CRITICAL SUCCESS FACTORS FOR ENTERPRISE RESOURCE PLANNING (ERP) IMPLEMENTATION IN TURKISH CONSTRUCTION INDUSTRY

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ABSTRACT

CRITICAL SUCCESS FACTORS FOR ENTERPRISE RESOURCE PLANNING (ERP) IMPLEMENTATION IN TURKISH CONSTRUCTION INDUSTRY

Even though the construction industry is one of the largest contributors to the economy, it is considered as one of the highly fragmented, inefficient, and project oriented industries. Also, the construction industry has always been criticized for its low performance due to lack of high quality performance evaluation, project monitoring, cost effectiveness, security, and sustainability. In order to overcome this ineffectiveness, several solutions have long been offered including adaptation of information technology (IT) and information systems. Since each project is unique, they create some distinct challenges. Enterprise resource planning (ERP) systems present an integrated system that has the knowledge and databases of the different departments in a construction company. However, it is not easy to compensate all the functions of construction enterprise resource planning (C-ERP) systems by a regular IT system that is planned to automate all project management operations of the whole construction companies. C-ERP systems provide construction companies with much more integrated and effective system to overcome this ineffectiveness, fragmentation of departments and low performance issues. Not only acquiring ERP systems but also the implementation phase of them is very significant subject because there are many failure stories. Implementation of a system is a stage that all planned tasks and activities are realized. At this implementation stage, monitoring of implementation is essential to make sure that the system is implemented successfully as per the schedule and on the budget. Therefore, the investigation of the implementation phases and determination of Critical Success Factors (CSF) of ERP implementation in construction industry is a crucial subject in this context. In this thesis, this subject is studied based on data collected through a questionnaire survey and real experience case studies. Construction firms can benefit from the findings of this study as learning the negative and positive case study experiences of three different construction companies, critical success factors that companies should focus on at the implementation phase of their ERP system.

ÖZET

TÜRK İNŞAAT ENDÜSTRİSİNDE KURUMSAL KAYNAK PLANLAMASI (KKP) UYGULAMASININ KRİTİK BAŞARI FAKTÖRLERİ

İnşaat Endüstrisi ekonomiye en büyük katkı sağlayan endüstrilerden biri olmasına rağmen, inşaat endüstrisinin oldukça parçalanmış yapıya sahip, verimsiz, proje odaklı bir endüstri olduğu düşünülmektedir. Ayrıca, inşaat endüstrisi, yüksek kalite performans ölçümü, proje izleme ve denetleme, maliyet verimliliği, güvenlik ve sürdürülebilirlik konularının olmamasından dolayı, daima düşük performansı yönünden eleştirilmektedir. Bu verimsizliğini aşabilmek için, bilgi teknolojileri (IT) ve bilgi sistemleri de dahil olmak üzere bazı çözüm önerileri uzun zamandır sunulmaktadır. Tüm projelerin birbirinden farklı olması nedeniyle, bazı benzersiz zorluklar oluşmaktadır. Kurumsal kaynak planlaması (KKP-ERP) sistemleri bir inşaat firmasındaki farklı departmanların veritabanlarını ve bilgi birikimlerini entegre eden bir sistem sunmaktadır. Fakat, inşaat şirketlerinin tümünün, tüm proje yönetim operasyonlarını otomatize eden sıradan bir bilgi teknolojisi (IT) sistemi ile, inşaat kurumsal kaynak planlaması'nın tüm fonksiyonlarının yerini tutması kolay değildir. İ-KKP (C-ERP) sistemleri inşaat şirketlerine bu verimsizlik, departmanların parçalanmışlığı ve düşük performans meselelerini aşmak için çok daha entegre ve verimli bir sistem sağlamaktadır. Yalnızca KKP (ERP) sistemleri değil, aynı zamanda bu sistemlerin uygulanma aşamaları çok ehemmiyetli bir konudur çünkü bu bağlamda bir çok başırsızlık öyküsü de bulunmaktadır. Bir sistemin uygulanması, planlanan tüm görevlerin ve aktivitelerin gerçekleştirildiği aşamadır. Bu uygulama aşamasında, uygulamanın izlenmesi, sistemin takviminde ve bütçesinde, başarılı bir şekilde uygulandığından emin olmak açısından önem arz etmektedir. Bu nedenle, uygulama aşamalarının araştırılması ve inşaat endüstrisindeki KKP uygulamasının kritik başarı faktörlerinin (KBF) belirlenmesi bu bağlamda önemli bir konudur. İnşaat firmaları bu çalışmada geçen; üç farklı inşaat firmasının olumlu ve olumsuz vaka analizi tecrübeleri ve inşaat firmalarının ERP sistemlerinin uygulaması sırasında odaklanmaları gereken kritik başarı faktörlerinin neler olduğu konusunda yararlanabilirler.

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LIST OF ACRONYMS / ABBREVIATIONS

BPR	Business Process Re-engineering
BOM	Bill of Material
CERP	Construction Enterprise Resource Planning
CFA	Confirmatory Factor Analysis
CRM	Customer Relationship Management
DBMS	Database Management System
EDI	Electronic Data Interchange
EFA	Exploratory Factor Analysis
EIS	Executive Information Systems
ENR	Engineering News Record
ERP	Enterprise Resource Planning
GUI	Graphical user interface
IS	Information Systems
ISE	Istanbul Stock Exchange
IT	Information Technologies
KMO	Kaiser-Meyer-Olkin (Adequancy Test)
MMS	Material Management Systems
MRP	Material Requirement Planning
NSF	National Science Foundation
PM	Project Manager
REIT	Real Estate Investment Trust
TCA	Turkish Contractor Association

1. INTRODUCTION

1.1. Background of the Research

Construction industry has been changing rapidly since the beginning of the twentieth century. The development of new technologies has accelerated this pace. Because construction projects are mostly unique, one-time jobs, construction organizations struggle with the temporary status mindset. Teams are collected for a specific purpose or project and disbanded as soon as the tasks or the project are completed. People are motivated to complete their tasks within short period of time and under strict budgetary constraints.

There have been many changes in the business environment due to the advancement of technology and information systems. It can be seen that utilizing information technology (IT) would allow construction industry to connect the power of collective knowledge systems. In addition, regulation of municipalities and completion between construction companies, financial demands of owners, and shortening project durations increased the contribution to the utilization of IT in the construction industry. Compared to other sectors, it took much more time to realize the importance of IT applications and implementation of them.

In the past, all the information and knowledge about the projects were stored at notebooks. As technology developed, personal computers help to keep and search all the information about the project as simple digital documents like spreadsheets and document editors. Then, database systems have grown but these systems were not connected and cannot communicate with each other directly. Different departments use different systems and all of these databases are internal systems. Actually Enterprise Resource Planning (ERP) systems begin to enter the sectors right at this point. Along with ERP systems, different departments and units of an organization begin to communicate each other through a main database of ERP systems and these systems would carry the efficiency of organizations to new peak point.

One of the concepts that have been evaluated and, at times, utilized by construction organizations in achieving the goal of improved efficiency through better management of collaborated knowledge is ERP. ERP systems have been defined to be a "computer program that provides a general working platform for all departments of an enterprise with their management functions being integrated into the program" (Shi and Halpin, 2003). These systems have been utilized to optimize the company's internal and external processes. ERP has been a very rapidly growing business. By early 2000, the ERP revolution generated over $20 billion in revenues annually for suppliers and an additional $20 billion for consulting firms (Willcocks and Sykes, 2000).

Originally ERP was created and implemented for and in the industrial manufacturing sector as a planning tool. The original systems or Material Requirement Planning (MRP) were utilized as tools to maximize the efficiency of ordering and managing the inventory of materials required for the production processes by using forecast sales (Laudon and Laudon, 2002). Later, these systems were modified to also handle management of resource allocation for equipment and labor as well, by forecasting financial and production issues, as demand changed. With the advances made in information technology, MRPs were converted into ERPs, as they were modified to integrate additional front and back office functions such as warehousing, distribution, quality control, purchasing, financials, human resources, sales force, and electronic commerce.

Success of ERP implementation in construction depends on various factors. How construction companies can successfully select and use ERP systems is a critical issue that needs to be investigated.

1.2. Problem Determination

In today's business world, competition between construction companies has increased more than before. Local competition has migrated to international markets and the challenges to the construction companies have risen more than ever. Therefore, construction companies have to increase their profitability and effectiveness.

The development of new technologies has helped the construction companies to become more competitive. A lot of companies in the world in various regions have committed to spending and have already spent large sums of capital for the implementation of ERP in their organizations. However, although IT has helped companies be more effective, it should be defined and guided how construction companies should use IT resources to apply their organizations.

In order to have a successful implementation phase of any IT system, critical success factors of the implementation duration should be determined and controlled carefully. If construction companies know what critical success factors are important and what kind of positive or negative experiences other construction companies have had, they can implement their systems in much more healthy and effective way.

1.3. Problem Statement

Construction companies in Turkey are not accustomed to ERP systems but they begin to understand needs of this kind of IT systems in their organizations. Along with this study, it is examined the current situation of ERP systems in Turkish construction companies with respect to age, type of construction firms, departments, scale of organizations.

In this thesis, it will be examined that what critical factors of the implementation of ERP system should be appreciated by construction companies and what current status of the construction sector in Turkey is. All of these studies will be based on questionnaire survey and real experiences as case study.

1.4. Related Studies

There are a lot of studies that try to explain the history and effect of ERP systems in many sectors (Bell and Stukhart, 1987; Shi and Halpin, 2003; Willcocks and Sykes, 2000; Laudon and Laudon, 2002). Also there are some studies on the implementation phases of ERP and Construction Enterprise Resource (CERP) systems (Intermec, 1999; Ahmed *et al*., 2003; Voordijk *et al*., 2003; Adam and O'Doherty 2000).

Also, there are many studies that try to explain the importance of ERP system in construction companies; but there is limited number of studies that has explained the analysis of critical success factors at the implementation of ERP systems in construction companies (Chung 2007; Ahmed *et al*., 2003; Tatari and Skibniewski, 2011; Skibniewski and Ghosh, 2009).

Also, there has not been any research that investigates and covers the real implementation experiences and critical success factors of ERP systems at Turkish Contractors and Turkish construction-related project management companies.

1.5. Aims and Objectives of the Research

In order to implement ERP software, its modules and its tools at a construction company, understanding of critical success factors at the implementation phase is vital. Detailed analysis of the critical success factors, their relative importance level and impact on successful ERP implementation have been studied in this thesis.

By using questionnaire survey method, it is aimed to learn the critical success factors and their influence in the success of ERP implementation. By using case study method, it is aimed to learn what kind of implementation strategies and resources are used at real cases, what kind of enablers are used by implementation teams, and what kind of challenges and barriers have been experienced by the implementation teams within the construction companies.

The main objective of this research is to determine the critical success factors of the implementation of ERP systems and investigate these factors in detail based on real experiences and case studies.

1.6. Research Method

A detailed description of each phase of the research is as follows:



Figure 1.1. Research Methodology.

1.6.1. Phase 1 - Problem Identification & Literature Review

After identification of the problem of this research was completed, comprehensive literature review was conducted in the area of ERP, CERP and other IT systems but especially IT systems at construction sector. In particular, ERP applications utilized by construction companies were scrutinized, and in order to obtain an in depth knowledge of this subject, on-site interviews relating to their ERP experiences were conducted with various experienced engineers and architects of construction companies in Turkey. Current understandings of ERP systems and vendors of them were studied. Number of existing running ERP systems were reviewed on construction sites.

Based on literature reviews and pre-interviews, it was decided that the first step in advancing this topic would be to identify what drives construction companies to have ERP systems and what kind of implementation procedure they have to follow in order to have a better system.

1.6.2. Phase 2 - Preparing Questionnaire Survey & Case Study Questions

After literature review is done, a suitable questionnaire survey and case study questions are prepared in order to determine critical success factors of the implementation of ERP system at construction companies from questionnaire and learning what drive companies to have ERP system, what was the challenges/barriers the implementation team has faced, what resources the implementation teams have and what was the project level benefits.

1.6.3. Phase 3 - Control of CSF and Questions at Questionnaire and Case Studies

After preparation of the questions of questionnaire and case study, first of all, an internet-based questionnaire has been prepared by using Google Docs. Then a case study template has been prepared on MS Word application. After the survey and case study paper is done, the control of the questions is made by two professionals from construction sector and one academician.

1.6.4. Phase 4 - Collecting Data from Questionnaire Survey and Case Studies

After preparation of questionnaire and case study is done, the questionnaire is sent to the list of members of Turkish Contractors Association (TCA) and three case study are made by one Construction and Real Estate Development Company, one Real Estate Investment Trust (REIT) and one international contractor (construction company) belong to an international holding. All data from questionnaire survey and case studies are collected.

1.6.5. Phase 5 - The Analysis of the Questionnaire Survey and Case Studies

After collection of data from questionnaire survey and case studies, explanatory factor analysis is made at the part of the analysis of the questionnaire survey. Also, comparative case studies are made and a table is built according to answers of the interviewees.

1.6.6. Phase 6 - Discussion & Conclusion

After analysis of the questionnaire and case study are done, at the discussion part, comparison of the results is examined. Conclusion of the thesis is shortly explained.

1.7. Scope and Limitations

This research examines critical success factors of the implementation of ERP system and real case studies about the implementation of the new ERP systems at "only construction companies, real estate investment trust or construction-related organization like construction management companies."

The questionnaire survey has been sent to the list of targeted respondents that was created utilizing several sources, but the main resource was Turkish Contractors Association (TCA). This means that the questionnaire survey is not sent to the any construction company but only the members of large scale construction companies; such as TCA.

1.8. Organization of Thesis

The contents of the remaining chapters of this dissertation are organized as follows:

- Chapter 2 reviews the literature produced by previous research related to ERP implementation in the construction industry and other relevant topics. Particular attention is given to issues on ERP system, importance of ERP systems, advantageous and disadvantageous gain through ERP system, major vendors of ERP systems, main functions and characteristics of ERP systems. ERP system at construction companies and its importance are examined as Construction Enterprise Resource Planning (CERP). ERP in construction industry, basic features and concept of CERP in construction sector, advantageous and benefits of CERP systems for construction firms are highlighted.
- In Chapter 3, the research on the implementation of ERP systems in construction sector is examined. Also, implementation process of ERP systems and project

management success factors at ERP implementation are studied. Benefits of ERP systems, implementation obstacles, problems and possible risks and failures of ERP systems for construction companies are also examined.

- In Chapter 4, first of all, research methodology of this thesis is explained. In this chapter, there are two main research methods and these are "questionnaire survey method" and "case study of real experiences." At the questionnaire survey part, administration, content and problems encountered of the questionnaire survey is explained and then the analysis of the questionnaire survey is examined. Firstly, the definition of factor analysis is made and then the convenience of factor analysis method for this questionnaire survey is checked. Then, the explanatory factor analysis of the questionnaire survey is done and the results are given. Secondly, case study method is used and three case studies are explained and the analysis of them is presented.
- In Chapter 5, the results of three case studies and the questionnaire survey are explained and summarized. Especially, it is focused on critical success factors of Construction Enterprise Resource Planning system and the results of case studies. The differences and similar results of these two analyses are compared.
- In Chapter 6, at the conclusion and further works part, major findings and contributions of this study to the literature on CERP are mentioned and recommendations for further work are provided.

2. ENTERPRISE RESOURCE PLANING (ERP)

2.1. Definition and Overview of ERP Systems

First of all, one should explain what ERP is, what it means and what it really represents. ERP systems may mean different things to different entities and so, a clear definition should be made. Ohlsson and Ollfors (2001) define ERP as "A type of computer system that assists international companies in managing their information flows". Also, more specifically ERP is a system that enables automation and makes it easy to produce financial and sales reporting, easy customer resource management, effective management of manufacturing information and interdepartmental data flow within corporations.

Moreover, Tsung (2004) made more general but comprehensive definition of ERP as "ERP is a system that aims to integrate the main business functions across all the departments within an organization."

The definition of ERP should be modified for construction to be "information technology based computer platform that allows for integration of various business processes of an organization in order to increase efficiency, and thus profits, using a single database" (Negahban, 2008).

Modern ERP systems have begun as Materials Requirement Planning (MRP I) systems in the 1960s as a planning tool at manufacturing sector to maximize the effectiveness of managing the inventory of materials required for the production processes. MRP I systems are simple computer systems in order to control inventory and to manage production schedules. The more information from the production line, distribution floor and warehouses began to influence more department of the company, the need of carrying interrelated data between different departments or across the entire enterprise demanded that other business area databases should be interrelated with the MRP I system.

In later stage, these MRP systems were improved to the systems that also operate management of resource allocation for different kind of equipment and labor. Along with

the development of IT technology, MRP systems were improved to ERP systems by having some additional front and back office tools, such as; human resources, warehousing, sales, distribution, purchasing, shipping, accounting and quality control, etc.

Today, ERP systems are seen as a foundation for the integration of organization-wide information systems. ERP systems connect the entire organization's departments and their operations such as finance, accounting, human resources, manufacturing and distribution, etc. Furthermore, ERP systems also connect the whole organization to companies' customers and suppliers through the different stages of the product or the process life cycle.

ERP has its origins in manufacturing and production planning systems (Fitzgerald, 1992). The early systems were created three decades ago with the advent of MRP, which primarily organized the storage and allocation of production materials. Later, manufacturing resource planning, or MRP II, systems expanded those organizational efforts to include the allocation of production equipment and labor. The term ERP was born when the production oriented systems were integrated with purchasing, financials, human resources, and other front-office applications to enhance management of all business operations across the enterprise. The scope of ERP offerings expanded in the mid-1990s to include other back-office functions such as order management, financial management, warehousing, distribution, quality control, asset management, and human resources. The range of functionality of ERP systems has further expanded in recent years to include more front-office functions, such as sales force, electronic commerce, and supply-chain systems (Hare, 1999).

However, MRP I systems had limitations on this functionality leading to the development of Manufacturing Resource Planning (MRP II) systems, which have now given way to ERP. MRP II systems can evaluate the entire production environment and create or adjust master schedules based on feedback from current production and purchase conditions. Finally, companies such as SAP, Oracle, and others are reaping the rewards of dramatic growth as companies move away from legacy MRP II systems and begin the process of ERP implementation. Their solutions are more robust than any host-based MRP system to date (Bedworth and Bailey, 1987; Intermec, 1999; Januschkowetz, 2001).

The role of enterprise resource planning (ERP) does not match its name. It is no longer related to planning and resources, but is rather related to the enterprise aspect of the name. ERP attempts to unify all systems of departments together into a single, integrated software program based on a single database so that various departments can more easily share information and communicate with each other. This integrated approach can have a remarkable payback if companies install the software properly. An increasing number of companies want to obtain all relevant information about their business processes to control and guide them in a profitable direction (Koch, 2002).

Most of the ERP vendors e.g. SAP or Oracle have recommended that the best way to obtain the full benefits of ERP system software was to implement their full software packages with minimal changes. Nevertheless, today, instead of implementing entire ERP system packages, many companies have accepted a best-of-breed approach in which separate ERP software packages are selected and installed to the main system for each process or function. Therefore, no matter of the agreed upon implementation approach, any integrated corporate system which all the necessary business functions selected are pieced together for the company is considered the ERP system in this thesis. When a system is named as “ERP System” in this study, it means that all management and technical related packages selected and installed to the main ERP system.

ERP was a very fast-growing business in the 1990s. Its sales passed the $10 billion mark in 1998 (Hill, 1999). The world’s largest ERP providers include SAP, Oracle, PeopleSoft, and J. D. Edwards. SAP R/3 is the most popular system installed across the world (O’Conner and Dodd, 1999; Jacobs and Whybark, 2000). ERP systems have brought success to the manufacturing industry (Hare 1999). Some early adopters reported net return on investment ranging from 30 to 300% within a year after installing these systems. Oracle received 1 billion savings annually from the implemented ERP system (Oracle, 2000).

The great success sparked a leap in the research and development of ERP systems. Despite the reported business successes, a wide range of failures were also reported (Krasner, 2000). ERP systems are expensive and difficult to implement. ERP implementation costs from $2 million to $130 million, according to a survey of 15 implementations (Ross, 1999), and takes at least 6 months for a simple business with the

accelerated R/3 system (Jacobs and Whybark, 2000). Statistics show that the majority of implementations could not be completed in scheduled duration and within budget. A 1999 NSF-sponsored workshop realized the problems and concluded that a science base is not developed yet and that the ensemble of separated functional systems is untested on ERP technology (Shi and Haplin, 2003).

Enterprise resource planning (ERP) systems target to accomplish all-in-one and continuous integration of all the processes and information flowing through a firm, including but not limited to internal and external departments such as; financial and accounting information, human resource information, supply chain information between warehouses and plants, and all kind of customer information.

2.2. Importance and Motives of ERP

A company that has not any ERP system will be managing on many kinds of different software that do not allow interaction. The modification of old fashion simple resource planning systems and customization of their software databases and GUI's are also generally difficult in many cases. This will negatively affect the optimized functioning of organization's business activities.

Many organizations are facing difficulties in many areas of their operations. More effective engineering design and planning software will be needed in order to improve efficiency, decrease cost and increase the quality of the products, and to follow the client's behavior and choices. Administration of the different receipts interdependence, tracking transactions, managing customer relations, purchases, expenditures and controlling the effectiveness of the operations will be very complex when an organization is getting bigger.

All of these things can easily be managed when an ERP system is implemented in an organization. Information about operations flows regularly and permits you to follow a client's processes at any moment, no matter which part of the process they are going through. Procurements, expenses and payments are recorded in a centralized main database

which lets you to have close control over these activities. In this regard ERP supports you to prevent potential misuse.

When business procedures are restructured into a single organized unit, companies that have ERP systems will operate at a higher level. This will cause a higher level of productivity and efficiency, and this, in turn, will produce more profits. Another powerful motive of ERP is greater levels of information flow, along with a higher quality of information. Given the fact that we are living in the information age, it is critically important the information to flow across the companies efficiently and easily. Companies must be able to rapidly transfer information from one place to another. When information is transferred quickly and efficiently, companies and organizations will be able to respond on the data within a short period of time.

An integrated ERP system enables interactions of different operations, such as; marketing, sale transactions, controlling quality, managing products processes, supply lines and stocks, and many other operations. All the data are kept in a main single database and this will eliminate the occasional loss of and retyping errors. ERP systems integrate all departments and operations across a company in a single database that is able to assist the entire different department's particular functions and needs. ERP systems also automate business processes by placing them into a useful format that is standardized and common for the whole organization.

2.3. Advantages and Disadvantages Gained Through ERP Systems

ERP systems can support a company’s work in many ways. Since ERP systems integrate all parts of a company seamlessly, more proper control is possible. ERP systems are able to minimize redundant data registration; control data produced by different departments, and reduce registration errors. The interconnectivity among all the modules of ERP systems reduces the time to perform the different operational tasks, so the company’s efficiency can be increased. ERP systems enable users to access timely information and accurate reports can be produced at any time. The main reasons that companies undertake ERP systems are summarized as follows (Koch, 2002);

Integrated financial and operational information is one of the advantages gained through ERP systems. ERP systems integrate financial and operational management information across an entire organization, including finance/accounting database, production line, sales and service, customer relationship management information. ERP systems automate this integrated information flow activity with an integrated software application and all departments can reach the information of other departments.

Finance systems have their own set of data entries and outputs, such as; incomes, sales, expenses, budgets, and other kind of information. Different departments may have their own types of financial information and types of calculation on how much percentage they contribute to taxes and revenues. ERP systems create a single version of the information that cannot be questioned because all members of a company are using the same database system.

Integrated customer and service information is one of the advantages gained through ERP systems. The organization will be facing difficulties in many areas of its operations. ERP software will be needed to advance the production line, and to monitor the client's behavior and choices. Administration of the different receipts and orders will be very complex, such as invoices regarding materials purchases, expenditures, general expenses or payments.

ERP systems can become the platform for where the customer order stays from the time a customer service representative receives it until the merchandise is shipped and an invoice sent. By having this information in one integrated system rather than scattered among many different systems that cannot communicate with one another, companies are able to keep track of orders more easily and coordinate other related departments with them across many different locations at the same time (Chung, 2007).

By using ERP systems, it can easily managed how efficiently an organization can distribute its services to its customers, how easily this service can be monitored and reported. Sometimes, different units in an organization can have different customers and also give different services. Integrating these separated customer and service information

powerfully can provide an organization with more effective customer and service management.

Standardize and speed up manufacturing processes is one of the advantages gained through ERP systems. ERP systems also automate business processes by placing them into a useful format that is standardized and common for the whole organization. Moreover it could even be used between their suppliers and customers.

Many companies that have production line generally have different departments and each of these departments manufacture the same product using different devices and different computer systems. ERP systems have standard methods for computerizing some of the production steps. Standardizing all of these processes and having an integrated computer system can save time in manufacturing, increase efficiency, and reduce product cycle time.

Reduce inventory and operation costs is one of the advantages gained through ERP systems. ERP systems try to integrate business processes across departments onto a single database system. A few of the main benefits of ERP are improved coordination across functional departments and increased efficiencies of doing business. The immediate benefit from implementing ERP systems we can expect is reduced operating costs, such as lower inventory control cost, lower production costs, lower marketing costs and lower help desk support costs.

By using ERP systems, manual processes are automated, the manufacturing scheduling is more efficiently managed and the inventory of a company is more correctly assessed. Also, ERP systems can make the business process flow more efficiently, and it improves observation ability of the customer orders. This can make happen reduced inventories of the parts used to make products, and can help users make better planned deliveries to customers, decreasing the completed product inventory at the stores and shipping docks.

Standardize HR information and using HR strategically is one of the advantages gained through ERP systems. ERP can fix the HR problem of a company that may not

have a unified, simple method for tracking employees' time and communicating with them about benefits and services, especially in the case of companies with multiple business units.

While there can be many advantages of ERP systems, as described above, there are also several disadvantages. The implementation costs of ERP systems are so high that this prohibits small and medium businesses from acquiring such systems. In addition, ERP systems require considerable time to implement in a company, and they may slow down the routine operations within a company during the implementation period. Since this integrated system has to be well-defined in the beginning of implementation, it will be difficult to change it afterwards (Davenport, 2000).

Strategic Planning is another advantageous side of ERP systems. Strategic planning is a set of stages that evaluate needs and resources; describe a target audience and a set of objectives; "plan and design coordinated strategies with evidence of success;" by associate these strategies to needs, resources, and desired results; and measure and analyze the process and outcomes. Some part of ERP software systems is designed to support resource planning portion of strategic planning. As a matter of fact, resource planning has been the weakest link in ERP practice due to the complication of strategic planning and absence of suitable integration with decision support systems.

Inflexibility is one of the disadvantages gained through ERP systems. Enterprise Resource Planning is a long-range investment. A flexible ERP system will develop with a company, accepting new specifications as they emerge. Flexibility can be crucial in the implementation phase, to provide that the ERP software can align with existing business needs and achieve integration. Companies should look for an ERP solution that will provide new operating protocols, upcoming corporate growth, market growth, and any other resourcefulness that may arise.

Once an ERP is installed in a company, it is too difficult to change how the company works and is organized. ERP systems are like cement, which is highly flexible in the beginning, but rigid afterward (Chung, 2007).

Long implementation periods is another disadvantages gained through ERP systems. It takes too long to implement ERP systems. A three to five year implementation period of ERP systems is fairly common in a large company. In the current rapidly changing business world, five and even ten year projects are not supportable.

Overly hierarchical organizations ERP systems presume that information will be centrally monitored and that organizations have a well-defined hierarchical structure. Therefore, these systems will not match with organizations of empowerment or with employees as free agents. ERP systems for the construction industry have similar advantages and disadvantages according to the literature (O'connor and Dodd 2000; Shi and Halpin 2003). In particular, construction firms can achieve benefits associated with materials management by using such systems. Lee *et al.* (2002) stated in their study that an ERP system can shorten the procurement cycle up to approximately 80%, by automating the repeating transactions, and reducing manpower to perform the task (Lee *et al*., 2004).

2.4 Major Vendors of ERP Systems

There are many ERP vendors in the world but many of them are specialized with respect to their industry, country or region. However, there are some ERP vendors that give service to many industries and many companies around the world. At tier I, some of them are SAP, Oracle and MS Dynamics. Because MS Dynamics has only 10% of market share as shown below, larger vendors – SAP and Oracle- are tried to be explained.

2.4.1. SAP

The first company which introduced a functional enterprise system was SAP AG, headquartered in Walldorf, Germany. Five software engineers at IBM in Germany had the idea for a cross-functional information system. However, the idea was rejected by IBM, so the engineers founded their own company in 1972. R/2, SAP's earliest integrated system, ran on mainframes. R/3, the next version of the system, was a client/server system introduced in 1992. MySAP ERP, the successor to SAP R/3, is the first service-oriented business application on the market based on SAP NetWeaver, an open integration platform that allows new applications to be developed. In 2005, SAP had about 26,150 customers,

12 million users, 88,700 installations, more than 1,500 partners and a share of over 30 percent of the ERP market. SAP is the world's largest inter-enterprise software company and the world's third largest independent software supplier (Davenport, 2000; SAP 2005).

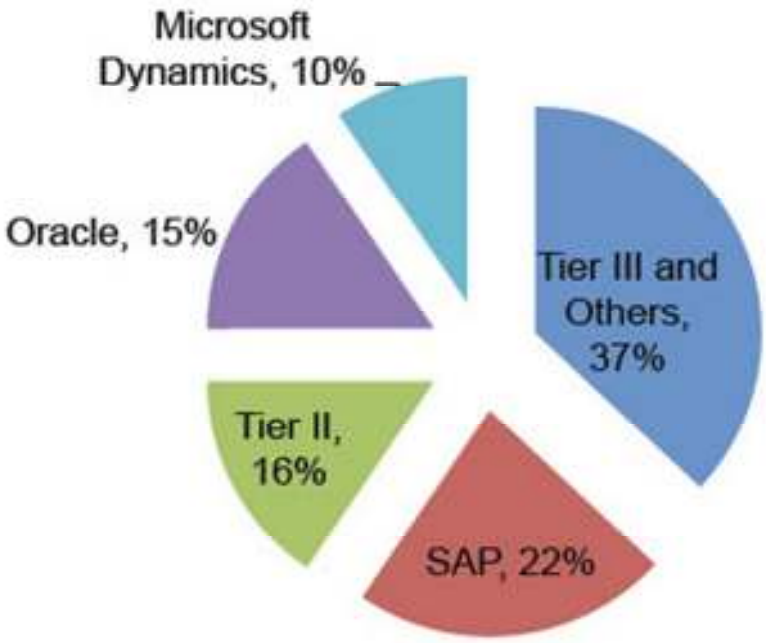

Figure 2.1. Market Shares of ERP Vendors (Panaroma Consulting, 2012).

