DETERMINING AND SIMULATING THE BEST POSSIBLE SYSTEM ARCHITECTURE OF PROJECT-BASED ERP SYSTEMS IN CONSTRUCTION INDUSTRY

by

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ABSTRACT

DETERMINING AND SIMULATING THE BEST POSSIBLE SYSTEM ARCHITECTURE OF PROJECT-BASED ERP SYSTEMS IN 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. At this point, Construction Enterprise Resource Planning (C-ERP) systems provide construction companies with much more integrated and effective system to overcome this ineffectiveness, fragmentation of departments and low performance issues. However, regular ERP systems is not completely suitable for project-based construction organizations and transforming a regular ERP system to a tailored C-ERP system for a construction organization can have very long implementation periods until a smooth and efficient performance. Therefore, identifying the needs and expectations of construction industry for a well-defined and prepared C-ERP system, and determining and examining best possible system architecture components of project based C-ERP systems plays crucial role. In this thesis, this subject is studied based on data collected through six real experience case studies and a questionnaire survey. Architecture of Integrated Information Systems (ARIS) House methodology is used to guide the components of system architecture and to build and to explain theoretical background of the data comes from researches. At the end of the thesis, a sample Graphical User Interface (GUI) is also presented.

ÖZET

TÜRK İNŞAAT ENDÜSTRİSİNDE PROJE TABANLI KURUMSAL KAYNAK PLANLAMASI (KKP) SİSTEMLERİNİN EN MUHTEMEL SİSTEM MİMARİSİNİN BELİRLENMESİ VE SİMÜLASYONU

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 (BT) ve bilgi sistemleri (BS) de dahil olmak üzere bazı çözüm önerileri uzun zamandır sunulmaktadır. Tüm projelerin birbirinden farklı olması nedeniyle, bazı benzersiz zorluklar oluşmaktadır. Kurumsal kaynak planlaması (KKP) 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 BT sistemi ile, inşaat kurumsal kaynak planlaması'nın (İ-KKP) tüm fonksiyonlarının yerini tutması kolay değildir. Bu noktada, İ-KKP sistemleri inşaat şirketlerine bu verimsizlik, departmanların parçalanmışlığı ve düşük performans meselelerini aşmak için çok daha entegre ve verimli bir sistem sağlamaktadır. Fakat standart KKP sistemleri proje-tabanlı inşaat organizasyonları için tam olarak uygun değildir. Düzgün ve etkili bir performans gösterene kadar, herhangi bir inşaat organizasyonuna özel hazırlanmış bir İ-KKP'nin standart KKP sisteminden dönüştürülme süreci de çok uzun uygulama süreçleri alabilmektedir. Bundan dolayı, iyi tanımlanmış ve hazırlanmış bir İ-KKP sisteminin hazırlanabilmesi için inşaat endüstrisinin beklentilerinin ve ihtiyaçlarının tanımlanması, ve proje tabanlı İ-KKP sistemlerinin en muhtemel sistem mimarileri elemanlarının tanımlanması ve incelenmesi kritik rol oynamaktadır. Bu tezde, altı adet vaka çalışması ve bir adet anket üzerinden toplanan veriler ile bu konu çalışılmıştır. Sistem mimari elemanlarının kılavuzluk edilip yönlendirilmesi ve araştırmalardan gelen verinin teorik altyapısının oluşturulup açıklanabilmesi için ARIS House metodu kullanılmıştır. Tezin sonunda, örnek bir grafik kullanıcı arayüzü de sunulmuştur.

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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
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
KW	Kruskal-Wallis Test
KS	Kolmogorov-Smirnov Normality Test
MMS	Material Management Systems
MRP	Material Requirement Planning
NSF	National Science Foundation
PM	Project Manager
REIT	Real Estate Investment Trust
SW	Shapiro-Wilks Test
TCA	Turkish Contractor Association

1. INTRODUCTION

1.1. Background of the Research

In construction industry, the rivalry between construction companies has risen more than ever before. Same region construction companies compete in international markets and the threats to the construction companies have risen more than ever before. Thus, companies in construction industry have to rise their profitability and effectiveness.

The development of new technologies has assisted the construction companies to be more productive. 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 choose and use IT resources to apply their organizations.

Among several information technology (IT) tools, enterprise resource planning (ERP) systems are used by construction companies for higher productivity and effectiveness through improved management of cooperated knowledge and know-how systems [137]. Tsung [150] defined ERP as “a system that aims to integrate the main business functions across all the departments within an organization”. Negahban [96] indicated that the definition of ERP should be modified for construction as “IT 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.”

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 perceptions that have been appraised and applied by construction companies in reaching the aim of better and enhanced efficiency through improved management of cooperated 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" [137]. 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 [156].

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 [82]. Afterwards, these systems were adapted to manage and allocate resources for inventories and manpower by estimating financial and manufacturing subjects. Along with the developments made in IT, MRPs were transformed into ERPs, as they were modified and changed to add extra front and back office modules such as logistics and warehouse management, supply chain management modules, quality control, procurement, human resources, customer relationship management, and electronic sales modules.

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 Construction ERP (C-ERP) systems in their organizations. However, although this kind of IT systems have helped companies to be more effective; it should be defined and guided how C-ERP systems should run and work within a project based companies such as; construction industry, what kind of different properties that project based C-ERP systems should have with respect to regular ERP systems like ERP systems have being used by manufacturing or production industries.

In order to have a successful project based C-ERP system, system architecture of that system should be determined and controlled carefully. Well-prepared research methodologies should be used and final system architecture should be controlled.

Construction companies in Turkey are not accustomed to ERP systems well but they begin to understand needs and importance of this kind of project based ERP systems in their organizations.

Along with this study, it will be well examined what kind of system architecture components a project based C-ERP system should have in order to address the problem of construction industry and regular manufacturing type ERP systems and help construction companies. All of the system architecture and the study of project based ERP system architecture will be structured and controlled according to knowledge and vision of academicians, ERP and C-ERP experts, construction industry specialists and managers, ERP vendors, managers and developers.

1.3. Problem Statement

Construction companies in Turkey are not accustomed to C-ERP systems but they begin to understand needs of this kind of IT systems in their organizations. Along with this study, first of all, 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.

Also, in this thesis, it will be examined that what kind of criteria and properties a well-defined C-ERP system should have and what kind of framework structure a C-ERP should have.

1.4. Related Studies

There are a number of studies that try to explain the history and role of ERP systems in many different sectors [15, 156, 82, 137]. There is also another other group of studies focusing on the ERP systems developed for or used by construction firms [2, 3, 4, 153, 138]. Some other studies focus on the performance and critical success factors (CSF) of EPR and ERP implementation in construction [24, 25, 145, 146]. For example, Tatari *et al.* [145] proposed a model to evaluate the performance of ERP mainly focusing on the perceived business benefits. Chung *et al.* [24, 25] developed an information system (IS) success model

based on the CSFs and success indicators of ERP implementation. Tatari and Skibniewski [146] studied the performance of construction enterprise information systems (CEIS) and identified 9 CSFs. These studies aimed at only identifying the CSFs of adopting ERP systems and used quantitative research methods.

There are a number of studies focusing on ERP and ERP implementation in manufacturing and service industries that used single or multiple case study methodologies [93, 121; 126, 147, 160, 161].

Also, there are studies that focus on *system architecture* of ERP and MEP systems [21, 23, 24, 52, 83, 92, 106, 137]. However, there is not a specific study on system architecture of a complete project-based ERP systems and this should be defined well in order to create a C-ERP system that satisfies the need of construction industry.

Also, there are some studies on the implementation phases of ERP and Construction Enterprise Resource (CERP) systems [2, 3, 4, 61, 153]. Also, there are some studies that has explained the analysis of critical success factors at the implementation of ERP systems in construction companies [3, 4, 26, 138, 146].

Also, Tserng *et al.* [149] have investigated the transformation of current IT systems to the implementation of new ERP system at a general contractor organization for only project management module. However, complete system architecture components of a project-based C-ERP systems for their all modules have never been proposed.

1.5. Aims and Objectives of the Research

The major objectives of this research are to;

- identify the needs and expectations of construction industry for a well-defined and prepared C-ERP system by using quantitative and qualitative research methodologies,
- examine and determine the best possible system architecture components of project based ERP systems according to literature and the results of a questionnaire survey

and case study analysis that examined with academicians, ERP and C-ERP experts, construction industry specialists and managers, ERP vendors, managers and developers,

- determine a well-defined project based ERP system architecture components analytically and presenting them with a theoretical background.
- test the new project based C-ERP system components with academicians, ERP and C-ERP experts, construction industry specialists and managers, ERP vendors, managers and developers, then make a *user satisfaction questionnaire survey* in order to understand the feedback of defined criteria and components of new C-ERP system,
- create a framework structure and theoretical project based C-ERP software GUI that simulates the system architecture that is defined in this study.

1.6. Contribution to Body of Knowledge

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 Construction ERP (C-ERP) systems in their organizations. However, although this kind of IT systems have helped companies to be more effective; it should be defined and guided how C-ERP systems should run and work within a project based companies such as; construction industry, what kind of different properties that project based C-ERP systems should have with respect to regular ERP systems like ERP systems have being used by manufacturing or production industries. Along with this study, it is aimed to examine and determine ERP system architecture components for project-based C-ERP systems and making a GUI simulation of this new C-ERP system as a prototype model.

In order to have a successful project based C-ERP system, system architecture of that system should be determined and controlled carefully. Well-prepared research methodologies should be used and final system architecture should be controlled.

Construction companies in Turkey are not accustomed to C-ERP systems well but they begin to understand needs and importance of this kind of project based C-ERP systems in their organizations.

Along with this study, it will be well examined what kind of system architecture components a project based C-ERP system should have in order to address the problem of construction industry and regular manufacturing type ERP systems, and help construction companies. All of the system architecture and the study of project based ERP system architecture will be structured and controlled according to knowledge and vision of academicians, ERP and C-ERP experts, construction industry specialists and managers, ERP vendors, managers and developers.

1.7. Research Method

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



Figure 1.1. Research Methodology.

1.7.1. Phase 1 - Problem Identification & Literature Review

After identification of the problem of this study was completed, a comprehensive and wide-ranging literature review was performed in the area of ERP, CERP and other IT systems and system architecture, especially in construction sector. Especially, ERP systems and applications employed and actively used by construction companies were inspected, 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 project-based ERP systems and vendors of C-ERP systems were studied. Number of existing running ERP systems were reviewed on construction sites and disadvantages of them are noted.

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 modules and functions they required from their ERP and ERP implementations.

1.7.2. Phase 2 - Preparing Case Study Questions on Project-Based C-ERP System Architecture

After literature review is done, a suitable case study questions are prepared in order to determine best system architecture components of project-based ERP systems. The case study questions are prepared in order to learn what properties, needs, requirements and tools are expected from a project-based ERP system and what kind of differences are needed by the user of project based ERP systems.

1.7.3. Phase 3 - Control of Questions at Case Studies

The control of the questions at the case study are done by mostly academicians but also ERP experts, construction company ERP executives and construction company executives. The changes that the experts and academicians mentioned about the case study questions are made accordingly.

1.7.4. Phase 4 - Collecting Data from Case Studies

After preparation of case study, 6 case studies are made by 4 ERP Professionals working at ERP vendors and 2 ERP Experts working at Construction companies. All data from case studies are collected and used in order to make ARIS (Architecture of Integrated Information System) House structure at Phase 5.

Also, some workshops were done to understand the information flow in a construction company and what kind of system modules, data type, functions, control processes and organizational architecture that a project-based ERP system should has in order to satisfy this kind of information flow.

Also, what kind of challenges and barriers are faced by the users of ERP systems in construction industry and what kind of resources used to eliminate that challenges were examined.

1.7.5. Phase 5 - The Analysis of Case Studies and Preparation of ARIS House Structure

After collection of data from case studies, "Organization, Data, Control and Function" lists of ARIS (Architecture of Integrated Information System) House Structure is created.

It is also presented that which functions belong to which ERP systems case studied have currently.

Correlation matrix tables are created between function, organization, data and control lists and it is presented the correlations between ARIS components.

1.7.6. Phase 6 – Preparing a User Satisfaction Questionnaire Survey on New C-ERP System

After collection of data from case studies; organization, data, control and function lists of ARIS House Structure are created and in order to understand that the function list of ARIS

House Structure is enough to make a project-based C-ERP system and to understand the proficiency of the module is enough for users' expectations, a user satisfaction questionnaire survey is prepared.

1.7.7. Phase 7 – Control of User Satisfaction Questionnaire Survey

After preparing a user satisfaction survey, the control of the questions at the questionnaire survey are done by mostly academicians but also construction company ERP executives.

1.7.8. Phase 8 - The Analysis of User Satisfaction Survey

After collection of data from questionnaire survey, it is made a quantitative data analysis by using SPSS analysis software.

1.7.9. Phase 9 – Creating a Project-Based C-ERP System Software GUI

After the analysis of questionnaire survey and getting "positive feedback" from user satisfaction survey, it is made a Graphical User Interface (GUI) sample of new defined project-based C-ERP by using Balsamiq Mockup software.

1.7.10. Phase 10 - Discussion & Conclusion

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

1.8. Scope and Limitations

This research examines the needs, requirements, ARIS structures component information and possible GUI of project-based C-ERP systems. It cannot be applied for other ERP systems or industries except construction.

The questionnaire survey has been done by face-to-face limited number of targeted respondents that it is aimed to reach as many as related expert possible. However, it cannot be reached all of large scale construction companies of Turkey.

1.9. 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 and C-ERP 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, 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 investigation of current ERP system in construction industry is performed in order to understand and define better CERP system structure. In this chapter, SAP, MS Dynamics and YAPITAŞI ERP systems are investigated, the modules are explained and some of screenshots of the modules are presented.
- 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 “case study of real experiences of ERP developers and experts” and “questionnaire survey method” of user satisfaction of module maturity. First of all, case study method is used and six case studies are explained. The results of the case study analysis are presented and ARIS House methodology components are created based on case studies. 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 ANOVA (Analysis of Variance) analysis is made and then the convenience of ANOVA analysis method for this questionnaire survey is checked. Then, proper statistical analysis of the questionnaire survey is done and the results are given. Also, cross tables are presented.

- In Chapter 5, Graphical User Interface (GUI) sample is created based on case study and questionnaire survey results by using GUI mockup tools. Some screenshots of GUI are given in this chapter.
- In Chapter 6, the results of six case studies and user satisfaction questionnaire survey are explained and summarized. Especially, it is focused on ARIS House components and characteristics of new C-ERP system. The differences and similarities between regular ERP systems and new C-ERP system are compared and explained briefly.
- In Chapter 7, at the conclusion and further works part, major findings and contributions of this study to the literature on C-ERP 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 [101] 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 [150] 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" [96].

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.

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 enhanced to the systems that also operate managing resource allotment for different kind of machinery and labor. Together with the enhancement of IT systems, MRP systems were upgraded to ERP systems by acquiring some extra forward-facing and back-facing office utilities and modules, such as; sales and distribution management, HR management, logistics and warehousing management, procurement management, shipping and delivery management, accounting and related finance management, and quality assurance and quality control management, etc.

Currently, ERP systems are seen as a basis for the integration and collaboration of organization-wide IT systems. ERP systems connect all of the units of the companies and their department operations such as; finance, accounting, human resources (HR), production, sales and distribution, procurement and purchasing, etc. Furthermore, ERP systems also connect the whole organization to companies' customers and suppliers over the different stages of the process life cycle.

ERP has its origins in manufacturing and production planning systems [45]. The initial structures of ERP systems were developed a few decades ago along with the arrival of MRP systems, which mainly managed the storing raw or production materials. In later phases, manufacturing resource planning, or MRP II, systems developed these organizational systems to include the allocation of machinery and labor planning modules and systems. The term ERP has been generated after these production-oriented IT systems were combined with other business operation modules and units, such as; purchasing module, finance and accounting modules, HR and administration modules and other front-office modules in order to improve other business operations through entire organization. The purview of ERP

systems contributions have expanded in the mid 90's to embrace other back-office modules such as order management module, financial management module, logistics and warehousing related modules, HR, asset management, distribution, quality assurance and control modules. The range of module variaties and functionality of ERP systems has extra expanded in recent years in order to include more front-office functions, such as sales force, electronic commerce, and supply-chain systems [53].

