labor costs" had loading lower than 0.6 and were removed from the model during the validation.

Main Hypothesis H2 - Appropriate ERP Selection has a positive impact on ERP Application

To understand if ERP application success is related to the ERP selection, the H2 hypothesis is generated. The ERP Selection construct before the validation of the model contained eight items, while during the validation two of the items "An external ERP consultant is involved in the evaluation team" and "Organization has run a pre-implementation pilot" had loading factor lower than 0.6 and were removed from the construct, while on the ERP application construct one of the eight items "The organization reduced operating/labor costs" was removed because of loading factor lower than 0.6.

Table 29 H2 - Appropriate ERP Selection has a positive impact on ERP Application hypothesis testing results

	Standardized path	95% Bootstrap CI	
Path (Hypothesis)	coefficient	lower	upper
H2: Appropriate ERP Selection -> ERP Application	0.55*	0.41	0.70

* - significant at the level 0.05

Table 29 presents the H2 testing results, where according to the results, the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05. Considering this, at the significance level 0.05, Appropriate ERP Selection has a positive impact on ERP Application, which confirms that H2 is accepted.

Sub-Hypothesis H2.1 - Appropriate ERP Selection has positive impact on ERP Implementation

The testing results of H2.1 - Appropriate ERP Selection has positive impact on ERP Implementation approves that this hypothesis is accepted considering that the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05. So this hypothesis proves that there is a relationship between the ERP selection and ERP implementation success.

Table 30 H2.1 - Appropriate ERP Selection has positive impact on ERP Implementation hypothesis testing results

	Standardized path	95% Bootstrap CI	
Path (Hypothesis)	coefficient	lower	upper
H2.1: Appropriate ERP Selection -> ERP Implementation	0.69*	0.55	0.84

* - significant at the level 0.05

Results of the H2.1 hypothesis testing are presented in Table 30. For the final version of hypothesis testing, the ERP selection construct contained seven items, also the ERP Implementation seven items. All the items that had loading lower than 0.6 were removed during the model validation.

Main Hypothesis H3 - ERP Implementation has a significant and positive impact on ERP Application

To understand if a successful ERP application could be impacted by the process of ERP implementation, the H3 hypothesis was generated. Based on the testing results presented in Table 31, it is verified that H3 - ERP Implementation has a significant and positive impact on ERP Application is accepted, considering that the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05.

Table 31 H3 - ERP Implementation has a significant and positive impact on ERP Application hypothesis testing results

	Standardized path	95% Bootstrap CI	
Path (Hypothesis)	coefficient	lower	upper

H3: ERP Implementation -> ERP Application	0.29*	0.09	0.53

* - significant at the level 0.05

After the model validation, for H3 hypothesis testing were used seven items from ERP Implementation, and seven items from ERP Application.

Sub-Hypothesis H3.1 - ERP Application has a positive impact on Performance Indicators

During the theoretical model validation, one of the eight items of ERP application construct as it is mentioned in the previous description, is removed from the final construct because the loading factor was lower than 0.6, while the final construct of Performance Indicators contains eight items.

Table 32 H3.1 – ERP Application has a positive impact on Performance Indicators hypothesis testing results

	Standardized path coefficient	95% Bootstrap CI	
Path (Hypothesis)		lower	upper
H3.1: ERP Application -> Performance Indicators	0.74*	0.65	0.81

* - significant at the level 0.05

Based on the analysis on Table 32, hypothesis H3.1 - ERP Application has a positive impact on Performance Indicators is accepted considering that the corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05.

Main Hypothesis H4 - ERP Application can support organization to evaluate their readiness for Industry 4.0

In support of the aim that ERP application can be used by the organization to check if they are ready for further digitalization of their organization, specifically for Industry 4.0 technologies, the H4 hypothesis was generated. Table 33 presents the H4 hypothesis testing results.

Table 33 H4 - ERP Application can support organization to evaluate their readiness for Industry 4.0 hypothesis testing results

Path (Hypothesis)	Standardized path coefficient	95% Bootstrap CI	
		lower	upper
H4: ERP Application -> Industry 4.0 technologies	0.53*	0.36	0.66

* - significant at the level 0.05

While for the testing of hypothesis, H4 are considered only items from construct ERP application and Industry 4.0. The initial construct of ERP application contained eight items, and the construct Industry 4.0 contained thirteen items. After the statistical analysis, the loading factor for one item "The organization reduced operating/labor costs" from construct ERP application and nine items from construct Industry 4.0 have loading < 0.6. In this case, these items where removed. After the item removal, the final analysis for hypothesis H4 is done, where the hypothesis is accepted.

According to previous analysis and hypotheses testing results, all the main hypotheses and sub-hypotheses are supported, considering that all corresponding path coefficients are positive and significantly differ from zero at the significance level 0.05.

6.2 Research questions

The answers to the research question of the study are presented below:

Research Question 1 - What is the relationship between ERP selection, ERP implementation and ERP application with the organization's IT Strategy?