SAP's strength is the breadth and extensive capability of its software's functionality, even though it leads to complexity in the system and its implementation. SAP spends much more on R&D than any other competitor and is most likely to introduce new functionality as a result (Davenport, 2000). In 2003, SAP NetWeaver became the first platform to allow seamless integration among various SAP and non-SAP solutions, reducing customization and solving the integration issue at the business level.

The solution of SAP regarding the integration issue is the use of open standards that allow software applications to be accessed as web services. With SAP NetWeaver, customers could pick and choose the specific SAP web services modules that met their own needs. It delivers much more valuable business functions, such as order management, with the flexibility of web services (SAP 2005).

2.4.2. Oracle

Oracle Corporation was first founded by Larry Ellison in 1977 as a database company. Oracle technology can be found in nearly every industry around the world; its database offering is the most popular repository of ERP data. Oracle began to develop its own business applications in the late 1980s, the early version of the applications coming from co-development projects with customer companies. Its ERP package, named Oracle EBusiness Suite, has almost 50 different modules in seven categories: Finance, Human Resources, Projects, Corporate Performance, Customer Relationship, Supply Chain, and Procurement. It also offers industry-specific solutions, most of which were acquired from companies that had developed them to a certain degree. Currently, Oracle has developed 100 percent internet-enabled enterprise systems across its entire product line: databases, business applications, and application development and decision support tools. Oracle is the world's leading supplier of software for information management, and the world's second largest independent software company overall (Davenport 2000; Oracle, 2012).

Among the Oracle product lines, PeopleSoft Enterprise enables organizations to reduce costs and increase productivity by Pure Internet Architecture, directly connecting customers, suppliers, partners, and employees to business processes on-line, in real time. PeopleSoft's integrated applications include Customer Relationship Management, Supply Chain Management, Human Capital Management, Financial Management and Application Integration. J.D. Edwards EnterpriseOne, suitable for large organizations, is the complete solution for modular, pre-integrated industry-specific business applications designed for rapid deployment and easy administration on pure internet architecture. J.D. Edwards World is ideally suited for small businesses because of its reliable, functionality-rich, web-enabled environment for managing plants, inventories, equipment, finances, and people. It is synchronized, integrated, and pre-bundled enterprise software on a single database, which reduces implementation cost and complexity (Oracle, 2012).

2.5 Main Functions and Characteristics of ERP Systems

2.5.1. Structure

An ERP system has the following technological characteristics (Keller 1994):

- Use or integration of a relational database
- Several interfaces, including a graphical user interface (GUI)
- Openness to different hardware platforms
- Client-server architecture
- Consideration of supply chain
- Openness to internet and intranet

Since ERP systems fulfill the managerial functions and the information needs of the organization, the structure of ERP systems is typically divided into three data layers as follows:

- Operational system (Registration layer)
- Tactical system (Controlling layer)
- Strategic system (Executive Information Systems (EIS) layer

The structure of an ERP system is shown in Figure 2.2 (Chung, 2007).

Most ERP systems are now working on a client/server computing architecture. This means that some portions of the software are processed on a server and some by the client. These ERP systems are large and multiple software needing powerful servers. However, early versions of ERP systems ran on central mainframes.

Today, only few firms use these mainframe versions, but most companies are moving toward to the client/server version.

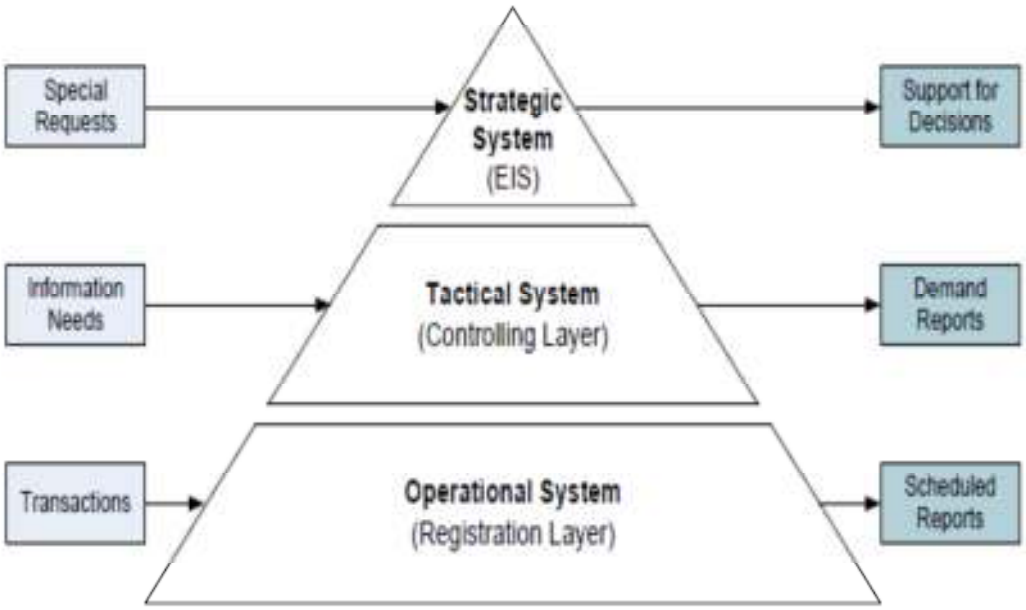

Figure 2.2. Structure of an ERP System (Januschkowetz, 2001; Schultheis *et al*., 1992).

Some brands of ERP (e.g., SAP) currently use *the three-tier model* of a client/server version, which has a clear division between the three different system layers. The basic layer is the database server, which manages the working data of an organization, including master data, transaction data, and meta-data in a relational database.

The second layer is the application server where the complete system applications are processed. The application servers use the data of the database server and write data back to that server. The top layer is the presentation server, the graphical user interface (GUI).

Currently, additional layers can be used for web applications, CAD systems, or simulation tools. Figure 2.3 shows an example (SAP R/3) of the client/server system architecture (SAP, 1999).

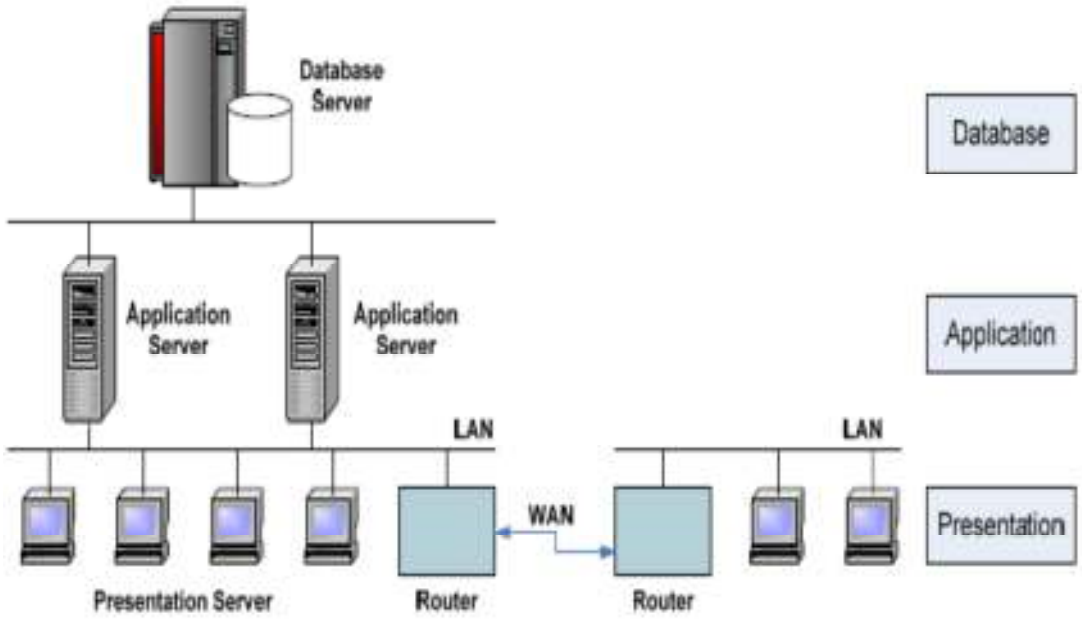

Figure 2.3. Client/Server System Architecture (SAP, 1999).

2.5.2. Functions

Most major operational processes can be supported by ERP systems. Although there is some variation across vendor packages, ERP systems can support all financial processes, supply chain processes, manufacturing processes, customer service process, and human resource management. The main functions and their interrelation within ERP systems are shown in Figure 2.3. Detailed descriptions of each follow (Januschkowetz, 2001):

Production Planning and Controlling is one of the important functions that consist of following tools and items; material, bill of material (BOM), quantities, production times, goods on order, routings, work order, machinery, sales planning, primary and secondary demand, jobs.

Procurement is one of the important functions that consist of following tools and items; Bills of Materials (BOM), material, prices, conditions, source of supply, quantities, order requests, orders, offers of suppliers, procurement information, inventories, handling of stock.

Plant Management: is one of the important functions that consist of following tools and items; facilities, investment, service plans, maintenance plans, maintenance orders

Sales and Distribution is one of the important function that consist of following tools and items; information about partners, customers, Bills of Material (BOM), sales prices, quantity, sale conditions, revenue, mailing conditions, transportation, contracts, offers, inquires, service contracts.

Financials and Accounting is one of the important functions that consist of following tools and items; accounts of debtors, creditors, receipts, liquidity calculations.

Controlling is one of the important functions that consist of following tools and items; type of costs, type of outputs, receipts, cost units, cost calculations, cost centers, profit centers.

Personnel is one of the important functions that consist of following tools and items; number of co-workers, qualifications, departments, type of wages, travel information, time management, application information.

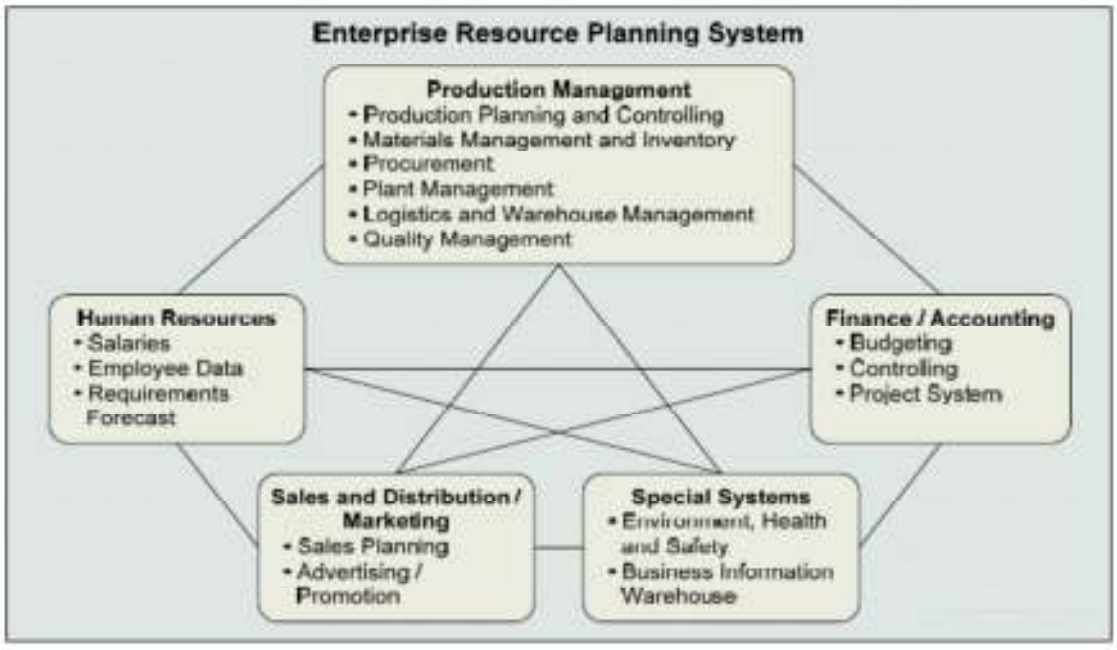

Figure 2.4. Business Functions within ERP System (O'Brien, 2004).

2.5.3. Modules

ERP systems are groups of application modules. SAP, the most comprehensive ERP package, has 12 modules, as shown in Figure 2.5. The modules can interact with each other either directly or by updating a central database. All modules can be implemented as single modules and only those needed are installed.



Figure 2.5. Modules in SAP R/3 (SAP, 1996).

Companies can expand or replace functionality offered by an ERP vendor with software from a third party provider. The goal in such cases is that the third party software acts as another module, so some customized interfaces must be developed in order for the third party software to connect with the ERP system (Davenport 2000).

Oracle has similar application modules which provide business information for effective decision-making, enable an adaptive enterprise for optimal responsiveness, and offer a superior total ownership experience that drives profitability (Oracle, 2007).

2.6. Construction Enterprise Resource Planning (CERP)

2.6.1. ERP in Construction Industry

The construction industry is a highly fragmented industry. It wants to communicate with other related businesses such as material and equipment suppliers, vendors, subcontractors and clients. ERP systems are being used by construction companies to improve responsiveness in relation to customers, strengthen supply chain partnerships, enhance organizational flexibility, improve decision making capabilities and reduce project completion time and lower costs. These information systems are designed to integrate and partially automate many of the company's business processes such as human resources, financial management, manufacturing, procurement, construction, operations and maintenance. The goal of ERP is to support one time entry of information at the point where it is created and to make it available to all the participants within the organization (Ahmed *et al*., 2003).

Even though the construction industry is one of the largest contributors to the economy, construction industry is considered as one of the highly fragmented, inefficient, and project oriented industries. In order to surmount this ineffectiveness, a number of solutions have long been offered including adaptation of information technology IT and information systems IS.

Project-based industries like construction sector are the largest among all industries in the global economy. Because all of the projects are different from each other, they create some unique challenges. It is not easy to satisfy all the requirements of construction enterprise resource planning C-ERP systems by a regular system that is planned to automate all project management operations of the whole construction companies. Also, the construction industry has been criticized for its low performance due to lack of high quality performance evaluation, project monitoring, cost effectiveness, security, and sustainability.

By tradition, the construction industry has been challenged with the problems of meeting the projects under budget, on schedule and at enough quality mentioned in

specifications set by the owner and architect/engineer. The suitable usage of internal and external resources is crucial if construction companies are to make the best business decisions, maximize their organizational objectives, and continue in the competitive environment.

A significant number of major construction companies embarked on the implementation of integrated information technology solutions such as enterprise resource planning systems (ERP) to better integrate various business functions. However, these integrated systems in the construction sector present a set of unique challenges, different from those in the manufacturing or other service sectors. There have been many cases of failure in implementing ERP systems in the past, so it is critical to identify and understand the factors that largely determine the success or failure of ERP implementation in the construction industry (Chung *et al*., 2007).

The availability of resources defines the production capability of a contractor. In general, a construction company can access two categories of resources:

- Internal resources, which the company owns; and,
- External resources, which the company can obtain from the open market at a price.

The common objective is to maximize the usage of the company's internal resources and use the market to balance the company's operation. Given that construction projects are transient in nature, span different lengths of time periods, and require different resources, it is usually very difficult to achieve a balance between the production capability and the actual workload on hand for a construction enterprise all the time. In practice, a construction company has various ways to adjust its operations to approach such a balance. For instance, when the company does not have enough jobs, it may rent out some of its owned equipment and may bid lower prices on new projects. On the other hand, the contractor may rent outside equipment, recruit personnel, or request its employees to work overtime. Such enterprise-wide business decisions require using extensive information across the company and the market; otherwise, whether the company has made the best use of its owned and market available resources to serve its business objective remains a question. It is a common phenomenon to hear complaints

from the people working in the construction industry. They complain of being overloaded and of being required to work overtime when the business is good; on the other hand, they worry about their job security if there is not enough work. Moreover, it is not unusual to see lower-than-cost bids when contractors are hungry for projects. Such a gambling strategy has driven many contractors out of business. Poor profits were found to be the top cause responsible for construction business failures (Kangari, 1987).

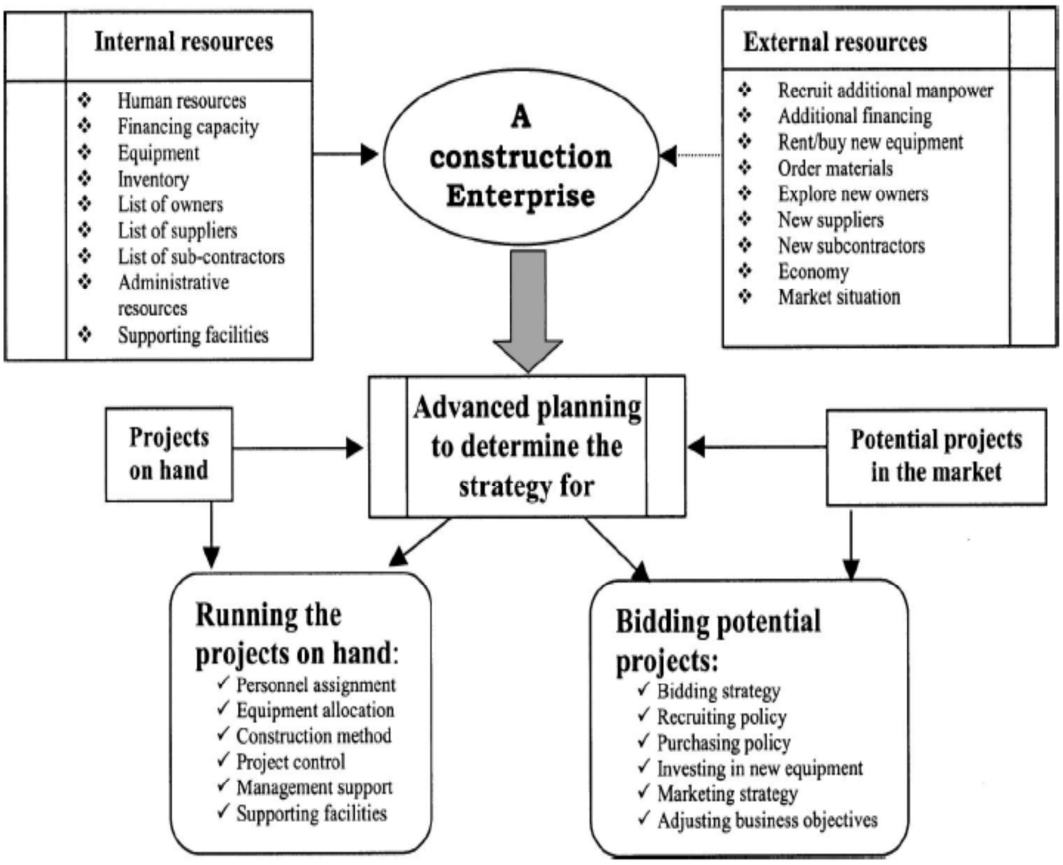

Figure 2.6. Construction Enterprise Operation (Shi and Haplin, 2003).

Schematically, the operation of a construction enterprise can be described as shown in Figure 2.6. The top of the figure presents the internal and external resources available to the enterprise. A solid line is used to represent the ‘‘owned-relationship,’’ showing the available resources inside the enterprise. A dotted line is used to describe the ‘‘can-have ownership,’’ for external resources that the company can get from the market at a price.

How can a construction enterprise optimize the utilization of its internal and external resources in order to maximize its business objective? Specifically, it must decide (Shi and Haplin, 2003):

- how to allocate corporate resources to the projects on hand;
- whether or not and how to compete for additional resources in the market; and
- the strategy for bidding projects and how to run these potential projects if they are awarded.

The business decision-making process described above contains much data between many units that traditional human subjectivity and segregation systems are not suitable. As an alternative, better planning techniques are required and Internet technologies provide a cooperative working environment for usual separated management functions so that information and the knowledge of the organization can be shared and cooperative judgments and critical decisions can be successfully made. This ensures the result that an internet-based integrated resource planning system is a probable solution for accomplishing construction enterprise-wide business automation.

Construction is the process of transforming materials and permanent equipment into a finished facility (Peurifoy *et al*., 1996). Compared with other industries, typically the manufacturing industry, the unique characteristics of the construction industry have been widely recognized (Tucker, 1988; Oglesby, 1990).

From the business perspective, a construction company also operates in a different manner from its manufacturing counterpart. The uniqueness of the industry has prevented the direct implementation of many methods and concepts developed in the manufacturing industry, such as the mass production method. Such uniqueness forces researchers in the construction community to develop their own science base for the sustainability of this major industry. Construction enterprise resource planning (CERP) systems need to be studied and developed (Shi and Haplin, 2003).

2.6.2. Basic Features of Construction Enterprise Resource Planning (CERP) Systems

To facilitate various users in the industry in accepting and using the system, a CERP system should be:

Project-oriented: The construction sector is mostly operated on projects. Every project is a final product to be constructed and is aimed to be completed on time, under budget and within quality standards. After a construction agreement is signed, the total income at the end of delivering the final construction product is usually fixed and the profit from the agreement is generally determined by the total cost, which is generally depend on the good organization of the site processes.

A Construction Enterprise Resource Planning system must be able to organize current projects with the ability of reporting and forecasting progress status on the fields, cost status on the budget, profitability on working schedule, and potential problems such as dropping behind schedule and exceeding cost so that proper actions can be taken before complications occur.

Furthermore, the income and the progress of a project influence the whole performance of the organization. Project progression data should be occasionally summarized and reported timely to the high management level to show the general situation of the company as far as financing necessities, cash flow, purchasing, procurement, and human resources. If there are dispute among projects on competing the same resources corporate level judgments must be taken by maximizing the overall interest of the enterprise.

Integrated: A traditional construction company has two front-office departments and these are estimating and operations, but many back office departments and units, such as; procurement, engineering, accounting, contracting, purchasing and equipment. These units trust and depend on each other for right information flow and cooperation with each other in decide for running current operations and having new projects.

In order to get high productivity and computerization, the front and back units should be connected with each other. The computer system must have enterprise-wide database which is connects all units of organization and every office in it should have its corresponding level of access to the same system according to its business functions. Any department in organization can acquire the required info and decisions online for supporting its organization functions; also, every department can continuously update and grow its responsible databases and make judgments, which become available online for other offices.

For example, when a new delivery is arrived on site, it is updated by the construction site office and this allows site managers and planning engineers to plan their site operations. Also, a newly granted project entered by the bidding department allows the operations division to schedule and plan its construction. Even though all ERP systems must be integrated with various front and back office functions, a construction company has dissimilar organizations and management functions from a manufacturer.

Paralleled and distributed: Multiple management functions are concurrently carried out by managers in various offices across a company. Therefore, an integrated ERP system must use parallel and distributed technology in order to support multiple concurrent applications or requests. For example, an estimator may be searching the historic cost database for determining the bid price of a new project; at the same time, a cost engineer may be updating the database with recently completed project data. This feature is commonly needed for all ERP systems (Shi and Haplin, 2003).

Open and expandable: Applications are needed for supporting management functions, such as Timberline for estimating and Primavera Project Planner (P3) (Primavera Systems 1999) for scheduling and planning. An ERP system may interact with an application through three different approaches:

i. to run an application for responding a direct request—a user may start P3 to schedule a project;

ii. to call an application for getting needed information—when preparing a progress payment request, the project manager needs the percent completion of the project, which can be calculated by a project information system; and
iii. to facilitate two-way data exchanges between an application and the ERP system—after a new project is added using an estimating or scheduling application, the project data should be stored in the central database for users to access.

It is well known that each construction enterprise has its own characteristics essential for its success. Applications will vary significantly from company to company. An open and expandable architecture allows a company to tailor its needed applications to fit its business needs. Meanwhile, new applications can be added to the environment and unneeded ones can be removed from the environment. Therefore, a high level of customization must be achieved with a minimal effort needed for an end user. This feature is much more highly required for a CERP than for a general ERP system.

Scalable: Scalability is a common requirement for all ERP systems. Implementing an ERP system requires major capital investment and reengineering of business practices. An ERP system must be able to facilitate the strategic development of a company for many years to come. Scalability is reflected in the need for the system to accommodate expanded management functions. The functional offices of a construction enterprise are organized according to its tradition and size. A contractor may start implementing an ERP system with two functional modules, such as accounting and project management, so that only staff in the two offices can access the system at the initial stage. As time goes by, other functional modules and new users may be added to the system. Moreover, the construction business reflects the overall economic cycle. A scalable system is essential for a construction enterprise to meet rapidly expandable requirements and in the meantime to be flexible for economic down turns (Shi and Haplin, 2003).

Remotely accessible: Each project is constructed on a specific site, which may be hundreds or thousands of miles away from the head office. Remote accessibility enables project managers and other site personnel to remotely access central information such as purchasing and financing data; meanwhile, the head office can obtain the updated project

progress information so that the senior management can assess the project performance and its impact on the company (Shi and Haplin, 2003).

Transparent: The construction industry is traditionally resistant to new technologies. One of the effective strategies to overcome this obstacle is to provide a self-explanatory mechanism in the system to allow users to trace down relevant reasoning for decisions or recommendations resulted in the system. For instance, the system may request a project manager (PM) to reschedule the site work of a project under his/her supervision. The reasoning behind may be explained as "The needed material is not available because Universal Supplier, Inc., is unable to deliver the material as scheduled, based on the delivery information updated by the purchasing office" (Shi and Haplin, 2003).

Reliable and robust: This is a common feature required for all decision-supporting systems. For example, correct historical cost data must be retrieved from the cost database for supporting estimating; a purchase order must be reviewed and be approved in a right sequence; and a request for reserving a piece of equipment for a project must be processed accordingly and a reservation made, or the requester must be informed if the request cannot be satisfied (Shi and Haplin, 2003).

2.6.3. Basic Concept of CERP Systems in Engineering & Construction Firms

Major ERP solution vendors such as SAP and Oracle now provide specific solutions for the construction industry. Figure at below show each company's solution maps for the construction industry. As shown in these figures, their solutions handle the full range of business processes that a construction company needs. Even though these solutions have a broad scope, some construction companies may not choose all the solutions provided. Enterprise Portals by Oracle can give employees and partners access to the full range of information, applications, and services they need to work and collaborate online. With this solution, construction companies can manage integrated information from across the organization and the supply chain as well as improve communication with different parties (Chung, 2007).



Figure 2.7. SAP Engineering, Construction & Operation Solution Map (SAP, 2004).

Due to the project-oriented nature of the construction sector, project management modules of CERP systems are generally considered as top important subject, so these ERP modules from vendors will be clarified more in detail. After that, the general concept of ERP Systems together with most important functions and the structure of such systems in the construction industry will be provided.



Figure 2.8. Oracle Solution Map for Engineering and Construction (Oracle, 2006).

The main application area for the construction industry is project management. Major ERP vendors such as SAP and Oracle provide robust project management solutions for the construction industry. In their project management modules, they cover all the necessary functions in construction project administration, including project cost management, contract management, resource management, collaboration with other parties, and project data management. All the data produced in each module will be updated automatically in real time, because all the functions and modules use one central database. They provide more accurate and timely information to users, which in turn help them make better decisions. The representative "project management modules" are described below (cited in Chung, 2007; Oracle, 2012; SAP, 2012):

Project Cost Management; functions are influentially connected to many important modules of the ERP system. These functions also contain project costing, project billing and change management modules. Chung (2007) has stated that project costing offers integrated cost management solutions, such as the analysis of cost tracking and cost trend analysis. Project billing can simplify client invoicing, improve cash flow, and measure the profitability of contracting with support for planning, execution, and analysis. Also, change management can streamline the workflow required for the change order process. It can help control the change process and analyze the impact of changes. The change will be updated to project costing, which in turn will simultaneously update finance accounting.

Project Contract Management; is one of the critical module that presented by the system. This module consists of management functions and these are managing contracts with clients and managing contracts with subcontractors. The first one helps manage contractual responsibilities, contract documents and specifications; whereas the latter manages subcontract-related processes and payment control.

Resources Management: Project resources control the resources of materials, equipment, and labor. This function ensures correct information regarding project resources and is directly connected with accounting, finance and purchasing modules. The running time of machines, working days of employees and expense-related information in the project are handled by different functions such as time and labor, which is directly connected to the human resources modules.

Project Collaboration; Chung (2007) states that this module enables team members to collaborate in reviewing and completing project work. Both SAP and Oracle provide very good workflow functions that can support not only users within an organization, but also the other project participants including the owner, A/E, subcontractors and suppliers.

Project Data Management: This module is connected to knowledge management module and achieves all the project data as well as project information, drawing files, technical documents and specifications of the details and material classifications so on... This module also controls the version of files and drawings.

Since implementation costs of Enterprise Systems are very high, there are few construction companies implementing fully integrated ERP systems. In addition, the benefits of ERP systems are difficult to quantify, so a very limited number of construction companies are now using or implementing them in the U.S. Even most of those companies use only finance or HR modules and they have legacy systems or use commercially available software in project management areas. However, construction companies require optimizing the utilization of their internal and external resources to maximize their business goals, and need better business decision to be made in a timely manner as their business grows. For this reason, many large construction companies have recently implemented or are considering implementing fully integrated ERP systems, so this research will help them make appropriate decisions (Chung, 2007).

In the figure below, Chung (2007) has explained the general concept of ERP system structure for construction companies. Even though the project that construction companies have being built and the process flow of the work depend on the construction companies, there are many similarities between them due to the project-based production in construction. The main applications that construction companies need are Financial Accounting and Project Management modules. These two essential modules are strongly connected each other.