Nevertheless, MRP I systems had limits on its abilities and this limited functionality has lead these systems to upgrade to more advanced MRP systems that is called as Manufacturing Resource Planning (MRP II) systems that have developed to now ERP systems. MRP II systems can perform the whole production and manufacturing environment, and these systems can generate or change master schedules and time tables based on the responses comes from existing production lines or procurement conditions. Lastly, ERP venture companies such as; SAP, Oracle, and others are gaining the rewards of impressive growth as companies move away from legacy MRP II systems and commence the process of ERP employment. The solution of these companies is more powerful than any host-based MRP system to date [14, 61, 65].

The role of ERP systems does not match its name. These systems are no longer related with only planning of resources, yet they are pretty related to the enterprise part of their system name. ERP tries to amalgamate all systems of company departments all together into a sole, unified and integrated system working on an only database so that numerous departments and units can more easily share data, materials and interconnect with each other. This combined and united approach can have an extraordinary repayment if companies implement the ERP systems accurately. A growing number of companies want to attain all relevant data about their professional processes to control and guide them in a gainful route [75, 76].

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 system implementation and applications were very fast developing business in the 1990’s. ERP system sales values have reached 10 Billion Mark in 1998 [163]. The world’s largest ERP ventures including SAP, Oracle, PeopleSoft, and J. D. Edwards. SAP R/3 are the most popular systems implemented around the world [63, 99]. ERP systems have won additional accomplishment to the production industry [53]. Some initial implementers have stated that their net return on investment have been ranged from 30 to 300% in same year after implementing these ERP systems. Oracle has saved 1 billion USD savings per annum after installing ERP system [103].

The exciting achievement flashed a leap in the examination and progress of ERP systems. In spite of the reported corporate accomplishments, many failure cases have also been reported [78]. ERP systems can be difficult to implement and they are costly IT systems. All installment of ERP systems with many modules can costs from 2 million USD to 130 million USD, based on a survey of 15 implementations [123], and receive at least 6 months for a modest company with the accelerated R/3 system [63]. Figures indicates that the most of installments of ERP systems could not be finalized in planned period and within planned cost. A 1999 NSF-sponsored case study have understood the problems and concluded that a science base is not established yet and that the ensemble of separated functional systems is untested on ERP technology [137].

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 reinforce a company’s operations in countless ways. Yet these systems connect all parts of an organization or company effortlessly and more suitable control mechanisms is possible. ERP systems can lessen unnecessary data record-keeping; manage data created by different organizational units and decrease recording mistakes. The collaboration and connectivity between all the modules and units of these systems decreases the duration to achieve the different operative jobs and duties, and so the efficiency of organizations can be improved. ERP systems permit their users and the employee of the companies to reach appropriate information in time and precise intelligences and documents can be created at any time. The key motives that businesses accept these ERP systems are summarized as follows [75, 76].

Integrated financial and operational information is one of the advantages gained through ERP systems. Chung [26] indicates that 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 produce only one version of the data that cannot be investigated because all members of a company are using the same database system [26].

Integrated customer and service information is one of the advantages gained through ERP systems. Chung [26] indicates that 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 are able to create a common platform for where the clients purchasing order stays from the moment a client service employee accepts it until the transaction and the product is shipped and an invoice and bill have been sent. By getting this kind of data from a sole and unified integrated ERP system rather than fragmented between many different IT systems that cannot communicate between each other, business organizations can record all of the tracks orders effortlessly and can manage other related departments along with these systems across many different locations at the same time [26].

By using ERP systems, it can easily be 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. Chung [26] indicates that 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 [26].

Reduce inventory and operation costs is one of the advantages gained through ERP systems. Chung [26] indicates that ERP systems try to unify and collaborate the processes of the companies between organizational units onto a sole system database. A few of the main gains of these systems are enhanced harmonization and collaboration across related organizational units and departments, and improved productivities of making business operations. The direct advantage from executing these systems is decreased running costs, such as lesser warehousing and machinery control cost, lesser manufacture costs, lesser marketing costs and lesser 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 create decreased inventories of the parts used to produce goods and can assist system users perform healthier planned transfers to clients, declining the finished goods inventory at the warehouses and distributing docks [26].

Standardize HR information and using HR strategically is one of the advantages gained through ERP systems. Chung [26] indicates that ERP can solve the Human Resources problems of an organization that may not has a combined, simple system for tracing time tables of the employees and cooperating with them about gains and services, particularly in the case of organizations with several business units.

Whereas there can be many benefits of ERP systems, as mentioned above, there are also some disadvantages. The implementation budgets of ERP systems are so costly that this forbids small and medium companies from getting this ERP systems. Moreover, ERP systems need significant duration to implement in an organization, and the implementation period may decelerate the regular daily operations within that organization during the system installment period. Because this kind of combined ERP system has to be well-defined in the

commencement of implementation of the system, it will be very problematic to make revisions later [34].

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 ventures and investments. 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.

After an ERP system is implemented in an organization, it is very problematic and hard to modify or change how the company performs and is organized. ERP systems are like cement, which is very elastic in the beginning, but very inflexible after implementation has been finished [26].

Long implementation periods is another disadvantages gained through ERP systems. It takes too long to implement ERP systems. A three to five years implementation period of ERP systems is fairly common in a large company. In the current rapidly changing business world, five and even ten years 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 [99, 137]. In particular, construction firms can achieve benefits associated with materials management by using such systems. Lee *et al.* [87] 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 [86].

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. According to recent research of Panorama Consulting [105] at Figure 2.1, SAP has 19% of market share, MS Dynamics has 16% of market share and Oracle has 13% of market shares. Tier II and Tier III ERP system (mostly local or deeply specified systems) has 39% of market share. The research is based on the frequency of ERP systems in the companies.

2.4.1. SAP

The first firm that presented a functional enterprise software was SAP AG in Germany. Five software developer working for IBM in Germany had the idea for a cross-functional IT system. Nevertheless, 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 [34; 125].

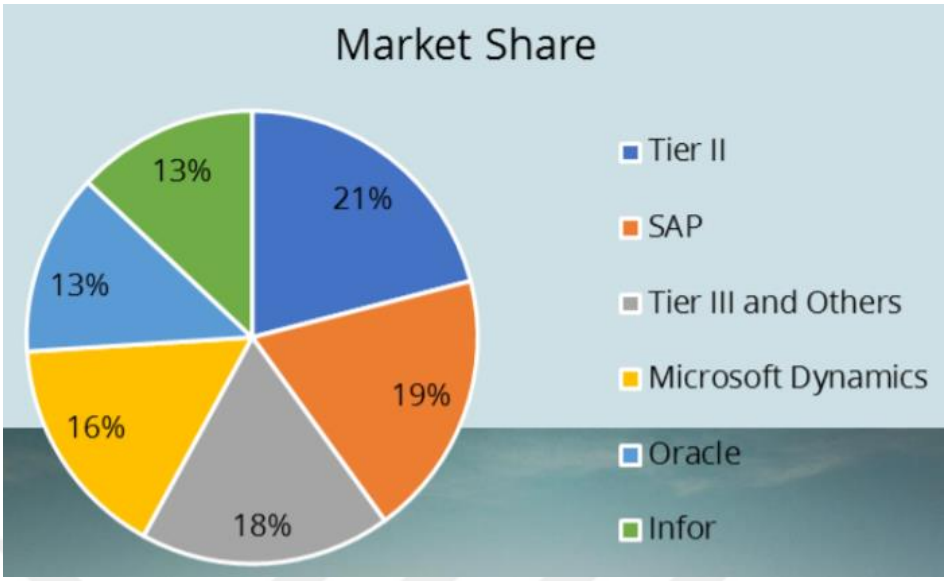


Figure 2.1. Market Shares of ERP Vendors at 2017 [105].

The one of the advantages of SAP systems is the wide-ranging ability and competence at the functionality and working in complex organizations with proper implementation. Also, SAP company develops and consume its resources on research and development projects than its any other competitor. This makes this system to have much newer functionality in time [34]. In 2003, SAP NetWeaver have become the first system to let seamless incorporation between SAP and non-SAP products by declining integration problems.

The one of the key ability of SAP systems with respect to other system is the integration and collaboration of this system with other systems due to using open standards and easy web services. By using SAP NetWeaver, the clients can select SAP web service modules that met their own requirements. It brings much more appreciated business functions, such as order management by using flexibly web service tools [125].

2.4.2. MS Dynamics

Microsoft Dynamics ERP is an enterprise resource planning (ERP) software mainly prepared for medium size companies and some departments of larger organizations. Its modules are part of Microsoft Dynamics created or developed by Microsoft. MS Dynamics has five main ERP Solutions. They are Microsoft Dynamics NAV, Microsoft Dynamics GP, Microsoft Dynamics AX, Microsoft Dynamics SL and Microsoft Dynamics C5.

Microsoft has entered the industry of enterprise product by using purchasing some other products. In 2000, Microsoft has bought one of the well-known finance and accounting software in the U.S.A that can be run under MS Windows [105].

Microsoft Dynamics GP is developed for small and medium size companies. Microsoft Dynamics NAV is developed for small and medium size companies that need comprehensive functionality, performance and the capability to modify the system. Microsoft Dynamics AX is the leading MS Dynamics system that developed for medium to large scale organizations and operations [105].

Microsoft has lately renamed their ERP systems and the products are named as MS Dynamics 365 and MS Dynamics 365 Enterprise [105].

2.4.3. Oracle

Oracle company was first established by Larry Ellison in 1977 as a database company. Oracle company has involved in almost all industries around the world and now Oracle database products are the most widespread database system of ERP system data. Oracle has started to progress its own business system software in the late 1980s and the initial version of the Oracle software coming from collaborative projects along with its customers. The ERP packages of Oracle systems that is called as “Oracle EBusiness Suite” have almost 50 different ERP modules in 7 main categories, that’s are Finance, Human Resources, Projects, Corporate Performance, Customer Relationship, Supply Chain, and Procurement. Oracle systems also presents industry-specific products. Presently, Oracle company has developed fully internet-enabled ERP across its complete system line by using tools that are databases, business applications, and application development and decision support tools. Now, Oracle is the leading provider of IT and information management system software in the world and it is the second biggest independent software development company in the world [34, 103].

In IT systems of the Oracle products, PeopleSoft Enterprise allows companies to decrease expenses and rise efficiency by Pure Internet Architecture, by supplying connections between clients, dealers, distributors and other shareholders each other in real time through online business processes. PeopleSoft's unified systems include CRM

(Customer Relationship Management), SCM (Supply Chain Management), HCM (Human Capital Management), FM (Financial Management) and Application Integration modules. J.D. Edwards EnterpriseOne, appropriate for large companies, is the whole wide-range system solution for modular, pre-integrated industry-specific business systems designed for rapid placement and easy management on pure internet architecture. J.D. Edwards World is perfectly suitable for small businesses because of its consistent, functionality-rich, web-enabled environment for handling plants, warehouses, accounts, machinery, accounting, and human resources. It is harmonized, combined, and pre-bundled ERP system on a single database, which decreases installment and employment budget and difficulty to healthy implementation [103].

2.5. Main Functions and Characteristics of ERP Systems

2.5.1. Structure

A standard ERP system has some technological characteristics and Keller [162] has indicated as the following;

- 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

Because ERP systems accomplish the administrative and executive functions, and they provide information requirements of the associations, the arrangement of ERP systems is classically separated 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 [26].

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 [34].

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

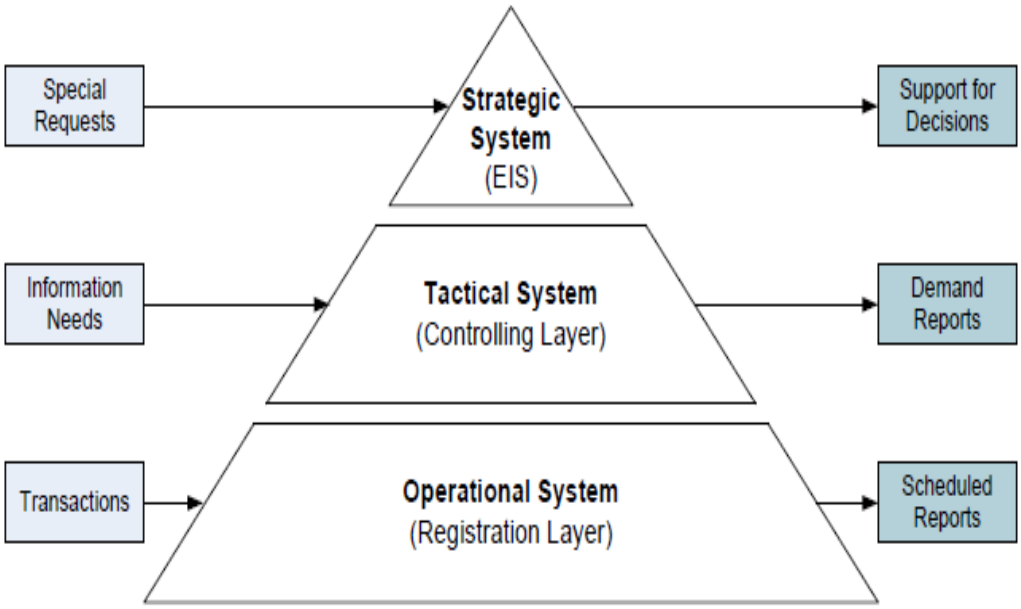


Figure 2.2. Structure of an ERP System [65; 134].

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. Davenport [34] indicates that 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.

Davenport [34] indicates that the second layer is the application server that all of system functions and modules are processed. The application servers belong to this layer receive the information from the database server and write processed data back to that server.

The third top layer is the presentation server that can be named as the graphical user interface (GUI).

Presently, further layers can be created for many applications such as; web server or any internet applications, CAD or any other drawing systems or any simulation tools. Figure 2.3 illustrates an example (SAP R/3) of the client/server system architecture of SAP systems [124, 125].

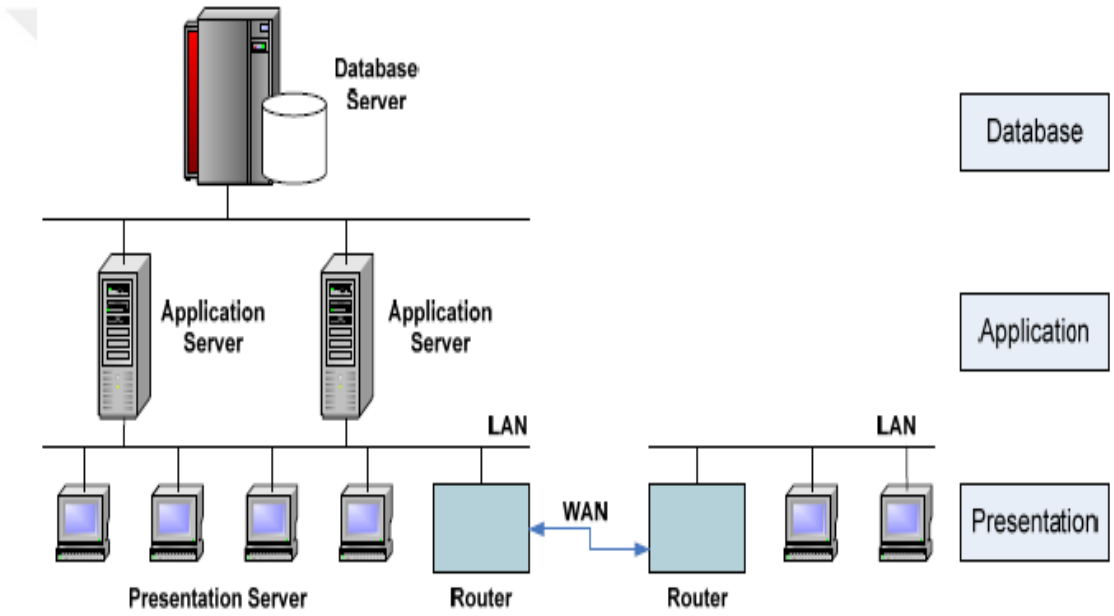


Figure 2.3. Client/Server System Architecture [124].