During this study, there are identified factors that are important during the definition of the organization's IT strategy and also for ERP selection, implementation and application. Top management support for investing in IT projects was one of the factors that is identified as the critical point during the IT strategy development. Also, the involvement of employees as a stakeholder it is considered another critical factor, while for the planned project, it is essential also that feasibility studies should be done in order to check if the organization has technical and human resources to support the implementation of the IT

projects. For the ERP projects, it is essential that there should be cross-department cooperation to support smooth and effective business processes to ensure that the requirements for ERP implementation can be carefully defined based on the organization's culture. The aim of the organization for ERP implementation and application should be defined clearly in IT strategy by developing the vision of ERP implementation and followed by an analysis of cost-benefit for ERP implementation and application it is vital as an initial point before starting this process. In order to validate if the mentioned points of IT strategy regarding the ERP implementation and application and if there is a relationship between IT strategy and ERP selection, implementation, and application, one main hypothesis and two sub-hypotheses, H1 - Strategic use of IT significantly and positively affects ERP Implementation, H1.1 - Strategic use of IT significantly and positively affects ERP Selection, and H1.2 - Strategic use of IT significantly and positively affects ERP Application, were generated. Based on the results of the hypotheses testing, it is confirmed that: Strategic use of IT significantly and positively affects ERP Selection; Strategic use of IT significantly and positively affects ERP Implementation; Strategic use of IT significantly and positively affects ERP Application.

Research Question 2 - What is the impact of ERP selection on ERP implementation and ERP application?

To assess the impact of ERP selection on ERP implementation and application, based on the literature review, the critical success factors that affect this process are identified. During the ERP selection, there are categorized many factors that must be considered. For the purpose of selecting factors that have the highest impact, only those who are mentioned mostly by researchers are selected. Based on this, it is crucial that during the ERP selection, the evaluation team should have full support on this process, also the necessity to involve in the team the management and user’s representative as key stakeholders for the ERP application. The ERP vendor and implementation partner portfolio in terms of technical and financial capacities, also the solution that ERP vendors offers and their expertise to understand the organization culture and industrial norm where the organization operates are important factors that must be considered during the ERP selection. Also, the selected ERP vendor requirements for hardware and infrastructure should be in line with the investing capacities of the organization. Based on factors for ERP selection and for the purpose of validation of these factors and to answer the research

question, the following hypotheses were generated: main hypothesis H2 - Appropriate ERP Selection has a positive impact on ERP Application and sub-hypothesis H2.1 - Appropriate ERP Selection has a positive impact on ERP Implementation. After testing of these hypotheses, it is confirmed that appropriate ERP Selection has an impact on the ERP implementation and ERP application.

Research Question 3 - Does the ERP implementation have an impact on the ERP application?

Many previous studies have stated that the decision for implementation and application of ERP system is related to the strategy of the organization by determining the aim and objectives they want to achieve for e period of time. Based on this study, it is identified that definition of scope and clear objectives by the implementation team and the ability of them to bridge the gaps between the existing workflow and new ERP business practices should be well considered during the implementation and application of the ERP system. Also, the organization should be prepared to accept the changes for the best practices for the new ERP system during the implementation in order to eliminate the problems when the ERP system goes live. Another factor that is important during the implementation is employee training for the new system usage and operation, while the implementation of the project in time, planned budget, and the selection of appropriate implementation technology affects the success of the implementation. Considering the above-mentioned factors, in order to answer the research question, the hypothesis H3 - ERP Implementation has a significant and positive impact on ERP Application has been generated. Based on the literature review and hypothesis testing, it is validated that ERP implementation has an impact on the ERP application.

Research Question 4 - Is there any significant evidence that ERP application has a positive impact on organization performance?

As it is stated in the literature review, the ERP application can support the organization's benefits from these systems in many areas, which are presented on the sub-chapter of the Benefits of ERP application. In order to evaluate the success of the ERP application, the most mentioned factors identified by previous authors are considered. One of the main factors is if the organization achieved the goals and objectives they had when they decided to implement and apply an ERP system, followed by the support of ERP application in the automation of business processes and functionalization and reducing the

manufacturing or service offering time. Also, ERP application should support the digitalization and integration of communication between the departments in order to increase the efficiency and do an easier job for the employees. At the same time, the organization should be adopted with the new business changes and their new business process based on the ERP application to support people, technology, and organization culture.

Based on the mentioned factors that affects the ERP application and the generated hypothesis H3.1 - ERP Application has a positive impact on Performance Indicators, it is confirmed that ERP application significantly affects the organization's performance. Below are mentioned the key performance indicators that result in a positive manner after the ERP application:

- Implementation and application of ERP resulted in Increased profit;
- Improved delivery time of product/services;
- Reduced administrative workload;
- Improved interaction between the department, customers, and suppliers;
- Business success in terms of sales and market share;
- The organization achieved the goals to create new innovative product/services;
- Reduced costs;
- Availability of information and better decision-making.

Research Question 5 - What is the impact of Industry 4.0 on the ERP systems approach?

The answer to this question is done based on secondary data. According to Hochmuth et al. on a Deloitte report, declare that the role of ERP systems will change, from a central database system that collects data, to support mobile role-based user interactions (Hochmuth, Bartodziej, & Schwagler, 2017). They declare that if ERP system vendors want to support Industry 4.0, they need to adapt their ERP systems to the technical and process-related requirements, in the context of data storage, data exchange, and data usage.

Haddara et al., in their research, raised the question if ERP systems are ready for the FoF (Factory of Future) (Haddara & Elragal, 2015). According to them, within this new concept of FoF, it is required a real-time two-way communication between machines,

processes, and products. Here comes the question if ERP systems can support such communication, which will bring ERP systems to the next level.