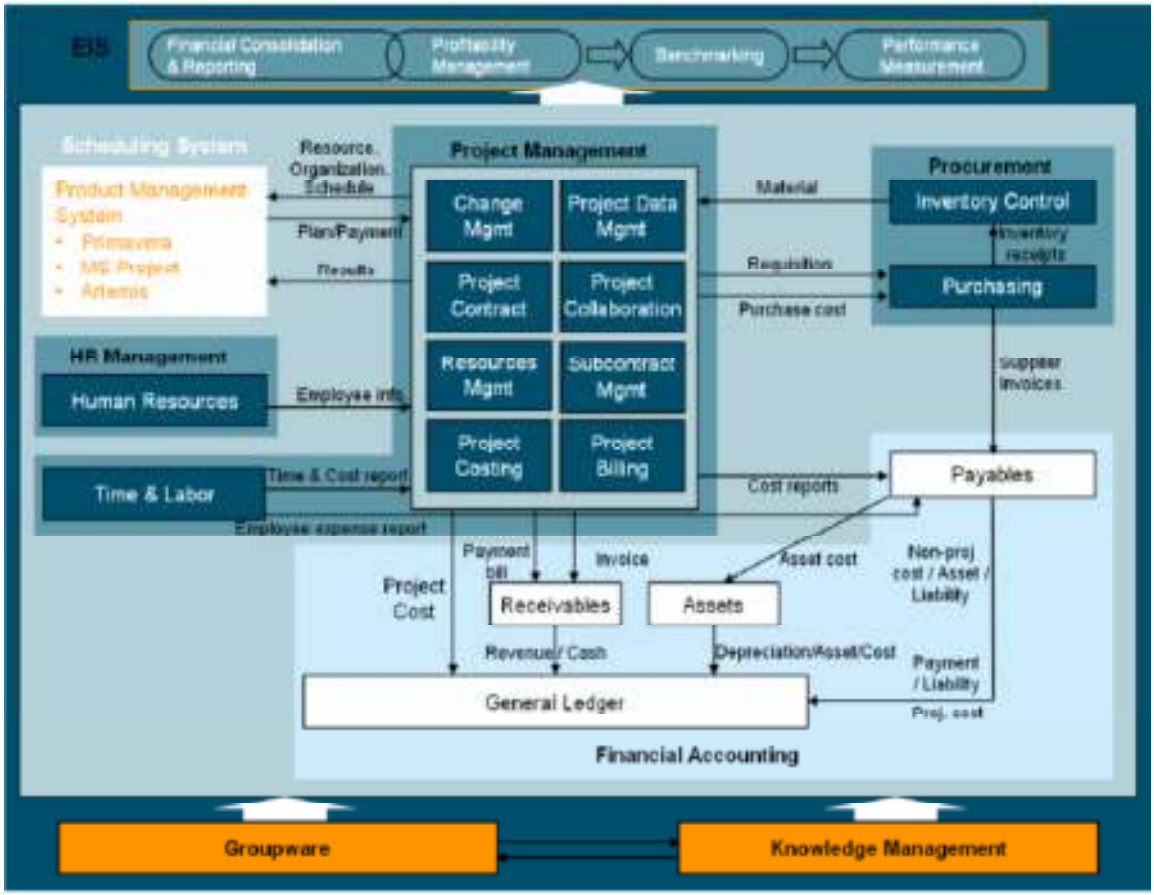

Figure 2.9. General Concept of ERP Systems in Construction (Chung, 2007).

2.6.4. Advantages and Benefits of CERP Systems for Construction Firms

The major expected benefits of a CERP system include information sharing, improved transparency of management responsibilities, and improved management efficiency. These benefits will allow better business decisions to be made in a timely manner (Shi and Haplin, 2003).

Information Sharing is one of the advantages and benefits of CERP systems for construction firms. In a traditional management environment, construction information is maintained by responsible offices across a company. A user must cross over organizational barriers between offices in order to get information that belongs to other offices. An ERP system runs off one single database. As soon as a piece of information is generated, it is stored in the central database and is available to all eligible users in the system. For example, if equipment data are available online, project managers would be able to use the information to reserve their needed equipment online, although the same result can be

achieved in a traditional environment through back-and-forth communications between the project team and the equipment department. If the delivery status of materials is available online, project managers would be able to promptly notice a late delivery and to evaluate its impact on a project schedule.

Information sharing removes the necessity of regenerating or reentering the same information in different offices. Eliminating multiple data entries also help maintain data consistency and reduces human errors. For instance, the needed quantity of cement in a project is estimated by the staff in the estimating department. Using this information together with the project schedule, a purchasing officer can place an order. Traditionally, this information is reentered into various isolated systems such as scheduling and purchasing (Shi and Haplin, 2003).

Improved Transparency of Management Responsibilities is one of the advantages and benefits of CERP systems for construction firms. Many management processes require a sequential set of tasks to be performed by various offices. For instance, a purchasing process involves preparing a purchase request, approval of the request, soliciting quotations from suppliers, sending a purchase order, and receiving the product. Traditional manual paper circulations between offices frequently cause delays or losses of information, or even errors in business decisions. For example, a purchase request from a project team may be misplaced somewhere so that the request is not processed. If the delivery information is not directly available to the project manager, the mistake may not be discovered until the material is needed on the job site. After the instance, it is very difficult to trace down the responsibility because the status of the request is not fully traced. The project team may criticize the purchasing staff, while the purchasing staff may argue that a request was never received (Shi and Haplin, 2003).

An ERP system performs a management function by executing a corresponding process model that consists of management tasks. Tasks are performed one-by-one by following the sequence given in the model. A seamless collaboration between offices is achieved through the networked connections between offices. After one task is performed, the ERP system will move to the next task in the model. During the process, the system keeps all details regarding when a task can be performed and when and by whom a task is

performed. If a purchase request is generated, it is traceable to when it is generated and when it is sent to the purchasing office. Therefore, the responsibility is clear if the request is not processed anywhere. Moreover, with the delivery status online, the project team can discover the problem if the request is not processed properly (Shi and Haplin, 2003).

Improved Management Efficiency is one of the advantages and benefits of CERP systems for construction firms. An ERP system improves management efficiency through two improved practices:

- providing timely consistent information;
- providing a coordinated decision-making environment.

Making business decisions requires relevant information in a timely manner. In a traditional management environment, management is frequently confronted with different or even conflicting figures obtained from different sources. Decisions have to be delayed in order for the management to verify these figures. For instance, a consensus decision may be hard to reach for an ongoing project if the project team, the financial office, and the engineering department have presented different pictures for the project because they focused on different aspects, updated the project status at different time intervals, and/or did not communicate with each other during their updating. In an ERP system, each piece of information has one single source and has one responsible party who may update it, so that all parties will have the same information (Shi and Haplin, 2003).

The network technology eliminates the physical barriers between offices so that all offices work on their responsible tasks in a coordinated manner. A management process runs from one office to another and information flows from one office to another seamlessly. For example, after a purchase request is initiated, the request will automatically be transmitted to a responsible office (e.g., the financial controller's office) for approval as defined in the process model. All requests for approval are listed on the terminals in the controller's office. A control officer evaluates one request at a time. After being processed by the controller's office, a request continues its journey to the next office (Shi and Haplin, 2003).

Standardization versus Customization of Management Functions is one of the advantages and benefits of CERP systems for construction firms. Existing ERP systems achieve business management automation through standardization. A standard process model is created based on the best practice for performing a management function. Whenever the management function is needed, the same standard process will be executed in an ERP environment. At the installation stage of an ERP system, a company has the option whether or not to activate a standard model. If the company decides to use it, its staff must follow the standard process to execute the function when the ERP system is up and running. Therefore, standardization usually requires a company to reengineer its business practices.

The benefits of standardization include improved management efficiency and reduced human errors, but it requires the staff in the company to adopt new working procedures that are different from what they were used to. Although it is possible to request an ERP provider to customize standard processes to fit a company's practices, it has proven expensive and time consuming, and presents a lack of compatibility with future releases of the ERP system (Krasner, 2000). Customization is therefore not recommended by existing ERP providers.

There are two separate research issues: standardization and customization of construction management functions. Some management functions can be standardized based on the industry-wide practice. Standardizing a management function includes:

- Identifying management tasks;
- Linking these tasks logically; and
- Defining performance procedures of the tasks.

For example, an order cancellation management process is shown. If the purchase office is informed that an order for a batch of window frames is cancelled because the supplier is out of business, a purchasing officer can activate the process. In the order cancellation box, ‘‘window frames’’ is highlighted. An alternative supplier is identified by the officer from the alternative supplier list, and a new order is placed with the endorsement of the purchasing officer. The affected project and offices are then informed

of the updated cost and delivery information. The project manager can update the job-site plan to accommodate the new delivery date (Shi and Haplin, 2003).

On the other hand, the construction industry is characterized by non-standardization in many areas. Many management processes cannot be standardized. Research is needed to develop corresponding technology that will allow custom management processes to be created with little or no effort (Kurucu, 2001).

Because existing ERP systems are primarily developed for the manufacturing industry, they can hardly meet the needs of the construction industry. A knowledge base is needed for developing CERP systems by addressing the nature and business culture of the industry (Shi and Haplin, 2003).

In a study made by Lee *et al*. (2002), a simulation model to implement ERP in the material management is created. They implemented the model based in four distinct steps, which are application integration, internal integration, external integration, and automation. This study shows that the durations of almost all of the activities involved in the material management process are successfully been reduced and even in many cases these activity durations have become eliminated. They stated in their study that an ERP system shortens procurement cycle by 80% approximately, through automating most of the repeating transactions, and by reducing manpower to perform the tasks. Hereby implementing ERP systems in the materials management area has measurable benefits in all other areas, which interface with the material management module. (Lee *et al*., 2002)

In the study of R/3 software made by Connor and Dodd (2000), there are 15 functions provided by R/3, but deficient in some way and/or to some extent. These are: unit price tracking, job cost reports, labor cost report and work hour forecasting, change order cost tracking, work breakdown structure model, project conceptual/milestone schedule, detailed activity precedence network, project schedule reports, short interval planning, purchase order development and issuance, monitoring of change orders, rework, and back-charges, management of contractor retainage, tracking and documenting percentage of physical completion, field warehouse inventory management and warehouse inventory reorder management (Ahmed *et al*., 2003).

The success of ERP in manufacturing enterprises resulted in its adoption in some large construction companies (ML Payton Consultants, 2002; Voordijk *et al*., 2003). Yet, because of the differences in manufacturing and construction processes, ERP adoption in these companies resulted in the integration of financial management processes only Helms 2003. There are many reasons for the discrepancies between manufacturing and construction industries.

First, the construction industry is unique in its work environment and the distributed nature of stakeholders. Although it shares many similarities with the manufacturing industry in regard to production processes and systems, it mostly produces one-of-a-kind, prototype-like products. Also, the construction industry operates project-based activities that are carried out by many different parties which may be geographically dispersed. As different organizational entities, each of the project participants has different goals to accomplish in the project. Furthermore, the amount of information and its time sensitiveness in the construction industry makes it hard to manage. For these reasons, generic or standard ERP systems intended originally for manufacturing or non-construction service industries are not able to address the unique business needs of the construction industry. Extensive customization is required to respond to these specific needs. This has been the primary reason to date for the low implementation rate of the ERP systems in the construction industry (Tatari *et al*., 2008).

The existing disparity between the needs of the construction applications of the ERP systems and their standard features available today has formed a gap between solutions offered by ERP systems vendors and the needs of the construction industry. In the meantime, with the saturation of the market in other industries, ERP vendors moved to other industries to expand their existing services (Piturro, 1999). As a result, with the advent to the new millennium, major ERP vendors such as SAP and Oracle have attempted to tailor their standard systems software to the needs of the construction market. Construction industry-specific solutions such as C-ERP conform to a set of criteria that make them different from generic ERP. For instance, C-ERP are project-oriented, integrated toward the project life cycle, and remotely accessible, among other characteristics (Shi and Halpin, 2003). The benefits expected from C-ERP implementation are as follows (Ahmed *et al*., 2003; ML Payton Consultants, 2002; Piturro, 1999): real-

time visibility of the finances of projects and enterprise; managing projects on time and within budget; enhanced decision-making capabilities; strengthened client, supplier, and subcontractor relationships; eliminating data reentry; and increasing management efficiency (Tatari *et al*., 2008).

As the ERP systems environment becomes popular, software applications emerge to help business managers implement ERP in diverse business activities such as project planning and management, subcontracting, material tracking, service, finance, and human resources. Currently, SAP, Oracle, and PeopleSoft offer C-ERP solutions. The functionality of C-ERP covers the entire construction project life cycle. The scope of the C-ERP system is depicted in Figure below and the implications to the project life cycle are described below (Tatari *et al*., 2008).

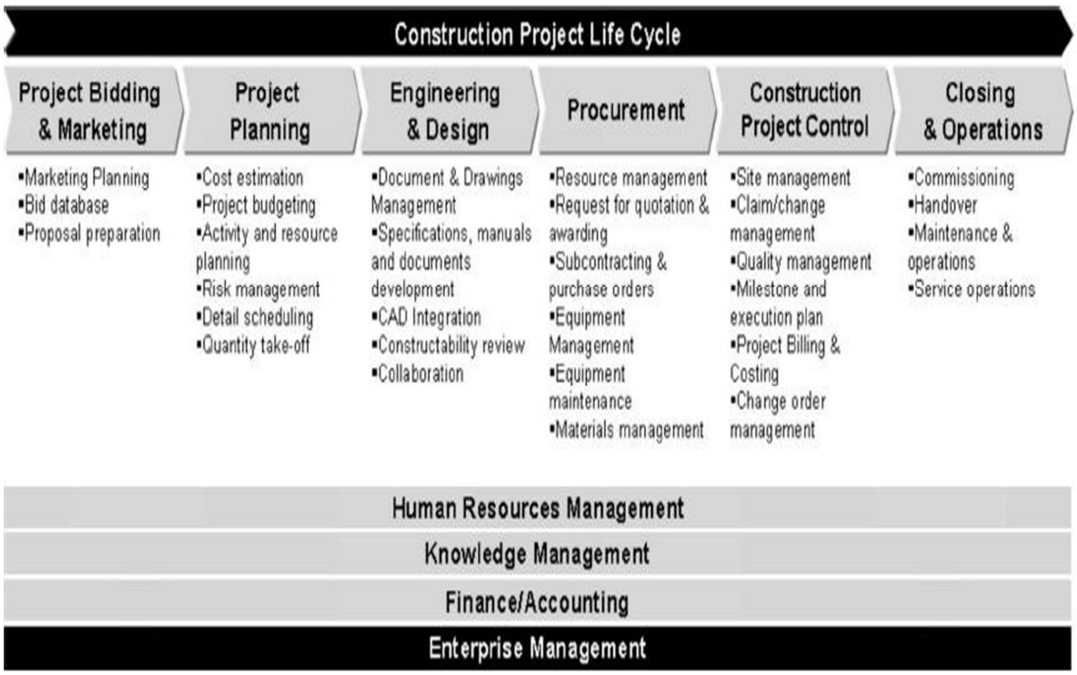

Figure 2.10. Scope of C-ERP system in construction project life cycle (Tatari *et al*., 2008).

Project Bidding/Marketing is one of the advantages and benefits of CERP systems for construction firms. C-ERP automates the procedure of proposal preparation, bidding and reviewing bids, marketing campaign management, customer databases, and competitor analysis (Tatari *et al*., 2008).

Project Planning is one of the advantages and benefits of CERP systems for construction firms. C-ERP automates activities related to cost estimation, project budgeting, activity and resource planning, and detailed scheduling. All of these are realized in single software, which eliminates duplicate data entrance, especially between preliminary estimation and detailed planning (Tatari *et al*., 2008).

Design/Engineering is one of the advantages and benefits of CERP systems for construction firms. With C-ERP preparation of detailed specifications and requirements is automated. C-ERP maintains all specifications and drawings with the aid of its document management system. Computer aided design CAD integration is realized to avoid duplicate generation of drawings and specifications during the project life cycle and collaboration tools are used to aid the mutual communication needs of project participants (Tatari *et al*., 2008).

Procurement is one of the advantages and benefits of CERP systems for construction firms. C-ERP streamlines procurement of required materials, equipment, and services. It automates the processes of identifying potential suppliers, supplier evaluation, price negotiation, contract management, awarding purchase orders to the supplier, and supplier billing. Supply chain management of materials is managed through this function. For equipment management, it also automates maintenance scheduling and service operations data (Tatari *et al*., 2008).

Construction Project Control is one of the advantages and benefits of CERP systems for construction firms. Through integrated information visibility from other functions, it is much easier for the project manager to execute the project. Also, project billing and project cost is integrated in real time which allow the main office to keep track of projects. C-ERP also automates the change order management which is an important time consuming activity during project execution (Tatari *et al*., 2008).

Workforce Management is one of the advantages and benefits of CERP systems for construction firms. C-ERP handles personal and payroll related activities of the construction firm. A complete employee database is maintained including contact information, salary details, attendance, performance evaluation, and promotion of all

employees. Also, this function is integrated with the knowledge management system within the firm to optimally utilize the expertise of all employees (Tatari *et al*., 2008).

Finance/Accounting is one of the advantages and benefits of CERP systems for construction firms. As one of its core functions, C-ERP streamlines the financial operations of both the enterprise and projects, collects financial data from all departments, and generates all financial reports, such as the balance sheet, general ledger, accounts payable, accounts receivable, and quarterly financial statements (Tatari *et al*., 2008).

With C-ERP it is possible to share and exchange information in digital format throughout the project life cycle. Thus, information is stored once and all project participants are able to access this information. It is shown the potential effect of C-ERP in streamlining communication between participants (Tatari *et al*., 2008).

Data integration can be realized through a centralized database system in the core of C-ERP. All data are entered only once, and are visible throughout the entire project life cycle. Process integration is realized by utilizing one integrated information system for the whole project life cycle, instead of using several standalone applications. By streamlining and connecting all business functions, business processes can be executed without interruption.

Finally, linking project participants is realized through online access to project information by all of the participants. The participants can view project information with varying levels of access authorization, and enter or revise information related to their part of the business. The vision of computer integrated construction CIC is to integrate data, information, and project participants. C-ERP is also intended for this particular purpose (Tatari *et al*., 2008).

3. IMPLEMENTATION OF ERP SYSTEMS IN CONSTRUCTION SECTOR

3.1. Implementation of ERP Systems in Construction Sector

Implementation of a system is a stage that all planned tasks and activities are realized. At this implementation stage, monitoring of implementation is essential to make sure that the system is implemented successfully as per the schedule and on the budget. Therefore, the implementation stage begins before project start and continues until the end of the system test duration. This is a continuous process that should begin before the implementation of the system starts.

Monitoring of ERP system implementation stage is significant to understand that all the modules of ERP system and its all activities are implemented as planned. This aids the implementers to measure how well they are completing their objectives.

There are some success factors that support to finalize the implementation of ERP systems successfully and one of them is human factor. Abdinnour-Helm and Lengnick-Hall (2003), point out that pre-implementation involvement is a key issue for having a positive attitude towards the ERP. It can be mentioned as end user involvement to the implementation of ERP system can play important role at the result of implementation process.

Another success factor related to the human factors is the trust between team members and other participants of the project. Lander *et al*. (2004), consider the trust building mechanism between team members and other participants of the project as a major factor in the implementation process.

Moreover, the impact of cultural aspects on the success of the implementation is also analyzed in several papers. Jones *et al*. (2004), suggest a multi-site case study showing that a similar culture facilitates knowledge sharing during ERP implementation. Also, Yen and Sheu (2004), allege culture to be a significant factor, and Amoako-Gyamph and Salam

(2004), approve that shared beliefs may make implementation of the system easier due to better acceptance of the system.

A construction project varies from one context to another depending on determinants including complexity, duration, budget, and quality. In ERP projects, the complexity depends on the project scope that includes the number of business functions affected and the extent to which ERP systems implementation changes business processes (Chung *et al*., 2009).

There are few studies conducted about the implementation of ERP in the construction industry. However most of the concerns have been made within both the owner engineering/project management organization and contractor/supplier organizations; and the impact that these systems will have on the facility engineering and construction delivery process (Connor and Dodd, 2000).

The material management process combines and integrates the individual functions of material requirements planning, material takeoff, vendor evaluation and selection, purchasing, expedition, shipping, material receiving, and inventory, material distribution, and even accounting functions (Bell and Stukhart, 1987). Those engaged in this complex process has to be coordinated and communicated effectively. This is what makes material management systems suitable to be benefited from information technology implementation (Ahmed *et al*., 2003)**.**

Many construction firms have got computer base material management systems (MMS), which stores, sort, combine and print data files pertaining to materials requisition, purchasing, vendor evaluation and warehouse inventories (Bell and Stukhart, 1987). Now the purpose is to integrate MMS with external computer systems to perform functions related to design, project scheduling and accounting, improving so cost and document processing cycle time by the used of information technology systems. Implemented information technology systems are DBMS (data base management system) and EDI (Electronic data interchange) (Elzarka and Bell, 1995). DBMS permits the user to organize, store and management all electronic data relating to a major activity or area of interest, while allowing users to enter and store data for once and utilized by multiple users

and application and EDI is a direct computer application exchange of business data in standard format, thus eliminating the need for the reentering the information.

In today's construction world, ERP systems play significant role at the operations of companies, because today's business economy has forced companies to become more efficient at their operations. International companies also have been encompassed by new actualities of different cultures and time zones. Implementation of ERP systems has made it possible for these companies to be able to control their operations across the entire world and provide their customers with their products and services at the best competitive rates. Along with the globalization, the market size enlarged and this rise in the size of construction market has resulted in significant growth in their revenues. Keeping market share and being able to stay with competition has forced the construction companies to use more advanced technological systems that increase their efficiency and competitiveness.

3.2. Implementation Process of ERP Systems

Implementation processes of ERP systems and the stages of that implementation processes are studied by a few number of researchers, such as; Power, Barry (2005); Botta-Genoulz *et al*. 2005. Also, (Somers and Nelson, 2003) have studies and new methodology to identify a critical step in implementation. That research uses a probabilistic method to find the activitie associated with processes of the ERP implementation which are significant.

Moreover, Botta-Genoulaz *et al*. (2005), has identified the important sides of the implementation process as user training, communications between parties and role of the steering committee.

Also, the research led by Mabert, Soni, and Venkataramanan (2003), deals with the identification of the most appropriate implementation processes for different companies. Their research is based on the case studies in US. At the end of the research, the researchers suggest that the implementation method of ERP system is dependent upon the size of the company.

The most significant factor identified by various corporations as a main reason to implement ERP has been integration. Most corporations see ERP as a tool that allows them to integrate functions of their front and back offices into a single platform (Negahban, 2008).

Oliver, *et al*. (2002) have made a study on the importance of integration for ERP adoption and indicated that "integration was the most important rationale in terms of the frequency of reference in each of the technology and organization dimensions and was the most important single rationale."

ERP systems in construction companies create a single database and common, unique platform that company employees can reach the central and reliable information and all the past data produced by different departments at past projects. Integration between the all the department of a construction company causes a friendly and efficient teamwork in an organization.

The goal of the ERP systems success model is to better evaluate, plan, and implement ERP projects and help senior managers make better decisions when considering ERP systems in their organization (Chung *et al*., 2009).

Recently, major construction companies embarked on the implementation of integrated IT solutions such as enterprise resource planning ERP systems to better integrate their various business functions, particularly those related to accounting procedures and practices. However, implementing these integrated systems in the construction industry presents a set of unique challenges, different from those in the manufacturing or other service sectors. In general, the best way to achieve the full benefits from ERP systems is to make minimal changes to the software. Each construction project is characterized by a unique set of site conditions, project team, and the temporary nature of relationships between project stakeholders. As a result, construction companies are required to have extensive customization of pre-integrated business applications from the vendors of ERP systems. Unfortunately, such extensive customizations result in a greater challenge in implementing ERP systems. Therefore, finding the best ERP systems implementation

strategy is needed to maximize the benefits of such integrated IT solutions for construction companies (Chung *et al*., 2009).

Access to reliable information of a company is dependent on a successful implementation of C-ERP system. Reaching reliable know-how of a company and improved information access by a proper implementation of CERP system provides construction organization with central control and better strategic decision making. Oliver, *et al*. (2002) indicates that organizations anticipate that the improved access to information will result in a better central control. Also, the same study shows that about 16% of all justificatory reports for ERP adoption were based on improved information access to ERP system.

In addition, ERP systems are utilized as an agent of "business process re-engineering." The organization is introduced to and forced to adhere to new procedures. This procedural approach cuts across functional departments and widens the functions that an employee can perform. Adherences to ERP systems also provide uniformity throughout the organization so that all inefficiencies associated with different interpretations are eliminated. (Negahban, 2008)

Many researchers have indicated that a company's business processes can be considered as critical phase and factor of a successful ERP implementation (Botta-Genoulaz, *et al*., 2005). Also, Daneva (2004), defines reuse measurements and mentioned that reusing business reengineering and data requirements is a major issue for successful implementation. The study explains the problem about process configuration in term of composition and reconciliation: a general set of business processes and data requirements is established, then standard ERP functionalities are explored to see how closely it match the organization's process and data needs (Daneva, 2004).

3.3 Project Management Success Factors at ERP Implementation

What is considered a large project varies from one context to another depending on determinants including complexity, duration, budget and quality of the project. In ERP projects, the complexity depends on the project scope, including the number of business

functions affected and the extent to which ERP implementation changes business processes. ERP projects achieving real transformation usually take from one to three years in duration. Resources required include hardware, software, and consulting, training and internal staff, with estimates of their cost ranging from $0.4 million to $300 million, with an average of about $15 million (Koch, 2002).

Therefore, by viewing ERP implementation as a large project in general, we can adhere to the fundamentals of project management for achieving the success of ERP implementation. There is vast project management literature in the field of organizational research. Several researchers have developed sets of fundamental project success factors which can significantly improve project implementation chances (Pinto and Slevin, 1987; Shenhar *et al*., 2002).

In addition, several researchers have identified the best practices and risks related to IS projects such as ERP implementation. Akkermans *et al*. (2002) provided success factors for ERP implementation based on a broad literature review followed by a rating of the factors by 52 senior managers from the U.S. firms that had completed ERP implementations. Ewusi-Mensan (1997) identified reasons why companies abandon IS projects based on surveys of canceled projects in Fortune 500 companies in the U.S. Keil (1998) proposed significant software project risks based on a Delphi study of experienced software-project managers in Hong Kong, Finland, and the U.S. (Akkermans and Helden, 2002; Ewusi-Mensah, 1997; Keil *et al*., 1998). Based on this literature, Ferratt *et al*. (2006) grouped the best practice questions together forming four success factors for ERP implementation as follows (Ferratt *et al*., 2006):

- top-management support, planning, training, and team contributions,
- software-selection efforts,
- information-systems area participation, and
- consulting capability and support.

Ferratt *et al*. (2006) validated these success factors through the empirical study of ERP projects. They also provided five outcome questions, which were shown to be significantly correlated and should therefore be combined to form a single outcome factor,

effectiveness. Their regression analysis identified that all the success factors can affect the outcome significantly, so now these factors can be considered the representative success factors in ERP implementation (Chung, 2007).

3.4. Benefits of ERP for Construction Companies

ERP systems at construction companies provide the organizations and their employees with many benefits by having an integrated and reliable information system. First of all, management team of construction companies can have more suitable and accurate control on the data they and other department processed.

Easy and effective information flow and connectivity between different modules of ERP systems in construction companies reduces the operation time and increases the efficiency. Reliable operation and management report about construction sites can be prepared easily.

Olliver and Romm (2002) explain main benefit of ERP system as that “in common with other types of investment activity the adoption of an ERP system is a purposive intervention by an organization for bringing about a new state of affairs that is judged to be superior to the current state”.

In today’s competitive business environment, organizations can easily understand their lack or deficient systems due to internal and external forces, and try to change their current business processes. Chen (2001) indicates the need and benefit of ERP system in main concept as that “planning for ERP adoption generally occurs when an organization realizes that current business processes and procedures are incompetent for their current and or future strategic needs”. Benefits of ERP systems for construction companies can be defined in this respect as the acts that rise of efficiency in operation and additional incomes generated from operational and management changes such as; business process reengineering.

In general context, researchers try to divide the benefits into some groups but first of all the benefits of C-ERP systems should be defined. Anderson (2001) has listed benefits

of ERP systems for Construction Organizations as a result of successful ERP implementation as follows;

- Improved responsibilities in relation to customers
- Stronger supply chain partnerships
- Enhanced organizational flexibility
- Improved decision-making capabilities
- A Reduction in project completion time and cost
- Opportunity for the enterprise to re-engineer and upgrade its business process

Anderson (2001) indicates that process-based benefits that come from IT investments can be categorize into three categories. These are typical efficiency benefits, typical effectiveness benefits, and typical performance benefits.

Also, the mentioned benefits above could be group into two categories as “tangible” and “intangible” benefits. A tangible benefit could be defined as that a company can get a direct profit from that benefit. The International Accounting Standard defines an intangible as an identifiable non-monetary asset without physical substance held for use in the production or supply of goods or services, for rental to others for administrative purposes (Bradbury, 2001). Yet, an intangible benefit could provide a company with profit indirectly.

In today’s business world, many investments are intangible, and these investments return higher profits then tangible investment due to better output and savings. Also, intangible benefits comes from any IT system cannot be easily assessed. Construction companies have different kind of project at different part of the world at different time and time zones. Therefore; construction sector has a dynamic environment factor. Nandish & Irani (1999) discussed the difficulty of evaluating IT projects in the dynamic environment, especially when intangibles are involved in the evaluation.

It is easy to estimate tangible costs and benefits, but intangible benefits are more difficult to estimate. Hares & Royle (1994) point out that there are four main intangible benefits in IT investment. The first benefit is internal improvement or infrastructure

investment; tangibly important to the business. The second benefit concerns the perception of the business by its customers. The customer-based intangible benefits, consist of those services that the customer sees now and wants in the future, and includes customer service and user satisfaction.

The final two categories are future-based and include market trends, and the ability to adopt and adjust to change. It can be understood that CERP investments could be thought as strategic investments because of that the main purposes of CERP system for construction companies are improvements in customer relationships, reduction of lead times, reduction in production cost and increase in company sales.

Furthermore, Murphy (2002) indicated that improved customer service and other related intangible benefits, such as updated and streamlined technical infrastructure, are important intangible benefits that organizations are often seeking when making these investments.

There are some difficulties when we think about the topic of ERP implementation and its benefits. These are "identification of the benefits of ERP implementation" and "Quantification of ERP benefits".

The process of identifying benefits that are applicable is rather complicated and since there are no guidelines or standard procedures that all organizations can follow, this leads into inconsistencies (Anderson, 2001).

Ohlsson, *et al*. 2001, states that due to the ERP system's multidimensional nature, intangible benefits will affect many aspects of the investing company. He further states that although it is hard to assign any financial values to these intangible benefits, at least without stretching assumptions beyond an acceptable level, it is still important to quantify them.

The most common metrics used for these benefits are binary, numeric, or qualitative in nature, and by using these, it is possible to identify and evaluate how they will impact on the company.

3.5. Implementation Obstacles, Problems and Possible Risks & Failures of ERP for Construction Companies

Even if it is known that there are many successful ERP implementation stories at different kind of organizations, however some papers mentioned about ineffective and disastrous ERP implementation stories.

As Chen (2001) reports, “while companies such as Cisco Systems, Eastman Kodak, and Tektronix have reaped the expected benefits of ERP systems, many businesses are discovering that their ERP implementation is a nightmare”.

For example, Chen (2001) mentions some of these failure stories that one of the examples of this sort of disaster was case of FoxMeyer Drug, a large pharmaceutical company that had to file for bankruptcy as a result of problems caused by a failed ERP system.

In addition, Chen (2001) mentioned about Dell Computer Company that it spent large sum of money on ERP system that had to be scraped. Some other failures of note are cases at Boeing, Dow Chemical, Mobil Europe, Applied Materials, Hershey, and Kellogg’s. It is reported that 40% of all ERP installations only achieve partial implementations and 20 % of attempted ERP adoptions are scrapped as total failure.

In view of these failure stories, one must examine the reasons why these companies have such failure stories at the implementation of ERP system. In this thesis, one of the subjects that it is focused on is the reasons of failure of ERP implementations at construction companies.