2.5.2. Functions

Utmost main working processes can be maintained by ERP systems. Even if there is some difference between vendor software, ERP systems can perform all financial procedures and transactions, supply chain works, manufacturing process flows and managements, CRM and related services and HR (Human Resource) management. The key functions and their correlation within ERP systems are shown in Figure 2.4. Detailed descriptions of each follows as below [26, 65]:

Production Planning and Controlling is one of the important functions that consist of following tools and items; material or any other machinery or equipment, (BOM) bill of material and (BOQ) bill of quantities, manufacturing periods and durations, ordered product line information and any other work orders, sales and marketing planning, etc.

Procurement is one of the important functions that consist of following tools and items; (BOQ) bill of quantities, Bills of Materials (BOM), cost and budget of material items, supplier information, ordered quantities and requests, offers received from suppliers, general procurement information and stock conditions.

Plant Management: is one of the important functions that consist of following tools and items; facility management, investment management, 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, (BOQ) bill of quantities, Bills of Material (BOM), sales prices, item sale conditions, revenue received, mailing conditions, transportation information, contracts of the transactions, offers of suppliers, inquires of the units or departments and service contracts.

Financials and Accounting is one of the important functions that consist of following tools and items; general ledger book transactions, accounts lists, accounts of debtors, creditors, receipts, liquidity calculations, bank and case information.

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.

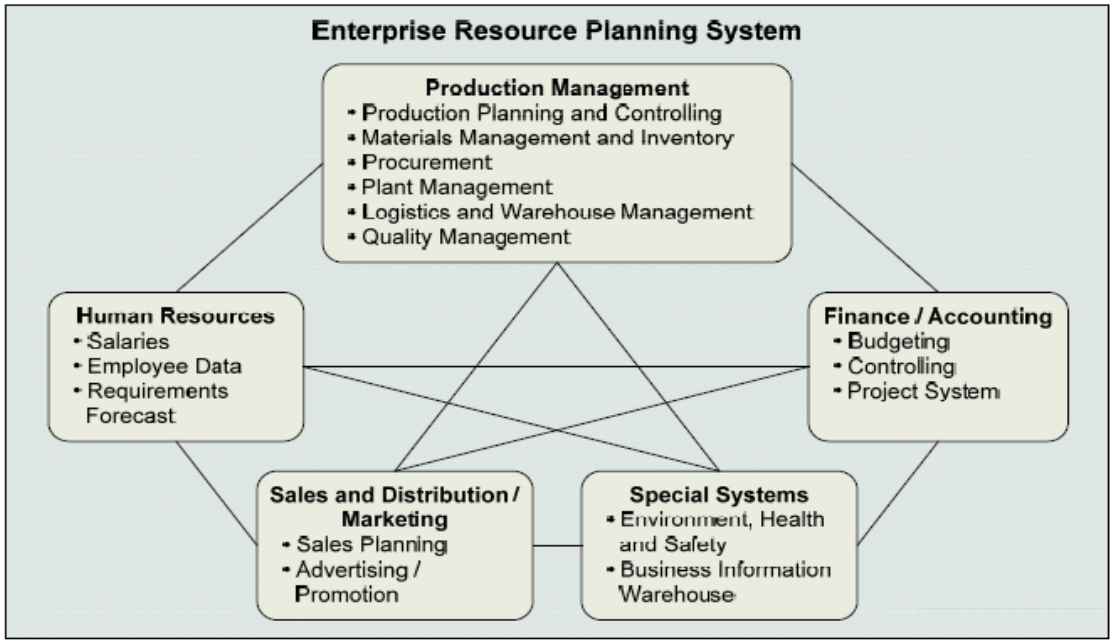


Figure 2.4. Business Functions within ERP System [68].

Personnel is one of the important functions that consist of following tools and items; number of employees, white-collar or blue-collar workers, qualifications of the employees, departments, type of wages and salary packages, travel information, time management, application information.

2.5.3. Modules

ERP systems can be grouped according to their function modules. SAP is one of the most comprehensive ERP system that has 12 modules, as shown below in Figure 2.5. The modules can cooperate between each other directly or by getting data from their central database. Davenport [34] and Chung [26] indicates that All of the SAP modules can be implemented and can be used as single modules and that modules can be installed individually.

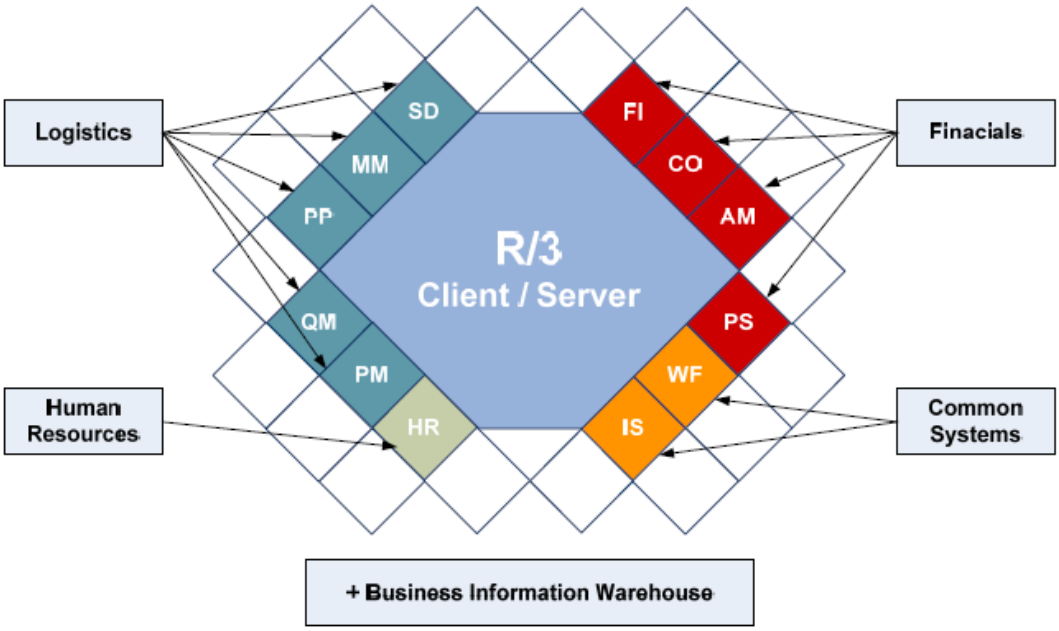


Figure 2.5. Modules in SAP R/3 [124].

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 [34].

Oracle system has related application modules which ensure business information for active decision-making, allow implementers to make much optimal responsive system, and offer a greater level comprehensive ownership in order to create profitability [103].

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 associated industries and organizations such as distributors, ERP system developers, contractors and consumers. ERP systems are being used by construction organizations to develop collaboration between consumers or clients, reinforce supply chain organizations, improve managerial elasticity, progress decision making skills and decrease

project duration and lesser expenses. These IT are planned to incorporate and partly computerize many of the company's business practices and department functions. The one of the aim of ERP systems is to make possible to user to enter a data for only one time and to make that information available for all the employees at that company [3, 4].

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 [26].

The readiness and reachability of resources describes the manufacture ability of a contractor. As a whole, a construction organization is able to 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 purpose and objective is to take full advantage of the usage of the resources of the company and use the construction market to balance the company's operation. Shi and Haplin [137] indicates that construction projects are transitory in nature, take different duration, and need different kind of resources, it is generally too hard to accomplish an equilibrium among the manufacturing ability and the real capability and capacity on hand for a construction organization all the time. Actually, a construction organization has numerous techniques to regulate and manage its procedures and work routines and works to approach such a balance. For example, if a company does not have sufficient projects, it may rent out some of its possessed machinery and may offer lesser rates and bids on new construction tenders. Alternatively, the contractor may lease outside machinery, outsource personnel, or demand its workforces and teams to work overtime. Such wide-range organizational business decisions necessitate using broad information across the company and the market; or else, whether the company has made the best use of its owned and market available resources to assist its business objective remains a question. It is a common occurrence to receive complaints from the employee working in the construction sector. The employees in construction sector complain about working overloaded and working overtime when the business is good; in contrast, they concern about their job availability if there are not sufficient construction projects. Furthermore, it is usual to see lower-than-cost bids when contractors do not have any project for long time. Such a gambling strategy has driven many contractors out of business. Very low profit rage is the main reason for the business failures of construction companies [68].

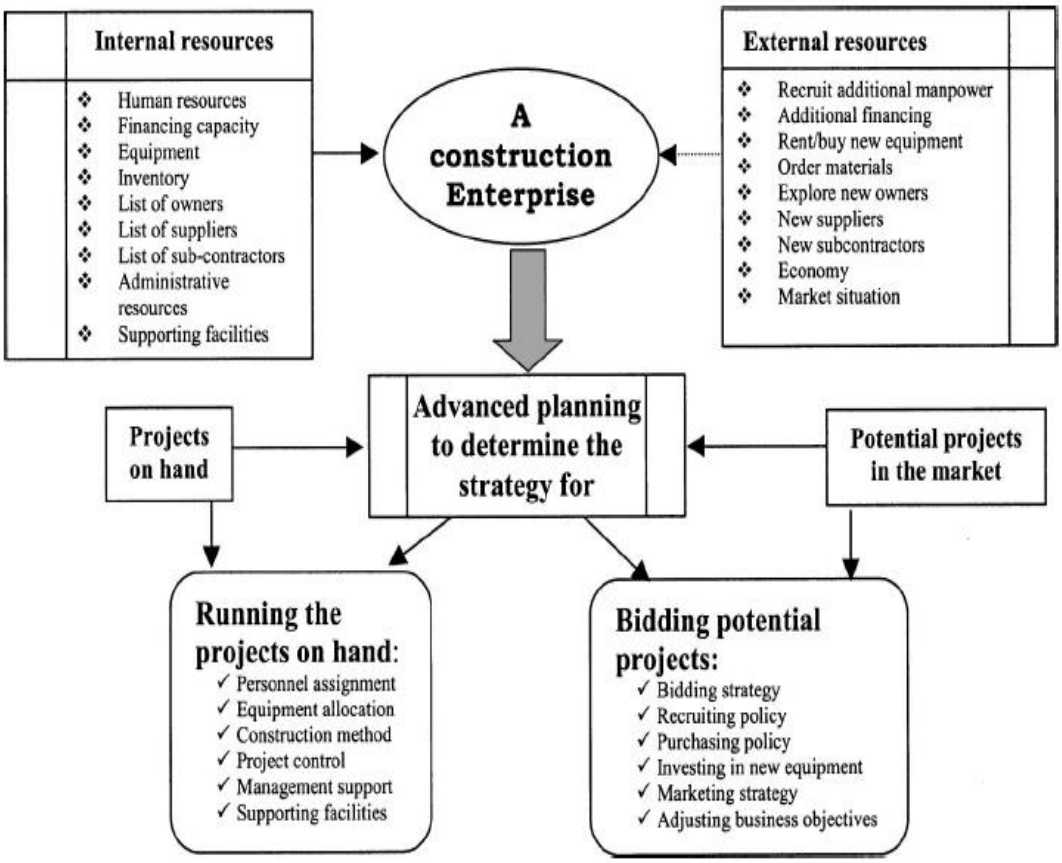


Figure 2.6. Construction Enterprise Operation [137].

As illustrated, the operation of a construction organizations can be defined as presented in Figure 2.6. The top of the figure indicates the internal and external resources available to the construction organization. A link is used to symbolize the ‘‘owned-relationship,’’ viewing the available resources inside the organization. A dotted line is used to define the ‘‘can-have ownership,’’ for outside resources that the company can get from the market at a price.

How can a construction organization improve the usage of its internal and external resources so as to optimize its business objective? Precisely, Shi and Haplin [137] indicates that the construction companies must decide;

- 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 practice of transforming materials and permanent equipment into a finished working facility [112]. Compared with other industries, usually the manufacturing industry, the distinctive features of the construction sector have been broadly documented [100, 151].

From the business perspective, a construction business also works in a dissimilar way from its industrial and producing industries. The distinctiveness of the industry has prohibited the direct implementation of many techniques and theories developed in the manufacturing industry, such as the mass production method. Such uniqueness makes investigators in the construction industry to improve their own knowledge base on the sustainability of construction industry. Construction enterprise resource planning (CERP) systems need to be studied, examined and developed [137].

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 [137].

A Construction Enterprise Resource Planning (C-ERP) system must be able to organize and form present and past projects with the ability of reporting, estimating and forecasting progress status on the fields, cost situations and status on the budget, profitability and budget conditions on construction site working schedule, and possible difficulties such as being behind of work schedule and exceeding budget so that proper actions can be taken before complications occur.

Besides, the revenue and the progress of a project can affect the whole performance of the organization. Project progression information and evaluation data should be occasionally summarized and reported timely and regularly to the high management level to show the general situation of the company as far as financing requirements and 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 [137].

Integrated: A old-style construction company has two front-office units and these are estimating (also tendering/bidding) and operations, but many back-office departments and units, such as; procurement/purchasing, main engineering, financing and accounting, contracting 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 [137].

In order to get high efficiency 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 [137].

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. Shi and Haplin [137] indicates that 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: Numerous business module functions are simultaneously managed by executives in many workplaces in a corporation. Thus, a unified ERP system must perform parallel and modular IT systems and functions so as to support numerous simultaneous functions or requests. For instance, a tender engineer can try to find the past expenses or budget figures on database in order to use the tender offer value of a new tender bid, but simultaneously, a cost control engineer may be bringing up-to-date the database with current finished project cost information. These properties are needed for effective ERP systems [137].

Open and expandable**:** Shi and Haplin [137] indicates that software programs are required to support business and organization functions, such as; Timberline for cost control and cost estimation and Primavera Planner (Primavera Systems 1999) for scheduling and time planning. An ERP system can cooperate with an software program over three different methods:

- To start a third-party software in order to reply a straight user request – an ERP user may run a Primavera Planner in order to schedule a project
- To call a program software in order to obtain desired data - 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
- To enable cross information transfers among a 3rd party software and an ERP system - after a new project is added to the system in order to use cost control or budget estimation or time scheduling applications, the project information must be recorded in the central database for users to access.

It is commonly accepted that all construction organizations have their own characteristics and features for their achievements. Software programs or functions will change dramatically from an organization to another organization. A flexible and growable system structure permits an organization to modify its desired functions to fit its professional business needs. In the meantime, new software programs can be inserted to the system and unnecessary applications can be uninstalled from the system. Thus, a high level of modification can be accomplished with a very less energy required for an ERP end user. This kind of property are very essential for a C-ERP than for a standard ERP system.

Scalable: Scalability is a frequent obligation for all kinds of ERP systems. Executing an ERP system needs key and major money investment and reengineering of company business processes. Each ERP system have to be able to enable the planned growth of an organization. Scalability is imitated in the necessity for the system to contain extended business functions. The functional offices of a construction organization are managed based on its business practice and company size. A construction company can begin installing an ERP system with two fundamental modules, such as; accounting/finance and project management sub modules, so that the employees at only these two departments can reach the system at the primary phase of the implementation. As time passes by, other ERP system modules and new end users from different departments can be added to the system. Furthermore, the construction organizations imitate the general economic cycle. A scalable system is crucial for a construction organization to reply quickly flexible necessities and in the time being to be shrinkable at the time of economic recessions [137].

Remotely accessible**:** Each construction project site is located on a different part of the world, which may be thousands of miles away from the headquarters. Distant reachability allows construction managers and other project employees to remotely access main server data such as procurement and accounting information; in the meantime, the headquarter employees can get the current and timely construction project progress data so that the executive management team can reach the project performance and its impact on the organization [137].

Transparent: The construction sector is very conservative and it is usually resistant to change and new technologies. One of the efficient strategies to handle this problem is to

ensure a self-explanatory methodology in the organization that this method can let end users to trace down related perceptive for decisions or suggestions comes from the system. For example, the new ERP applications may demand a project manager (PM) to reschedule the construction site work of a project under his/her supervision. The reasoning behind this rescheduling can be mentioned as “The required construction materials are not available because one of the suppliers is not able to send that construction equipment as time schedule, according to the transport data received from the procurement office of headquarters” [137].