Porter and Heppelmann, in their article How Smart, Connected Products are Transforming Competition, presented an analysis of the impact of IT on the competition waves (Porter & Heppelmann, 2014). Initially, they give an overview of the first wave of IT, which started with automation in the manufacturing industry, with MRP (Manufacturing Resource Planning) and MRP II technologies. Then, they continue with the second wave, where the internet was viewed as an opportunity for doing business, by enabling coordination and integration between different levels across enterprises in focus to the relation of suppliers and customers in a global market where the Internet was seen as a way for information sharing. This wave, in other words, presents the ERP systems application. According to Porter and Heppelmann, in the third wave of competition, operational effectiveness is the key to competition, and smart connected products can contribute to it by changing the approach to product design, services, marketing, human resources, and security. The authors in this article identified four dimensions, how the usage of smart connected products can contribute. 1. Monitoring, real-time information related to the operation of products reported by themselves. 2. Control, the ability to manipulate, maintaining the machines from a distance. 3. Optimization, managing the resources by using data generated from real-time monitoring and optimizing the product operation and production capacity. 4. Autonomy, adoption to dynamic requirements for self-optimizing, coordination, and diagnosis. According to the authors above, it can be concluded that the future of ERP systems is closely related to Industry 4.0 technologies.

In theory, Industry 4.0 contains nine technologies, and each of them is related to the ERP systems. Some of them are analyzed below. Starting from the Internet of Things (IoT), which is the first technology of Industry 4.0, which should be supported by ERP systems. With the support of IoT, all other Industry 4.0 technologies could be interconnected with ERP systems. IoT should be an integration point of Industry 4.0 and ERP systems. The integration of this technology in Industry 4.0 is closely related to communication protocols between the machines and different frameworks, which should be harmonized in the future. Nowadays, in most of the cases, data from manufacturing warehouses, production planning, quality control, processes, and other sources are entered manually in ERP systems. The use of IoT would help to automatically enter data into ERP systems,

which are collected from different production sources and this would have the effect of eliminating data entry errors. Entering data through the use of IoT equipment would also help in changing the approach to ERP systems. There would be another link between ERP and Big Data Analytics and the other technologies of Industry 4.0. With the use of Big Data Analytics, ERP systems can enable the collection and evaluation of data from different sources in real-time and can help in decision making, quality control, optimizing costs, and other aspects. Also, Simulation the other technology of Industry 4.0, can relate to ERP through the use of Big Data Analytics for prediction and evaluation of the performance of systems that are analytically intractable to simulate in order to test and optimize the resources.

With the use of ERP systems, which can be supported by Big Data Analysis in combination with technologies like smart glasses, can be applied to Augmented Reality, which can completely change the way how maintenance services and performing works in the warehouse can be achieved. After the scene has been captured by smart glasses, it can be identified by using data that are stored in an ERP system and choosing accurate information for boosting it for scene processing and visualization of the augmented scene. Also, employees can finish their tasks by using these technologies which support of 3D Visual Enterprise models of the workplace, getting instruction from ERP systems, finding products in the warehouse, checking if the products are available in the stock and all the information directly to the smart glasses which help the employers to make a decision based on the information they are getting form ERP systems. By using the Horizontal and Vertical integration approach supported by ERP systems, autonomous production methods can be powered by using Robots that can complete tasks intelligently, with the focus on safety, flexibility, versatility, and collaboration. Different ERP system vendors should think about integrating and supporting smart connected products into their systems by applying Industry 4.0 technologies. This integration would be a benefit in generating value for customers, creating a new competitive environment, increasing company productivity and global economic growth. The benefits of the integration of Industry 4.0 and ERP systems will be very high, especially in support of intelligent machines and processes, data analytics, and modeling, which can help companies in the real-time decision-making process. In support to answer to this question, a hypothesis is generated, H4 - ERP Application can support organizations to evaluate their readiness for Industry 4.0, to understand if ERP application could support the organization for further

digitalization, specifically for Industry 4.0 technologies. The result of H4 hypothesis testing is accepted.

Based on the concepts analyzed in this study, ERP systems can be easily integrated with Industry 4.0, but there are also some challenges when it comes to M2M (machine to machine) and machine to ERP communications because there are no unified standards and protocols (Haddara & Elragal, 2015; Rüßmann et al., 2015). Another essential issue in Industry 4.0 is security. This is due to the diversity of devices and technologies that are interconnected and a large amount of data passing through various communication channels. ERP systems should support Cyber-Physical Systems, which leads to feature end-to-end vertical integration, from inbound logistics, planning, marketing to outbound logistics, and services. Also, ERP system providers should integrate the MES - Manufacturing Execution Systems into their application, to create a new approach to ERP systems that could be implemented in manufacturing industries that can have a large impact and application in Industry 4.0.

6.3 Summary

Based on the research questions of the study and the hypotheses, the results are presented in this chapter. Each of the hypotheses testing results are shown in the table also are described based on the hypotheses testing results. All four main hypotheses and four sub-hypotheses are accepted. At the significance level 0.05, “Strategic use of IT” has positive effect on “ERP Selection”, “ERP Implementation” and “ERP Application”; “ERP Selection” have impact on “ERP Implementation” and “ERP Application”, “ERP Implementation” have impact on “ERP Application”; as well the “ERP Application” positively affects the “Performance Indicators”. While for the H4 hypothesis, ERP application can be used to predict the readiness of the organization for Industry 4.0, specifically only for a part of Industry 4.0 technologies such as Predictive Analytics and Maintenance; Autonomous Systems (vehicles, warehouses, drones); Big Data and Business Analytics; Machine to Machine Communications. Furthermore, the answer to the research questions are presented.

7 DEVELOPED PROTOTYPE ERPMM

Taking into consideration that identifying the gaps in the implementation and application process of ERP systems for an organization is very important, the developed prototype aims to offer them a more accessible and simple method of evaluation of their ERP system maturity. The prototype is developed based on the proposed ERP maturity model (ERPMM). The developed prototype will enable the organization to do the evaluation of the maturity of implementation and application of the ERP system based on themselves without the need for support from another third party.