The reasons why ERP implementations have experienced failures and disappointments that (Negahban, 2008) has indicated in his study can be listed under six criteria. (Negahban, 2008), has argued that in most organizations, failure at ERP implementation occurs when one or more of failure criteria are not properly addressed. These criteria can be identified as:

- Evaluation
- Cost – Benefit Analysis
- High Cost & Complexity
- Training
- Time Scale
- Current Practices

Evaluation; word is defined by Ohlsson *et al*. (2001) as a weighing process to assess the value of an object or the merit of a situation.

It is very important to have a clear understanding of ERP in order to have a successful implementation or elimination of a new ERP system. We evaluate things when we are trying to accomplish a better understanding of them, therefore suitable evaluation of ERP and well understandings of critical criteria of ERP evaluation are essential in order to the eventual successful implementation.

The strategic impact of an ERP implementation must be considered in an evaluation process. ERP implementation goals must match and fit within the overall strategic goals of the organization. Doing so will force the organization as a whole to come into focus with its ultimate goal. These goals must be set with both short and long term views in mind (Nagehban, 2008).

Ballentine *et al*. (1998) discuss that IT investments like ERP systems should be associated to a company's IT strategy and that there is also a need to align IT strategy with business strategy. Kefi (2002), give emphasis to the significance of knowing the strategic context before implementing a system or beginning an IT project so as to achieve the right business focus. Also, Gemmeland Pagano (2003), mentioned that it is critical to make sure that the IT system also supports the business strategy of the organization during "the post-implementation evaluation."

If a construction company is determining on which ERP system and tools should be used, they must consider the requirements needed from the system. A design for ERP system must be created by considering following factors; interactivity between

departments, usability and easy to use factor, synergism, reliability and sustainability of the system, flexibility of the modules, speed of the system, and accuracy. Frisk (2004), indicates that there are some authors that find it important to consider system-specific characteristics in the evaluation of general or specific type of systems. Martin, Bolissian, Pimendis (2003), considers the system features as one part of the evaluation content, but others view them as the most important part to evaluate (Skok *et al*., 2001; Lee, 2001).

Another methodology to "the process of evaluation" is life cycle method and this method should be considered in the evaluation of implementation. Life cycle approach permits a construction company to complete its evaluation in whole steps of ERP system. Frisk and Planten (2004) have mentioned these steps as the following: feasibility, development, implementation, post implementation, and routine operations.

Another vital factor that needs to be prudently evaluated and examined at the implementation of ERP systems is the economic one. Most construction companies consider financial subjects as crucial even if the system they invest money rise their efficiency and productivity. When considering economic criteria, it should be concerned with quantitative values and it should be measured; however, economic feedback of implementation of ERP system cannot be satisfactorily evaluated quantitatively. Economic return of ERP investment cannot be encouraging in short-term view because the system will not truly reflect the potential benefits. Experience shows that the ERP implementation process will take anywhere between 2 to 5 years to complete (Gunson and Blasis, 2001). Therefore, the economic return of ERP due to its efficiency increasing and other positive factors should be considered at more than 5 year time interval.

Only relying on subjective measurements will not produce reliable results. In addition, organizations need to approach the investment in an ERP as capital asset expenditure, an asset that needs time to mature and pay dividends. Considering only a short-term view in evaluation of ERP will not truly reflect the potential benefits and costs that must be considered. Experience shows that at times, the ERP implementation process will take anywhere between 2 to 5 years to complete (Gunson and Blasis, 2001).

Cost Benefit Analysis: Negahban (2008) indicates "cost benefit analysis" as the most often method used by various organizations to evaluate and justify their investment in ERP. This method of analysis bears such an important imprint on the evaluation process that it needs to be looked into with greater detail. Cost benefit analysis is defined by Prest and Turvey (1965), as "… a set of questions, the answers to which constitute the general principles of cost benefit analysis:

- Which costs and which benefits are to be included?
- How are they to be valued?
- At what rate are they to be discounted?
- What are the relevant constraints?"

Parker (1982), has define "cost or benefit analysis" as measurement of the amount of resources required to produce a product. Costs are normally expressed in terms of quantitative dollars required, whereas benefits could take the qualitative form of cost-saving, cost-avoidance.

In today's world, numbers and quantitative representation dictate results; executives, the board members and managers of organizations in construction sectors can rely upon cost benefit analysis to finalize their decision when it comes to investment in an ERP.

Among all available factors affecting evaluation, it seems that this cost and benefit analysis has demonstrated both quantitative and qualitative terms. Cost of the ERP system can be examined in quantitative way, but benefits of it generally explained as qualitative ways because benefits are intangible.

High Cost & Complexity is one of the important criteria to analyze the cost of the implementation of an ERP system because the high cost of implementing an ERP system can be thought as a failure criterion.

Chen (2001), indicates that the total cost of ERP implementation as well as software, hardware, consultant, and internal and external personnel can easily run as high as 2% - 3% of a company's incomes. Total cost of ERP implementation can change between $2

million to $4 million for a small firm, to over $1 billion for a large company in order to implement one of the well-known ERP systems. Cotteller, Austin, and Nolan (1998), indicated a breakdown of a total implementation expenses for a ERP system as following; software, 16%; hardware, 32%; system integration, 38%; and headcount, 14%. Consultant cost is not included at the study above but Adam and O'Doherty (2000), has suggested that the ratio of the software cost to consultant cost is 1 to 7, indicating the significant impact of cost associated with hiring a consultant.

Training: Successful ERP implementation should be followed by extensive training of the personnel of the organizations. Also, ERP systems continuously are updated and so, additional training should be given to the stuff of organizations.

Therefore, all additional training due to update of the system including general training of the organizations make companies to allocate much more money for better ERP implementation. Because of that, a successful implementation and better training of it can require continuous funding and some companies try to educate some key personnel on their own ERP system and let them to train other personnel.

Time Scale: Total duration to full implementation of an ERP system is quite long for construction industry. In construction sector, results need to be accomplished in a very little of time due to its project base nature. However, ERP is an investment that create its benefits and values to the construction company which implemented a ERP system, long after the completion of the implementation of it. Frisk (2004), states an approving study that according to an article in Business Week (Coy & Mullaney, 2003) American companies today have improved their results thanks to investments in IT made 7 to 8 years ago. Also, as indicated by West and Daigle (2004), "achieving many of ERP's benefit takes time".

Also, Frisk (2004), indicates that the time element associated with the realization of benefits of ERP implementation is one of the four major problems in IT benefit management. Firsk (2004), also indicates that "benefits evolve over time, which implies that they are not stable. This makes it extremely difficult to create a comprehensive catalogue of potential benefits" (Negahban, 2008).

Construction companies must understand that ERP system implementation is a long term investment for organizations. Parker (1982), indicates that ERP investment unlike most other capital expenditures does not depreciate and, in fact, should appreciate as the number of applications is increased. Also, Parker (1982), indicates that ERP investments most probably cannot be sold as can other assets because of its unique implementation but it can be copied easily and provide to another function in the enterprise, with no development cost incurred by recipient.

Current Practices; consists of existing computer systems the companies have over a period of time. These systems in currently used have software packages that have been bought and operated by the organization to be responsible for a solution at a particular department or a particular operation. Obviously, any change at current system will need re-engineering and re-training of the company and its employees. As indicated by Tsung, (2004), implementation of ERP systems requires a great deal of management change; it affects the whole organization and it is a people centered application like organizational change management. Organizational Change Management (OCM) is defined as the process of controlling changes to the infrastructure or any aspect of services in a controlled manner (Robins, 2001).

Several studies have mentioned that many IT investments become unsuccessful to ensure the productivity and efficiency benefits that are expected (Wilcocks *et al*., 2000), often due to the fact that IT systems are used simply to computerize existing procedures and practices, rather than radically rethink them.

Tsung (2004) indicates that Business Process Re-engineering (BPR) would fall under this category and can be described as a radical re-design of business processes in order to eradicate repetitive and/or paper-intensive tasks to decrease costs, increase quality and services, and maximize utilization of the information technology in place.

Implementation of an ERP system creates many issues that directly or indirectly deal with people and their interaction with the system. ERP impacts people within the organization as the nature of their work changes. Role responsibilities and processes change (Pereira, 2004).

Also, attitudes of users to the new ERP system and their motivation to use it are important. Adam, *et al*., (2000) indicates that as time passes, the staff's attitude rises and falls through four distinct segments. These segments deal with level of enthusiasm of the end users toward ERP utilization and range from lack of motivation to business as usual on one side and growing enthusiasm to total commitment on the other side. It has been documented that initially a staff is very enthusiastic about the new system ; however, as it becomes clear that they would need to learn new ways and cannot rely on the current legacy systems to meet the day to day needs of their job, their hesitancy increases. How organizations react and deal with this phenomenon will have significant impact on the success or failure of ERP implantation.

Currently, SAP, Oracle, and other companies such as Deltek, CMiC, and Timberline provide specific solutions for the construction industry. They claim that their solutions can support all the functions a construction company needs. However, most engineering and construction firms in the U.S. have implemented their ERP systems adopting a bestof-breed approach in which separate software packages are selected for each process or function rather than using the full packages of major ERP vendors. They pick several modules, such as Financial Accounting and HR, from major ERP vendors and piece them together with their own in-house developed software or other third party products using custom-built interfaces. The main reason for using this approach is that construction processes are unique for each project: each project has a different owner, is managed by a different project team, requires different specifications, etc (Chung, 2007).

There is one case study in which initial ERP implementation was a failure. This company is one of the biggest home builders in the U.S. and has grown through mergers and acquisitions, so the company needed standard business processes and an ERP system that could integrate their old business units with the newly acquired divisions. SAP provided consulting and their software packages to implement the company's ERP system at the cost of $65 million. However, this project was eventually abandoned because of the rigid standardized processes insisted upon by SAP. Most ERP benefits are obtained by standardized processes, but the company needed mass customization because their buyers usually want to change an average of 30-40 options in home design. As a result, if a community had a large amount of customization, the data overflowed. The other reason

that the project was abandoned is that the education level of users in the construction industry is relatively low, so easy interfaces are mandatory. However, SAP software is such a mature technology that users need extensive training. Due to its lack of flexibility and not being easy to use, the company users were reluctant to adopt it, which eventually resulted in failure and $65 million wasted. From this case study, we can learn that strategies from other industries, e.g., manufacturing, may not be suitable for the construction industry. The success or failure factors and their significance for ERP implementation in the construction industry may be different from those in the manufacturing industry, and the approach to successful ERP implementation should therefore also differ (Chung, 2007).

4. RESEARCH METHODOLOGY

The nature of research questions dictates the type of data that needs to be collected. Data types are separated into two groups; as quantitative and as qualitative. Qualitative & quantitative methods are two standard ways to carry out scientific researches. Generally, qualitative research has been utilized in the human and social science disciplines (Denzin and Lincoln, 1998). Denzin and Lincoln (1998), indicates that qualitative research is a multi-method in focus, containing an interpretive, naturalistic approach to its subject matter. It attempts to study things in their natural settings and interpret the meanings humans bring to them. Qualitative studies also ensure researchers with a rich description and help them gain a complete understanding of the socially structured nature of reality by building a near connection between researchers and what they studied, getting the individual's point of view, and examining the constraints of everyday life (Denzin and Lincoln, 1998).

In this thesis, there are three case studies as qualitative method of the research. All of case studies, questions, answers and what lessons learnt from them are explained at case study chapter of the thesis.

Also, "quantitative research" gives emphasis to the measurement and analysis of fundamental relationships between variables, not process (Denzin and Lincoln, 1998). It is generally used in positivist studies to test hypotheses objectively or to test models that are built based on theories (Kaplan and Duchon 2000). It is a robust and systematic way to examine and measure developed research models significantly (Denzin and Lincoln, 1998). The most common examples of quantitative methods include survey, laboratory and field experiments and mathematics modeling (Shadish *et al*. , 2002).

In this thesis, there is a questionnaire survey analysis filled by 90 different professionals as quantitative method of the research. All of the survey analysis and its results are explained at questionnaire survey chapter of the thesis.

In order to collect primary data, several collection methods were investigated and it is decided that an internet-based questionnaire would generate better results because of the nature of this research. Surveys/questionnaires are frequently used for exploration projects that are based on descriptive and explorative research approach.

4.1. Questionnaire Survey

In this thesis, an internet-based online questionnaire survey is prepared, which respondents can fill in online. The list of targeted respondents was created utilizing several sources, but the main resource is Turkish Contractors Association (TCA). Internet-based questionnaire were sent to the 152 members of the TCA. Also, the questionnaire survey was sent to some construction related organizations like project management companies and other middle/large scale contractors but not member of TCA contractors.

Before the questionnaire was sent to respondents' email address, it was reviewed by one academician and one executive related with ERP systems in construction sector. Several detailed consultations were held to ensure that that the questionnaire was inclusive and comprehensible.

The questionnaires were administered during December 2012 and 90 responses were obtained. The total number of respondents that the online questionnaire survey was sent is 250. The number of questionnaires that were returned is 90. This gives a rate of response to the questionnaire as 36%. There were significant number of participants that were not used ERP system before. Only 52.22% of respondents were used ERP system before.

4.1.1 Administration and Content of the Questionnaires

In beginning of the survey, all respondents have replied general questions about them and their company as below;

- Age
- Company Age
- Business Type of Their Company
- Their Experience in The Construction Sector as Age

- Turnover of Their Company (Total)
- The Number of Total Employee of Their Company
- Company Position
- Department
- ERP Usage (Yes or No)
- Which ERP System do They Use or Implemented Before
- ERP System Implementation Phase at Their Company

The above question is about general information on the respondents and their company. If the respondents reply the question on ERP Usage as "Yes", then second page comes and the respondents reply the question on "which ERP system do they use or implemented before" and "ERP system implementation phase at their company."

Afterwards, critical success factors questions in the survey come at the third page. There are 14 critical success factors mentioned in the survey and all respondents are answered according to the importance of the factors from 1 to 5 scales.

- 1: very low
- 2: low
- 3: moderate
- 4: high
- 5: very high

4.1.2 Problems Encountered During Questionnaire

Only problem that was recognized by respondents that it took time to complete the questionnaire. Even though the entire survey takes only 5 to 10 minutes, it was considered as "long time".

4.2. Analysis of the Questionnaire Survey

In the questionnaire part of the investigation, there are 90 input sets from 90 respondents. As mentioned before, in beginning of the survey, all respondents have replied general questions about them and their company. Later, critical success factors questions in the survey are answered according to 1 to 5 scale from “very low” to “very high”.

It can be seen below the general descriptive statistics table of the whole questions mentioned in the survey.

Table 4.1. Descriptive Statistics.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
age	90	23	56	31.967	7.224	52.190
business_type	90	1	4	1.844	.718	.515
comp_age	90	1	60	19.011	13.156	173.090
constr_experience_year	90	1	32	7.844	6.704	44.942
turnover	90	0	6	3.078	2.549	6.500
total_employee	90	1	6	4.500	1.567	2.455
comp_position	90	2	11	7.933	1.578	2.490
department	90	1	12	4.156	2.049	4.200
erp_usage_yes_no	90	0	1	.522	.502	.252
which_erp_sys	47	1	9	5.064	2.974	8.844
erp_implmnt_phase	47	1	5	3.872	1.345	1.809
top_mng_spprt	90	2	5	4.422	.887	.786
Prjct_team_competence	90	1	5	4.144	1.066	1.136
Clear_goals_objctv	90	1	5	4.311	.856	.734
Team_composition	90	1	5	3.889	.929	.864
Effectvnss_Prjct_Leader	90	1	5	4.056	.916	.840
Cooperation_Btwn_Team_Mmbrs	90	2	5	4.056	.839	.705
Vendor_Spprt	90	1	5	3.700	.999	.999
Choice_ERP_Softw_Packg	90	1	5	3.644	1.095	1.198
Training_spprt_for_users	90	1	5	3.856	1.034	1.069
Choice_ERP_Modules	90	1	5	3.744	.931	.867
Organizational_Chng_Mngmnt	90	1	5	3.700	.905	.819
Use_consultants	90	1	5	3.367	.953	.909
End_user_Involvemnt	90	1	5	3.733	.992	.984
Testing_System_StartUp	90	1	5	3.689	1.046	1.093
Valid N (listwise)	47					

Table 4.2. List of Variables (Factors).

No	VARIABLE	FACTORS
1	*Top_mng_spprt*	Top management support and Commitment
2	*Prjct_team_competence*	Project Team Competence
3	*Clear_goals_objctv*	Clear goals and objectives
4	*Team_composition*	Team Composition
5	*Effectvnss_Prjct_Leader*	Effectiveness of Project Leader
6	*Cooperation_Btwn_Team_Mmbrs*	Cooperation Between Team Members
7	*Vendor_Spprt*	Vendor Support
8	*Choice_ERP_Softw_Packg*	Choice of ERP Software Package
9	*Training_spprt_for_users*	Training and support for users
10	*Choice_ERP_Modules*	Choice of ERP Modules
11	*Organizational_Chng_Mngmnt*	Organizational Change Management
12	*Use_consultants*	Use of consultants
13	*End_user_Involvemnt*	End User Involvement
14	*Testing_System_StartUp*	Start-Up and Testing the System

In the table; *age* means the ages of the respondents. *Business_type* number explains the business types and they are given as below;

- 1: Counselor (Advisor) & Consulting / Project & Construction Management
- 2: Contractor (Construction)
- 3: Project Design (Architectural / Structural / MEP) Firms
- 4: Others

Also, *"comp_age"* means company age of the respondent. *constr_experience_year* means the experience of the respondents as total years in construction sector.

Turnover number means the total turnover of the company that the respondents currently working for. Turnover numbers means as below;

- 0: I do not know
- 1: 2 Million USD or less
- 2: 2 Million USD - 5 Million USD
- 3: 5 Million USD - 10 Million USD
- 4: 10 Million USD - 20 Million USD
- 5: 20 Million USD - 50 Million USD
- 6: 50 Million USD or more

Total_employee means the number of total employee of respondent's company. Total employee numbers means as below;

- 1: 0 - 20
- 2: 21 - 50
- 3: 51 - 100
- 4: 101 - 200
- 5: 201 - 500
- 6: 501 or more

Comp_position means position of the respondent at his/her company. Total employee numbers means as below;

- 1: Chairman of the Board of Directors
- 2: Member of the Board of Director
- 3: General Manager
- 4: Vice General Manager
- 5: Project Coordinator
- 6: Project Manager
- 7: Manager Level (Planning / Cost Control / Design / Sale etc.)
- 8: Chief Level (Construction Site / Planning / Mekanical / Elektrical / Design etc.)
- 9: Engineer & Architect

- 10: Technician
- 11: Others

Department means the department of the respondents at his/her company. Department numbers means as below;

- 1: Accounting Department
- 2: Finance Department
- 3: Technical Office / Planning / Cost Control & Tender / Progress Payment Department
- 4: Administrative Affairs / Operation Department
- 5: Architectural / Structural / Mechanical / Electrical Design Department
- 6: Construction (Site)
- 7: Sale Department
- 8: Human Resources (HR) Departmant
- 9: Business Development Department
- 10: Marketing Department
- 11: Purchasing / Procurement Department
- 12: Others

Erp_usage_yes_no means whether the respondent has used or implemented any ERP system or not. ERP usage numbers means as below;

- 0: No
- 1: Yes

Which_erp_sys means that which ERP system the respondents or his/her company are currently using. Which ERP system are currently being used numbers means as below;

- 1: SAP
- 2: Oracle
- 3: MS Dynamics (Navision)

- 4: Yapitasi
- 5: Sage
- 6: NetSuit
- 7: OpenERP
- 8: My Company has developed/is developing its own ERP system!
- 9: Others

Erp_implmnt_phase means current ERP system implementation phases at the companies of the respondents. ERP system implementation phases numbers means as below;

- 1: It is not planned to use any ERP system
- 2: At the primary stage of ERP system implementation
- 3: At the final stage (close to completion) of ERP system implementation
- 4: The implementation of ERP system has been completed about 1 year ago
- 5: ERP system has being used more than 1 year

According to descriptive table given above, the average age of the respondents is about 32. Also, age variable is transformed to a new variable by making some arrangement at the range of the ages of the respondents. The code of *AgeGroup* variables is given as below;

- 1: 30 or less
- 2: 31 - 40
- 3: 41 - 50
- 4: 51 or more

Table 4.3. AgeGroup.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30 or less	53	58.9	58.9	58.9
	31 - 40	27	30.0	30.0	88.9
	41 - 50	5	5.6	5.6	94.4
	51 or more	5	5.6	5.6	100.0
	Total	90	100.0	100.0	

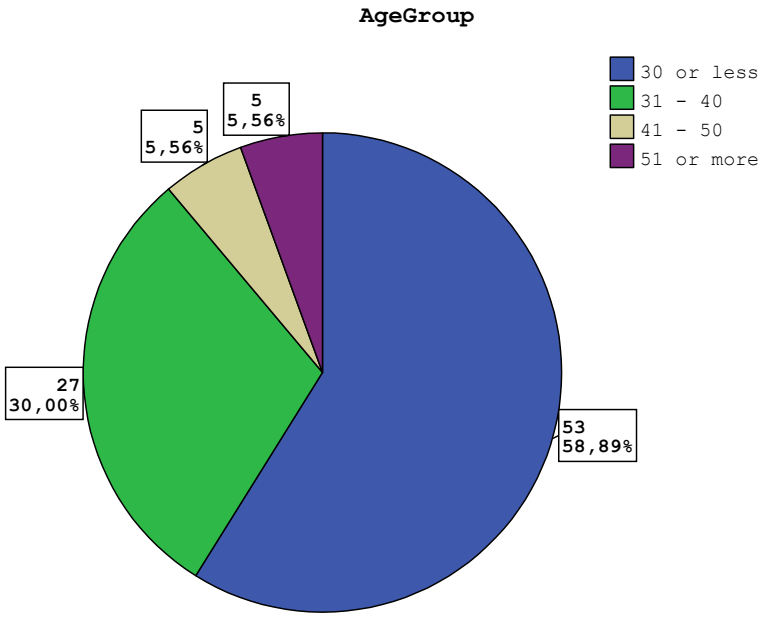

Figure 4.1. Age Group Pie Chart.

Mean of the company age is about 19 and average experience in construction sector of the respondents is about 8 years.

Table 4.4. Descriptive Statistics of Age, Company Age, Constr. Experience.

	N	Range	Min	Max	Mean	Std. Dev.	Variance
age	90	33	23	56	31.97	7.224	52.190
comp_age	90	59	1	60	19.01	13.156	173.090
constr_experience	90	31	1	32	7.84	6.704	44.942
Valid N (listwise)	90						

The mean of total turnover of the companies is close to number 3 (3.08) but this does not mean that most of the companies' turnover is about the range of 5 to 10 Million USD. It is only 6.67% of the companies have this turnover. There are also 24.44% of the companies that the respondents don't know total turnover of their own companies. However, the pie chart below; Figure 4.2 can give as a general idea about the company turnover profile.

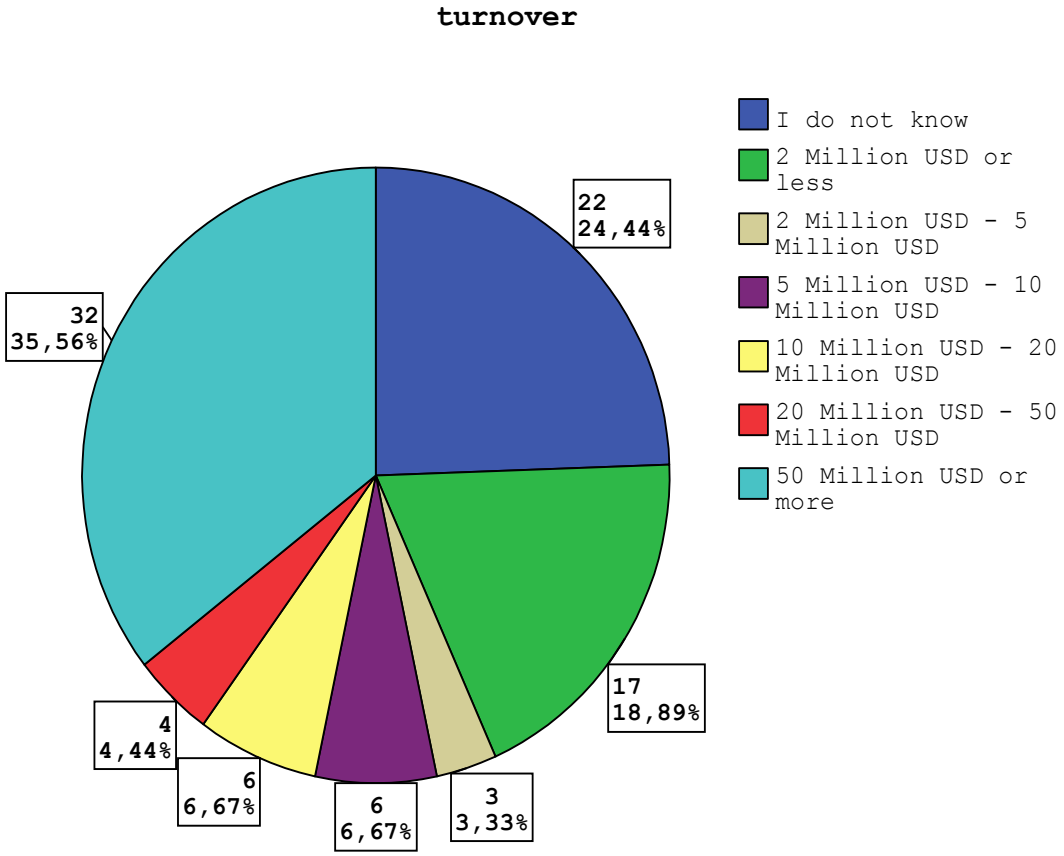

Figure 4.2. Turnover Pie Chart.

The mean of the total employee at the companies that respondents are working for is 4.5 and it can be seen at the Figure 4.3. This is the middle of number 4 and number 5. The number 4 refers to 101 – 200 and the number 5 refers to 201 – 500. It cannot be said exactly but may be indicated that number 4.5 refers the number of the employees about between 250 and 300.

It can be seen the position chart of the respondents at their companies as shown at Figure 4.4. 38 of the total respondents are engineers or architecture and this is the dominant group at the survey numerically. Secondly, the number of the respondents at chief level is 22. Thirdly, the number of the respondents at manager level is 18. These are three position groups of the employees that consist of 86.66% of all respondents' position level.

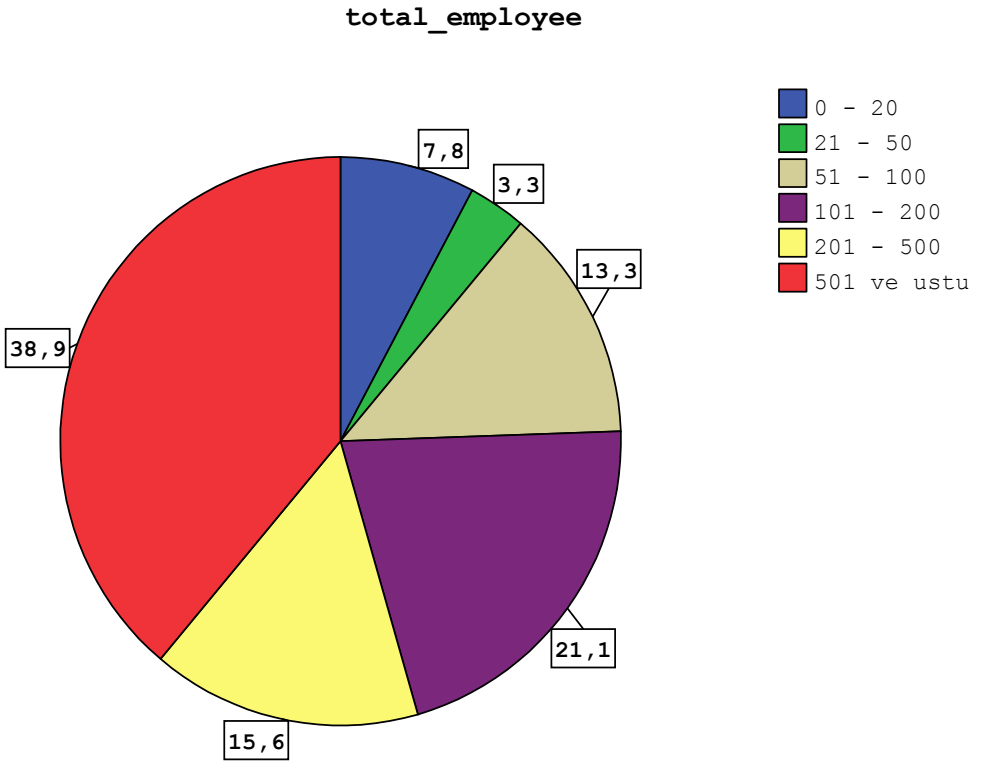

Figure 4.3. Total Employee Pie Chart.

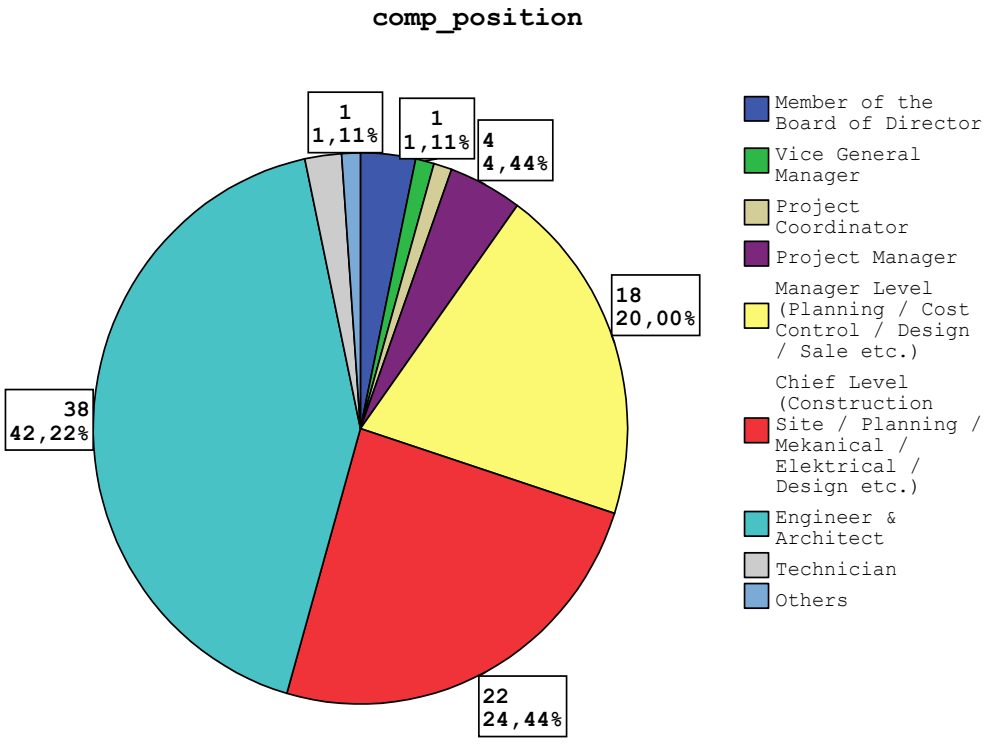

Figure 4.4. Position Pie Chart.