Reliable and robust: This is a property that is mandatory for all decision-supporting systems. For instance, precise past budget information has to be received from the cost control database for supporting tender department; a procurement request must be viewed and should be approved in the same time; and an order for storing a piece of machinery for a project should be managed and an arrangement made, or the requester end users should be informed if the order cannot be fulfilled [137].

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

Main ERP system developers like SAP and Oracle try to ensure specific business solutions for the construction organizations. Figure at below display a construction company’s key charts for the construction organizations. Their resolutions manage the whole variety of business processes that a construction organization requests. Even if these solutions have a broad scope, some construction organizations may not select all the modules and methods provided. For example, Enterprise Portals by Oracle system can enable staffs and other shareholders reach to the full range of data, software programs, and services they wanted in order to work and cooperate online. Along with this kind of solutions, construction organizations can handle unified data from different parties and the supply chain relationship can be improved by the communication of the several shareholders [26].

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.

Streamline Opportunity Management	Drive Bid and Proposal Efficiently	Optimize Delivery of Pre-Construction Tasks	Control Project Changes and Enhance Execution	Manage Close-Out and Ongoing Operations
Sales - Sales - Project Costing **Customer Data Mgmt.** - Customer Data Hub - Customer Data Spoke - Cust. Data Librarian	**Proposal Management** - Proposals - Project Management - Project Collaboration - Project Costing - Project Contracts - CADView-3D - Adv. Project Catalog - Sourcing	**Project Planning** - Project Contracts - Project Management - Project Collaboration - Adv. Project Catalog - CADView-3D **Resource Management** - Project Resource Mgmt. - iProcurement - Purchasing - Service Procurement - iSupplier Portal	**Project Planning** - Project Management - Project Collaboration **Cost Management** - Project Costing - Time & Labor - Payroll - Advanced Benefits - Financials - Project Billing	**Accounting** - Financials - iReceivables - Project Costing - Project Billing **HR Management** - Human Resources - Self-Service HR **Facilities Maintenance** - Enterprise Asset Mgmt. - Self-Service Work Reqs. - Network Logistics

Performance Management	E-Business Intelligence, Balanced Scorecard, Enterprise Planning & Budgeting
Corporate Governance	Internal Controls Manager, Financials, Tutor, Learning Management
IT Infrastructure	Database Server, Applications Server, Systems Management, Development Tools, Collaboration Suite
Services	Consulting, On Demand, Education, Support

Figure 2.7. Oracle Solution Map for Engineering and Construction [103].

The key application area for the construction organizations is project management modules. Main ERP developers like SAP or Oracle try to ensure healthy project management module solutions for the construction companies. In their project management applications, they contain all the crucial applications in construction project control modules such as; project cost control and budget management, tender management, resource management, contract management, and project document management. All the information generated in each module will be recorded inevitably in current time, due to the fact that all the applications and modules run one central database. They provide precise and timely information to their users, that support the users to estimate better budgets and make better decisions. The typical “project management modules” are defined as below [26; 103, 124]:

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 [26] has stated that project costing offers

integrated cost management solutions, such as the analysis of cost control and cost tendency examination. Construction site billing is able to make easy at customer billing, progress at realization and cash flow diagrams, and calculate the effectiveness and productivity at contracting with support for time and resource planning, management, and resource analysis. Also, change management can reorganize the business workflow essential for the change order procedures. It can support and help the controlling of the change order progresses and processes and examine the effect of changes. The change will be recorded to project budgeting that will simultaneously update finance and accounting information [26].

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 [26].

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 [26].

Project Collaboration: Chung [26] indicates that this module allows team members and end users to cooperate in reviewing and implementing project activities. ERP systems provide very good workflow functions that can support not only end users within an construction company, but also the other project parties including the owner, architects, engineers, contractors and distributers.

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 [26].

Because the realization and installment budgets of ERP systems are too costly, there are limited number of construction organization that install and execute complete integrated ERP systems with all of their modules. Furthermore, the advantages of ERP systems are problematic and hard to measure, so a few number of construction organizations are now executing them in the U.S. [26].

Although most of those construction organizations implement only finance, accounting or human resources modules and they have legacy systems or use project management applications in current software market. Nevertheless, construction organizations need the optimization of the utilization of their both internal and external resources in order to make the most of their business aims and want improved management decision to be made in an appropriate time as their companies and market grows. Hence, several large construction organizations have lately understood or are seeing installing a fully integrated ERP system in their organizations [26].

In the Figure 2.8 below, Chung [26] 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.

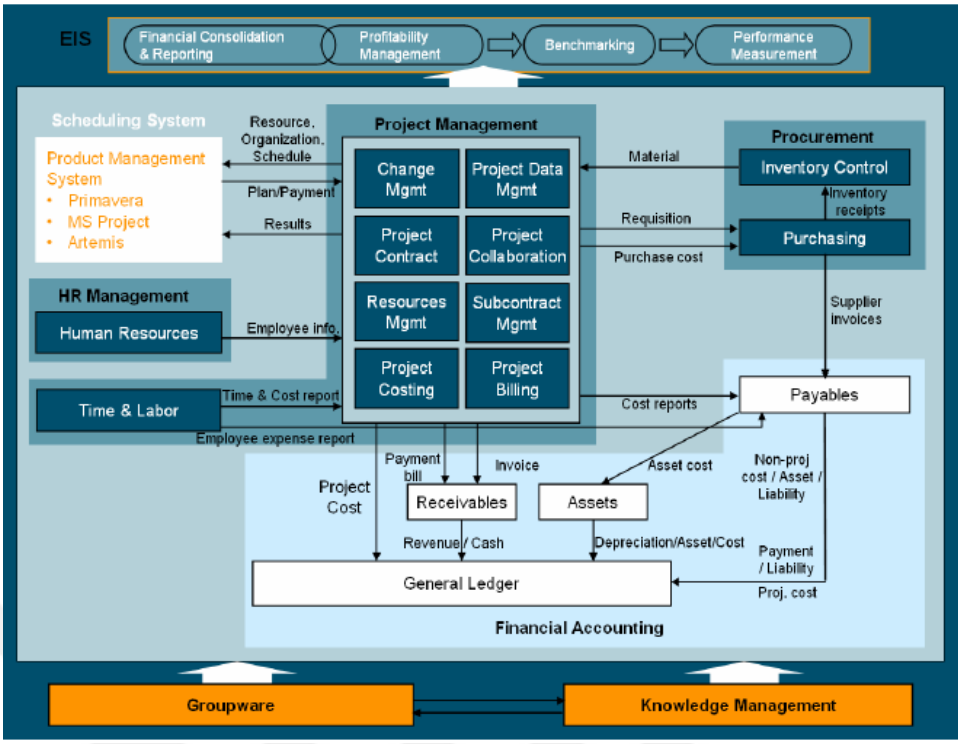


Figure 2.8. General Concept of ERP Systems in Construction [26].

2.6.4. Advantages and Benefits of C-ERP Systems for Construction Firms

Main construction organizations have decided to implement an integrated IT system on their companies such as enterprise resource planning ERP systems in order to better integration of their numerous management processes, mainly those related to accounting and finance procedures and applications. Nevertheless, implementing these integrated IT systems in the construction organization bring a set of unique problems and challenges, different from those in the production, manufacturing or other service sectors. Generally, the best method to realize the full benefits from ERP systems is to make minimal variations at standard ERP applications after implementation. Each construction project is characterized by a unique set of site conditions, unique site team, and the temporary nature of relationships between project stakeholders. Consequently, construction organizations are mandatory to have wide-ranging modification of standard ERP module software from the developers of ERP systems. Sadly, such wide-ranging modifications consequence in a better challenge in implementing ERP systems. Thus, choosing the suitable ERP systems realization methodology is required to make the most of the gains of such integrated ERP solutions for construction organizations [24].

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 departments 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 [102] 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 [20] 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. 164. Yakovlev and Anderson [164] have 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

Yakovlev and Anderson [164] indicate 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 describes an intangible as a recognizable non-financial asset without physical material held for use in the making or supply of products or services, for rent to others for organizational drives and motives [18]. 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 and Irani [95] 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 harder to estimate. Hares and Royle [54] point out that there are four chief intangible advantages in IT system investment. The initial advantage is inner development or infrastructure investment; physically it is crucial for the business. The next advantage is about the insight of the business by its customers. The customer-based intangible advantages, consist of those services that the customer realizes now and wants in the future, and comprises customer service and user fulfillment.

The last two categories are future-based and contain market trends, and the ability to adopt and modify to change. It can be seen that CERP investments could be assumed as planned investments due to that the key drives and motives of CERP system for construction

organizations are enhancements in customer relationships, decrease of lead times, decrease in production expenses and rise in company sales.

Furthermore, Murphy and Simon [165] indicated that enhanced customer service and other associated intangible advantages, such as; renewed technical infrastructure, are significant intangible advantages that companies are often looking for when performing 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 recognizing advantages that are appropriate is rather complex and because there are not any procedures or plans that all companies can track, this provides into contradictions [164].

Ohlsson and Ollfors [101] indicates that because of the multidimensional conditions of ERP system, intangible advantages and benefits will affect directly countless parts of the investing business organizations. Ohlsson and Ollfors [101] additionally indicates that although it is difficult to allocate any economic values to these intangible advantages, at least without stretching expectations beyond a suitable level, it is still significant to measure them.

The mostly known measurement used for these benefits are binary, numeric, or qualitative in nature, and by using these measurement systems, it is likely to recognize and appraise how they will influence on the organization.

The main predictable advantages of an integrated CERP system contain data distribution and sharing, enhanced transparency of executive and management tasks, and enhanced business effectiveness. These advantages will permit healthier business choices to be completed in a timely manner [137].

“Information Sharing” is one of the advantages and benefits of CERP systems for construction firms. In a traditional business management situation, construction information

is preserved by related and responsible departments in a construction organization. An end user must reach and overcome organizational challenges and barriers among departments in order to reach data that belongs to other departments. An ERP system performs and works on one single database. Once a part of data is created, it is recorded in the dominant database and is accessible to all qualified end users in the system. For instance, if equipment information is presented online, project managers would be able to use the data to keep their desirable equipment online, though the similar consequences can be realized in an outdated situation through back-and-forth communications among the project team members and the logistics and warehousing department. If the sending status of construction items is available online, project managers would be able to promptly notice a late transfer and to appraise its effect on a construction time schedule.

Data sharing eliminates the requirement of redeveloping or reentering the identical data in different departments or construction units. Removing numerous information entrances also support keep information reliability and uniformity, and decreases human mistakes. For example, the required number of construction material in a construction site is projected by the engineer in the estimating department. Using this data and knowledge organized with the construction time schedule, a procurement officer can make an order. Conventionally, this data is reentered into several separated applications such as time scheduling applications and purchasing applications [137].

“Improved Transparency of Management Responsibilities” is one of the advantages and benefits of CERP systems for construction firms. Several business processes need a consecutive set of responsibilities to be achieved by several departments. For example, a procuring progression contains making a procurement demand, endorsement of the request order, soliciting quotations and offers from distributers and suppliers, transferring a procurement command, and getting the product. Conventional technical manual and instructions circulations among workplaces regularly give rise to time delays or losing of data, or even mistakes in commercial choices and decisions. For instance, a procurement demand from a construction team may be misplaced anywhere so that the demand is not processed. If the sending/transport data is not directly available to the construction manager, the mistake may not be discovered until the material is needed on the job site. Later the example, it is very hard to trace down the responsibility since the position of the procurement

demand is not completely traced. The construction team may criticize the procuring employee, whereas the procuring employee may claim that a procurement request was not ever established [137].

An integrated ERP system achieves a business management modules' functions by performing a consistent process model that contains organization tasks. Tasks are achieved one-by-one by next the order specified in the model. A whole association among departments is accomplished over the networked connections between departments. Afterward a task is completed, the ERP system will pass to the next task in the model. Through the process, the system retains all details concerning when a task can be achieved and when and by whom a task is done. If a procurement request is created, it is traceable to when it is created and when it is delivered to the procurement department. Thus, the duty is clear and understandable if the procurement request is not handled anyplace. Furthermore, with the transport status online, the project team can determine the problem if the procurement request is not handled appropriately [137].

"Improved Management Efficiency" is one of the advantages and benefits of CERP systems for construction firms. Shi and Haplin [137] indicates that an ERP system improves management efficiency through two improved practices:

- Providing timely consistent information
- Providing a coordinated decision-making environment.

Making business decisions needs related data and knowledge in a timely manner. In a conventional business management location, business executives are regularly challenged with dissimilar or even contradictory numbers gotten from different sources. Management decisions have to be overdue in order to be confirmed these numbers by the business management team members. For example, an agreed decision may be tough to agree for a continuing construction project if the project team, the financial department, and the project management department have presented different pictures for the construction project since each department have focused on different parts of project evaluation, up-to-date the project status at different time intervals, and/or did not interconnect with each other through their updating. In an ERP system, each piece of data and knowledge have one single source at

central database and has one responsible party who may update it, so that all parties at construction organization will take the same data [137].

The networking IT solutions removes the location barriers among workplaces of an organization so that all workplaces perform on their responsible jobs in a harmonized way. A business execution process performs from one location to another and data transfers from one workplace to another flawlessly. For instance, after a procurement request is started, the related demand will directly be transferred to a responsible department and workplace in order to submit as well-defined in the procedures. All demands for approvals are recorded on the screen in the financial employee's department. A financial controller appraises one demand at every time. After being handled by the financial controller's department, a demand continues its voyage to the next department [137].

"Standardization versus Customization of Management Functions" is one of the advantages and benefits of CERP systems for construction firms. Shi and Haplin [137] indicates that present ERP systems accomplish business management computerization over standardization. A standard process model is performed according to the greatest practice for executing a business function. Whenever the management function is needed, the same standard process will be performed in an ERP system. At the implementation phase of an ERP system, an organization has the opportunity whether or not to implement a standard system. If the organization agrees to use it, its employees must follow the standard process to perform the functions when the ERP system is up and running. Thus, standardization frequently necessitates an organization to reengineer its business processes.

The advantages of standardization comprise enhanced management competence and declined human mistakes, nevertheless it necessitates the employees in the organization to accept new working procedures that are different from what they were used to before ERP implementation. Even though it is likely to demand an ERP consulting firm to modify standard processes to fit a company's practices, it is clear that it can be expensive and time consuming, and this can generate some future problems at the next releases of ERP system selected [78]. Customization is consequently not suggested by ERP providers if it is not necessary.

There are two distinct exploration subjects: standardization and modification of construction management module and functions. Shi and Haplin [137] indicates that some management modules and functions can be standardized based on the industry-wide practice. Standardizing a management function embraces:

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

For example, at a request termination management process, if the procurement department is up-to-date that a request for a batch of window frames is cancelled due to the material supplier is out of business, a procurement employee can start the termination process. In the order cancellation box, ‘‘window frames’’ is emphasized. Another supplier or distributor is acknowledged by the procurement employee from the alternative supplier list, and a new order is generated with the endorsement of the procurement employee. The affected construction projects and departments are then informed about the renewed cost and transport data of new construction material. The construction manager can update the job-site plan to accommodate the new sending date [137].

Alternatively, the construction sector is considered by non-standardization in many ways. Countless business management progressions cannot be standardized. Research is needed to advance conforming technology that will permit specific management procedures to be performed easily [80].

Due to the fact that current ERP systems are mainly established for the manufacturing, service and production industry, they can barely encounter the requirements of the construction organizations. A knowledge base is required for evolving CERP systems by addressing the nature and business culture of the industry [137].

In a research made by Lee *et al*. [87], a simulation model to implement ERP system in the material management (MM) is created. They employed the model based in four separate phases, which are application integration, internal integration, external integration, and automation. This research indicates that the intervals of almost all of the activities

involved in the material management process are positively been declined and even in many cases these action intervals have become removed. They indicated in their research that an ERP system has declined purchasing cycle by almost 80%, through computerizing most of the repeating transactions, and by dropping labor resources to run the tasks. Hereby executing ERP systems for a construction organization in MM has quantifiable advantages in all other areas, which interface with the MM module [87].