The prototype is a web-based application, the prototype is developed as a Client/Server architecture. There are three levels on the system: 1. Client-Side, 2. Server Side, and 3. Database. The web application is developed on PHP and MySQL database.

7.1 Client-Side

In order to get the final result or the maturity of implementation and application of ERP systems, the users must go through the following activities. On the client-side, initially, the organization must be registered in order to use the prototype. The data that must be filled on the registration form are:

- Organization name
- Name
- Surname
- Email
- Password
- Position on the organization
- Country of the organization
- Number of employees on the organization
- Industry
- ERP vendor that organization implemented
- Deployment option and
- Implementation strategy

Before sending the data for registration, the representative of the organization must accept the Terms and Conditions to use the prototype. After successful registration, the representative of the organization must be logged in by using the email and password from the registration form. After a successful login, the user will see the prototype Home page, as presented in Figure 12.

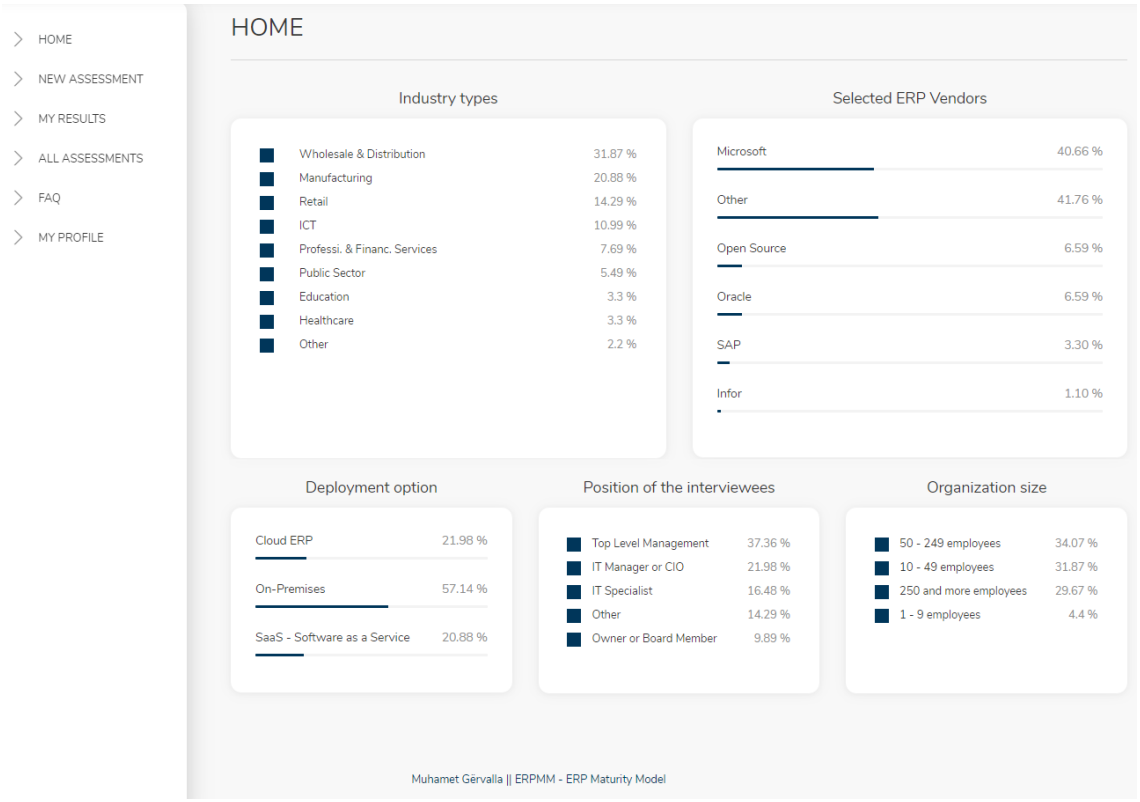

Figure 12 ERPMM home page

The Home page presents comprehensive data regarding the organizations that have already used ERPMM. These data include the percentage for each of the industries where these organizations belong, ERP vendor selection, deployment option, organization size based on the employee numbers, and the position of the users who have filled the ERPMM.

The next step of the prototype allows the representative of the organization to start answering the questions from the ERPMM. In the first step, the representative should answer the general question regarding the ERP vendor, deployment option and implementation strategy, then to go through five constructs of the model, and finally to

get the result of ERP maturity level for the organization. The representative is allowed to answer the questions based on the Likert scale from 1 to 5. Figure 13 shows the form of the evaluation process.