It can be seen the department chart of the respondents at Figure 4.5. It explains that at what department of the companies of the respondents they are working for. 55 of the total respondents are from Technical, Planning, Cost Control & Tender, Progress Payment Office Departments and 13 of them are from construction site. Also, 10 of the respondents are from Architectural / Structural / Mechanical / Electrical Design Departments. These are the dominant departments of the respondents.

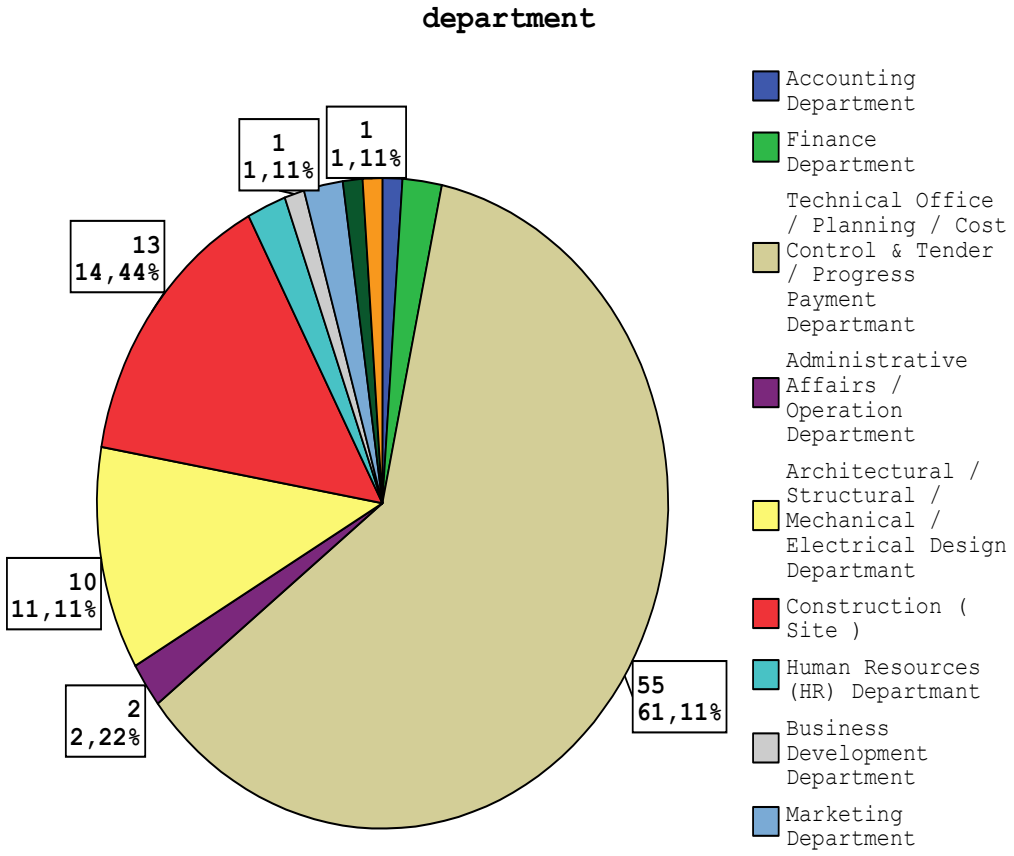

Figure 4.5. Department Pie Chart.

It can be seen the ERP usage chart of the respondents at Figure 4.6. It is asked to respondents that whether their companies have been using any ERP system or not. Afterwards, if they are using or ERP system is under implementation phase, it is asked what phase the ERP system is.

When it is asked to the respondents that whether their companies are using any ERP system or not, 52.22% of them answered this question as Yes.

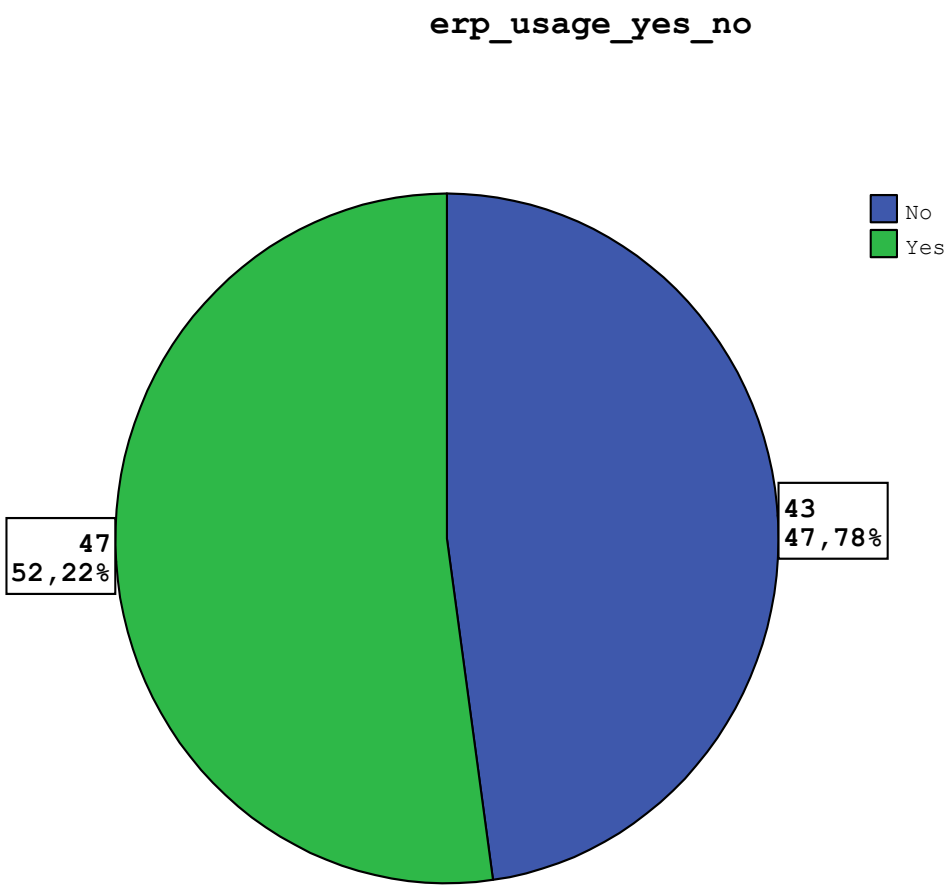

Figure 4.6. ERP Usage Pie Chart.

When it is examined that which ERP system the companies of the respondents whose companies are using any ERP system are using, it can be seen from the pie chart Figure 4.7 below that 25 percent of the respondents are replied as “My company has developed or developing its own ERP system”.

Secondly, it can be seen at Figure 4.7 below that 19.15% of them have answered as “Yapıtaşı”. Also, 12.77% of the respondents have been using SAP, Oracle and MS Dynamics (Navision) system each.

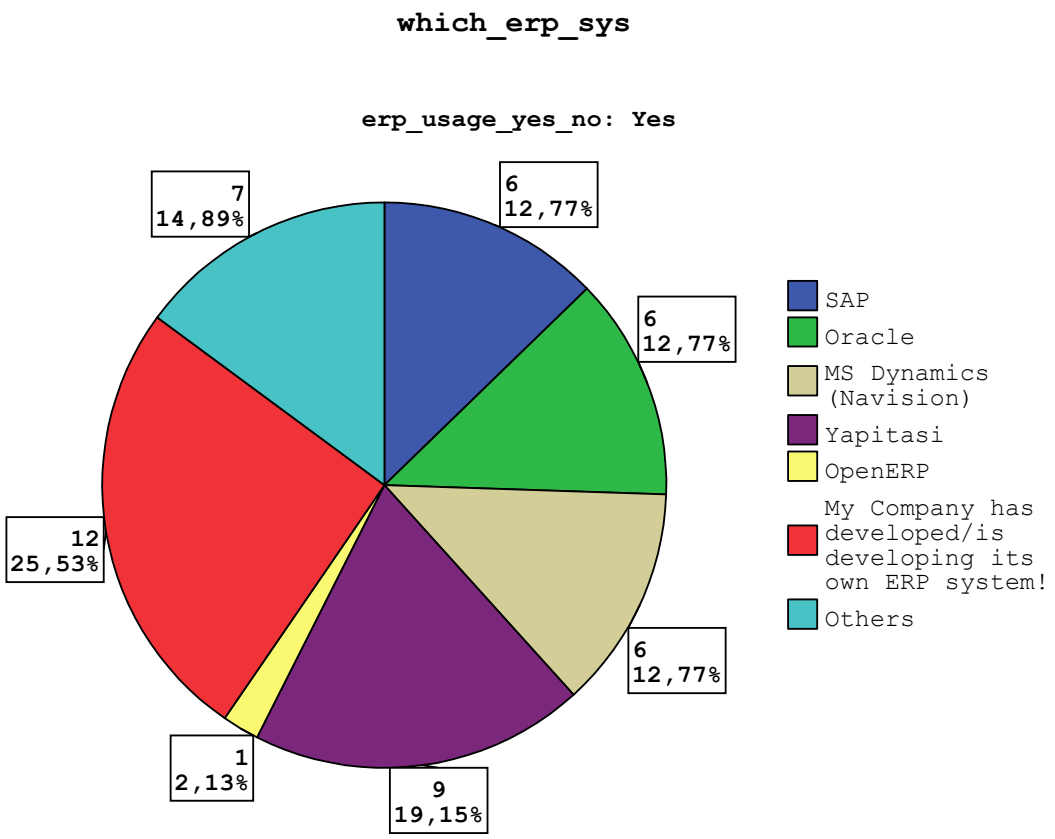

Figure 4.7. Which ERP System Pie Chart.

When it is examined that at what implementation phases the companies of the respondents whose companies are using any ERP system has currently been, it can be seen from the pie chart Figure 4.8 below that about 51% of the respondents have answered as that their ERP system in their companies has being used for more than 1 year. About 19% of the respondents have answered as that the implementation of their ERP system is at primary stage.

About 13% of the respondents have answered as that the implementation of their ERP system has been completed one year ago. About 13% of the respondents have answered as that the implementation of their ERP system is at final stage.

A weird result has come from the survey that 4% of the respondents have answered as that it is not planned to use any ERP system but they have an ERP system in their company because only the cases that the respondents have answered the question of

whether they are using an ERP system or not, are selected. Thus, it can be mentioned that this 4% part of the related answers may refer to *implementation failure* of an ERP system.

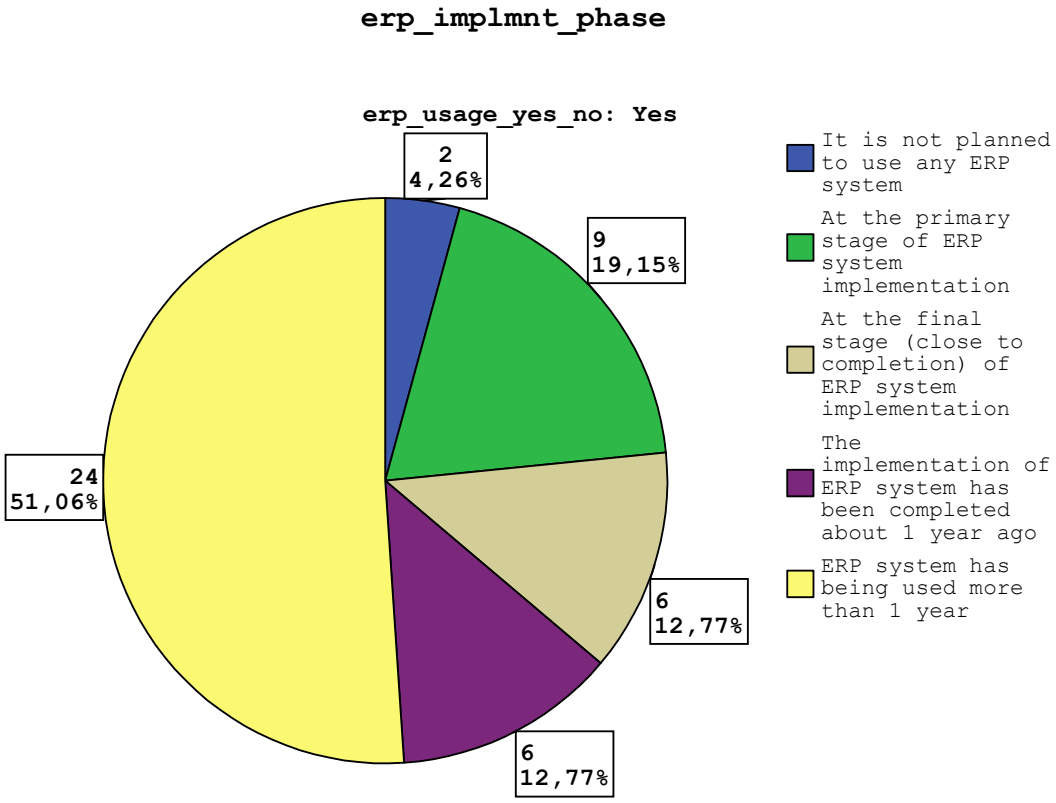

Figure 4.8. What Implementation Phase Pie Chart.

When ERP usage is examined based on how it is distributed by business type of the respondents, Figure 4.9 is obtained. When "Counselor (Advisor) & Consulting / Project & Construction Management companies" is examined, it can be seen that 51.9% of them has been using any ERP system.

When "Contractor (Construction) companies" is examined, it can be seen that 55.6% of them has been using any ERP system. The respondents that are working for Project Design companies have not been using any ERP system.

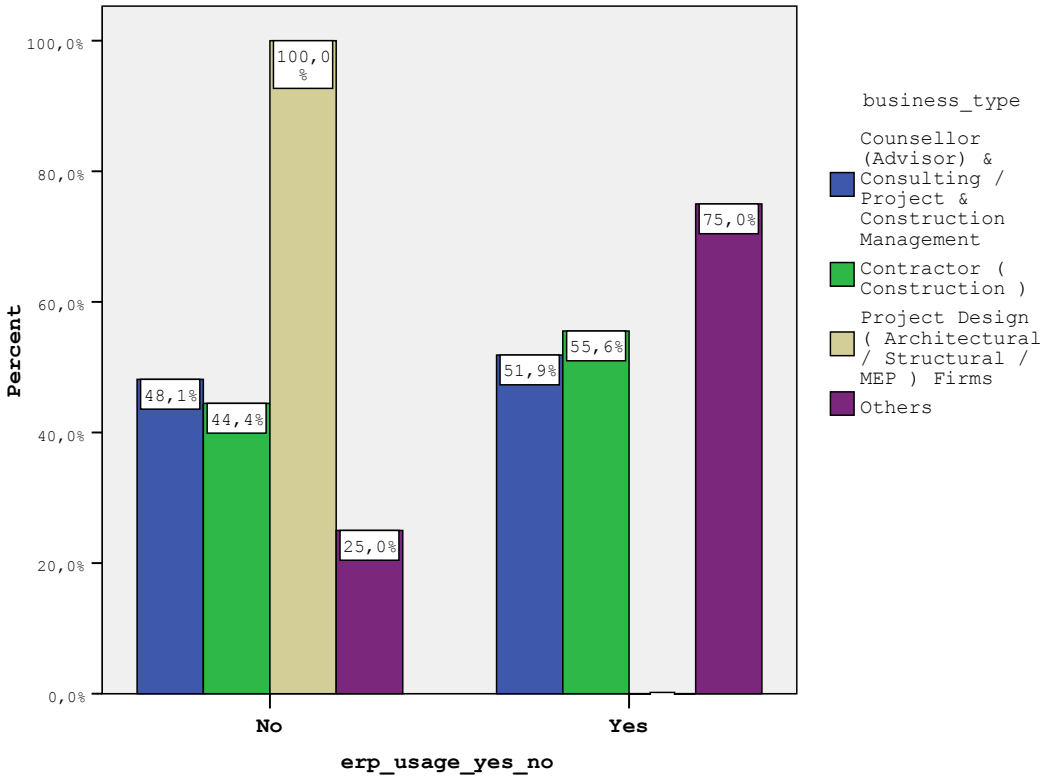

Figure 4.9. ERP Usage with respect to Business Type Bar Chart.

If what percentage of ERP usage is distributed by department of the respondents is examined that, it can be seen at the bar chart Figure 4.10 below. When "Accounting Department" is examined, it can be seen that all of the respondents who are working at Accounting Department has been using any ERP system.

When "Finance department" is examined, it can be seen that only 50% of the respondents who are working at Finance Department has been using any ERP system. When "Technical Office department" is examined, it can be seen that only 56.4% of the respondents who are working at Technical Office department has been using any ERP system.

Also, when "Administration Affairs & Operation department" is examined, it can be seen that only 50% of the respondents who are working at Administration Affairs & Operation department has been using any ERP system.

Moreover, when Design department is examined, it can be seen that only 20% of the respondents who are working at Design department has been using any ERP system. Additionally, when Construction Site is examined, it can be seen that only 53.8% of the respondents who are working at Construction Site has been using any ERP system.

When Human Resources department is examined, it can be seen that all of the respondents who are working at Human Resources Department has been using any ERP system. When Business Development and Marketing departments are examined, it can be seen that none of the respondents who are working at Business Development and Marketing Departments have been using any ERP system.

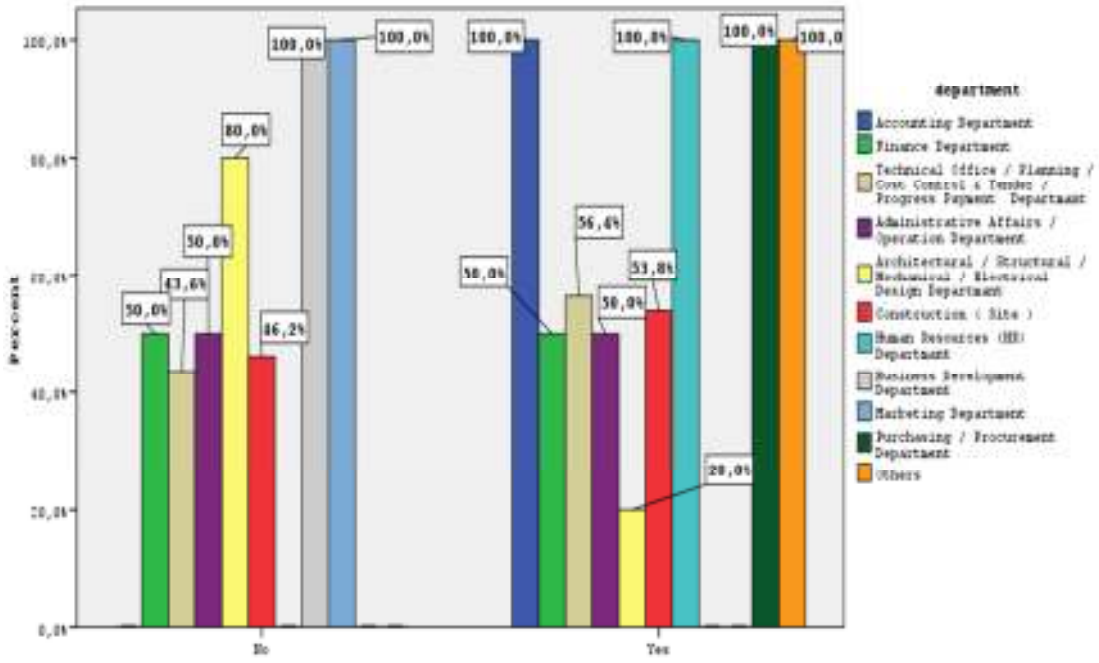

Figure 4.10. ERP Usage with respect to Department - Bar Chart.

Moreover, if what age groups the respondents who are not using any ERP system are belong to is examined, the following pie chart Figure 4.11 can be created. According to the pie chart Figure 4.11 below, about 70% of the respondents who are not using any ERP system before is in “30 or less” age group and about 19% of the respondents who are not using any ERP system before is in “between 31 and 40” age group.

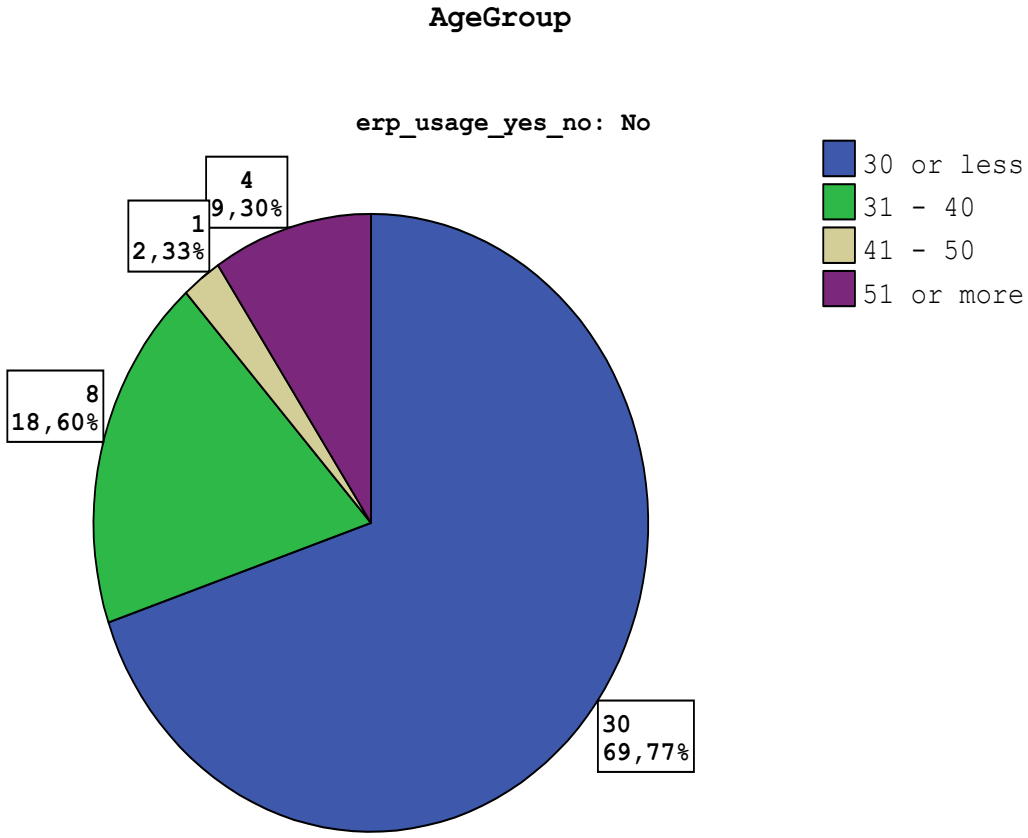

Figure 4.11. ERP Usage No vs. Age Group - Pie Chart.

Additionally, if what age group that the respondents who are using any ERP system is belong to is examined, the following pie chart Figure 4.12 can be created. According to the pie chart below, about 49% of the respondents who are using any ERP system before is in “30 or less” age group, about 40% of the respondents who are using any ERP system before is in “between 31 and 40” age group and about 9% of the respondents who are using any ERP system before is in “between 41 and 50” age group.

Moreover, if what company age group that the respondents who are *not* using any ERP system is belong to is examined, the following pie chart Figure 4.13 can be created as below. According to the pie chart below, about 35% of the companies that are not using any ERP system before is in “10 or less” company age group, about 35% of the companies that are not using any ERP system before is in “between 11 and 20” company age group and about 19% of the companies that are using any ERP system before is in “between 21 and 30” company age group.

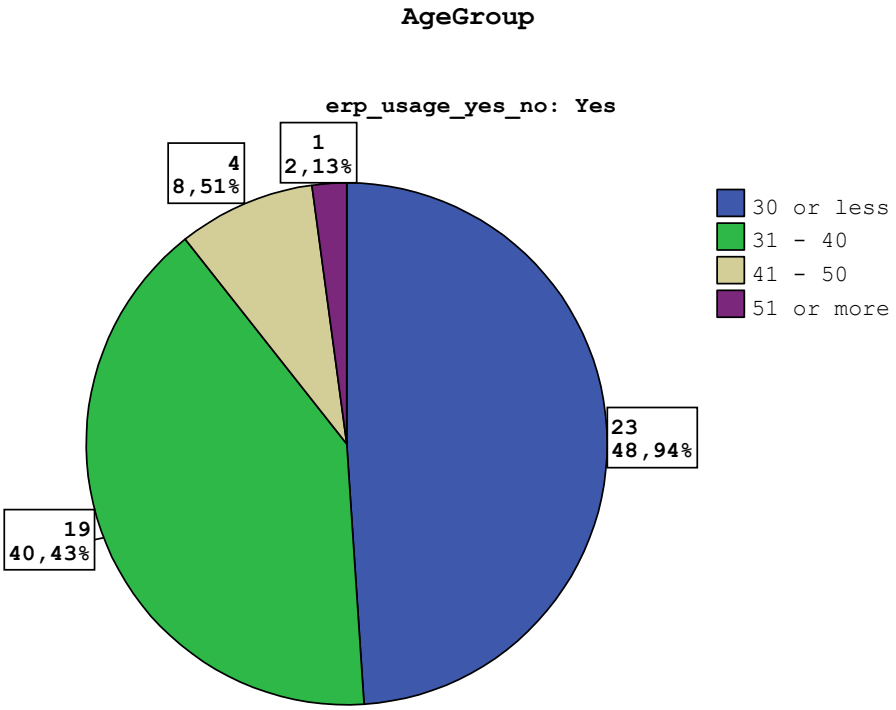

Figure 4.12. ERP Usage Yes vs. Age Group - Pie Chart.

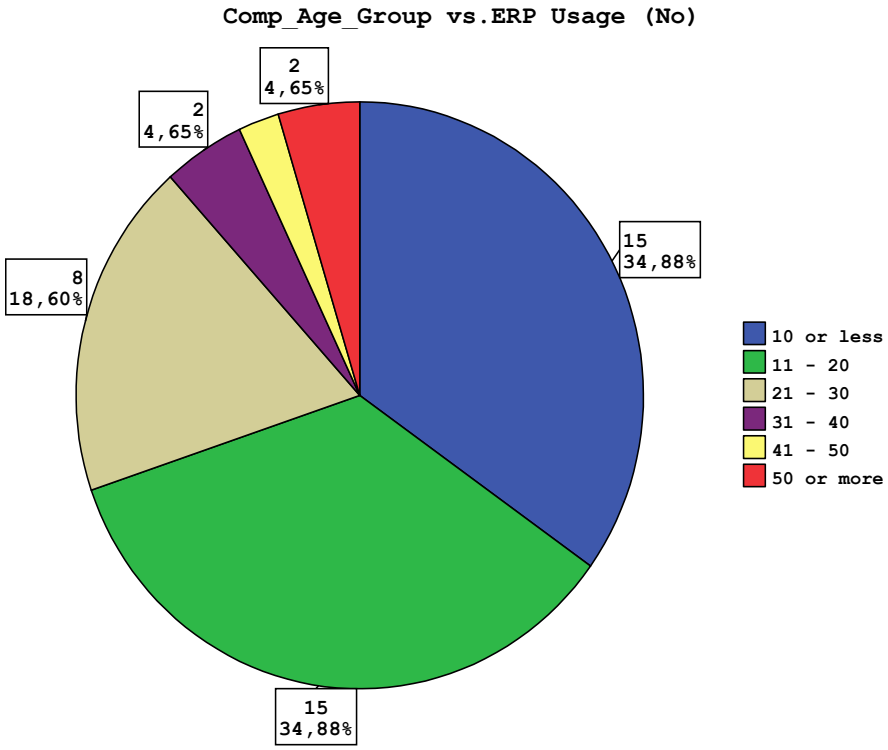

Figure 4.13. Company Age Groups with respect to ERP Usage No.

Moreover, if what company age group that the respondents who are using any ERP system is belong to is examined, the following pie chart Figure 4.14 can be created as below. According to the pie chart below, about 34% of the companies that are using any ERP system before is in “10 or less” company age group, about 32% of the companies that are using any ERP system before is in “between 11 and 20” company age group and about 19% of the companies that are using any ERP system before is in “between 21 and 30” company age group.

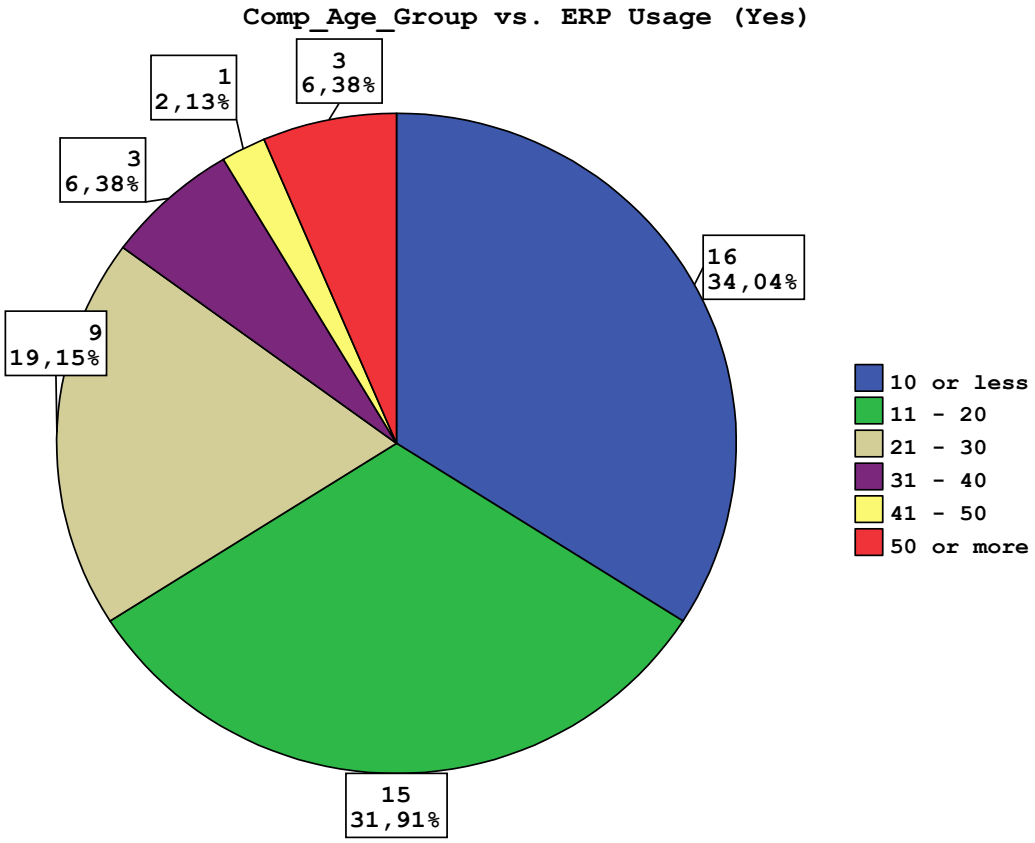

Figure 4.14. Company Age Groups with respect to ERP Usage Yes.