In the study of SAP systems made by Connor and Dodd [27], there are 15 functions ensured by SAP, but scarce in some way and/or to some extent. These limited areas can be listed as following that; unit price tracking, job cost reports, labor cost report and work hour estimation, change order cost tracking, WBS model, project milestone schedule, detailed activity precedence network, project schedule reports, short interval planning, procurement request and order development and issuance, monitoring of change orders, re-work, and back-charges, management of contractor retainage, tracking and documenting percentage of physical completion, field warehouse inventory management and warehouse inventory reorder management [3, 4].

The achievement of ERP in industrial production enterprises caused in its adoption in some large construction organizations [94, 153]. However, due to the differences in manufacturing and construction processes, ERP modifications in these organizations caused in the combination of financial management processes only [1]. There are many explanations and motives for the differences between production and construction organizations and sectors.

Initially, the construction industry is unique in its work environment and the distributed nature of stakeholders. Even though construction industry has many likenesses with the production and service industries about manufacturing processes, it generally creates one kind and well-defined prototype products. Moreover, the construction organizations manage project-based actions that are managed by many dissimilar parties which may be physically spread. As diverse organizational entities, each of the project members and parties have different aims to achieve in the construction projects. Besides, the volume of data and its time limitations in the construction projects makes it very difficult to perform in time. Therefore, general or usual ERP system packages are planned to implement

initially for production and non-project-based industries like construction industry. Wide-ranging modification are essential in order to answer to these specific requirements of construction industry. This has been the main purpose up-to-date for the low number of implementation of standard ERP systems in the construction organizations [145].

The current difference between the requirements of the construction organizations and applications from ERP systems and their average features offered has created a hole between solutions presented by ERP developers and the requirements of the construction organizations. Meanwhile, with the saturation of the market in other sectors, ERP developers have turned to other sectors in order to increase their existing market shares [114]. Consequently, with the beginning to the new millennium, main ERP developers like SAP and Oracle have tried to modify their typical ERP applications to the requirements of the construction organizations. Project-based construction industry solutions such as C-ERP imitate to a set of criteria that make them different from common standard ERP systems. For example, C-ERP are project-based, combined, unified through the construction project life cycle, and remotely reachable, between other features [137]. The advantages anticipated from C-ERP execution are explained as following that; [3, 4, 94, 114]: “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 [145].”

When the ERP systems platforms becomes popular, software programs begin to support business executives to implement ERP systems in various business departments and functions such as; project planning and control, subcontracting and its related functions, material management, service management, finance and accounting management, and human resources management. Presently, SAP, Oracle and PeopleSoft propose C-ERP solutions. The functionality of C-ERP contains the complete construction project life cycle. The scope of the C-ERP system is represented in the figure below and the implications to the project life cycle are defined below [145].

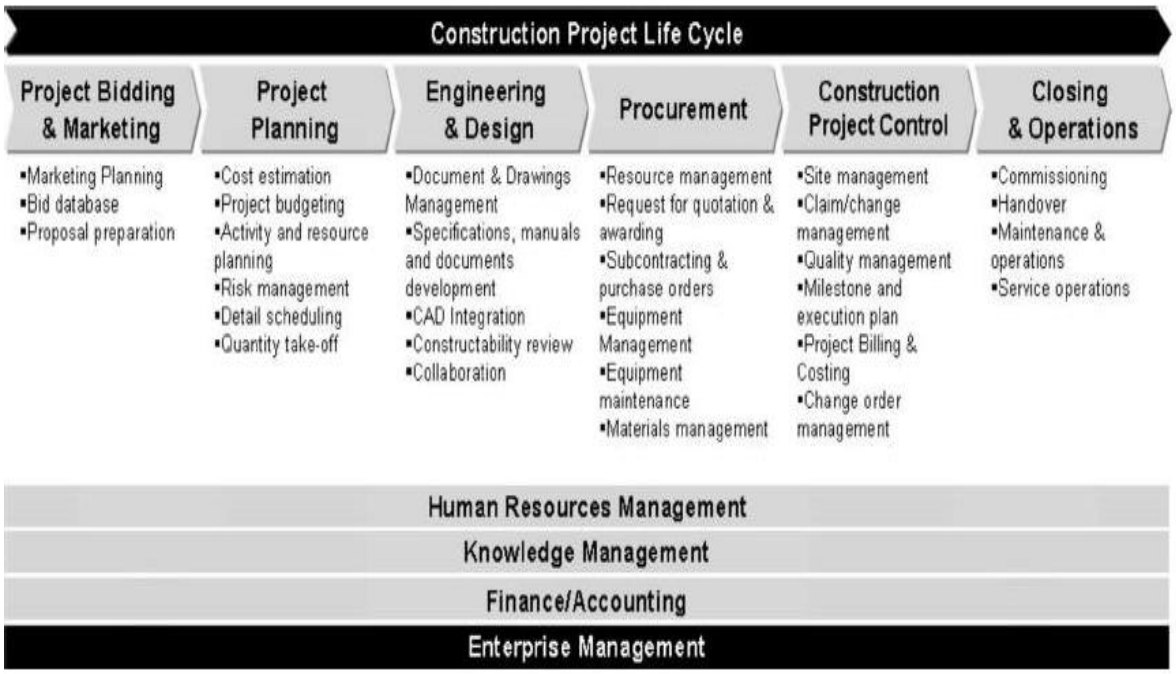


Figure 2.9. Scope of C-ERP system in construction project life cycle [145].

“Project Bidding/Marketing” is one of the advantages and benefits of CERP systems for construction firms. C-ERP mechanizes the processes of tender preparation, offers and reviewing bids, marketing campaign and advertisement management, CRM management, and competitor analysis [145].

“Project Planning” is one of the advantages and benefits of CERP systems for construction firms. C-ERP systematizes actions related to cost estimate, project cost control, action and resource planning, and comprehensive time scheduling. All of these are performed in single software, which prevent identical data entry, particularly between initial cost and budget estimation and complete time planning [145].

“Design/Engineering” is one of the advantages and benefits of CERP systems for construction firms. With C-ERP preparation of complete specifications and necessities is computerized. C-ERP sustains all specifications and drawings details along with the support of its document management module. Computer aided design (CAD) colloboration is generated to evade identical generation of CAD drawings or specification documents during the project life cycle and teamwork applications are used to support the mutual communication requirements of project contributors and shareholders [145].

“Procurement” is one of the advantages and benefits of CERP systems for construction firms. C-ERP restructures purchasing requirement items, equipments, and services. It systematizes the processes of determining possible distributors, supplier and subcontractor evaluation, offer value negotiation, contract management, awarding purchase orders to the supplier, and supplier billing. Supply chain management (SCM) of materials is managed through this function. For equipment management, it also systematizes maintenance time scheduling and service operations information [145].

“Construction Project Control” is one of the advantages and benefits of CERP systems for construction firms. Over combined data reachability from other functions, it is much easier for the project or construction managers to perform the project. Similarly, project billing and project budget are integrated in real time which permit the main office to keep track of projects. C-ERP also industrializes the change order management which is an significant time consuming action at project duration [145].

“Workforce Management” is one of the advantages and benefits of CERP systems for construction firms. C-ERP manages personal and payroll related actions and works at the construction organizations. A comprehensive worker and white-collar database is preserved including main contact information, wage details, attendance of the employees, performance evaluation scores, and promotion of all employees. Likewise, this function is combined with the knowledge management system within the organization to optimally utilize the skill of all employees [145].

“Finance/Accounting” is one of the advantages and benefits of CERP systems for construction firms. As one of its central module, C-ERP reorganizes the financial and accounting actions and processes of both the enterprise and projects, gathers financial information from all different departments, and produces all financial and financial management reports like main balance sheet, accounting general ledger, accounts payable, accounts receivable lists, and quarterly financial statements of the construction organizations [145].

Along with C-ERP it is likely to share and exchange data and knowledge in digital format through the project life cycle. Therefore, data is recorded only once and all project

contributors are able to reach this data. It is exposed the probable outcome of C-ERP in streamlining communication between members [145].

Data combination can be generated over a centralized main database system in the central of C-ERP. All information is entered only once by related department employee, and are reachable through the whole project life cycle. Process integration is generated by applying one combined IT system for the entire project life cycle, rather than using numerous separate software applications. By reorganization and joining all business functions and departments, business processes can be performed without any break [145].

Lastly, connecting project contributors is understood through online access to project data by all of the project contributors. The project shareholders and members can view and use project data with changing levels of access permission, and enter or review data related to their departments or work units. The idea of computer integrated construction (CIC) is to combine data, information, and project participants altogether. C-ERP is similarly proposed for this particular purpose in its ways [145].

3. INVESTIGATION OF CURRENT ERP SYSTEMS IN CONSTRUCTION INDUSTRY TO DEFINE BETTER C-ERP SYSTEM STRUCTURE

In order to define a new and better project-based C-ERP system for Turkish Construction Industry, first of all, it is aimed to observe and understand the current situation of ERP systems in Turkish construction companies. In order to understand current situation, it is selected three different ERP systems in Turkish construction industry and they are SAP that is one of the best-known ERP system in the world especially for large-scale companies, MS Dynamics that is also one of the best preferred ERP system in the world and Yapıtaşı ERP that is local ERP solution for Turkish construction companies.

In order to understand how the systems works, both literature review has been done and live ERP platforms experience have been performed. ERP system user manuals and procedures have been read. Also, each platform workshop has been taken at least two months in order to understand how system works, what kind of modules they have and what kind of functions and processes they are performs. Each module is used actively and the abilities of the modules are understood by receiving guidance from the employees of the vendors or consultants mentioned at the part of case studies of these thesis.

3.1. SAP ERP System for Construction Industry

In order to understand SAP ERP systems, it is investigated both the literature on SAP Systems and its training documents, and also it is experienced live SAP platform to see how it works.

During the investigation of SAP systems, all module and functions are listed as an MS Excel table. At Figure 3.1, it can be seen some part of the module list table of SAP systems. The whole list can be found at the Appendix A.

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO (MBS 04)	MODULE NO	NO	WORK NO	MAIN MODULES (MBS 01)	MODULES (MBS 02)
03	04	05	00	03.04.05.00	85	03.04.05.00.85	Cross-Application Components	Engineering Change Management
03	04	06	01	03.04.06.01	86	03.04.06.01.86	Cross-Application Components	Engineering Change Management
03	04	06	01	03.04.06.01	87	03.04.06.01.87	Cross-Application Components	Engineering Change Management
03	04	06	01	03.04.06.01	88	03.04.06.01.88	Cross-Application Components	Engineering Change Management
03	04	06	02	03.04.06.02	89	03.04.06.02.89	Cross-Application Components	Engineering Change Management
03	04	06	02	03.04.06.02	90	03.04.06.02.90	Cross-Application Components	Engineering Change Management
03	04	07	00	03.04.07.00	91	03.04.07.00.91	Cross-Application Components	Engineering Change Management
03	04	07	00	03.04.07.00	92	03.04.07.00.92	Cross-Application Components	Engineering Change Management
03	04	07	00	03.04.07.00	93	03.04.07.00.93	Cross-Application Components	Engineering Change Management
03	04	07	00	03.04.07.00	94	03.04.07.00.94	Cross-Application Components	Engineering Change Management
03	04	08	00	03.04.08.00	95	03.04.08.00.95	Cross-Application Components	Engineering Change Management
03	04	08	01	03.04.08.01	96	03.04.08.01.96	Cross-Application Components	Engineering Change Management
03	04	08	01	03.04.08.01	97	03.04.08.01.97	Cross-Application Components	Engineering Change Management
03	04	08	01	03.04.08.01	98	03.04.08.01.98	Cross-Application Components	Engineering Change Management
03	04	08	01	03.04.08.01	99	03.04.08.01.99	Cross-Application Components	Engineering Change Management
03	04	08	02	03.04.08.02	100	03.04.08.02.100	Cross-Application Components	Engineering Change Management
03	04	08	02	03.04.08.02	101	03.04.08.02.101	Cross-Application Components	Engineering Change Management
03	04	08	02	03.04.08.02	102	03.04.08.02.102	Cross-Application Components	Engineering Change Management
03	04	09	00	03.04.09.00	103	03.04.09.00.103	Cross-Application Components	Engineering Change Management
03	04	09	00	03.04.09.00	104	03.04.09.00.104	Cross-Application Components	Engineering Change Management
03	04	09	00	03.04.09.00	105	03.04.09.00.105	Cross-Application Components	Engineering Change Management
03	04	10	00	03.04.10.00	106	03.04.10.00.106	Cross-Application Components	Engineering Change Management
03	04	10	00	03.04.10.00	107	03.04.10.00.107	Cross-Application Components	Engineering Change Management
03	04	10	00	03.04.10.00	108	03.04.10.00.108	Cross-Application Components	Engineering Change Management
03	05	01	00	03.05.01.00	109	03.05.01.00.109	Cross-Application Components	Classification System
03	05	01	00	03.05.01.00	110	03.05.01.00.110	Cross-Application Components	Classification System
03	05	01	00	03.05.01.00	111	03.05.01.00.111	Cross-Application Components	Classification System
03	05	02	00	03.05.02.00	112	03.05.02.00.112	Cross-Application Components	Classification System
03	05	02	00	03.05.02.00	113	03.05.02.00.113	Cross-Application Components	Classification System
03	05	02	00	03.05.02.00	114	03.05.02.00.114	Cross-Application Components	Classification System
03	05	02	00	03.05.02.00	115	03.05.02.00.115	Cross-Application Components	Classification System
03	05	02	00	03.05.02.00	116	03.05.02.00.116	Cross-Application Components	Classification System

Figure 3.1. SAP ERP Modules List (Continued in Appendix A).

It can be seen below some real time SAP system usage screenshots belong to main modules of it.

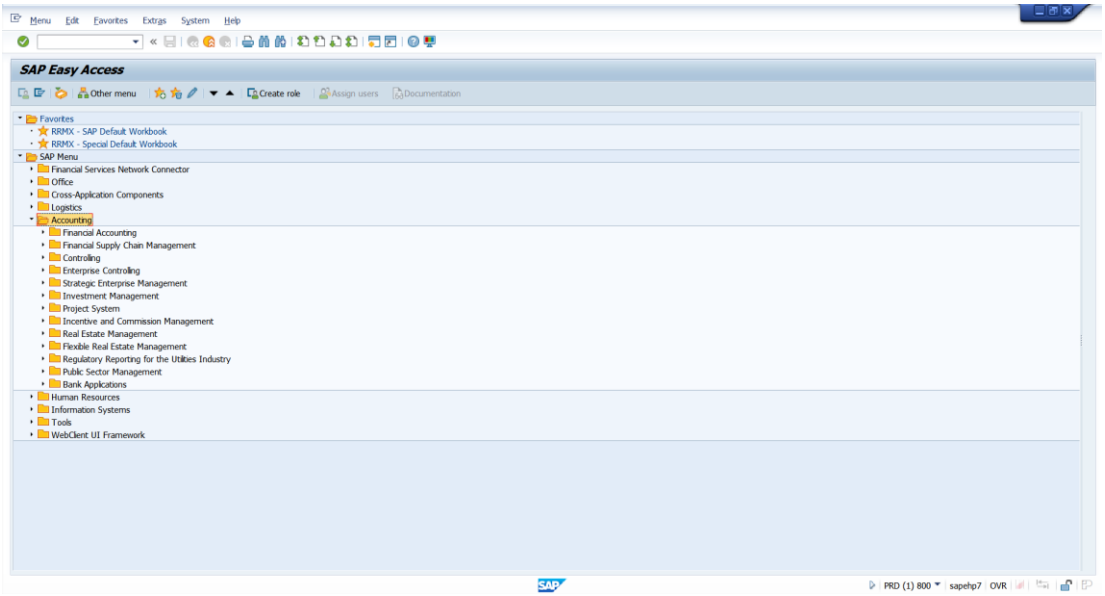


Figure 3.2. SAP Accounting Main Module.