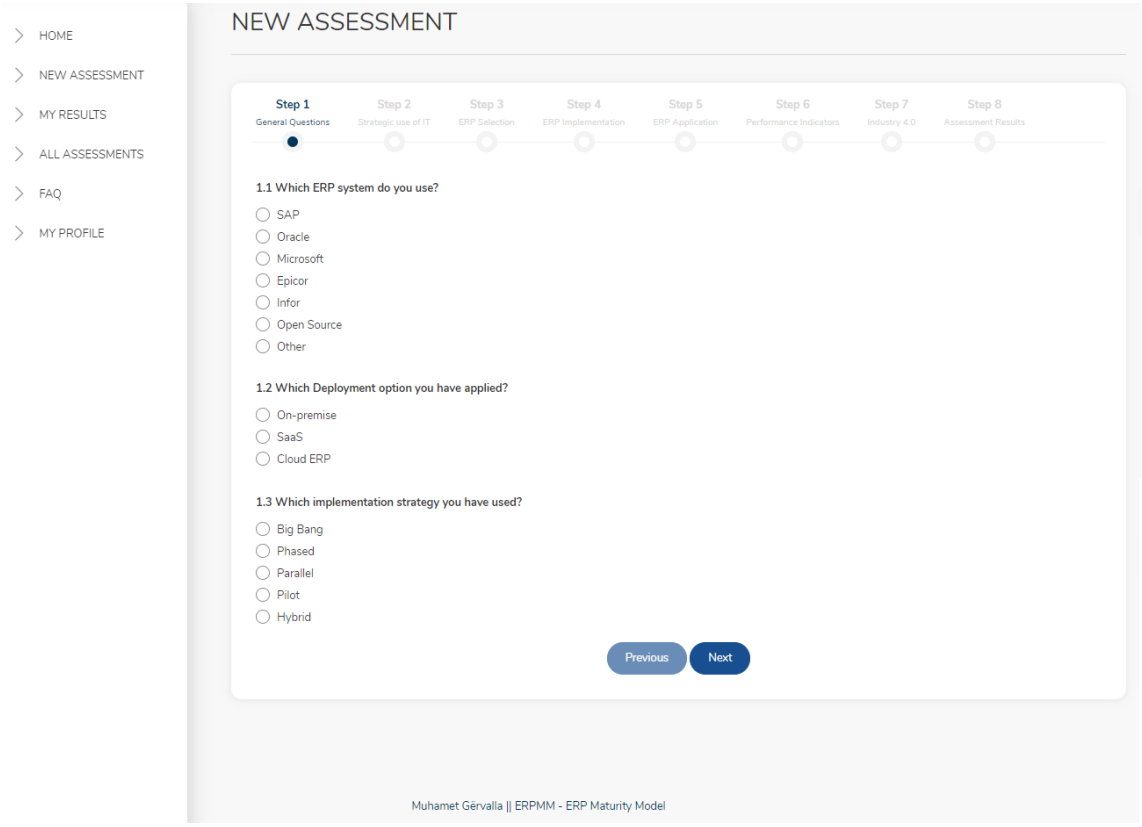

Figure 13 ERPMM prototype evaluation process

After finishing the ERPMM evaluation process, a figure similar to Figure 14 will be presented. Also, the results which are presented below can be accessed at any time by using the main menu option My Results page. In this page, it is also presented a comparison between other organizations ERP Maturity Level.

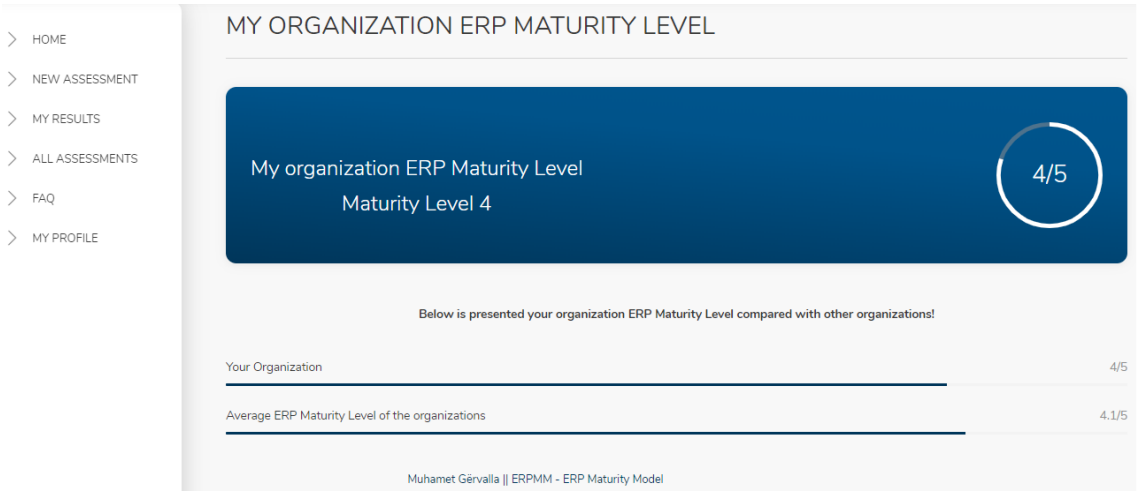

Figure 14 ERPMM prototype assessment result page

The results for all organizations that have used ERP Maturity Models can be accessed by the All Assessment page on the main menu. This page presents general data regarding the organization that used ERPMM, such as Industry, number of employees, ERP Maturity Level, while the company name is hidden, and it is presented as Company 1, Company 2, etc. as it is presented on Figure 15.

Figure 15 All organization ERPMM results

For the purpose of explainin usage of ERPMM prototype, the FAQ page is created. On this page, details regarding the ERPMM usage are presented.

While the general data of the organization and user can be accesses using My Profile page on the menu. Figure 16 presents a detailed overview of the organization's general data

and user details. On this page, data that does not affect the result of the ERP Maturity Model, such as email, phone, can be changed.