Furthermore, there are 14 possible critical success factors mentioned in the survey. These factors are selected from the literature review of this study (Garcia-Sanchez and Perez-Bernal, 2007; Somers and Nelson, 2004) and then, the list of critical success factors are eliminated and reviewed by an academician.

The following table shows the factors, their variable name in SPSS analysis, and the mean value of the factors and the importance level interval of the factors. If following mean values are examined, it can be seen that except "*Use of Consultants*" factor, all factors at the list of the critical success factors are at the "high importance level."

Table 4.5. Mean Table of CSF at Questionnaire Survey.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
1	*Top_mng_spprt*	Top management support and Commitment	4.42	High	Very High
2	*Prjct_team_competence*	Project Team Competence	4.14	High	Very High
3	*Clear_goals_objctv*	Clear goals and objectives	4.31	High	Very High
4	*Team_composition*	Team Composition	3.89	Moderate	High
5	*Effectvnss_Prjct_Leader*	Effectiveness of Project Leader	4.06	High	Very High
6	*Cooperation_Btwn_Team_Mmbrs*	Cooperation Between Team Members	4.06	High	Very High
7	*Vendor_Spprt*	Vendor Support	3.70	Moderate	High
8	*Choice_ERP_Softw_Packg*	Choice of ERP Software Package	3.64	Moderate	High
9	*Training_spprt_for_users*	Training and support for users	3.86	Moderate	High
10	*Choice_ERP_Modules*	Choice of ERP Modules	3.74	Moderate	High
11	*Organizational_Chng_Mngmnt*	Organizational Change Management	3.70	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High
13	*End_user_Involvemnt*	End User Involvement	3.73	Moderate	High
14	*Testing_System_StartUp*	Start-Up and Testing the System	3.69	Moderate	High

Also, Table 4.6 below shows the factors and its mean values in descending order, so that what factor is more important than the other ones can be easily seen.

4.2.1 Factor Analysis

Factor analysis is a collection of methods used to examine how underlying constructs influence the responses on a number of measured variables (DeCoster, 1998). Also, Tryfos (1997) explains the factor analysis as "a method for investigating whether a

number of variables of interest are linearly related to a smaller number of unobservable factors."

In the special vocabulary of factor analysis, the parameters of these linear functions are referred to as loadings. Under certain conditions, the theoretical variance of each variable and the covariance of each pair of variables can be expressed in terms of the loadings and the variance of the error terms.

Table 4.6. Descending Mean Value Table.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
1	*Top_mng_spprt*	Top management support and Commitment	4.42	High	Very High
3	*Clear_goals_objctv*	Clear goals and objectives	4.31	High	Very High
2	*Prjct_team_competence*	Project Team Competence	4.14	High	Very High
5	*Effectvnss_Prjct_Leader*	Effectiveness of Project Leader	4.06	High	Very High
6	*Cooperation_Btwn_Team_Mmbrs*	Cooperation Between Team Members	4.06	High	Very High
4	*Team_composition*	Team Composition	3.89	Moderate	High
9	*Training_spprt_for_users*	Training and support for users	3.86	Moderate	High
10	*Choice_ERP_Modules*	Choice of ERP Modules	3.74	Moderate	High
13	*End_user_Involvemnt*	End User Involvement	3.73	Moderate	High
7	*Vendor_Spprt*	Vendor Support	3.70	Moderate	High
11	*Organizational_Chng_Mngmnt*	Organizational Change Management	3.70	Moderate	High
14	*Testing_System_StartUp*	Start-Up and Testing the System	3.69	Moderate	High
8	*Choice_ERP_Softw_Packg*	Choice of ERP Software Package	3.64	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High

There are mainly two types of factor analysis. They are Exploratory Factor Analysis and Confirmatory Factor Analysis.

- *Exploratory Factor Analysis (EFA)* attempts to discover the nature of the constructs influencing a set of responses.
- *Confirmatory Factor Analysis (CFA)* tests whether a specified set of constructs is influencing responses in a predicted way.

Both types of factor analyses are based on the Common Factor Model, illustrated in the figure below. This model proposes that each observed response (measure 1 through measure 5) is influenced partially by underlying common factors (factor 1 and factor 2) and partially by underlying unique factors (E1 through E5). The strength of the link between each factor and each measure varies, such that a given factor influences some measures more than others (DeCoster, 1998).

The type of the factor analysis used in this thesis is "EFA". All of the 14 possible success factors are examined in the questionnaire survey and by using EFA, it is decided that which factors can be group as common factors.

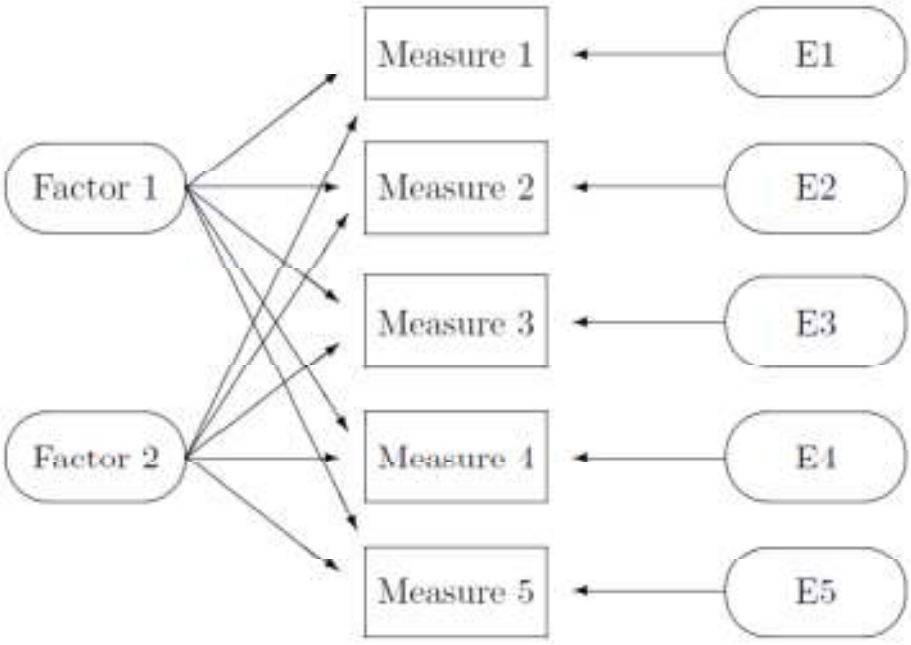

Figure 4.15. Factor Analysis – Common Factor Model (DeCoster, 1998).

The communality of a variable is the part of its variance that is explained by the common factors. The specific variance is the part of the variance of the variable that is not accounted by the common factors (Tryfos, 1997).

Factor analysis usually proceeds in two stages. In the first, one set of loadings is calculated which yields theoretical variances and covariances that fit the observed ones as closely as possible according to a certain criterion. These loadings, however, may not agree

with the prior expectations, or may not lend themselves to a reasonable interpretation. Thus, in the second stage, the first loadings are “rotated” in an effort to arrive at another set of loadings that fit equally well the observed variances and covariances, but are more consistent with prior expectations or more easily interpreted (Tryfos, 1997).

A method widely used for determining a first set of loadings is the principal component method. This method seeks values of the loadings that bring the estimate of the total communality as close as possible to the total of the observed variances. In addition to that, the “varimax rotation method” encourages the detection of factors each of which is related to few variables. It discourages the detection of factors influencing all variables (Tryfos, 1997).

In the examination of the factor analysis in the thesis, it is used varimax rotation method in order to calculate “the rotated component matrix.”

4.2.2. The Convenience of Factor Analysis Method of the Questionnaire Survey

First of all, whether factor analysis could be used for the collected data should be checked. for this purpose, there are two basic tests. They are *“Kaiser-Meyer-Olkin (KMO) adequancy test”* and *“Barlett's test of sphericity”*

Kaier-Meyer-Olkin measure of sampling adequacy is used to compare the magnitudes of the observed correlation coefficients in relation to the magnitudes of the partial correlation coefficients. Large KMO values are good because correlations between pairs of variables can be explained by the other variables. If the KMO is below 0.5, it should not be done a factor analysis (Bold-Ed, 2012).

According to KMO test, the value of this test varies between 0 and 1. The KMO values greater than 0.5 are acceptable and the values below 0.5 should lead us to either collect more data or rethink which variables to include. However, it is recommended to have a minimum value of 0.6 in order to ensure a healthy factor analysis.

Also, Field (2005) explains the KMO values levels as following that the KMO values between 0.5 and 0.7 are mediocre, the KMO value between 0.7 and 0.8 are good, the KMO values 0.8 and 0.9 are great and the KMO values above 0.9 are superb.

Bartlett's measure tests the null hypothesis that the original correlation matrix is an identity matrix. For factor analysis to work we need some relationships between variables and if the R-Matrix were an identity matrix then all correlation coefficients would be zero. Therefore, we want this test to be significant, such as; significance value less than 0.05. A significant test tells us that the R-Matrix is not an identity matrix; therefore, there are some relationships between the variables we hope to include in the analysis. For these data, Bartlett's test is highly significant ($p < 0.001$), and therefore factor analysis is appropriate (Field, 2005).

It can be seen the KMO and Bartlett's Test table of the questionnaire survey as below.

Table 4.7. KMO and Barlett's Test Table – Factor Analysis.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.876
Bartlett's Test of Sphericity	Approx. Chi-Square	810.216
	df	91
	Sig.	.000

If the KMO and Bartlett's Test table is examined, it can be seen that KMO adequacy value is 0.876. This value means that this data set is "*great*" for factor analysis.

Moreover, if the Bartlett's Test of Sphericity is examined, it can be seen that significance of the test value is 0.000 and less than 0.001 ($p < 0.001$). Thus, it can be said that *factor analysis is appropriate* for the test.

It can be understood that both KMO and Bartlett's Test approved that the data set at the questionnaire survey is very suitable for the factor analysis.

4.2.3. Factor Analysis of the Questionnaire Survey

After the approval of the suitability of the factor analysis method, the data set is transferred into SPSS program in order to get factor analysis tables. “Correlation matrix”, “total variance explained”, “scree plot”, “component matrix”, “rotated component matrix”, “component transformation matrix”, and “component plot in rotated space” tables are acquired from the SPSS Output file.

It can be seen the correlation matrix of the factor analysis as Table 4.8. In this table, correlation between factors in the questionnaire survey can be examined.

The total variance explained table is given below as Table 4.9. In this table, it can be seen that initial eigenvalues, extraction sum of squared loadings and rotation sum of squared loadings of total variance explained values of the components.

The table shows that along with 3 components of the factor analysis, *71.025% of the total data set is explained.* This is a fine percentage to continue (Koostra, 2004; Field, 2000; Reitveld & Van Hout, 1993) and apply a 3 components custom factor analysis again and to explain the whole data.

Table 4.8. Total Variance Explained – Factor Analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.273	51.950	51.950	7.273	51.950	51.950	3.639	*25.991*	25.991
2	1.542	11.012	62.962	1.542	11.012	62.962	3.521	*25.149*	51.140
3	1.129	8.063	71.025	1.129	8.063	71.025	2.784	*19.885*	71.025
4	.604	4.311	75.336						
5	.570	4.070	79.406						
6	.546	3.897	83.303						
7	.481	3.433	86.736						
8	.425	3.035	89.770						
9	.385	2.749	92.519						
10	.312	2.230	94.750						
11	.232	1.654	96.404						
12	.204	1.458	97.862						
13	.165	1.176	99.038						
14	.135	.962	100.000						

Table 4.9. Correlation Matrix – Factor Analysis.

	top_mng_spprt	Prjct_team_competence	Clear_goals_objctv	Team_composition	Effectvnss_Prjct_Leader	Cooperation_Btwn_Team_Mmbrs	Vendor_Spprt	Choice_ERP_Softw_Packg	Training_spprt_for_users	Choice_ERP_Modules	Organizational_Chng_Mngmnt	Use_consultants	End_user_Involvemnt	Testing_System_StartUp
top_mng_spprt	1,000	0,624	0,580	0,494	0,635	0,527	0,385	0,295	0,533	0,350	0,482	0,307	0,474	0,410
Prjct_team_competence	0,624	1,000	0,603	0,606	0,452	0,669	0,442	0,382	0,468	0,400	0,418	0,312	0,441	0,263
Clear_goals_objctv	0,580	0,603	1,000	0,481	0,407	0,523	0,386	0,431	0,508	0,340	0,368	0,244	0,429	0,260
Team_composition	0,494	0,606	0,481	1,000	0,588	0,570	0,339	0,303	0,556	0,343	0,574	0,427	0,491	0,438
Effectvnss_Prjct_Leader	0,635	0,452	0,407	0,588	1,000	0,551	0,374	0,278	0,625	0,399	0,603	0,478	0,523	0,452
Cooperation_Btwn_Team_Mmbrs	0,527	0,669	0,523	0,570	0,551	1,000	0,449	0,413	0,475	0,349	0,466	0,255	0,355	0,391
Vendor_Spprt	0,385	0,442	0,386	0,339	0,374	0,449	1,000	0,733	0,675	0,762	0,446	0,459	0,451	0,555
Choice_ERP_Softw_Packg	0,295	0,382	0,431	0,303	0,278	0,413	0,733	1,000	0,570	0,616	0,481	0,406	0,398	0,423
Training_spprt_for_users	0,533	0,468	0,508	0,556	0,625	0,475	0,675	0,570	1,000	0,697	0,722	0,533	0,663	0,613
Choice_ERP_Modules	0,350	0,400	0,340	0,343	0,399	0,349	0,762	0,616	0,697	1,000	0,535	0,461	0,509	0,518
Organizational_Chng_Mngmnt	0,482	0,418	0,368	0,574	0,603	0,466	0,446	0,481	0,722	0,535	1,000	0,507	0,698	0,494
Use_consultants	0,307	0,312	0,244	0,427	0,478	0,255	0,459	0,406	0,533	0,461	0,507	1,000	0,556	0,544
End_user_Involvemnt	0,474	0,441	0,429	0,491	0,523	0,355	0,451	0,398	0,663	0,509	0,698	0,556	1,000	0,602
Testing_System_StartUp	0,410	0,263	0,260	0,438	0,452	0,391	0,555	0,423	0,613	0,518	0,494	0,544	0,602	1,000

Furthermore, the scree plot of factor analysis at 3 components is given below at Figure 4.16. The elbow point of at the 3rd components can be seen and it is enough to explain the most of the data (as 71.025 %).

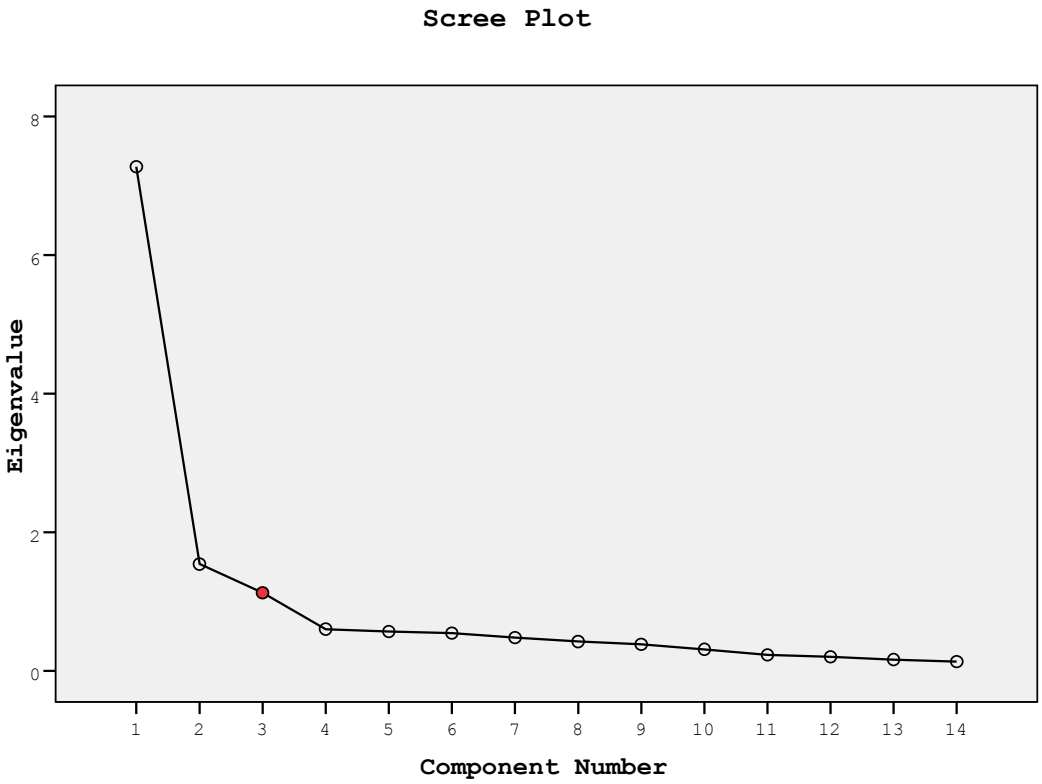

Figure 4.16. Scree Plot - Factor Analysis.

The component matrix of factor analysis is given below. These are the values before rotation. After rotation procedure done and rotated matrix is shown, the better explanation for the factors can be made.

Also, the component plot of the variables in rotated space and component matrix tables can be seen at Figure 4.17 and Table 4.10 as below.

Moreover, it can be seen *"the rotated component matrix table"* of factor analysis as given at Table 4.11 below. These are the values after rotation and it can be interpreted according to their values and component columns.

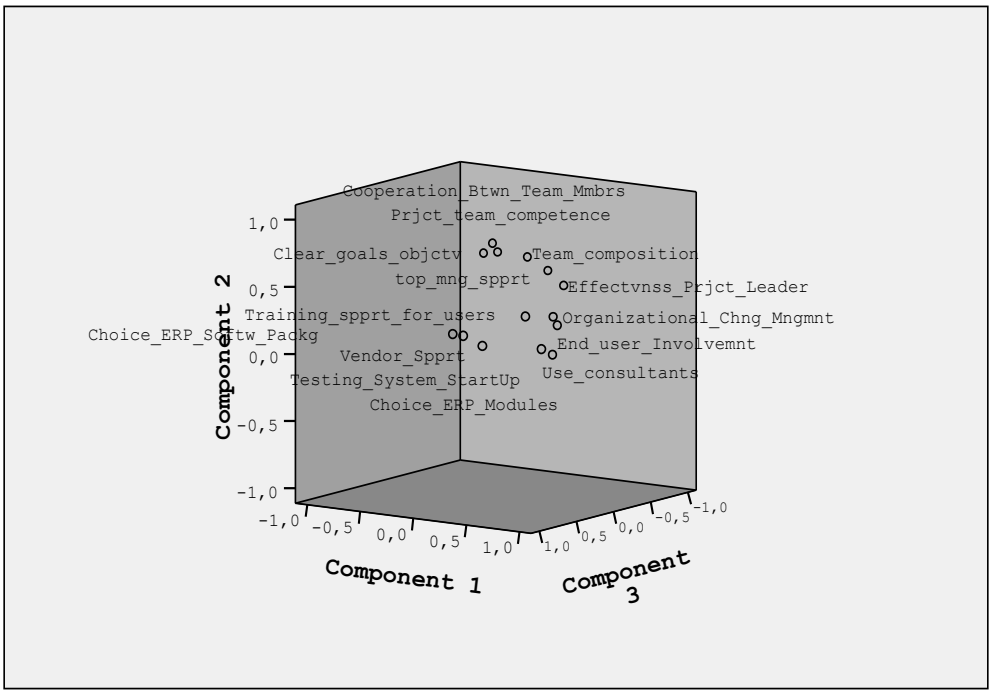

Figure 4.17. Component Plot - Factor Analysis.

Table 4.10. Component Matrix – Factor Analysis.

	Component		
	1	2	3
top_mng_spprt	.703	.411	-.024
Prjct_team_competence	.697	.454	.260
Clear_goals_objctv	.644	.385	.309
Team_composition	.715	.334	-.195
Effectvnss_Prjct_Leader	.734	.233	-.332
Cooperation_Btwn_Team_ Mmbrs	.690	.397	.210
Vendor_Spprt	.741	-.388	.391
Choice_ERP_Softw_Packg	.665	-.353	.461
Training_spprt_for_users	.866	-.174	-.049
Choice_ERP_Modules	.727	-.425	.228
Organizational_Chng_ Mngmnt	.782	-.071	-.278
Use_consultants	.642	-.303	-.339
End_user_Involvemnt	.759	-.119	-.323
Testing_System_StartUp	.693	-.310	-.239

Table 4.11. Rotated Component Matrix Table – Factor Analysis.

	Component		
	1	2	3
top_mng_spprt	.361	.725	.090
Prjct_team_competence	.139	.826	.243
Clear_goals_objctv	.087	.754	.289
Team_composition	.513	.630	.033
Effectvnss_Prjct_Leader	.650	.530	.015
Cooperation_Btwn_Team_ Mmbrs	.185	.765	.241
Vendor_Spprt	.284	.239	.846
Choice_ERP_Softw_Packg	.176	.239	.832
Training_spprt_for_users	.630	.367	.501
Choice_ERP_Modules	.403	.161	.757
Organizational_Chng_ Mngmnt	.718	.338	.253
Use_consultants	.732	.062	.282
End_user_Involvemnt	.748	.277	.241
Testing_System_StartUp	.693	.112	.375

The rotated component matrix table with bold font dominant value at each component number is presented in table 4.13. There are 14 variables processed at SPSS Factor Analysis and decided to investigate them in 3 components. It can be seen which variable should be categorized in which components at following table.

Table 4.12. Rotated Component Matrix Table2 – Factor Analysis.

Rotated Component Matrix			
Variables	Component		
	1	2	3
top_mng_spprt	0.361	**0.725**	0.090
Prjct_team_competence	0.139	**0.826**	0.243
Clear_goals_objctv	0.087	**0.754**	0.289
Team_composition	0.513	**0.630**	0.033
Effectvnss_Prjct_Leader	**0.650**	0.530	0.015
Cooperation_Btwn_Team_Mmbrs	0.185	**0.765**	0.241
Vendor_Spprt	0.284	0.239	**0.846**
Choice_ERP_Softw_Packg	0.176	0.239	**0.832**
Training_spprt_for_users	**0.630**	0.367	0.501
Choice_ERP_Modules	0.403	0.161	**0.757**
Organizational_Chng_Mngmnt	**0.718**	0.338	0.253
Use_consultants	**0.732**	0.062	0.282
End_user_Involvemnt	**0.748**	0.277	0.241
Testing_System_StartUp	**0.693**	0.112	0.375

When the factor analysis results are to be examined, the process should begin at 3 components or common factors of the variables. First of all, according to rotated component matrix; top management support and commitment, project team competence, clear goals and objective, team composition and cooperation between team members are at the same common factor group. Secondly, effectiveness of project leader, training and support for users, organizational change management, and use of consultants, end user involvement and testing & start-up system factors can be grouped in the same common factor group. Lastly, vendor support, choice of ERP Software Package and Choice of ERP Modules can be grouped in the same common factor group.

Table 4.13. Rotated Component Matrix with Common Factors – Factor Analysis.

Rotated Component Matrix				
Common Factors	**Variables**	Component		
		1	2	3
Common Factor Group 1	top_mng_spprt	0.361	**0.725**	0.090
	Prjct_team_competence	0.139	**0.826**	0.243
	Clear_goals_objctv	0.087	**0.754**	0.289
	Team_composition	0.513	**0.630**	0.033
	Cooperation_Btwn_Team_Mmbrs	0.185	**0.765**	0.241
Common Factor Group 2	Vendor_Spprt	0.284	0.239	**0.846**
	Choice_ERP_Softw_Packg	0.176	0.239	**0.832**
	Choice_ERP_Modules	0.403	0.161	**0.757**
Common Factor Group 3	Effectvnss_Prjct_Leader	**0.650**	0.530	0.015
	Training_spprt_for_users	**0.630**	0.367	0.501
	Organizational_Chng_Mngmnt	**0.718**	0.338	0.253
	Use_consultants	**0.732**	0.062	0.282
	End_user_Involvemnt	**0.748**	0.277	0.241
	Testing_System_StartUp	**0.693**	0.112	0.375

If it is investigated that there are 3 common factors group of 14 factors (variables) and all of the factors are split into 3 meaningful groups. The first common factors group is very related to organizational subjects and this common factors group can be entitled as *"Organizational Factors"*. The second common factors group is much related to technological subjects and this common factors group can be entitled as *"Technological Factors"*. The third common factors group is much related to human and personal subjects and this common factors group can be entitled as *"Human Factors"*. New table on rotated component matrix and its factors can be grouped as below.

Table 4.14. Rotated Component Matrix with respect to Common Factors.

Rotated Component Matrix				
Common Factors	**Variables**	**Component**		
		1	***2***	***3***
Organizational Factors	top_mng_spprt	0.361	**0.725**	0.090
	Prjct_team_competence	0.139	**0.826**	0.243
	Clear_goals_objctv	0.087	**0.754**	0.289
	Team_composition	0.513	**0.630**	0.033
	Cooperation_Btwn_Team_Mmbrs	0.185	**0.765**	0.241
Technological Factor	Vendor_Spprt	0.284	0.239	**0.846**
	Choice_ERP_Softw_Packg	0.176	0.239	**0.832**
	Choice_ERP_Modules	0.403	0.161	**0.757**
Human Factors	Effectvnss_Prjct_Leader	**0.650**	0.530	0.015
	Training_spprt_for_users	**0.630**	0.367	0.501
	Organizational_Chng_Mngmnt	**0.718**	0.338	0.253
	Use_consultants	**0.732**	0.062	0.282
	End_user_Involvemnt	**0.748**	0.277	0.241
	Testing_System_StartUp	**0.693**	0.112	0.375

Lastly, before rotation processes, common factors group 1 (human factors) consists of 51.950% of total extraction sums of squared loadings. Common factors group 2 (organizational factors) consists of only 11.012% of total extraction sums of squared loadings and Common factors group 3 (technological factors) consists of only 8.063% of total extraction sums of squared loadings. However, it should also be explained the percentage of variances of "*rotation sums of squared loadings"* of components (common factors groups).

After rotation processes, common factors group 1 *(human factors)* consists of *25.991%* of total rotation sums of squared loadings. Common factors group 2 *(organizational factors)* consists of only *25.149%* of total rotation sums of squared loadings and common factors group 3 *(technological factors)* consists of only *19.885%* of total rotation sums of squared loadings.

Table 4.15. Total Variance Explained.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7,273	51,950	51,950	7,273	51,950	51,950	3,639	**25,991**	25,991
2	1,542	11,012	62,962	1,542	11,012	62,962	3,521	**25,149**	51,140
3	1,129	8,063	71,025	1,129	8,063	71,025	2,784	**19,885**	71,025
4	,604	4,311	75,336						
5	,570	4,070	79,406						
6	,546	3,897	83,303						
7	,481	3,433	86,736						
8	,425	3,035	89,770						
9	,385	2,749	92,519						
10	,312	2,230	94,750						
11	,232	1,654	96,404						
12	,204	1,458	97,862						
13	,165	1,176	99,038						
14	,135	,962	100,000						

Extraction Method: Principal Component Analysis.

4.3. Case Studies

In this section, answers of the respondent people in construction companies are evaluated. Results of the interviews are presented as case studies since it would be misleading to generalize some perceptions, implementation and applications about ERP system due to the different ERP system used, organizational structure, characteristics, visions and cultures of the construction companies.

Table below shows some general information about the companies and the interviewees.

Table 4.16. Case Study Interviewee Table.

Case Study	Company	Company Age	Title of the interviewee	The ERP System that Company Using
A	A	36	Technical Office Chief	YAPITAŞI
B	B	44	Contract Manager	MS NAVISION (MS DYNAMICS)
C	C	17	Planning and Cost Control Expert	SAP

All interviewees were the key implementers of ERP systems of their companies during ERP implementation phases.

4.3.1 Administration of the Case Studies

This research consists of three face-to-face interviews that were carried out in the companies with the interviewee respondents at the managerial level. Each interview took about 2 hours. There was a case study form given at “the content of the case studies” part below. There are three large construction companies participated in this study and three case studies are carried out with interviewees who are key implementers at the implementation phase of ERP system in their companies. Thus, they know what was right and what was wrong about the implementation phase of the systems.

All three different companies use three different ERP systems. Company A decided to use a local ERP system that is developed by a Turkish software company. The name of the ERP system is “YAPITAŞI”. Company B decided to use a Microsoft product and its

name was “MS NAVISION” earlier but now it is called as “MS DYNAMICS NAV”. The third one; Company C decided to use one of the leading ERP system in the world which is “SAP.”

Company A is one of the local Real Estate Developer and Construction companies and has a lot of construction projects in Istanbul. Most of them are multi-functional multi-purpose high rise buildings projects. Company A is active in construction sector for 36 years. Company A’s domestic turnovers realized so far are stated as 350 million USD.

Company B is one of the largest REIT Company in Turkey and has a lot of residential projects at different cities of Turkey. The value of its active assets exceeds one billion US Dollars. Company B is traded at the Istanbul Stock Exchange with a public share of 49% and a market value of 594 million TL. 37% of shares of Company B are being circulated in the market. With its portfolio size of 1.85 billion TL, Company B is ranked third among 21 real estate investment trusts currently traded in Istanbul Stock Exchange (ISE). Company B is defining its mission as developing exclusive homes and living spaces worth living. Most of the projects that Company B constructed are residential projects. Only a few of them are office buildings. Company B is active in construction sector for 44 years.

Company C is the members of the Turkish Contractors Association (TCA) and belong to one of the largest holding in Turkey, that make business in Energy, Media, Construction, Textile, Finance, Mining and Telecom. Company C is active in construction sector for 17 years. Company C has completed large-scale construction projects in a number of countries around the world. It is progressing in line with its object of growing in the oil & gas sector in the medium term thanks to its qualified workforce and know-how particularly in Turkmenistan. Company C focuses on oil & gas, hospital and infrastructure projects in Turkmenistan, Iraq and Qatar. It is completed over 110 projects up to the present. The total value of the projects Company C has undertaken amounts to nearly 4.5 billion USD. Its main fields of operation in construction sector are: industrial facilities, energy projects, hospitals and health service buildings, urban renovation and urban transformation projects, infrastructure projects, multi-purpose housing and commercial area projects, public and military construction projects, works of art and landscaping.

Company C has branch offices in Iraq, Turkmenistan, Sudan, United Arab Emirates, Ukraine, Saudi Arabia, Qatar and Kazakhstan beside Turkey.