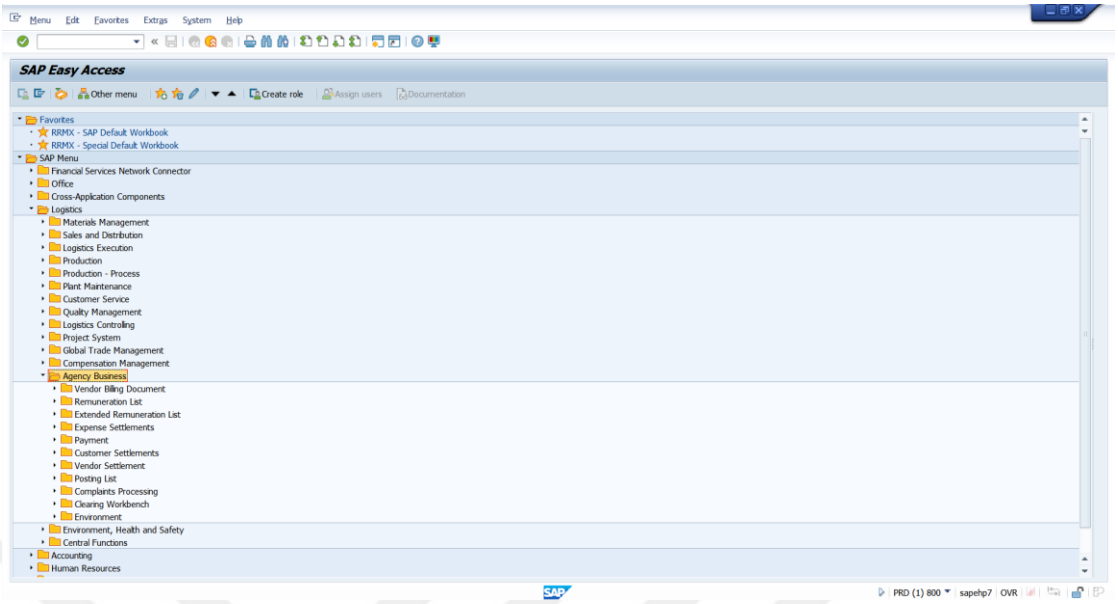


Figure 3.3. SAP Agency Business Main Module.

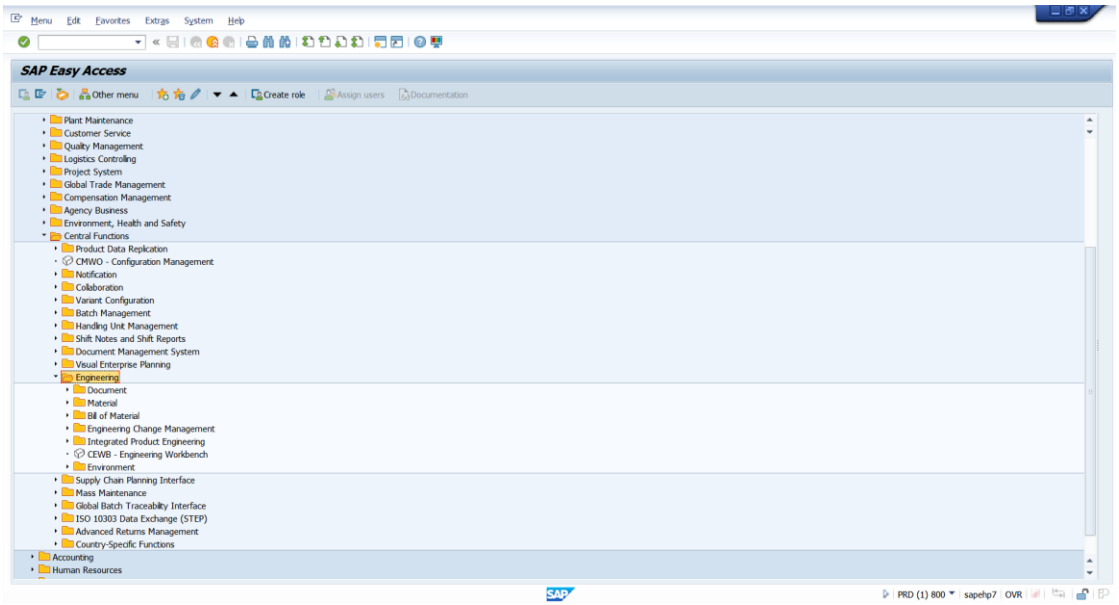


Figure 3.4. SAP Engineering Main Module.

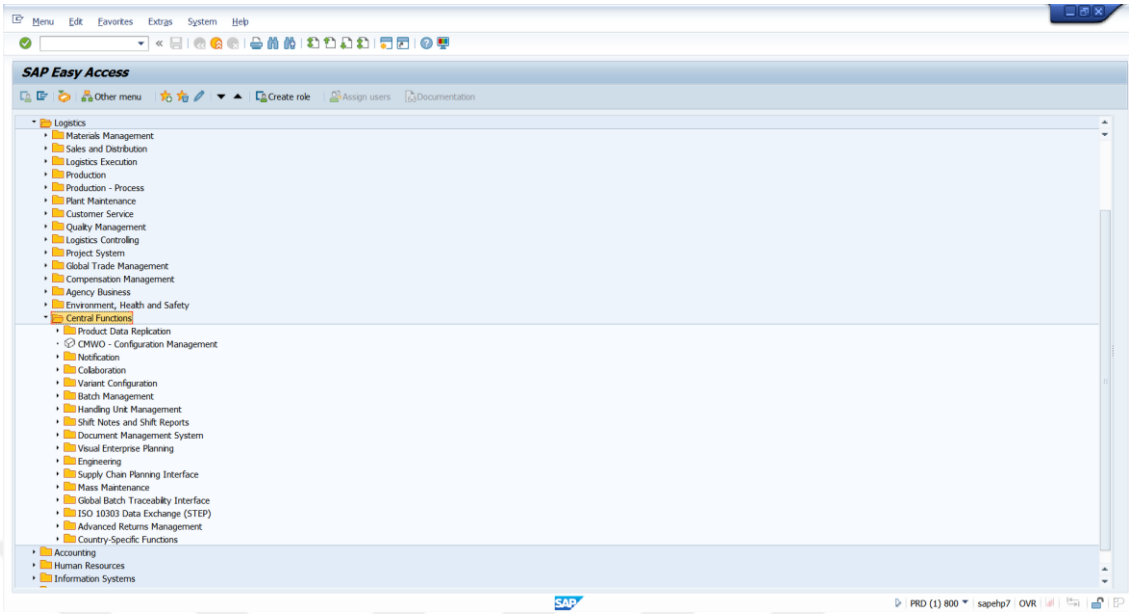


Figure 3.5. SAP Central Functions Main Module.

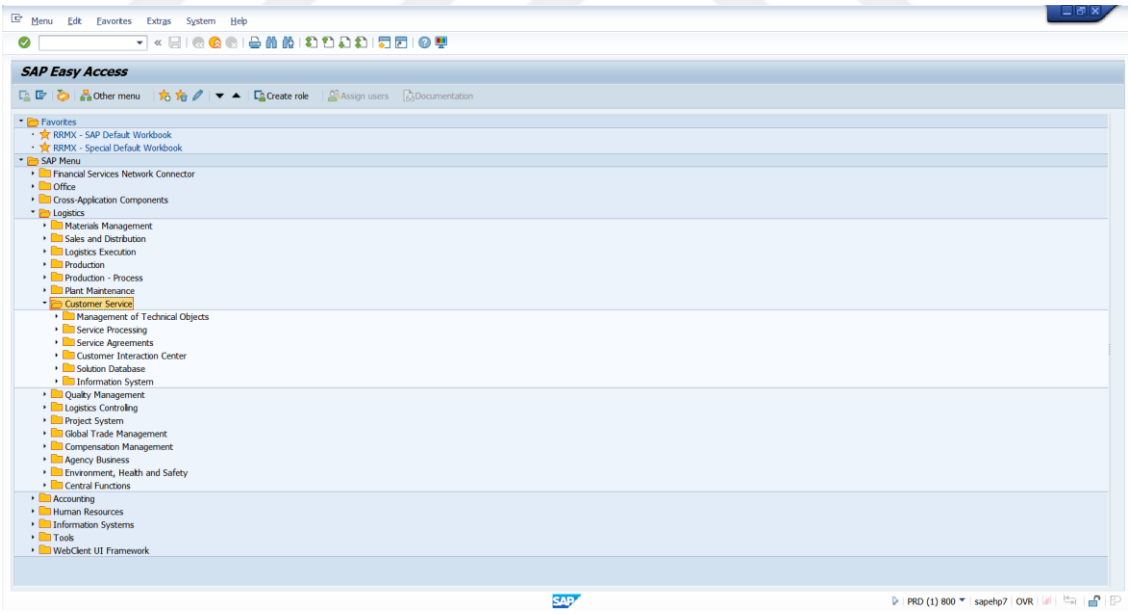


Figure 3.6. SAP Customer Services Main Module.

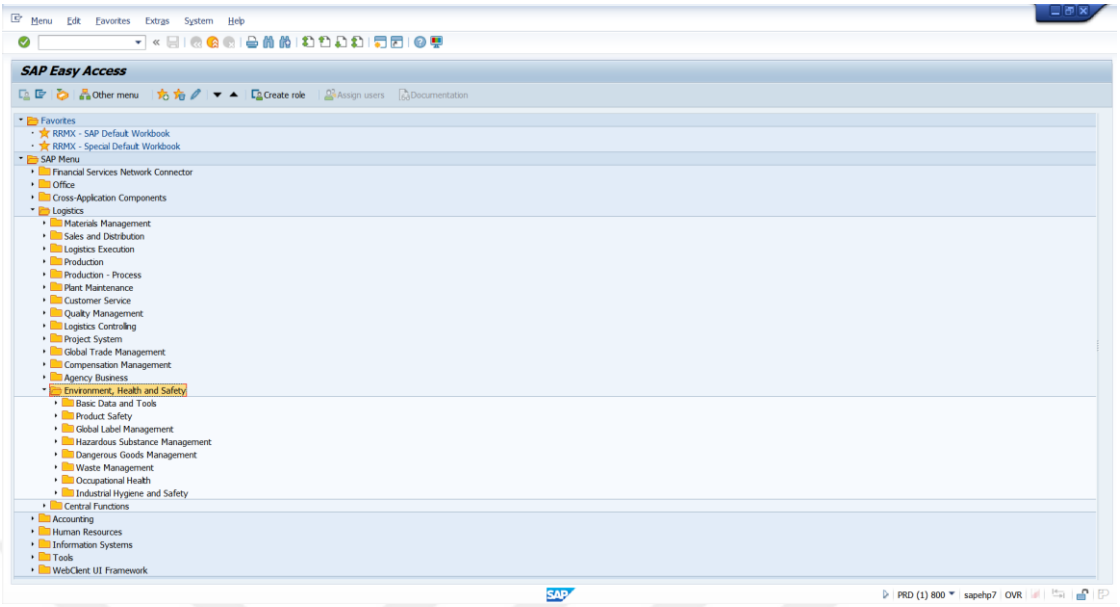


Figure 3.7. SAP Environment, Health and Safety Main Module.

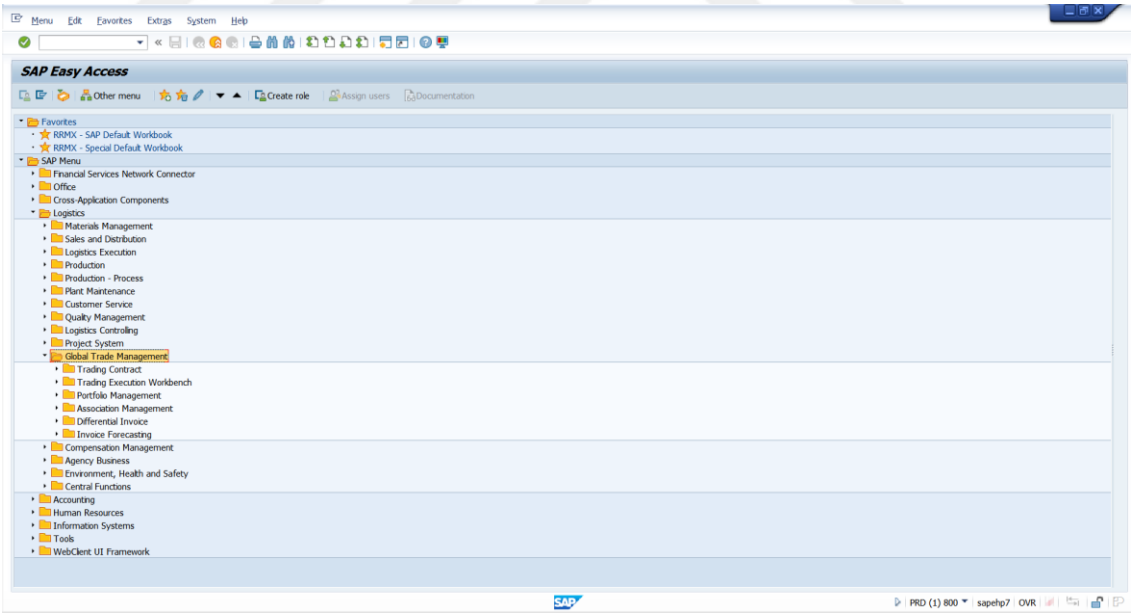


Figure 3.8. SAP Global Trade Management Main Module.

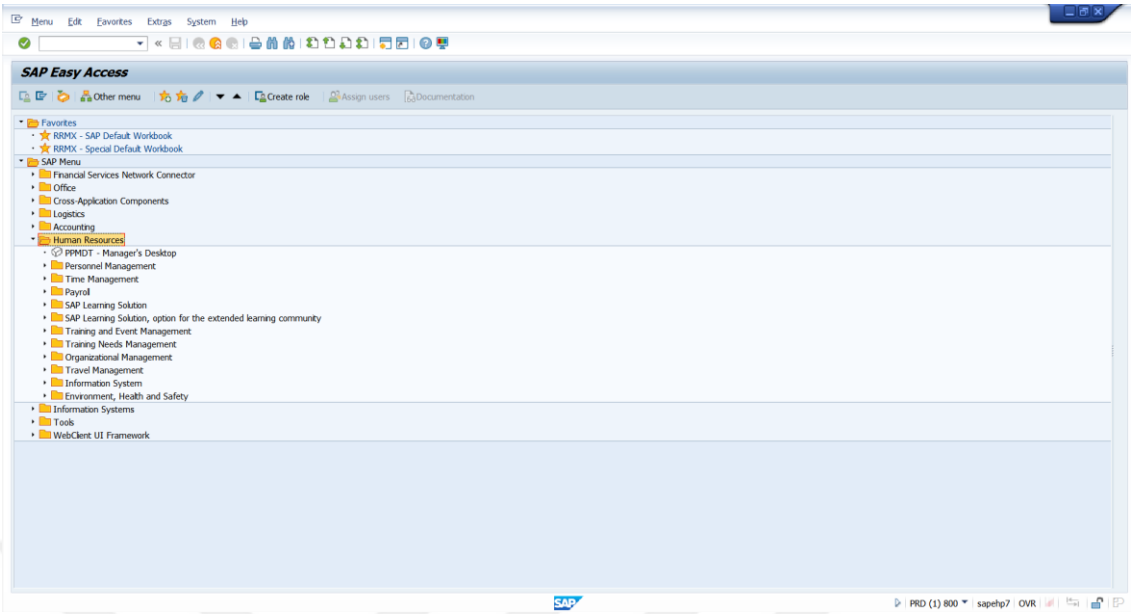


Figure 3.9. SAP Human Resources Main Module.