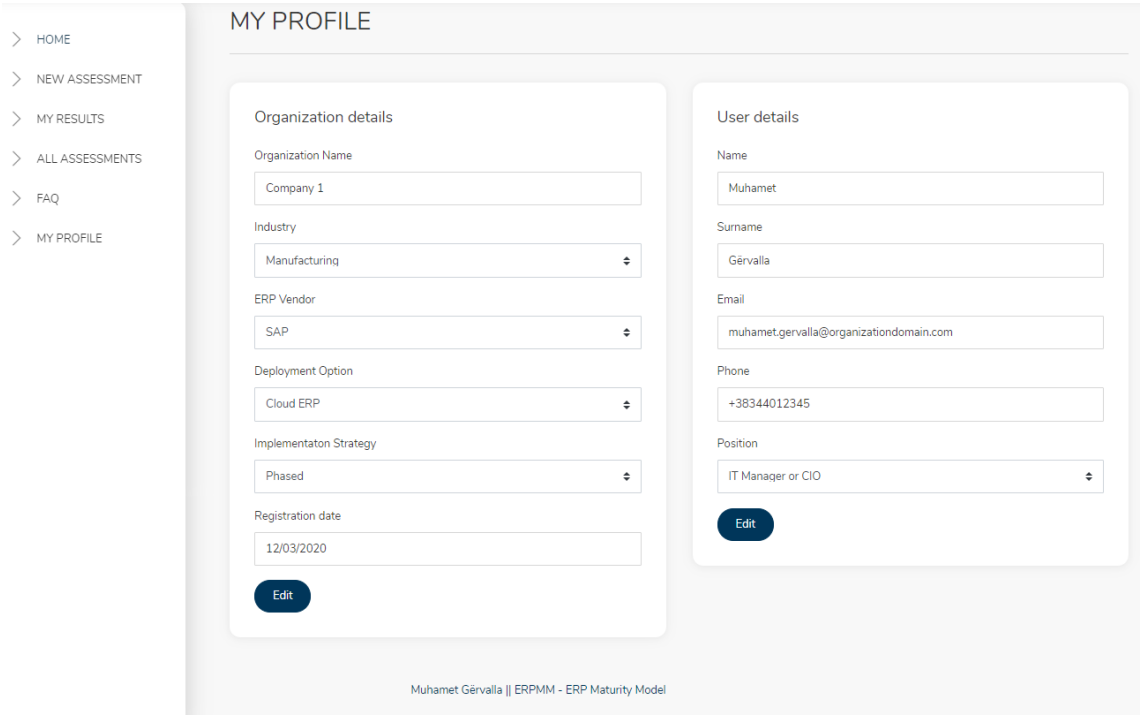

Figure 16 Organization and user profile details

7.2 Server-Side

After the completion of the assessment form on the client's side, the web application sends these data to the server-side for the calculation, in order the determine the maturity of implementation and application of ERP system for the organization. The calculation is done based on the defined weight of the constructs of the proposed model ERPMM. The weight of each item of the construct is generated based on the statistical analysis. Finally, after the completion of the calculation, the web application returns back to the representative of the organization on the client-side maturity level of implementation and application of the ERP system for the organization. All the data will be saved into the database, including their maturity level, as they are mentioned in the Terms and Conditions, which must be accepted during the registration.

7.3 Database

The database is on MySQL; all the data that are processed during the maturity level assessment will be saved into the database. In the database, data are saved for one organization, one assessment. The ER diagram of the database is presented in Figure 17. The new prototype, which is developed based on the new maturity model proposed in this study, will support the organization to measure their maturity of implementation and application of ERP system with a simple process and can access their result any time they want via the client-side. Also, the data saved in the database will support the organization to make a comparison where they stand in relation to ERP system maturity level compared with other organizations. The database population will support future work analysis, with a focus on the usage of data science techniques for data analytics and further investigation of the model.