Company C is the first Turkish contractor to have completed turnkey industrial projects abroad and also has figured since 2006 in the "the Top 225 International Contractors" list which is published every year by Engineering News Record (ENR). In addition to its achievements abroad, the Company is the author of many successfully ongoing operations in Turkey as well. Company C has the certificates of ISO 9001 Quality Management, ISO 14001 Environmental Management and ISO 18001 Occupational Health and Safety.

4.3.2 Content of the Case Studies

The interview has been established covering different topics with some questions. The main topics and questions of the case study about the implementation of ERP systems are presented in the table 4.17 below.

Table 4.17. Case Study Issues and Questions.

Implementation of ERP System in Construction Sector **General Questions**	What is the name of ERP system implemented? What is the total implementation duration of the system? What modules of ERP system are implemented? What is the type of the company that implemented ERP system?: *Construction/Consultant/Project Management/... Company*
Drivers	What needs drive the company to have an ERP system? What are the drivers that provide the ERP system to be implemented successfully?
Inputs	What have resources been utilized to have an ERP system in your company? What should resources be utilized to make ERP implementation successful?
Tools	What tools are used to implement ERP system in your company? What are the strategies used to implement ERP systems successfully?
Challenges / Barriers	What are the challenges faced by project implementation team in your company? What are the barriers to implement ERP system successfully?
Enablers	What are the factors facilitating the implementation process of ERP in your company?
Project Level Benefits	What are the achievements coming through from the implementation of ERP system at project level?
Wider Benefits	What are the outcomes coming through from the implementation of ERP system?
Lessons Learnt	What are the lessons learnt from the case study

4.4. Analysis of the Case Studies

Company A is a real estate development and construction company that uses an ERP system called YAPITAŞI. It is developed by a Turkish software company for Turkish contractors. It takes about 1.5 years to implement the system including parallel immigration of the past data of the company. Along with this ERP system, "purchasing/procurement module, partial accounting, project management with progress payment modules, reporting and planning modules" are implemented.

Company B is a real estate investment trust (REIT) that uses an ERP system called MS NAVISION (now it is called as MS DYNAMICS NAV). It is developed by Microsoft. It takes about 3 years to implement the system including parallel immigration of the past data of the company. Along with this ERP system, "finance, accounting, project management, purchasing/procurement, planning, human resources, CRM and post-sale support systems" are implemented.

The company C is a construction company that belongs to a large scale holding group and it uses an ERP system called SAP. SAP is one of the leader companies in ERP system business. It takes about 3 years to implement the system. Migration process was not a parallel immigration of the past data but instantaneous migration from old system to new SAP system. Along with this ERP system, "finance and financial accounting, cost accounting, material management (MM module), purchasing/procurement, project management, maintenance/repair (plant maintenance), human resources, asset accounting" modules are implemented.

4.4.1. Drivers

Two questions are asked to interviewees at "Drivers" part of the case study in order to learn what needs drive their company to have an ERP system and what drivers provide the ERP system to be implemented successfully.

In terms of the main drivers, all three interviewees replied commonly as *"reaching same business data, reporting right and current information about businesses, creating spontaneous management reports."*

Also, interviewee A at company A replied this question as *"creating a central system that can be used by the employees of different departments easily and ensures them to reach the data of different departments and so, the integration between different departments is created."*

Moreover, Company A wants to make payments according to a central system and thus, the ERP system is full of control on the payment bills and payment orders. However, there is not a complete accounting module that all accounting department uses in ERP system but there was a partial accounting module that active in following payment order. This is because of that the ERP system is not capable of doing all of official accounting calculations according to Turkish accounting regulations and old system is not capable of immigrating its past data to new system.

Furthermore, interviewee B at Company B also replied this question as following that the company B wants a system that provides *"healthy following of business orders and saves time and resources in the long run."*

Besides, interviewee C at Company C also replied this question as following that the company C wants a system that provides *"integration between different construction sites at different geography and the headquarter office, saving time and resources in the long run and healthy following of business orders. Also it is aimed to connect the different companies inside the holding by using ERP system."*

Afterwards, it is asked the companies what drivers provide the ERP system to be implemented successfully. All three interviewees are replied commonly following answers that following items are very important drivers that provide an ERP system to be implemented successfully;

- Top management support

- Including of end users to implementation phases
- Knowing what we are expected from the system
- Selecting right and proper team members (*key employee/implementer*) of ERP implementation team
- Goal of the ERP implementation project should be realistic not based on wishful thinking.

Interviewee A adds some other items to the items above to show that it was very important at the implementation of their system.

- First ERP structure scenario, connection between departments and module organization of the system is very important.
- Connection between the old system that the company currently using and the ERP system that will be implemented is very significant due to data migration of the past data. (The company A has some connection and compatibility problem between old accounting software and the accounting module of the new system.)
- Training is very crucial at successful implementation of the new ERP system.
- Due to parallel immigration choice of the top management, the employees have to do same work on both the old and the new system. This choice has brought some extra work on the employee, and so the motivation of the employee to the new system has dropt. Therefore, the top management support and commitment and the choice of the top executives are very important to pass successful implementation duration.

Interviewee B also adds some other significant items to the common items above to show that it was very important at the implementation of their system in Company B as following;

- Consultants
- Selecting right and suitable ERP software and its modules
- At some point, taking initiative on business process re-engineering and adapting the ERP system.
- Implementing the system module by module instead of whole organization.
- Give attention to test phase and experience a healthy test phase

Interviewee C also adds some other significant items to the common items above to show that it was very important at the implementation of their system in Company C as following;

- Consultant should be very experienced on their field.
- Selecting right and suitable ERP software and its modules (Also mentioned at Company B)
- Business Process Reengineering (BPR) is very important at the implementation phase of ERP system. If needed to change the business work flow of the company, the top management has to support this change in order to have successful implementation.
- Give attention to test phase and experience a healthy test phase (Also mentioned at Company B)
- Not migrating the whole company to new system at the same time but preferring migrating whole company department by department.

4.4.2. Inputs

Two questions are asked to interviewees at "Inputs" part of the case study in order to learn what resources have been utilized to have an ERP system in your company and what resources should be utilized to make ERP implementation successful.

When it is asked to learn what resources have been utilized to have an ERP system in their companies, all three interviewees replied commonly as *"funding (monetary support), time and patience from management level."*

Furthermore, interviewee A also replied this question as following that the company A also allocate some other resources to have a successful ERP implementation such as; "*allocating extra fund for training of the employees and hiring experienced consultants.*"

Interviewee B also replied this question as following that the Company B also show *"motivational support from top management"* to have successful ERP implementation as extra resource.

Interviewee C replied this question as following that the Company C has selected some important employees as key implementers and these employees do not work on their regular job but only work on EPR implementation. The company C has hired other employees to make the regular job of key implementers. Thus, there were no extra work load on these key implementers and they have focused on only their implementation job. Therefore, it can be mentioned that Company C has provided "*extra fund for the wages of key implementers*."

When it is asked what resources should be utilized to make ERP implementation successful, all three interviewees replied commonly as *"right and competent key implementation team and team members" and "right and competent consultants"*

Interviewee A also replied this question as following that *"top management support and commitment on getting ERP system implantation period done, asking own employees to help external consultants, motivational support from top executives, extra funding for training end users"* are very significant resources that a company should allocate in order to have a successful ERP implementation.

Interviewee B also replied this question as following that *"having support from ERP vendor and allocating extra fund to in order to train end users"* are very important resources that a company should allocate in order to have a successful ERP implementation.

Interviewee C also replied this question as following that *"allocating extra fund to in order to train end users"* are very important resources that a company should allocate in order to have a successful ERP implementation. Also interviewee C has mentioned that key implementer team has their own room and some privileges in the company.

4.4.3. Tools

Two questions are asked to interviewees at "tools" part of the case study in order to learn what tools are used to implement ERP system in your company and what strategies are used to implement ERP systems successfully.

When it is asked what tools are used to implement ERP system in your company, all three interviewees replied commonly as *"computer and computer systems, servers and some software to immigrate past data to new system."*

Only interviewee C added some extra tools to this category that SAP key implementers team has *extra tools and privileges like; extra room and extra director* at the company.

When it is asked that what strategies are used to implement ERP systems successfully, all three interviewees replied only one common item as *"top management to know what is expected at the end of the implementation phase"*.

Interviewee A and B also replied this question as following that *"planning system and module structure correctly at the beginning of the implementation phase" and "top management support to use the ERP system continuously at the end of the implementation"* are very important strategies that a company should use in order to have a successful ERP implementation.

Interviewee C also replied this strategy question as following that *"hiring key implementation team as full time and only focusing on the ERP system implementation not their regular works, not making parallel immigration and preferring direct immigration instantly, making contracts with key implementer team members in order to prevent them to quit from their jobs and not to cut implementation phase, using key implementer team as interior consultant after implementation system is done, making a back-up system"* are very important strategies that a company should use in order to have a successful ERP implementation.

4.4.4. Challenges / Barriers

One question is asked to interviewees at "Challenges & Barriers" part of the case study in order to learn what challenges and barriers are faced by project implementation team in your company.

In terms of the challenges and barriers, all three interviewees replied commonly as *"old habits of the employees and not to leave old system and procedures" and "defining new system as cumbersome."*

Interviewee A also replied this question as following that *Company A has not a general ERP strategy at the implementation phase.* Also, due to the parallel immigration of the past data, making extra works of implementation phase and making their regular jobs at the same time, there was *negative psychology at the employees.*

Interviewee B also replied this question as following that *"Impatience to the errors and mistakes at the implementation phase"* and *"negative psychology due to parallel immigration phase and additional works on the employees"* are challenges and barriers that implementation team at company B has faced during the ERP implementation.

Interviewee C also replied this question as following that *"additional works on the employees due to ERP implementation, having construction sites at different region of the world, internet connection problems in the construction sites at different region of the world, not training employees at the construction abroad and Impatience to the errors and mistakes at the implementation phase and leaving job of one the key implementers"* are challenges and barriers that implementation team at company C has faced during the ERP implementation.

4.4.5. Enablers

One question is asked to interviewees at "Enablers" part of the case study in order to learn what factors (enablers) are facilitating implementation process of ERP system in your company.

In terms of the enablers facilitating implementation process of ERP system in their companies, all three interviewees replied commonly as *"creating a know-how for the company and more transparent system on finance and accounting provide top management support" and "Creating executive and operational management reports easily and*

Reaching the right data from every department and construction sites provide top management and technical team support and motivation."

Interviewee C also replied this question as following that Company C has chosen *"very experienced key implementation team leader"* and this team leader has written procedures on ERP system, balance tension during immigration and supply well communication with critical departments. Also, the implementation team at Company C has made *training to end users continuously and made test on ERP systems continuously.*

4.4.6. Project Level Benefits

One question is asked to interviewees at "Project Level Benefits" part of the case study in order to learn what achievements come through from the implementation of ERP system at project level.

In terms of the project level benefits, all three interviewees replied commonly as *"Creating executive and operational management reports for each construction site fast and easily,"* and *"Reaching the correct and current data of the construction sites at different location fast."*

Interviewee A also replied this question as following that along with the new ERP system, *any employee of a construction site can reach only some portion of whole database* of ERP system according to its position, department and its construction site.

Interviewee B also replied this question as following that along with the new ERP system, *preventing information pollution* at any database is provided.

Interviewee C also replied this question as following that along with the new ERP system, *the information of the construction sites at different region of the world can be collected easily, integration between construction sites are ensured, control on the correct data is increased and optimization of usage of resource and human are provided.*

4.4.7. Wider Benefits

One question is asked to interviewees at "Wider Benefits" part of the case study in order to learn what outcomes come through from the implementation of ERP system at project level.

In terms of wider benefits at the corporate level, all three interviewees replied commonly as following that the more the construction company get bigger, the reaching the correct information get harder, so; *"ERP system and its database create a digital know-how memory for the company."* Also, *"ERP system provides the company a vision."*

Interviewee A also replied this question as following that along with the new ERP system, *headquarter office of the company can reach many data at construction site and managing construction projects become easier*.

Interviewee B also replied this question as following that along with the new ERP system, it is easier to create more correct and reliable analyze reports on short, middle and long run. Thus, *ERP systems increase the probability of having successful real estate development agreements and investments of the company.*

Interviewee C also replied this question as following that along with the new ERP system, *some processes are revised and enhanced due to business process reengineering that comes with ERP implementation*. In the long run, the system is getting accustomed to by current users and also, new employees began to work at the company by using this ERP system at the first day of their job. To sum up, *the new ERP system is accepted by all employees in the long run.*

4.4.8. Lessons Learnt

At this part of the case study, there were no a direct questions about the implementation phases of the ERP system that the interviewees have experienced but a general question about the whole story was asked, including the duration and process of the implementation of ERP system.

Only interviewee A from company A has defined the whole process of the ERP system implementation as “failure”. Other interviewees have defined the whole process and duration as success. When it is asked what the reason why the implementation of ERP system at company A is a failure is, the interviewee A has answered this question as following that in the long run, end users and other significant employees at the company A has shown a negative psychology to the new system and top management level did not give a strong support and commitment to the new system. At the end, many modules of the ERP system cannot be used and many critical processes for the company A are managed as old fashion like before the ERP system has implemented.

However, the implementations of the ERP system at company B and company C are defined as a “success” by the related interviewees. All modules of the ERP system has being used by the company B and company C. Also, because company C is a holding, it has carried the whole ERP system into the other branches and companies of the holding. Today, they have a huge ERP system that is very well implemented.

The interviewee C has also replied this question very well as following that *“not the computers we have used but the people at implementation team are carrying out all the implementation procedures. Therefore, even if the aim of the whole processes and implementations is a very detailed and advanced computer system, the main focus at the whole duration should be given to the humans; the end users of the company, the member of the implementation team (key implementers) and consultants… When only these people have become the focus of the whole process, a successful implementation of any system can be created.”*

5. SUMMARY AND DISCUSSION

5.1. Summary

This thesis has two research methods in its research methodology that try to explain how the implementation of an ERP system should be completed successfully. The first one is the questionnaire survey and second one is case study. The discussion chapter is based on these two analyses.

The questionnaire survey analysis is based on exploratory factor analysis and is made by using SPSS analysis and data reduction factor analysis tools. The case study is made face to face conversation in the guidance of case study question table given at the end of the case study part.

The discussion part at below is critical in terms of comparing the questionnaire survey results that comes from SPSS results, and the results of three case studies.

5.2. Discussion on the CSF of CERP Implementation and Case Study Analysis

During the interviews of the case studies, it is asked to the companies what drivers provide the ERP system to be implemented successfully, all three interviewees are replied commonly following answers that following items are very important drivers that provide an ERP system to be implemented successfully;

- Top management support
- Including of end users to implementation phases
- Knowing what we are expected from the system
- Selecting right and proper team members (*key employee/implementer*) of ERP implementation team
- Goal of the ERP implementation project should be realistic not based on wishful thinking

All interviewees have emphasized the importance of some factors that are important at the successful implementation of the ERP system. Some of them are already listed at the critical success factor analysis of this thesis. Top management support item above is in the survey as *"Top_mng_spprt"*. "Including of end users to the implementation phase" stays in the survey as *"End_user_Involvemnt"* and selecting right and proper team members (key employee/implementer) of ERP implementation team stays in the survey as *"Team_composition"*.

When it is looked at mean values of these three variables; it can be seen that the mean of top management support and commitment is about 4.5 and it can be said that this factor is at "high" or "close to very high" level, so the questionnaire survey approves that top management support is very important critical factor with respect to drivers that provide the ERP system to be implemented successfully.

The mean of team composition and end user involvement is 3.89 and 3.73, respectively. The values are close to 4 and it can be indicated that team composition and end user involvement is about at the high level, so the questionnaire survey approves that team composition and end user involvement are important critical factor with respect to drivers that provide the ERP system to be implemented successfully.

Also, top management support and commitment and team composition are at organizational factors and end user involvement is at human factors.

Table 5.1. Mean Table of Top Management Support / Team Composition / End User Involvement – Descriptive Statistics.

Descriptive Statistics

	N	Mean	Std. Deviation	Variance
top_mng_spprt	90	4,42	.887	.786
Team_composition	90	3,89	.929	.864
End_user_Involvemnt	90	3,73	.992	.984
Valid N (listwise)	90			

Table 5.2. Mean Table of Top Management Support / Team Composition / End User Involvement.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
1	*Top_mng_spprt*	Top management support and Commitment	4.42	High	Very High
4	*Team_composition*	Team Composition	3.89	Moderate	High
13	*End_user_Involvemnt*	End User Involvement	3.73	Moderate	High

At the interviews of the case study A, interviewee A adds some other items to the common items above to show that it was very important at the implementation of their system.

- First ERP structure scenario, connection between departments and module organization of the system is very important.
- Connection between the old system that the company currently using and the ERP system that will be implemented is very significant due to data migration of the past data. (The company A has some connection and compatibility problem between old accounting software and the accounting module of the new system.)
- Training is very crucial at successful implementation of the new ERP system.
- Due to parallel immigration choice of the top management, the employees have to do same work on both the old and the new system. This choice has brought some extra work on the employee, and so the motivation of the employee to the new system has dropt. Therefore, the top management support and commitment and the choice of the top executives are very important to pass successful implementation duration.

"First ERP structure scenario, connection between departments and module organization of the system" items have not been represented as only one critical factor, but it can be said that its meaning and what it stand for are close to "*choice of ERP modules*", "*cooperation between team members*" and "*team composition*" because connection between departments is provided by team composition and cooperation between team members.

Also, “connection between the old system that the company is currently using and the new ERP system” refers to “*Choice of ERP software package*” in the survey analysis, because it is a property of the new system to support old system’s data.

Interviewee B also adds some other significant items to the common items above to show that it was very important at the implementation of their system in company B as following;

- Consultants
- Selecting right and suitable ERP software and its modules
- At some point, taking initiative on business process re-engineering and adapting the ERP system.
- Implementing the system module by module instead of whole organization.
- Give attention to test phase and experience a healthy test phase

“Consultants” item has already been in the critical success factors of the questionnaire survey analysis as “use of consultants” and as variable; “*use_consultants*”. Selecting right and suitable ERP software and its modules items also stay as “Choice of ERP Software Package” and variable as *“Choice_ERP_Softw_Packg”* and also as “Choice of ERP Modules” and as variable; *“Choice_ERP_Modules.”*

Moreover, taking initiative on business process re-engineering and adapting the ERP system is defined in the questionnaire survey analysis as Organizational Change Management (*Organizational_Chng_Mngmnt* as variable in the SPSS analysis). Also, “Give attention to test phase and experience a healthy test phase” is indicated in the SPSS analysis as *“Testing_System_StartUp”*.

It can be seen that all factors mentioned by interviewee B is between level of moderate and high and, choice of ERP software package, choice of ERP modules, organizational change management and start-up & testing the system factors are close the high level importance.

Table 5.3. Mean Table of Choice of ERP Software Package, Choice of ERP Modules, Organizational Change Management and Start-up & Testing the System.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
8	*Choice_ERP_Softw_Packg*	Choice of ERP Software Package	3.64	Moderate	High
10	*Choice_ERP_Modules*	Choice of ERP Modules	3.74	Moderate	High
11	*Organizational_Chng_Mngmnt*	Organizational Change Management	3.70	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High
14	*Testing_System_StartUp*	Start-Up and Testing the System	3.69	Moderate	High

Moreover, there is an item that interviewee mentioned in the case study, that is that "Implementing the system module by module instead of whole organization." Interviewee B has explained that at the implementation of the new ERP system, it is tried to make a parallel immigration but whole company has begun to implement the new system at the same time. Thus, all errors and mistakes in the new system and the new procedures have appeared at all departments at the same time and the implementation team cannot solve the all problems in the short period of time. This situation has generated a negative feedback to the implementation team and the new system.

In the end, it can be recommended as even if parallel immigration procedures are followed, it should be thought that implementing the system module by module instead of whole organization can prevent negative feedback from end users against the implementation team and the new system.

Interviewee C also adds same significant items to the common items explained above. Many of them are similar with what interviewee B said.

- Consultant should be very experienced on their field (Also mentioned at Company B)
- Selecting right and suitable ERP software and its modules (Also mentioned at Company B)
- Business Process Reengineering (BPR) is very important at the implementation phase of ERP system. If needed to change the business work flow of the company,

the top management has to support this change in order to have successful implementation. (Also mentioned at Company B)

- Give attention to test phase and experience a healthy test phase (Also mentioned at Company B)
- Not immigrating the whole company to new system at the same time but preferring migrating whole company department by department.

The items above are same items what interviewee B said by using different words.

Furthermore, it is asked two questions to interviewees at "inputs" part of the case study in order to learn what resources have been utilized to have an ERP system in your company and what resources should be utilized to make ERP implementation successful. All three interviewees replied commonly as *"funding (monetary support), time and patience from management level"*. There is no a direct variable that refers the items above but it can be explained as "top management support" which is one of the high importance level factors that has explained at analysis part.

Additionally, interviewee A has also given details that the company A also allocate some other resources to have a successful ERP implementation such as; "*allocating extra fund for training of the employees and hiring experienced consultants.*" These items refer to "Training and support for users" and "use of consultants" at the analysis of the questionnaire survey.

Table 5.4. Mean Table of Training & Support for Users and Use Consultants.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
9	*Training_spprt_for_users*	Training and support for users	3.86	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High

Interviewee B has also given same details that the company B also show *"motivational support from top management"* to have successful ERP implementation as extra resource.

Interviewee C has given similar answers as explained at case study chapter that the company C has selected some important employees as key implementers and these employees do not work on their regular job but only work on the implementation of new EPR system. The company C has hired some other employees to make the regular works of key implementers. Thus, there were no extra work load on these key implementers and they have focused on only their implementation job. Therefore, it can be mentioned that company C has provided "*extra fund for the wages of key implementers*." This item can be defined as "*top management support."*

When it is asked to learn to companies that what *resources* should be utilized to make ERP implementation successful, all three interviewees have answered commonly as *"right and competent key implementation team and team members" and "right and competent consultants."* The first item refers to "*Project Team Competence*" and "*Team Composition*" at the SPSS analysis of the questionnaire survey. The second item partially refers to "*Use of Consultants*". As given table below; the means of the factors that come from SPSS analysis is are at high importance level at "project team competence" and "team composition factors" according to the analysis of the questionnaire.

Table 5.5. Mean Table Project Team Competence / Team Composition / Use of Consultant.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
2	*Prjct_team_competence*	Project Team Competence	4.14	High	Very High
4	*Team_composition*	Team Composition	3.89	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High

Interviewee A also indicated that *"top management support and commitment in order to get ERP system implementation period done, asking own employees to help external consultants, motivational support from top executives, extra funding for training end users"* are very significant resources that a company should allocate in order to have a successful ERP implementation. The all listed items above can be described as "top management support and commitment" factor at the SPSS analysis of critical success factors of the implementation of ERP system given in the questionnaire survey.

Interviewee B also indicated what resources they have as following that *"having support from ERP vendor and allocating extra fund in order to train end users"* are very important resources that a company should allocate in order to have a successful ERP implementation. The first item refers to "Vendor Support" at the questionnaire analysis part and the second item refers to "Training and support for users".

These both are high level importance factors at the implementation of ERP system according to the result of the questionnaire analysis.

Table 5.6. Mean Table Project Team Competence / Team Composition / Use of Consultant.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
7	*Vendor_Spprt*	Vendor Support	3.70	Moderate	High
9	*Training_spprt_for_users*	Training and support for users	3.86	Moderate	High

Interviewee C also replied this question similarly as following that *"allocating extra fund in order to train end users"* are very important resources that a company should allocate in order to have a successful ERP implementation as indicated at the case study of interviewee B.

When it is asked to learn to companies that what strategies are used to implement ERP systems successfully, all three interviewees replied only one common item as *"top management to know what is expected at the end of the implementation phase"*. This is one of the important factors mentioned at the questionnaire analysis and refers to the factor of "Clear goals and objectives". "Clear goals and objectives" is a high level importance factor with a mean of **"***4.31***"** according to the results of the analysis of the questionnaire survey.

Interviewees A and B have also indicated *"planning system and module structure correctly at the beginning of the implementation phase" and "top management support to use the ERP system continuously at the end of the implementation"* are very important strategies that a company should use in order to have a successful ERP implementation. The latter item can be described by one factor mentioned in the questionnaire analysis as

top management support but the first item is the collection of many factors, such as; clear goals and objectives, choice of ERP software packages, choice of ERP modules and use of the consultants, because in order to plan system correctly at the beginning of the implementation phase, you need knowledge on many things about the implementation phases, durations and procedures, the ERP system and modules.

Interviewee C has also indicated that *"hiring key implementation team as full time and only focusing on the ERP system implementation at not their regular works, not making parallel immigration and preferring direct immigration instantly, making contracts with key implementer team members in order to prevent them to quit from their jobs and not to cut implementation phase, using key implementer team as interior consultant after implementation system is done, making a back-up system"* are very important strategies that a company should use in order to have a successful ERP implementation. These are very significant "organizational" items mentioned by interviewee C but all of these items cannot be named by the factors in the questionnaire survey "*directly*."

However, they can be explained by the factors in the questionnaire indirectly as following that *"hiring key implementation team as full time and only focusing on the ERP system implementation at not their regular works" and "making contracts with key implementer team members in order to prevent them to quit from their jobs and not to cut implementation phase"* can be thought as "top management support and commitment".

"*Using key implementer team as interior consultant after implementation system is done"* is a very good strategy that company C has applied and this item can be defined as top management support as well because key implementers are satisfied by the top management level by making new contracts with their company.

"Not making parallel immigration and preferring direct immigration instantly" and "making a back-up system" items can be thought as "technological and organizational" common factors.

In case study part, it is asked to learn to companies that what challenges and barriers are faced by project implementation team in your company and all three interviewees have

answered commonly as *"old habits of the employees and not to leave old system and procedures" and "defining new system as cumbersome."* It can be seen that these items are not a direct factor mentioned in the questionnaire survey but it can be thought that both items mentioned above come from the "End User Involvement" because end users of the companies are not involved to the implementation phase and they cannot present their drawbacks about the new system. If the end users are involved and contributed to the implementation phase of the new ERP system, the employees cannot argue about the system they contributed after the startup.

Interviewee A also replied this question as following that *company A has not a general ERP strategy at the implementation phase.* Also, due to the parallel immigration of the past data, making extra works of implementation phase and making their regular jobs at the same time, there was *negative psychology at the employees.* The first item is indicated as "Clear goals and objectives" in the questionnaire analysis. Also, the second item cannot be referred directly to a factor but it may be mentioned as following that due to not having a top management support on getting extra employee has created extra work load and negative psychology on the current employees.

Interviewee B also indicated similarly this question as following that *"Impatience to the errors and mistakes at the implementation phase"* and *"negative psychology due to parallel immigration phase and additional works on the employees"* are challenges and barriers that implementation team at company B has faced during the ERP implementation.

Interviewee C also replied the question of what challenges and barriers are faced by project implementation team in your company similarly but in different words as following that *"additional works on the employees due to ERP implementation, having construction sites at different region of the world, internet connection problems in the construction sites at different region of the world, not training employees at the construction abroad and Impatience to the errors and mistakes at the implementation phase and leaving job of one the key implementers"* are challenges and barriers that implementation team at company C has faced during the ERP implementation. Because the company C is an international holding, there were additional challenges at the implementation of the system. "*Having construction sites at different region of the world, internet connection problems in the*

construction sites at different region of the world, not training employees at the construction abroad" are the geographical barriers that the implementation team of the company A has faced. These barriers can be eliminated by only top management support and commitment because the implementation team would need extra fund and time to pass these challenges.

In case study chapter, it is mentioned that it is asked to learn to companies that what factors (enablers) are facilitating implementation process of ERP system in your company and all three interviewees replied commonly as *"creating a know-how for the company and more transparent system on finance and accounting provide top management support" and "Creating executive and operational management reports easily and reaching the right data from every department and construction sites provide top management and technical team support and motivation."* If it is shown to the end users that the new ERP system will make your works easy and fast, of course the employees give support to new system. Creating many reports that normally take many man-hours easily and fast, reaching the data of different departments would create motivational support from both top management and end users.

Interviewee C also replied this question as following that company C has chosen *"very experienced key implementation team leader"* and this team leader has written procedures on ERP system, balance tension during immigration and supply well communication with critical departments. Also, the implementation team at company C has made *training to end users continuously and made test on ERP systems continuously.* The first item is "Effectiveness of Project Leader" factor mentioned at the analysis of the questionnaire and the latter one is "Training and support for users" factor investigated in the analysis of the questionnaire.

In the case study analysis part, it is asked to learn to companies that what achievements come through from the implementation of ERP system "at project level", all three interviewees replied commonly as *"Creating executive and operational management reports for each construction site fast and easily,"* and *"Reaching the correct and current data of the construction sites at different location fast."* These items also explain the

automation of the reporting and due to this automation, the optimization of the resources are provided such as; the less employee will be allocated for reporting works.

Interviewee A also replied this question as following that along with the new ERP system, *any employee of a construction site can reach only some portion of whole database* of ERP system according to its position, department and its construction site. All authorization procedures are determined at the implementation phase by the key implementers and the top management level executives.

Interviewee B also mentioned that along with the new ERP system, *preventing information pollution* at any database is provided. This item also can be thought as under the subject of authorization.

Interviewee C also mentioned that that along with the new ERP system, *the information of the construction sites at different region of the world can be collected easily, integration between construction sites are ensured, control on the correct data is increased and optimization of usage of resource and human are provided.* For an international holding, it is very significant to reach the correct data at different branches at different region. Along with the new system, the integration between the construction sites and headquarter office is provided and the control on the data is increased. The integration and the control of the branches and the construction sites will raise the optimization of the usage of the human and material resources.

Lastly, in the case study analysis part, it is asked to companies that what outcomes come through from the implementation of ERP system at project level, all three interviewees replied commonly as following that the more the construction company get bigger, the reaching the correct information get harder, so; *"ERP system and its database create a digital know-how memory for the company."* Also, *"ERP system provides the company a vision."* Interviewee A also replied same question as following that along with the new ERP system, *headquarter office of the company can reach many data at construction site and managing construction projects become easier*. Interviewee B also replied same question as following that along with the new ERP system, it is easier to create more correct and reliable analyze reports on short, middle and long run. Thus, *ERP*

systems increase the probability of having successful real estate development agreements and investments of the company. As being a REIT company, it is very significant to have right investment reports and prudent real estate development agreements.

Interviewee C also replied this question as following that along with the new ERP system, *some processes are revised and enhanced due to business process reengineering that comes with ERP implementation*. In the long run, the system is getting accustomed to by current users and also, new employees began to work at the company by using this ERP system at the first day of their job.

To sum up, *the new ERP system is accepted by all employees in the long run.* This item refers to "Organizational Change Management" factors mentioned at the analysis of the questionnaire survey and the mean of it is 3.70 which means that it is close to high level of importance.

Table 5.7. Mean Table of Critical Success Factors.