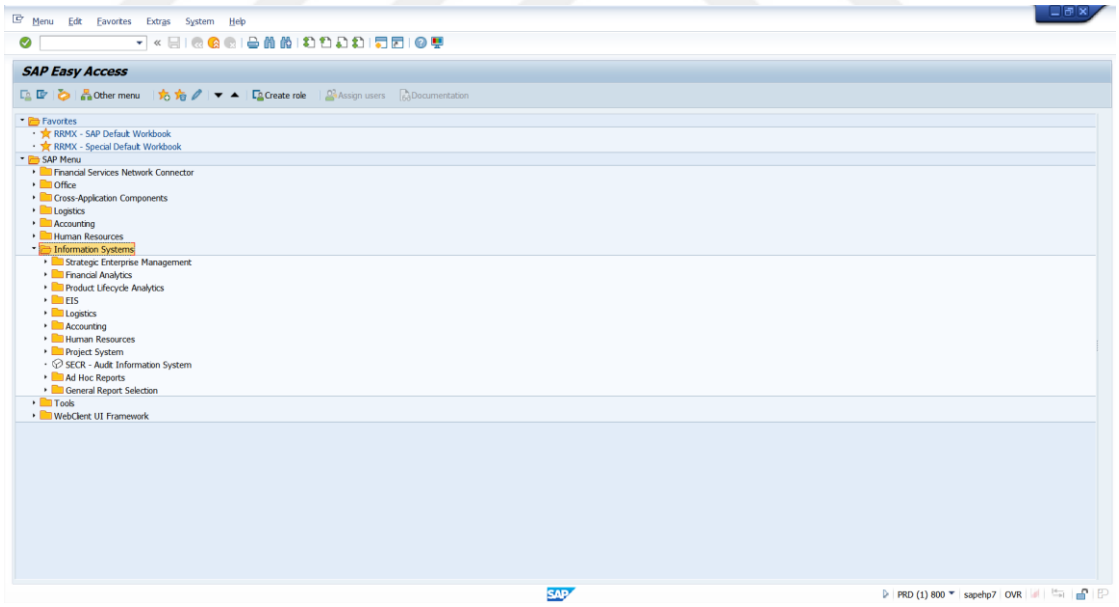


Figure 3.10. SAP Information Systems Main Module.

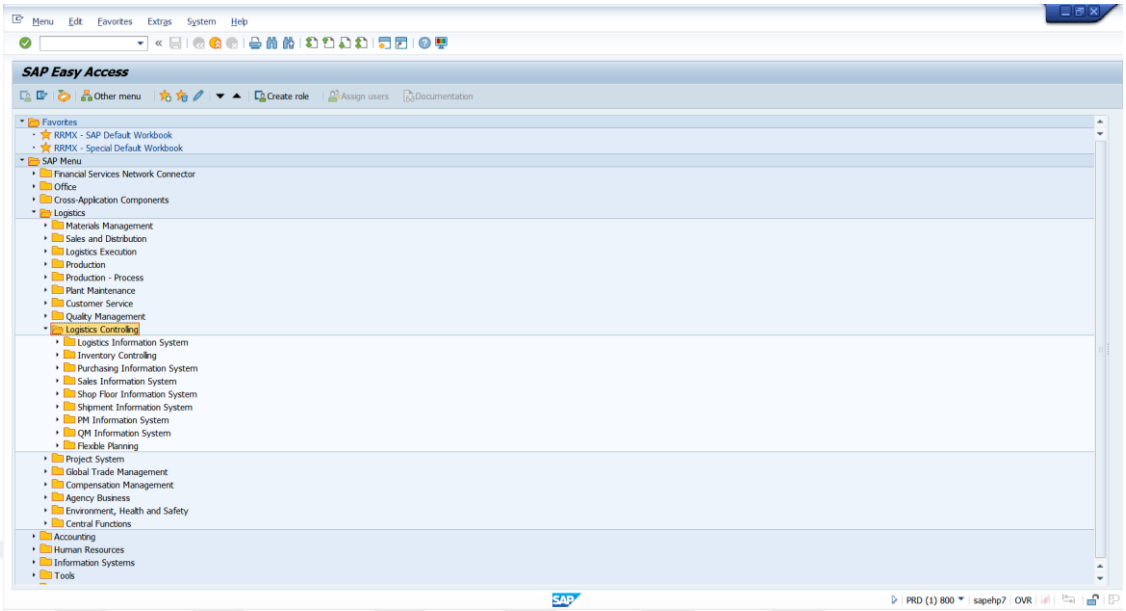


Figure 3.11. SAP Logistics Controlling Main Module.

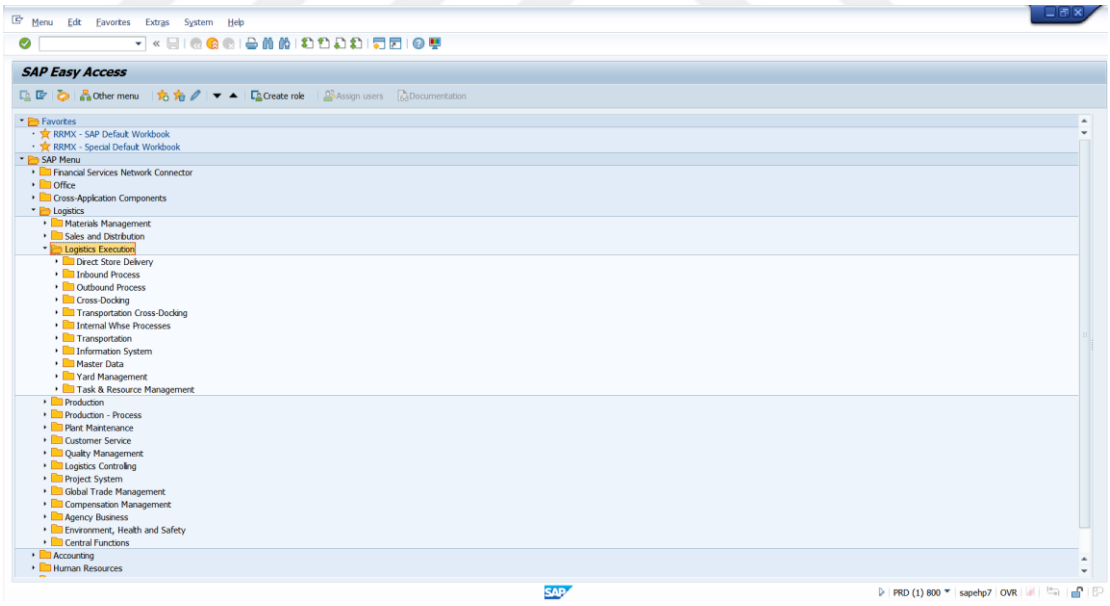


Figure 3.12. SAP Logistics Execution Main Module.

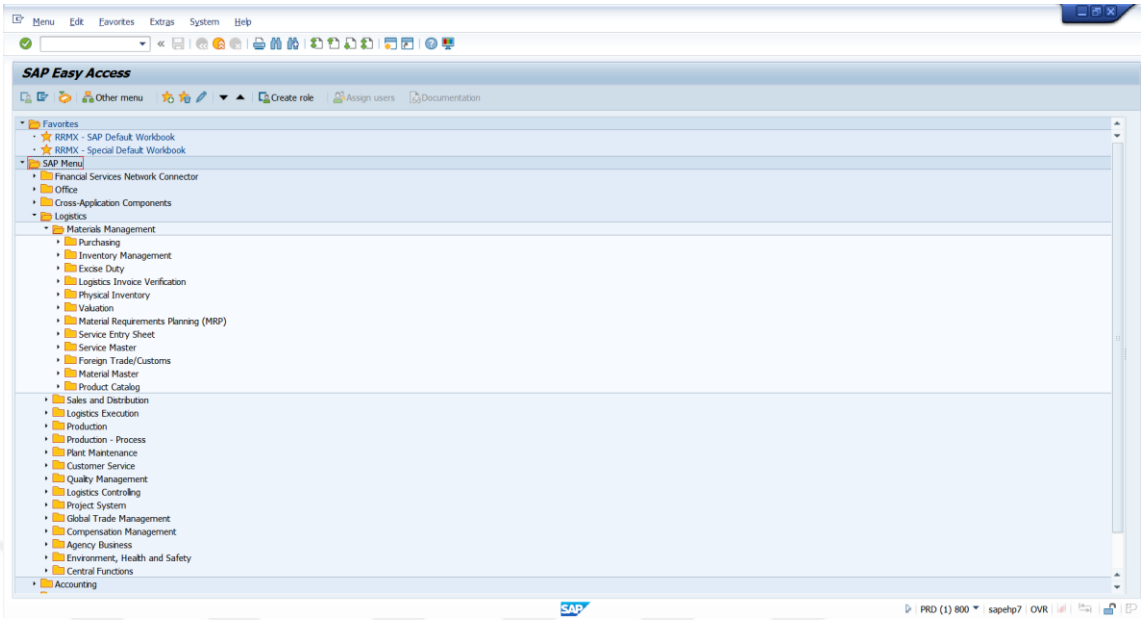


Figure 3.13. SAP Material Management Main Module.

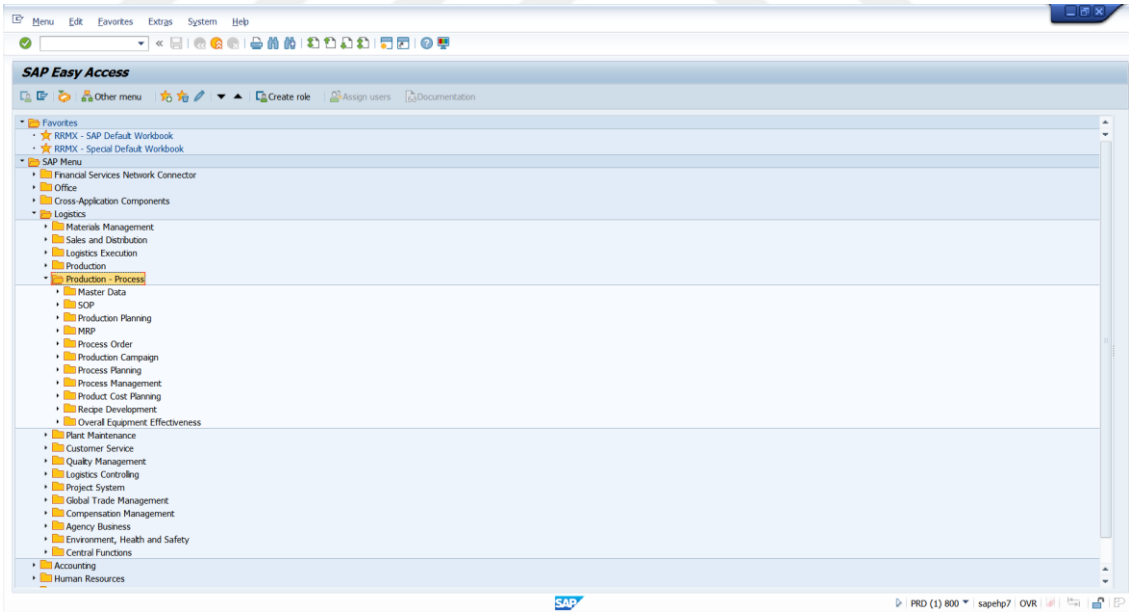


Figure 3.14. SAP Production – Process Main Module.

Here below the project systems main module of SAP ERP. SAP systems try to evaluate project-based construction ERP systems under this module. Further information is given at the followings of this section.

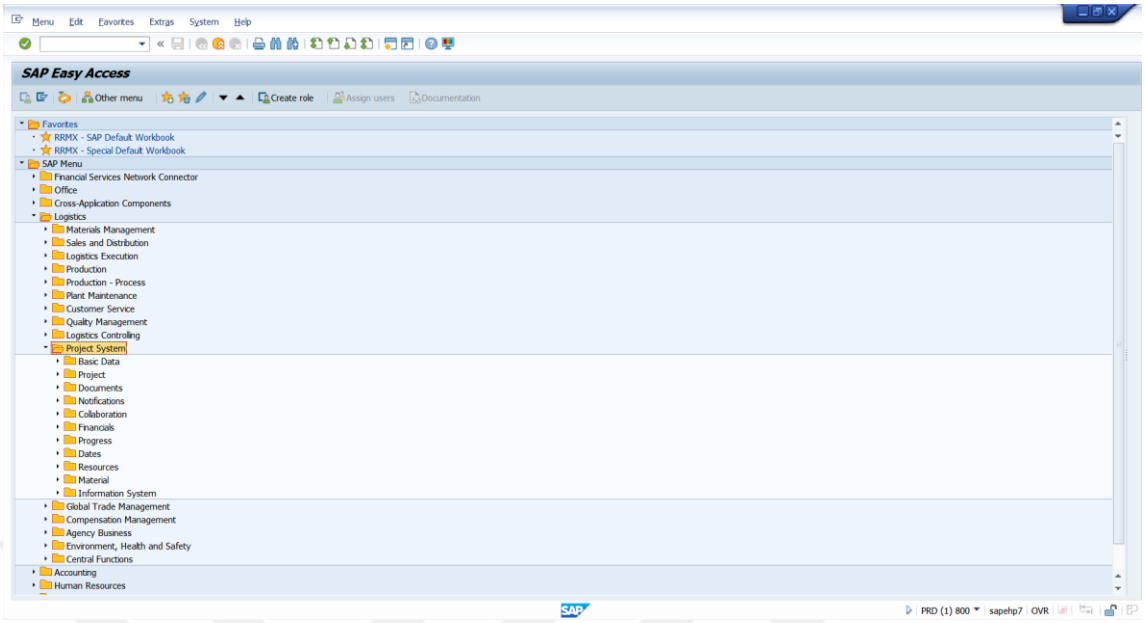


Figure 3.15. SAP Project Systems Main Module.

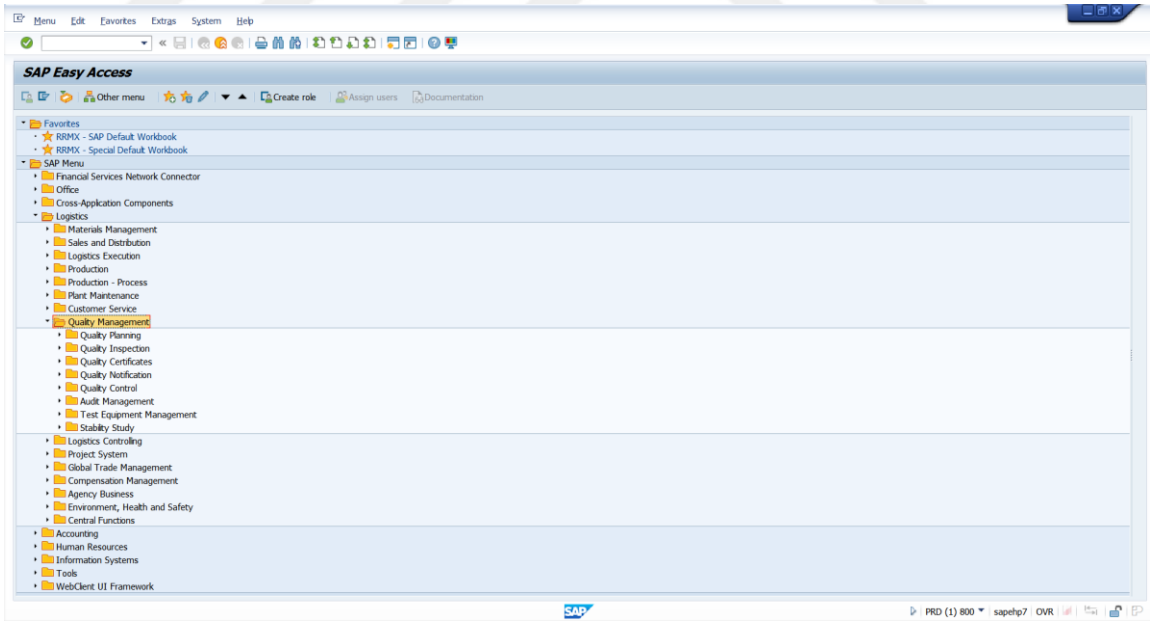


Figure 3.16. SAP Quality Management Main Module.