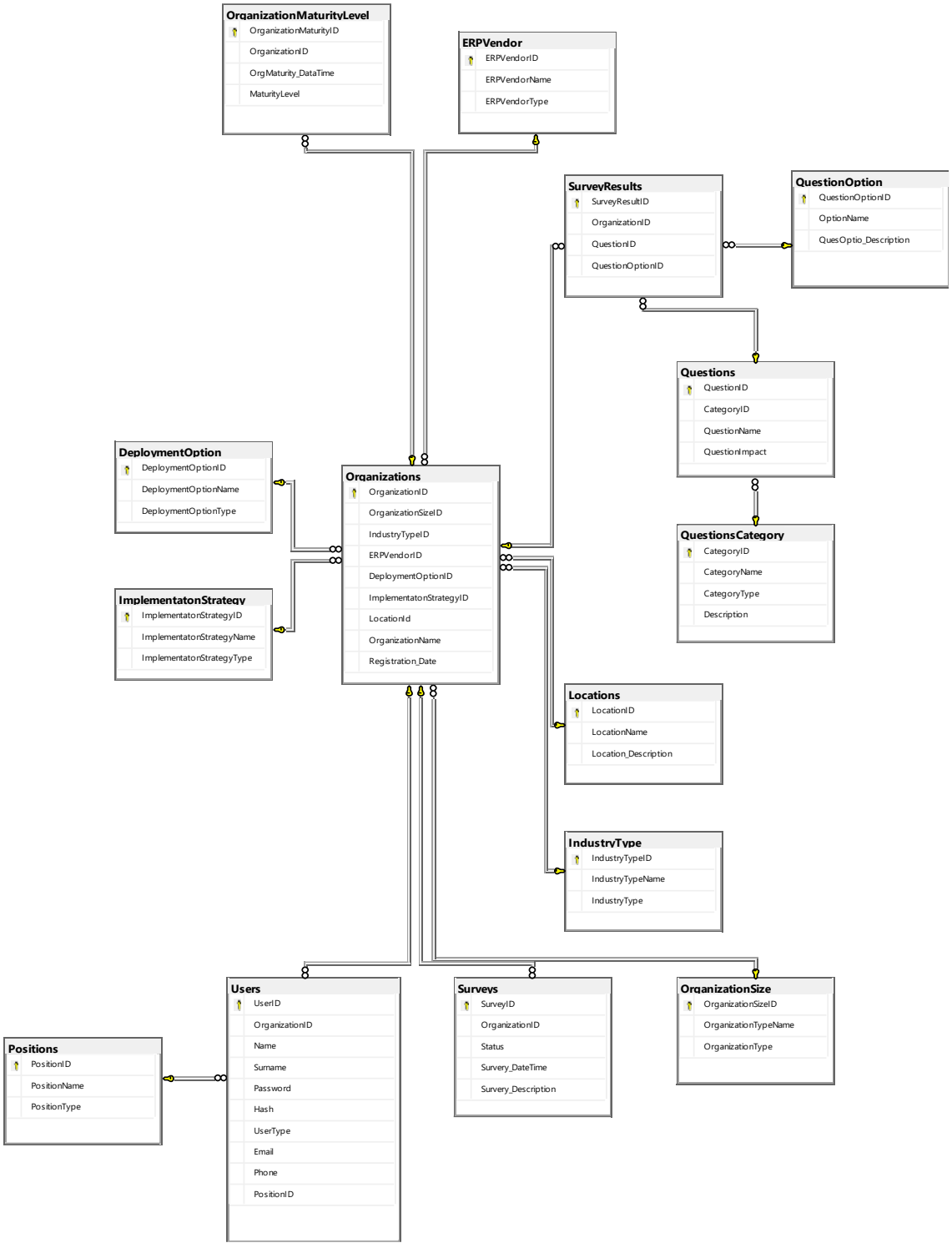

Figure 17 ER Diagram

7.4 Summary

The prototype is developed as a web-based application by using PHP and MySQL database. This chapter presents details regarding the registration also on the functions the prototype has. Furthermore, all the options that this prototype offers are presented and described, including figures on the client-side and the ER diagram of the database.

8 CONCLUSION

This thesis analyzes the evolution of ERP systems and the current trends of implementation and application of ERP systems with a focus on further digitalization of the organizations. The obstacles that organizations face during the process of implementation of an ERP system are identified by previous researchers and reports. At least 30% of the organization still do not know if they succeed in the implementation and application of ERP systems, which confirms that organizations are struggling with this process. Considering this, the organizations are having difficulties in the evaluation of ERP system implementation and application on their business performance. Previous studies have identified many critical success factors that have an impact on the implementation and application of ERP. Researchers have identified and proposed different frameworks of implementation and application of ERP systems. However, after analyzing all the frameworks in the content, it is viewed that almost all the frameworks have similar activities, except that they are positioned in different implementation and application stages. The most significant difference identified during this research is in the Esteves & Pastor framework, in the sixth stage, the retirement stage. During this study, there are identified three ERP maturity models that are developed by previous researchers in support of the evaluation of ERP system implementation and application. The current ERP maturity models are very complex to be used by organizations. Also, they lack defining the complete process, which supports the organization to check their maturity level of ERP systems by themselves.

On the other hand, Industry 4.0 is seen as the beginning phase, where computers and automation become connected and as an opportunity to increase the efficiency and effectiveness in the manufacturing industry. With the application of real-time data and information by integrating physical machinery and devices with networked sensors and software to predict, control and reduce costs in a long-term view. Regarding the Industry 4.0 and ERP system integration, previous studies proposed that ERP system vendors should adopt they ERP systems to technical and process-related requirements with a focus on data storage, data exchange, and data usage, also to support the real-time communication between machines, processes, and products or smart products. Compared to the previous researchers, where the focus is mostly in integration and communication

of ERP systems and Industry 4.0, this thesis is focused more on the readiness of the organizations for further digitalization, specifically for Industry 4.0 technologies as a process of implementation and application in the organization. Also, in line with previous researchers, challenges for integration of Industry 4.0 with ERP systems are presented.

Considering the mentioned points, new technological changes and the need of the organization for further digitalization, there was a need to develop a maturity model that supports the organizations in the evaluation of their position regarding the ERP system maturity on their organizations. Based on the undertaken study, it is proposed a new maturity model (ERPMM) to measure the maturity of implementation and application of the ERP system in the organization. The model contains five constructs: Strategic use of IT, ERP Selection, ERP Implementation, ERP Application, and Performance Indicators. The application of the proposed maturity model and ERPMM prototype should support organizations to reduce the failure rate of implementation and application of the ERP system.

The study is based on a quantitative methodology. After the new theoretical model development, for the purpose of validation and reliability check, a questionnaire was developed. The questionnaire was sent to different industries in Kosovo, and it was filled by different management levels of organizations. For the purpose of validation and reliability check of the model, the following analysis was applied Average Variance Extracted – AVE, Cronbach's alpha, Composite Reliability, and Loading. The loading values for all items of the model are larger than 0.6, where 74.28% of them are considered as "ideal items" loading values larger than 0.7. While the reliability check is done based on Cronbach's alpha, where all the values ranged from 0.84 for Strategic use of IT to 0.88 for Performance Indicators and ERP Implementation, that proves that internal consistency of all latent constructs is acceptable where the Crombach's alpha exceeds the 0.7 as it is recommended. Also, all the constructs exceed the level of 0.5 of Average Variance Extracted – AVE, which confirms that the level of convergent validity is acceptable. Also, the discriminant validity is investigated based on the correlation matrix that resulted in less than 0.85 correlation of coefficients between constructs, which proves that there no significant overlap between the constructs. The goodness of fit index of the final model (GoF index) is 0.55 that meets the range of 0.45 to 0.9 for the true model (Evermann & Tate, 2010). The proposed maturity model for ERP system implementation and

application will enable organizations to evaluate the maturity of implementation and application of an ERP system, and whether they should do something in the way they are applying such a system.