No	VARIABLE	FACTORS	MEAN	Importance Level FROM	Importance Level TO
1	*Top_mng_spprt*	Top management support and Commitment	4.42	High	Very High
2	*Prjct_team_competence*	Project Team Competence	4.14	High	Very High
3	*Clear_goals_objctv*	Clear goals and objectives	4.31	High	Very High
4	*Team_composition*	Team Composition	3.89	Moderate	High
5	*Effectvnss_Prjct_Leader*	Effectiveness of Project Leader	4.06	High	Very High
6	*Cooperation_Btwn_Team_Mmbrs*	Cooperation Between Team Members	4.06	High	Very High
7	*Vendor_Spprt*	Vendor Support	3.70	Moderate	High
8	*Choice_ERP_Softw_Packg*	Choice of ERP Software Package	3.64	Moderate	High
9	*Training_spprt_for_users*	Training and support for users	3.86	Moderate	High
10	*Choice_ERP_Modules*	Choice of ERP Modules	3.74	Moderate	High
11	*Organizational_Chng_Mngmnt*	Organizational Change Management	3.70	Moderate	High
12	*Use_consultants*	Use of consultants	3.37	Moderate	High
13	*End_user_Involvemnt*	End User Involvement	3.73	Moderate	High
14	*Testing_System_StartUp*	Start-Up and Testing the System	3.69	Moderate	High

Table 5.8. Descriptive Statistics Table of CSF.

Descriptive Statistics

	N	Min	Max	Mean	Std. Dev.	Variance
top_mng_spprt	90	2	5	4.42	.887	.786
Prjct_team_ competence	90	1	5	4.14	1.066	1.136
Clear_goals_objctv	90	1	5	4.31	.856	.734
Team_composition	90	1	5	3.89	.929	.864
Effectvnss_Prjct_ Leader	90	1	5	4.06	.916	.840
Cooperation_Btwn_ Team_Mmbrs	90	2	5	4.06	.839	.705
Vendor_Spprt	90	1	5	3.70	.999	.999
Choice_ERP_Softw_ Packg	90	1	5	3.64	1.095	1.198
Training_spprt_for_ users	90	1	5	3.86	1.034	1.069
Choice_ERP_Modules	90	1	5	3.74	.931	.867
Organizational_Chng_ Mngmnt	90	1	5	3.70	.905	.819
Use_consultants	90	1	5	3.37	.953	.909
End_user_Involvemnt	90	1	5	3.73	.992	.984
Testing_System_ StartUp	90	1	5	3.69	1.046	1.093
Valid N (listwise)	90					

In conclusion, only interviewee A has defined the implementation process of the ERP system as a failure. Interviewee B and C have defined the whole process and duration as success. When the main criteria at the failure of the company A are examined, it can be stated that end users and other significant employees at the company A has shown a negative psychology to the new system and top management level cannot give a strong support and commitment to the new system and top management executives cannot prevent end users to accept new system. Therefore, it can be expressed that top management support and commitment, clear goals and objectives of what top management level expected from the system and end user involvements are really critical subjects in order to have a successful implementation processes.

However, as mentioned before, the implementations of the ERP system at Company B and Company C are defined as a “success”. All modules of the ERP system has being used by the Company B and Company C. Also, because Company C is a holding, it has

carried the whole ERP system into the other branches and companies of the holding. Today, they have a huge ERP system that is very well implemented.

5.3. Comparison of the Results with Respect to Other Studies

Ahmed *et al*., (2003) has indicated the importance of training in the study as following that "7 respondents recommended the need of extensive training programs to fully understand the functionality of ERP software to enjoy their benefits. Majority of these respondents pointed out that the training must be started with the top management and then on the middle and lower management respectively." Also, they have stated that "Technical inspectors trained in the field generally do not have the computer skills to use an ERP system without substantial training and handholding." The study of Ahmet *et al*., (2003) has been carried out in US of America, but same comments also can be mentioned in this study. At both questionnaire survey and case study parts, it is mentioned that training of users is very important success factor at the implementation of ERP systems.

Also Ahmet *et al*., (2003) has stated that "Current management practices of many construction organizations are maverick and "shoot from the lip" style." Similarly, at the questionnaire survey part of this study, it is asked that what the barriers and challenges the implementation team has faced, the common answers from three interviewees was "old habits of the employees and not to leave old system and procedures"

Moreover, the same study has stated that "The ERP software vendors must work with the professional in the construction industry to developed more customized solutions for the contracting firms." Unfortunately, there is no tier I ERP vendor that has an ERP solution that is specifically produced for construction industry. Therefore, the support of ERP vendors in order to develop and customize the standard ERP system to a construction company is very significant. At this study, "Vendor Support" is one of the important technological factors in order to have successful ERP implementation. However, it should be noted that at the case study part, the interviewees have indicated that their companies choose to use external consultants instead of ERP Vendor support.

Chung (2007) has stated that “It can be interpreted that most users believe that if the functionality of their ERP system is good enough to support their necessary business functions, they think their system is useful. In other words, how to define the functions of the ERP system to match the business requirements is the most important thing to make the ERP system more useful.” At that study, functionality can be understood as enough tools that end user can use and can get benefits from. This statement is directly related to “Choice of ERP Software Package” and “Choice of ERP Modules.” If the software package and the modules of ERP system are selected correctly, the functionality of the system will be high for that construction company. Both two factors are mentioned as significant technological factors in this study.

Moreover, Chung (2007) has stated that “The progress and quality of the ERP implementation project are the main indicators of ERP project success in this research. As a result, “Internal Support” and “Consultant Support” are direct determinants of the progress of the ERP project, and both have a significant impact on it.” This study has same result that internal support of the study of Chung (2007) can be seen as “Top Management Support and Commitment” success factor of this study and consultant support has already mentioned at the list of questionnaire survey CSF list as “Use of Consultants.” Chung (2007) has also stated that “Choosing strong consulting partners is required for ERP project success. They can lead the company in the right direction to have a successful ERP implementation in both progress and quality.” It can be seen at Table 5.7. that top management support and commitment is the most important success factor with highest mean value. However, “Use of Consultants” success factor has lowest mean value according to questionnaire survey results at this study. It can be concluded that Turkish companies generally do not rely much on the consultant support during or before ERP implementation to the same extent that the U.S. companies do.

Chung (2007) has stated that “Selecting the right software and defining the necessary functions properly determines the project success in terms of overall quality and scope.” Similarly, at this thesis, “Choice of ERP Software Package” and “Choice of ERP Modules” are mentioned as important success factors at the questionnaire survey part. Also Chung (2007) has stated that “Use” and “Quality” are main predictors of “ERP Benefits.” “Use” part of this conclusion can be indirectly interpreted as “End User Involvement” of

this thesis because it is mentioned that usage of ERP system is provided by involving end users into the implementation phase. Chung also has stated at the same study that “All the members in the company should be encouraged to use the ERP system because their use can increase the company’s business value.” This statement also indicates the importance of end user involvement for a successful implementation period for USA companies. End user involvement is one of the critical success factors that mentioned in this study.

At the same study, Chung has indicated that “The Company should clearly define what positive results can be expected from the use of the ERP system before or during ERP implementation. This can make the system more useful, and help users understand why they should use the ERP system.” This is a direct definition of “Clear goals and objectives” success factors of this thesis and it has the second highest mean value of critical success factors.

6. CONCLUSIONS AND FURTHER WORK

6.1. Major Findings and Contributions of the Study to the Literature on CERP

Many researchers have studied the concept of ERP and CERP system in many ways in order to explain the increase at effectiveness of the construction companies by using these advanced computer systems. Construction companies need to learn to optimize their resources and raise their effectiveness in order to cope with competitiveness in today's business world. In order to increase their effectiveness and business performance, construction companies should use these ERP systems according to suitable implementation strategies.

Construction sector is different than manufacturing sector. It has a very dynamic structure because of the construction site at different region of the world and making different kind of construction projects. Because of this reason, it is important to learn from the professionals and from the project cases.

One of the main concerns of this thesis was to find out the importance level of the critical success factors of the implementation of CERP system at construction companies. Also, the results of the questionnaire analysis are compared with case study interviews in order to check and confirm the results.

According to both questionnaire survey and case study analysis, there are highly significant success factors. These are; "Top management support and Commitment", "Project Team Competence", "Clear goals and objectives", "Team Composition", "Effectiveness of Project Leader", "Cooperation Between Team Members", "Vendor Support", "Choice of ERP Software Package", "Training and support for users", "Choice of ERP Modules", "Organizational Change Management", "End User Involvement" "Start-Up and Testing the System." However this list of factors does not include "use of consultants". All of the significant factors mentioned have critical role at the implementation of an ERP system in construction firm. All factors should be provided at the implementation phase because every single of them has a significant role in itself.

- *Top management support and commitment* should be provided in order to have a continuity of the implementation with regards to supplying enough funding and motivational support and resources. ERP systems try to change management of business processes in order to make a more effective and productive management procedures and processes. However, this attempt is faced by negative feedbacks and resistance from the employees of the companies. Only top level management support and commitment can provide to exceed this problem and reengineer the business processes. Also, all of these attempts should be carefully managed and followed by competent team and team members at full time working hours. Therefore, top management should ensure some extra funds for team members of the implementation team as human resources and motivational support. Moreover, according to factor analysis, top management support and commitment is one of the important organizational factors.
- *Project Team Competence* is one of the important critical success factors in order to decrease the errors at the system and negative feedback at the business process re-engineering during the implementation phase. Along with the proper project team competence, it is ensured that the modeling of a construction company and understanding the processes of the departments can be made easily, fast and rightly. Moreover, according to factor analysis, project team competence is one of the important organizational factors. At the case analysis, all interviewees have stated that project team competence is very essential as drivers to implement ERP system successfully. Also, all interviewees have indicated that "right and competent key implementation team and team members" is a very significant factor in order to implement the new system successfully.
- *Clear goals and objectives* is very significant success factor in order to finish the implementation project successfully because this factor defines what a successful project is. Clear goals and objective factor is very dependent on top management support and commitment factor because clear goals and objectives of the ERP implementation projects begin at the top management level. Moreover, according to factor analysis, clear goal and objective is one of the important organizational factors. All interviewees have also indicated that it is one of the important subjects to know what we are expecting from the new system.

- *Team Composition* is an important critical success factor in order to integrate whole department of the company to the system and getting lesser negative feedback at the business process re-engineering during the implementation phase. Along with the proper team composition, it is ensured that the all departments of the construction company are modeled and connected to the system better and in the right way. Moreover, according to factor analysis, team composition is one of the important organizational factors.
- *Effectiveness of Project Leader* is one of the critical factors and key enablers to overcome many problems in order to have a healthy implementation phase because effective project leader can exceed some communication problems between people and departments and decrease the tension during the test and start-up the system phase. Moreover, according to factor analysis, effectiveness of project leader is one of the important human factors and its mean is at high importance level at the questionnaire survey.
- *Cooperation between Team Members* is one the critical factors to ensure a healthy implementation phase and experience a better immigration period. Also, this factor helps to exceed impatience to the errors and mistakes at the implementation phase. Moreover, according to factor analysis, team composition is one of the important organizational factors and this factor has high level importance.
- *Vendor Support* is one of the important technological factors in order to model ERP system better. However, only some of the companies mentioned at the case study part have willingness to receive vendor support. Interviewees do not mention about the vendor support a lot. They mean that companies generally try to buy the ERP system and use external consultants in order to decrease the cost of the system at the beginning, such as; SAP system at the company C. However, interviewee B has stated that “having support from ERP vendor” is an important resource at the successful ERP implementation. Therefore, it can be seen that vendor support factor is dependent on choice of ERP software package because company C has known that support from ERP vendor can be very costly. Vendor Support factor is close to high importance level with 3.70 mean.
- *Choice of ERP Software Package* is one of the important factors in order to model ERP system well. Integration of new system with the old system and the clear goals and objective factors are dependent to choice of ERP software package. Interviewee

A has indicated many times that the new ERP system at their construction company has serious problems with the old accounting software module of the system. It is very important choice to decide which ERP software system will be used at their company. It a factor that connects many technological and organizational common factors. According to questionnaire factor analysis, choice of ERP software package is a technological common factor.

- *Training and Support for Users* is one of the critical factors in order to have a successful implementation phase in many view. Training and support for users is an important resource that utilizes to finish the implementation phase of the ERP system successfully. Also, it decreases the negative feedback from the end users and increases the end users involvement to the implementation phase. Having extra fund for the training of the end users is also an important resource and connected with the "training and support for users" factor directly. Additionally, interviewee C has mentioned at the case study part that the company has known that training the end users of the company is very important but it was the one of main challenge to train the end users at the construction site abroad. Even if there were many technical problems, it is never stop to continue the training and all upgrades of the new ERP system has been announced to all end users related with that upgrade. According to factor analysis, it is one of the common human factors. All interviewees have mentioned about this factor that it is important to train users and update their knowledge with the new feature of the system regularly.
- *Choice of ERP Modules* is one of the important factors in order to model ERP system better and integrate the departments of the company with each other effectively. Integration between the modules of the system is as significant as the choice of the ERP system. It is directly connected with the choice of ERP software selection. According to questionnaire factor analysis, it is one of the common technological factors and it has close to high importance level with 3.74 mean.
- *Organizational Change Management* is one of the very important human factors in order to implement ERP system successfully. It is very dependent on top management support and commitment in order to manage change management and business process re-engineering in a healthy way. It is an opportunity to use new ERP system in order to make an organizational change management and business process re-engineering because whole this implementation phase can make this

organizational change meaningful, under control and effective. Company C at the case study has experienced similar change management period and new ERP system has guided them to change their routine works. According to factor analysis by using SPSS data reduction tools, it has examined that organizational change management is one of the common human factors with 3.70 mean.

- *Use of consultants* is one of the human factors according to questionnaire survey analysis. The mean of use of consultant is at moderate level however according to case studies, especially at the beginning of the implementation phase, the interviewees have indicated that it is very important factor to use consultants to select right ERP packages, modules and determining proper way of implementation. Also, the experienced external consultants can guide the top management level well and this is directly dependent on clear goals and objectives factors in order to ensure top executives to know what is expected from the new system.
- *End User Involvement* is one of the human factors according to questionnaire survey analysis. Its mean is at high importance level. According to case study part, it can be said that it is very critical factor to decrease the negative psychology at the test and start-up the system phase and also it really prevent the problems of the implementation at the beginning. Not only training them but also involving end users to the implementation phase, receiving ideas on the model of the company currently and on what it should be can help the implementation team members incredibly. The main and the most crowded user type will be the current end user of the company and the new system should satisfy their minimal needs.
- *Start-Up and Testing the System* is one of the common human factors according to questionnaire survey analysis with the mean of 3.69. Both interviewee B and C has indicated that "Give attention to test phase and experience a healthy test period" is critical driver to motivate implementation members and end users to complete the implementation phase.

In conclusion, it is very suitable and meaningful to mention that the success of the implementation can be shortly stated as Interviewee C has suggested as follows:

"Not the computers we have used but the people at implementation team are carrying out all the implementation phases and procedures. Therefore, even if the

aim of the whole processes and implementations is a very detailed and advanced computer system, the main focus at the whole duration should be given to the humans; the end users of the company, the member of the implementation team (key implementers) and consultants… When only these people have become the focus of the whole process, a successful implementation of any system can be created."

It is clear that even if the system that the companies try to implement is a computer software and hardware, the actual processes go through people who will implement and use the system. The main focus should be on the people and human resources in order to have a successful implementation period and positive result.

6.3. Limitations of the Study

One of the limitations of this study is about the case studies. The case studies are carried out with "only one person" at the construction company. The important points at the implementation of ERP systems may change according to his or her point of view. In order to overcome this limitation, three case studies are made and all interviews are made with "one of the key implementers at the implementation team" of the construction companies. However, interviews with more people could have enriched the data collected.

6.4. Recommendations for ERP Implementation

There are five implementation phases that are explained and used at the questionnaire survey. These are; "It is not planned to use any ERP system", "At the primary stage of ERP system implementation", "At the final stage (close to completion) of ERP system implementation", "The implementation of ERP system has been completed about 1 year ago" and "ERP system has being used more than 1 year." For each phases, some recommendations can be given according to the analysis and the results of this study.

- *Not planned to use any ERP system Stage*: Top executives and management level can investigate the benefits and suitability of ERP system for their company. Do any of these systems have some advantages, such as; lowering the operation cost, increasing the profitability and efficiency? Also;

competitor companies and their ERP systems can be examined. It can be asked some ERP consultant to guide whether an ERP system is a really need for your company in order to expand the company in near future.

- *Primary (Feasibility) Stage*: At this stage, top management level of construction company should be careful at the selection of ERP system and modules and should be informed on what benefits they will get from the new system. Therefore, "use of consultant", "clear goals and objectives", "choice of ERP software package" and "choice of ERP modules" factors are very important at this stage. Top management level of construction companies try to use experienced consultants in order to define what goals and objective will be at during and after ERP implementation period and what kind of system and modules should be selected.
- *(Main Implementation Period &) Final Stage*: At this stage, all factors mentioned in the questionnaire survey should be carefully monitored. At this stage, top management support and commitment to the system and the implementation team is very significant. End users should know that top management level supports the new system and the implementation team. Also, a competent and suitable implementation team should be created and cooperation between team members should be provided. Key implementer team members are tried to be employed during and after the implementation period. Effective project team leader should be selected and enough top management support should be given to the team leader. Training for the users at companies is crucial. End users should be informed from every update of the system. If business process re-engineering is needed, enough support should be given the implementation team to re-organize company work flow and manage organizational change management. Testing the new system and start-up procedures should be done carefully. End users and their comments should be involved at every period of this stage.
- *Completed System about 1 year ago:* The top management support and commitment have to continue to end users to understand that the new system will be used at the future of the company. This is very critical stage that the users to get accustomed to the new system.

- *System is active more than 1 year:* Training the new employees in order to learn and get them accustomed to new system is very important. Also, key implementation team members should be satisfied and keep at the company, and signing a long period contract with team members or increasing their wages are one of the good way to ensure this.

6.5. Recommendations for Further Works

By using the same parameters and research methods in this study, data from companies of other sectors or other nationalities can also be collected in order to examine the results of different sectors or same sector of different countries.

Also, in order to reveal the different experiences/perceptions of people, case study data can be collected from different interviewees and the list of the companies that filled the questionnaire survey can be enlarged. When the differences among those answers can be investigated, a more complete and reliable analysis can be made.

APPENDIX A: A SAMPLE OF THE QUESTIONNAIRE

The Questionnaire on The Investigation of Critical Success Factors at the Implementation of ERP Systems

ERP is the abbreviation of "Enterprise Resource Planning"

ERP systems are integrated IT systems that contains all departments and all functions of an organizations.

(Your feedback will be used only in this academic research.)
* Required

Your Age? *

What is the main business area of your company? *

- ○ Counselor (Advisor) & Consulting / Project & Construction Management
- ○ Contractor (Construction)
- ○ Project Design (Architectural / Structural / MEP) Firms
- ○ Other:

What is the age of your company that is in construction sector? *

How many years have you been working in construction sector? *

Please select the total turnover of your company.

- ◉ 2 Million USD or less
- ○ 2 Million USD - 5 Million USD
- ○ 5 Million USD - 10 Million USD
- ○ 10 Million USD - 20 Million USD
- ○ 20 Million USD - 50 Million USD
- ○ 50 Million USD or more
- ○ I do not know

What is the number of total employee in your company? *

- ○ 0 - 20
- ○ 21 - 50
- ○ 51 - 100
- ○ 101 - 200
- ○ 201 - 500

- ○ 501 or more

What is your position in your company? *

- ○ Chairman of the Board of Directors
- ○ Member of the Board of Director
- ○ General Manager
- ○ Vice General Manager etc.
- ○ Project Coordinator
- ○ Project Manager
- ○ Manager Level (Planning / Cost Control / Design / Sale etc.)
- ○ Chief Level (Construction Site / Planning / Mekanical / Elektrical / Design etc.)
- ○ Engineer & Architect
- ○ Technician
- ○ Other:

What is the your department? *

- ○ Accounting Department
- ○ Finance Department
- ○ Technical Office / Planning / Cost Control & Tender / Progress Payment Department
- ○ Administrative Affairs / Operation Department
- ○ Architectural / Structural / Mechanical / Electrical Design Department
- ○ Construction (Site)
- ○ Sale Department
- ○ Human Resources (HR) Departmant
- ○ Business Development Department
- ○ Marketing Department
- ○ Purchasing / Procurement Department
- ○ Other:

In your company, is there any ERP system that you have been currently using or at implementation phase? *

- ○ Yes
- ○ No

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The Questionnaire on The Investigation of Critical Success Factors at the Implementation of ERP Systems

* Required

Please inform us about the ERP system that has being currently used or the system that is at implementation phase?

What is the name of ERP Software Implemented in your company or which system has your company been implementing? *

- ○ SAP
- ○ Oracle
- ○ Microsoft Dynamics (Navision)
- ○ Yapıtasi
- ○ Sage
- ○ NetSuite
- ○ OpenERP
- ○ My Company has developed/is developing its own ERP system!
- ○ Other:

What is the level of implementation of ERP system in your company? *

- ○ It is not planned to use any ERP system
- ○ At the primary stage of ERP system implementation
- ○ At the final stage (close to completion) of ERP system implementation
- ○ The implementation of ERP system has been completed about 1 year ago
- ○ ERP system has being used more than 1 year
- ○ Other:

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The Questionnaire on The Investigation of Critical Success Factors at the Implementation of ERP Systems

* Required

Determination of "The Importance Levels" of CSF (Critical Success Factors)

Please state the importance level of listed factors in ERP implementation.

1 = Very Low; 2 = Low; 3 = Moderate; 4 = High; 5 = Very High

Top management support and commitment *

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Project Team Competence *

Qualitative and quantitative adequacy and competence of the implementation team that will manage and complete the ERP system implementation from the beginning to the end

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Clear goals and objectives *

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Team Composition *

Which departments the employees of ERP implementation team working at...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Effectiveness of Project Leader *

The competence and effectiveness of the leader of the implementation team in terms of knowledge and experience that will manage and complete the implementation of ERP system from feasibility phase to testing and start-up phase.

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Cooperation Between Team Members *

The cooperation between team members that will manage and complete the ERP system

implementation from feasibility phase to testing and start-up phase.

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Choice of ERP Software Package *

Determining right and suitable ERP software for a company...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Vendor Support *

The support of ERP Vendor company at pre-sales and, during and after implementation...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Choice of ERP Modules *

Determining right and suitable modules for your company. For example; CRM, Accounting, Project Management etc...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Training and support for users *

Training and support for users during and after the implementation of ERP...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

Organizational Change Management *

The management of business process re-engineering after the implementation of ERP system...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

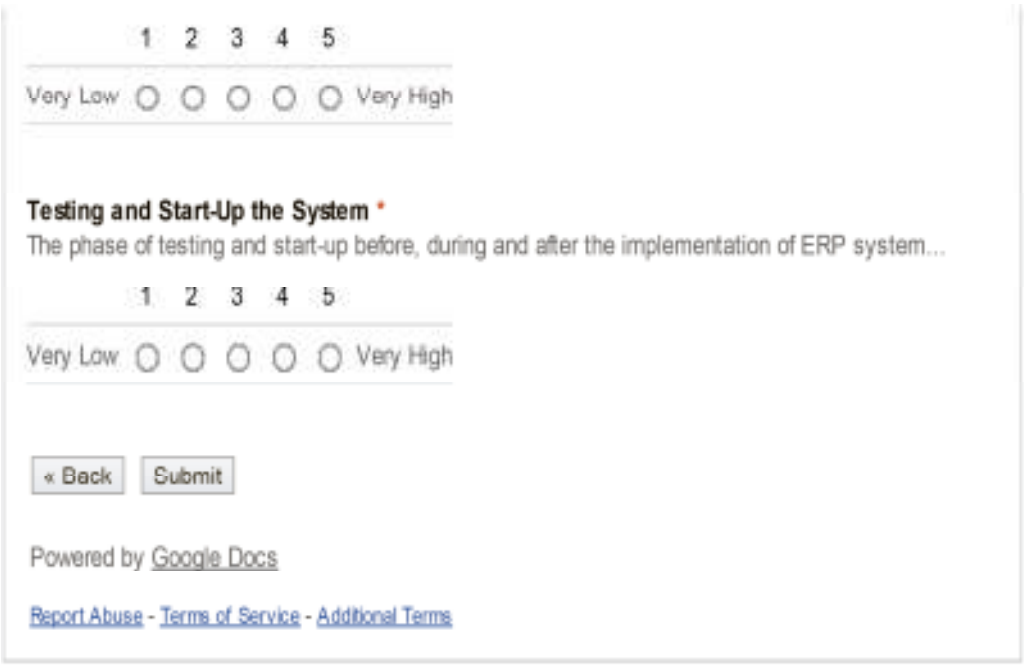
Use of consultants *

The employment of qualified consultants at the implementation of ERP system...

	1	2	3	4	5	
Very Low	○	○	○	○	○	Very High

End User Involvement *

The involvement of end users to the implementation phase of the system during the period of the implementation...



1 2 3 4 5

Very Low ○ ○ ○ ○ ○ Very High

Testing and Start-Up the System *

The phase of testing and start-up before, during and after the implementation of ERP system...

1 2 3 4 5

Very Low ○ ○ ○ ○ ○ Very High

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APPENDIX B: CASE STUDY COMPARATIVE ANSWER TABLE

SUBJECTS	QUESTIONS	COMMON	Company A	Company B	Company C
GENERAL	Name of ERP system implemented:		YAPITAŞI	MS Dynamics Nav. (Navision)	SAP
	Total Implementation duration of the system		ABOUT 1.5 YEARS	3 YEARS	3 YEARS
	Modules of ERP system implemented		Purchasing/Procurement, Progress Payment, Reporting and Planining Modules	Finance, accounting, project management, Purchasing/Procurement, Planning, Human Resources, CRM and post-sale support systems	Financial accounting, cost accounting, material management (mm), purchasing, project management, plant maintanance, HR, Asset accounting
	Type of the company that implemented ERP system		Real Estate Developer / Contruction	REIT / Real Estate investment trust	Contruction / Contractor
DRIVERS	The needs and drivers for ERP system	- reaching same business data, - reporting right and current information about businesses, - creating spontaneous management reports.”	- creating a central system that can be used by the employees of different departments easily and ensures them to reach the data of different departments and so, the integration between different departments is created	- healthy following of business orders and saves time and resources in the long run	- integration between different construction sites at different geography and the headquarter office, - saving time and resources in the long run and healthy following of business orders. - Also it is aimed to connect the different companies inside the holding by using ERP system.
	Drivers of ERP system to be implemented successfully	- Top management support - Including of end users to implementation phases - Knowing what we are expected from the system - Selecting right and proper team members (key employee/implementer) of ERP implementation team - Goal of the ERP implementation project should be realistic not based on wishful thinking	- First ERP structure scenario, connection between departments and module organization of the system is very important. - Connection between the old system that the company currently using and the ERP system that will be implemented is very significant due to data migration of the past data. - Training is very crucial at successful implementation of the new ERP system. - Due to parallel immigration choice of the top management, the employees have to do same work on both the old and the new system. This choice has brought some extra work on the employee, and so the motivation of the employee to the new system has dropt. Therefore, the top management support and commitment and the choice of the top executives are very important to pass successful implementation duration.	- Consultants - Selecting right and suitable ERP software and its modules - At some point, taking initiative on business process re-engineering and adapting the ERP system. - Implementing the system module by module instead of whole organization. - Give attention to test phase and experience a healthy test phase	- Consultant should be very experienced on their field. - Selecting right and suitable ERP software and its modules (Also mentioned at Company B) - Business Process Reengineering (BPR) is very important at the implementation phase of ERP system. If needed to change the business work flow of the company, the top management has to support this change in order to have successful implementation. - Give attention to test phase and experience a healthy test phase (Also mentioned at Company B) - Not migrating the whole company to new system at the same time but preferring migrating whole company department by department.

INPUTS	Resources utilized to have an ERP system	- funding (monetary support), - time and patience from management level	- allocating extra fund for training of the employees and hiring experienced consultants	- motivational support from top management	- extra fund for the wages of key implementers (Because they leave their normal routin jobs)
	Resources utilized to make ERP implementation successful:	- Right and competent key implementation team and team members - right and competent consultants	- top management support and commitment on getting ERP system implementation period done, - asking own employees to help external consultants, motivational support from top executives, extra funding for training end users	- having support from ERP vendor - allocating extra fund to in order to train end users	- allocating extra fund to in order to train end users
TOOLS	Tools used to implement ERP system:	- computer and computer systems, servers - some software to immigrate past data to new system	-	-	- extra tools and privileges like; extra room and extra director
	Strategies used to implement ERP systems:	- top management to know what is expected at the end of the implementation phase	- planning system and module structure correctly at the beginning of the implementation phase - top management support to use the ERP system continuously at the end of the implementation	- planning system and module structure correctly at the beginning of the implementation phase - top management support to use the ERP system continuously at the end of the implementation	- hiring key implementation team as full time and only focusing on the ERP system implementation not their regular works - not making parallel immigration and preferring direct immigration instantly, - making contracts with key implementer team members in order to prevent them to quit from their jobs and not to cut implementation phase - using key implementer team as interior consultant after implementation system is done - making a back-up system
CHALLENGES / BARRIERS	The Challenges/Barriers faced by project implementation team:	- old habits of the employees and not to leave old system and procedures - defining new system as cumbersome	- company A has not a general ERP strategy at the implementation phase. - there was negative psychology at the employees due to extra work of parallel immigration	- Impatience to the errors and mistakes at the implementation phase - negative psychology due to parallel immigration phase and additional works on the employees	- additional works on the employees due to ERP implementation, - having construction sites at different region of the world, - internet connection problems in the construction sites at different region of the world - not training employees at the construction abroad - Impatience to the errors and mistakes at the implementation phase - Leaving job of even only one the key implementers

ENABLERS	Factors facilitating the implementation process of ERP:	- creating a know-how for the company and more transparent system on finance and accounting provide top management support - Creating executive and operational management reports easily - Reaching the right data from every department and construction sites provide top management and technical team support and motivation	-	-	- very experienced key implementation team leader
PROJECT LEVEL BENEFITS	Achievements through implementation of ERP at project level:	- Creating executive and operational management reports for each construction site fast and easily - Reaching the correct and current data of the construction sites at different location fast	- any employee of a construction site can reach only some portion of whole database	- preventing information pollution	- the information of the construction sites at different region of the world can be collected easily - integration between construction sites are ensured, - control on the correct data is increased - the optimization of usage of resource and human are provided
WIDER BENEFITS	Outcomes of the implementation of ERP system	- ERP system and its database create a digital know-how memory for the company - ERP system provides the company a vision	- Headquarter office of the company can reach many data at construction site - Managing construction projects become easier	- ERP systems increase the probability of having successful real estate development agreements and investments of the company.	- Some processes are revised and enhanced due to business process reengineering that comes with ERP implementation

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