The study shows that there is a relationship between all the stages of ERP implementation and application, starting with the organization's IT strategy to the ERP application. Based on the hypotheses of the study, it is proved that the strategic use of IT, significantly and positively affects the ERP selection, implementation and application. Also, the study shows that appropriate ERP selection has an impact on the implementation and application based on the hypothesis: Appropriate ERP Selection has positive impact on ERP Implementation and appropriate ERP Selection has a positive impact on ERP Application. The study proves that ERP implementation has impact on the ERP application, which is proved with the hypothesis ERP Implementation has a significant and positive impact on ERP Application. Also, there is significant evidence that ERP application has a positive impact on the organization's performance based on the hypothesis ERP Application has a positive impact on Performance Indicators.

Based on the statistical analysis, it is proved that partially ERP Application can be used to predict the readiness of the organizations for the Industry 4.0, specifically for: Predictive Analytics and Maintenance; Autonomous Systems (vehicles, warehouses, drones); Big Data and Business Analytics; and Machine to Machine Communications. For a complete evaluation of the readiness of the organizations for Industry 4.0 based on ERP application, further studies are needed to be done. Also, the study presents an analysis of the integration of ERP and Industry 4.0, which is done based on secondary data. The study identifies the challenges of integration of current ERP systems with Industry 4.0. Furthermore, based on the research, there are many challenges related to the integration of Industry 4.0 and current ERP systems, especially when it comes to the machine to machine, machine to ERP communication, and the security of the data. Because there are different ERP vendors, and diversity of devices and technologies that are a must to be interconnected, the ERP system vendors should think about finding solutions and creating protocols that will support the integration of technologies in support of Industry 4.0.

Based on the proposed maturity model, it is developed a prototype that supports the organization to evaluate its status of ERP system implementation and application. The prototype is developed as a web application. It uses client-server architecture and was developed in PHP and MySQL database.

The main contributions of this study are:

- Identifies and presents the current status of implementation and application of the ERP system and ERP maturity models;
- Analyzes the role of strategic use of IT in the process of ERP selection, implementation, and application;
- Analyzes the impact of ERP selection on implementation and application also the effect of ERP implementation on the application;
- Identifies the ERP application effect on business performance also the ability of the organization to evaluate their readiness for further digitalization based on the ERP application;
- A new ERP Maturity Model (ERPMM) to support the organizations for evaluation of implementation and application of the ERP system is developed;
- A developed prototype that applies ERPMM to support organizations for ERP maturity level assessment.

The work that has been done during this research will support organizations to understand or investigate where they stand in relation to the ERP system implementation and application and does this investment achieves what they planned on their organization strategy. On the other hand, a successful ERP implementation and application which could be measured with the usage of proposed ERPMM supports them on decision making for further digitalization of their organization. It is important that ERP vendors should add new services to their ERPs towards Industry 4.0.

Future work must be on the usage of proposed ERPMM by the organization on a global level with a large number of organizations, to understand the potential impact that ERPMM will have on the managerial level. Also, the potential positive impact that ERPMM may have on decision making in the context of new IT investments based on the ERPMM classification for those who are identified as ready for further digitalization. Due to the research limitation, considering that modern data science methods and

algorithms require large data set to give reliable results after analyzing, in the future, after the database population, data science methods should be used for further investigation of the model. Below are presented some directions for future studies:

- Analyzing the potential effect of the proposed ERP Maturity Model from the perspective of managerial level;
- Investigating the role that the proposed ERP Maturity Model has on further digitalization of the organization;
- Are the ERP vendors ready to support complete integration of ERP system with Industry 4.0 in support of the organization;
- Analyzing the potential that ERP systems and Industry 4.0 integration could have on the organization's performance.

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ACRONYMS

AVE	Average Variance Extracted
BI	Business Intelligence
BPM	Business Process Management
BPR	Business Process Reengineering
CFA	Confirmatory Factor Analysis
CH	Case Handling
CIO	Chief Information Officer
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
COBIT	Control Objectives for Information and Related Technologies
COSO	Committee of Sponsoring Organizations
CPPS	Cyber-Physical Production Systems
CPS	Cyber-Physical System
CRM	Customer Relationship Management
CSF	critical success factors
DSS	Decision Supporting Systems
EAI	Enterprise Application Integration
EMM	ERP Maturity Model
ERP	Enterprise Resources Planning
FoF	Factory of Future
GoF	Goodness of Fit
GUI	Graphical User Interfaces
HR	Human Resources
IaaS	Infrastructure as a Service
IoT	Internet of Things
IT	Information Technology
ITIL	IT Infrastructure Library
KPA	Key Process Areas
M2M	Machine to Machine
MES	Manufacturing Execution Systems
MMERP	Maturity Model for Enterprise Resources Planning
MRP	Material Requirements Planning
MRP II	Manufacturing Resources Planning
PaaS	Platform as a Service
PLC	Programmable Logic Controller
PLS	Partial Least Squares Regression
SaaS	Software as a Service
SCM	Supply Chain Management
SEM	Structural Equation Modeling
SMEs	Small and medium-sized enterprises

SQL	Structured Query Language
SVS	Service Value System
VR	Augmented Reality
WEB	World Wide Web
WFM	Workflow Management
XML	Extensible Markup Language