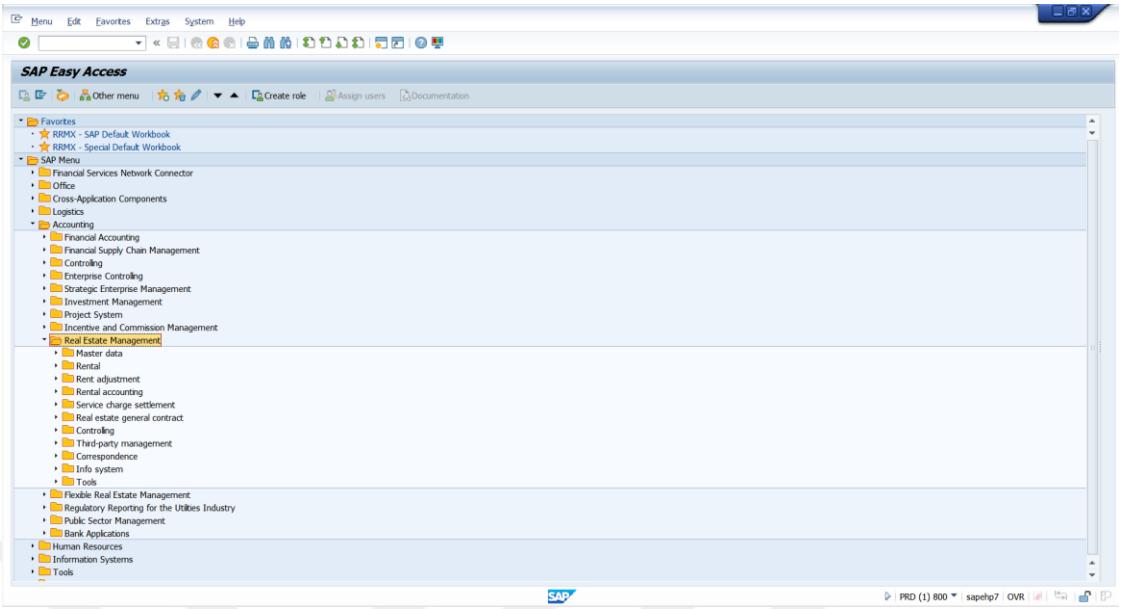


Figure 3.17. SAP Real Estate Management Main Module.

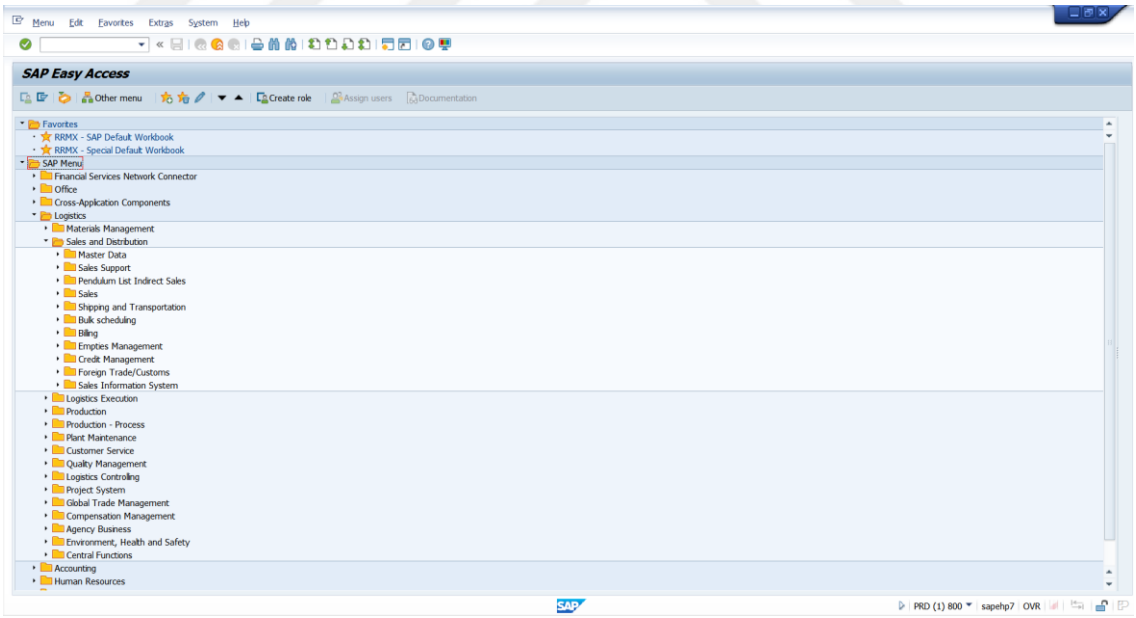


Figure 3.18. SAP Sales and Distribution Main Module.

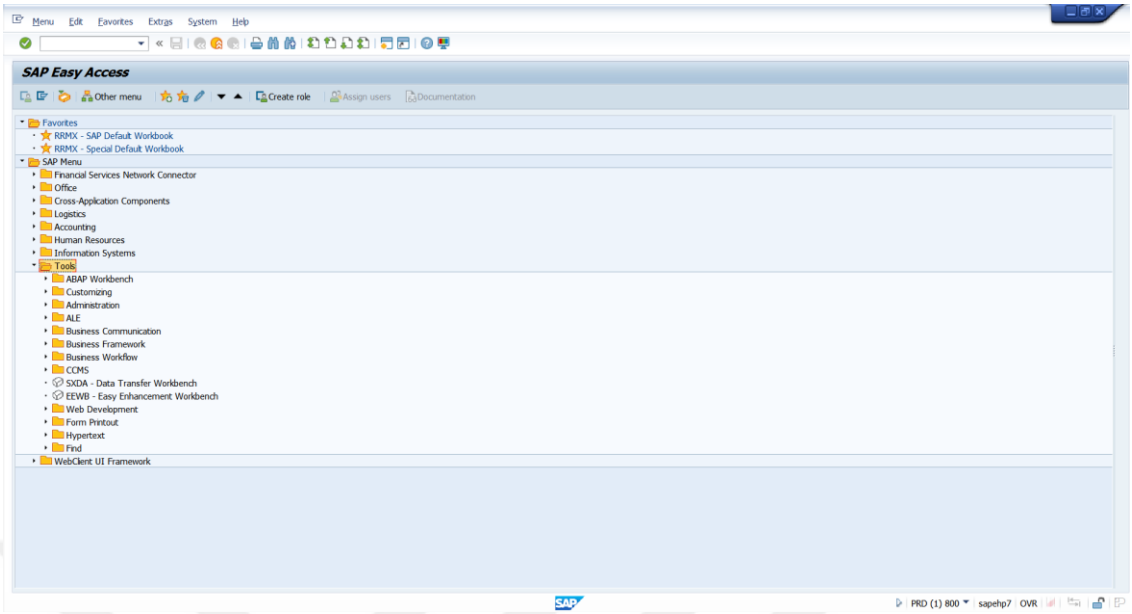


Figure 3.19. SAP Tools Main Module.

At the following part, it is given further information about SAP ERP systems that try to evaluate SAP ERP system to a project-based ERP system according to following procedures. *All procedures, figures, tables and other related data at following paragraphs are directly taken from the BFS [16] document.*

Along with the R/3 System, SAP constructs new features for usual systems. Based on advanced development IT systems, SAP system creates high level of cooperation among corporate management and information processing. The specific elements and parts in the R/3 SAP System are indicated by all-inclusive financial services which use the latest technology. Combination and coordination between the system modules and functions, accounting systems, and HR assurances agile and well-organized, effective treatment of the all professional works [16].

3.1.1. Functions

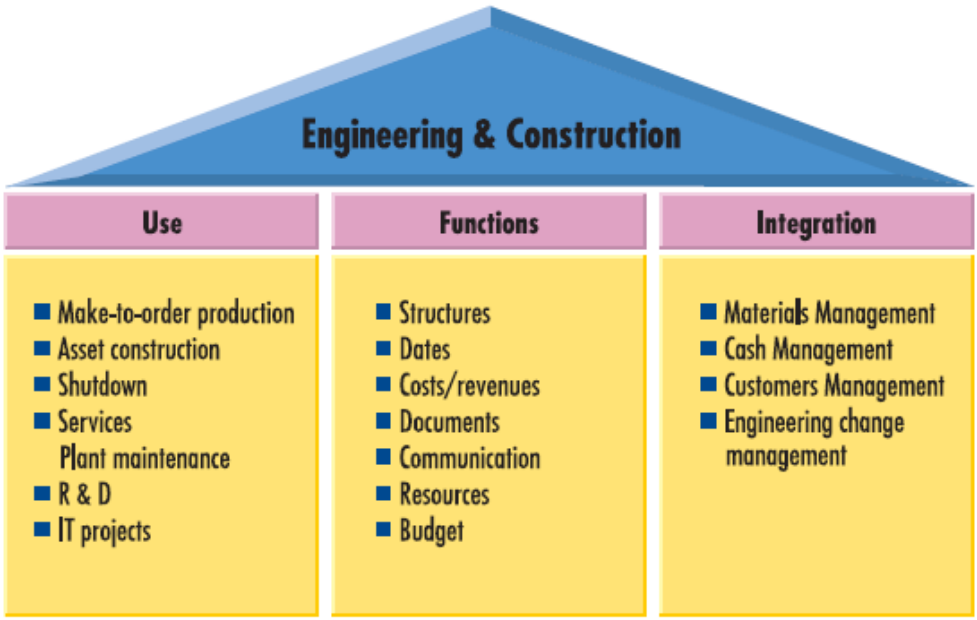


Figure 3.20. Integration and Wide Ranging Functions in E&C at SAP [16].

At the launch of all projects, whether it contains emerging a new goods, manufacture on order basis production, or inside organization, it is essential to describe and install the architecture required to achieve your plan and development and combine them into your present company organization and department procedures [16].

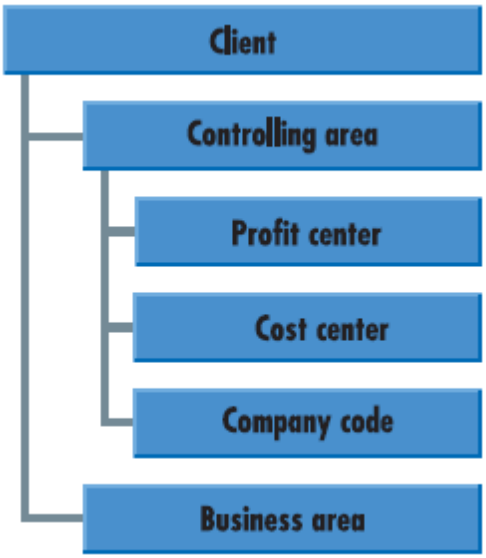


Figure 3.21. Organizational Structures in Accounting [16].

A financial investment program is a hierarchical organization for all the monetary venture expenses planned or planned budget in a commercial venture or organization for a specific duration. It can be used any organizing principles you want, such as; company department in charge, motives for the investment, so on [16].

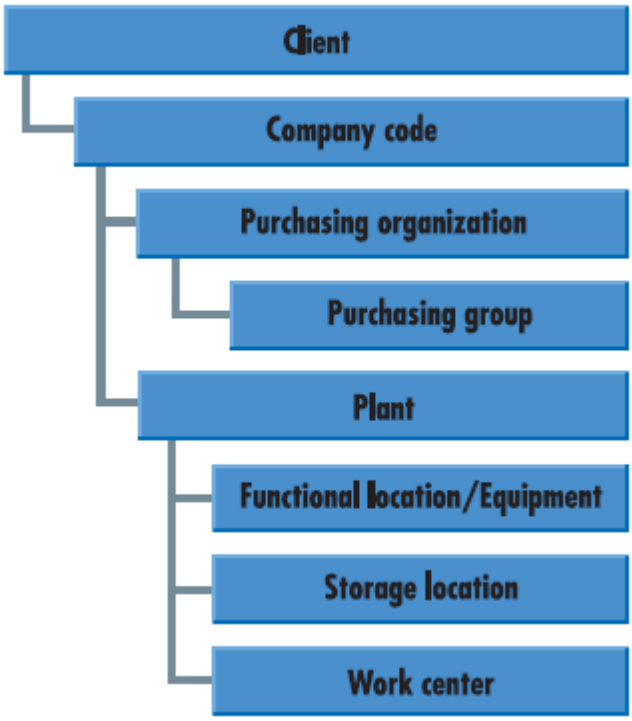


Figure 3.22. Organizational Structures in Logistics [16].

The procurement department is an organizational unit which obtains and manages supplies, services and materials for a few factories and arrange purchasing conditions with suppliers. The procurement department is separated into purchasing organizations or units which are responsible for specific purchasing actions. A factory can be a manufacturing place or simply adjacent places with their own stock of resources. It can be used storage places to distinguish between material stocks within a factory. The name “storage location” frequently indicates the place of the materials [16].

3.1.2. Project Structuring

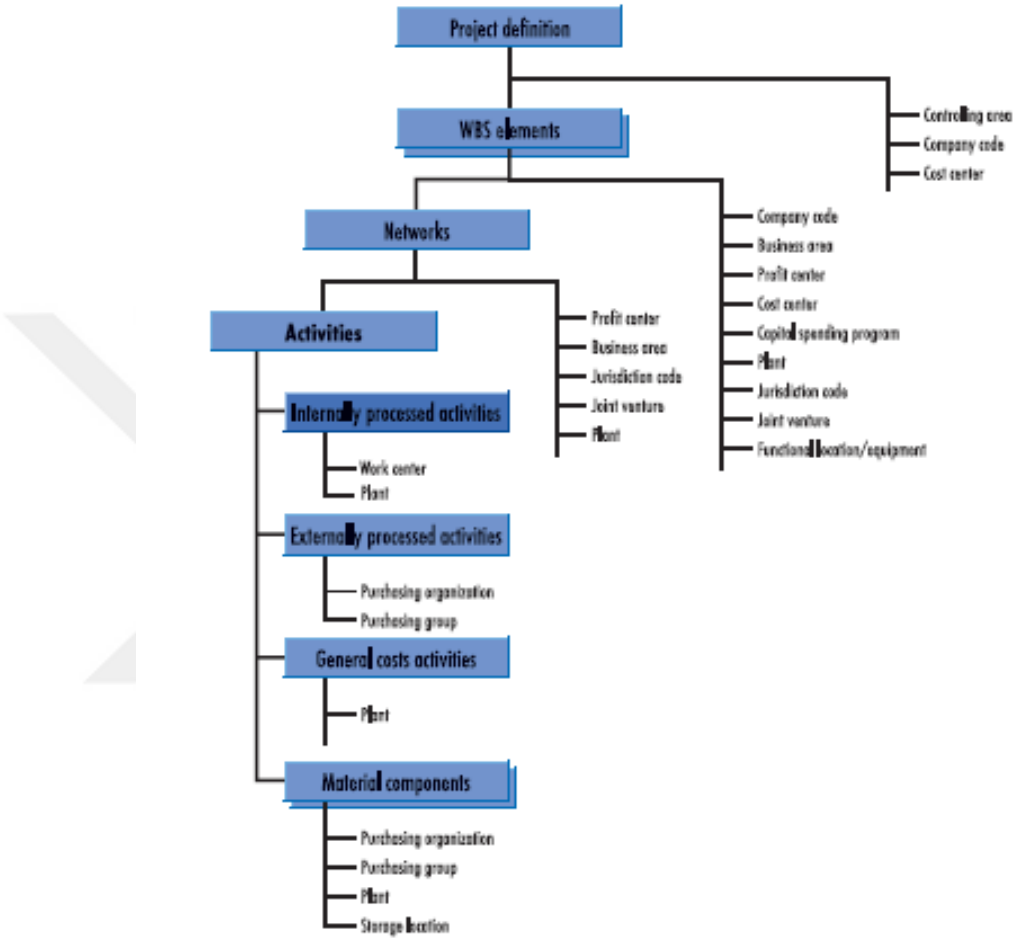


Figure 3.23. Organizational Structures in the Project System (BFS, 2016).

Before it can be run a project as a whole, it should be primarily defined the project aims exactly and generate an organization framework for the project actions to be managed. A pure project structure offers the foundation for effective project planning, tracking, and management. It can be performed and managed your project organization framework in SAP system by using work breakdown structures (WBS) tools and networks elements [16].

3.1.3. Work Breakdown Structure

The work breakdown structure (WBS) is the ordered framework model of the tasks to be managed in a project. It ensures an outline of the project and creates baselines of an project management by indicating project works, time schedules and cost items [16].

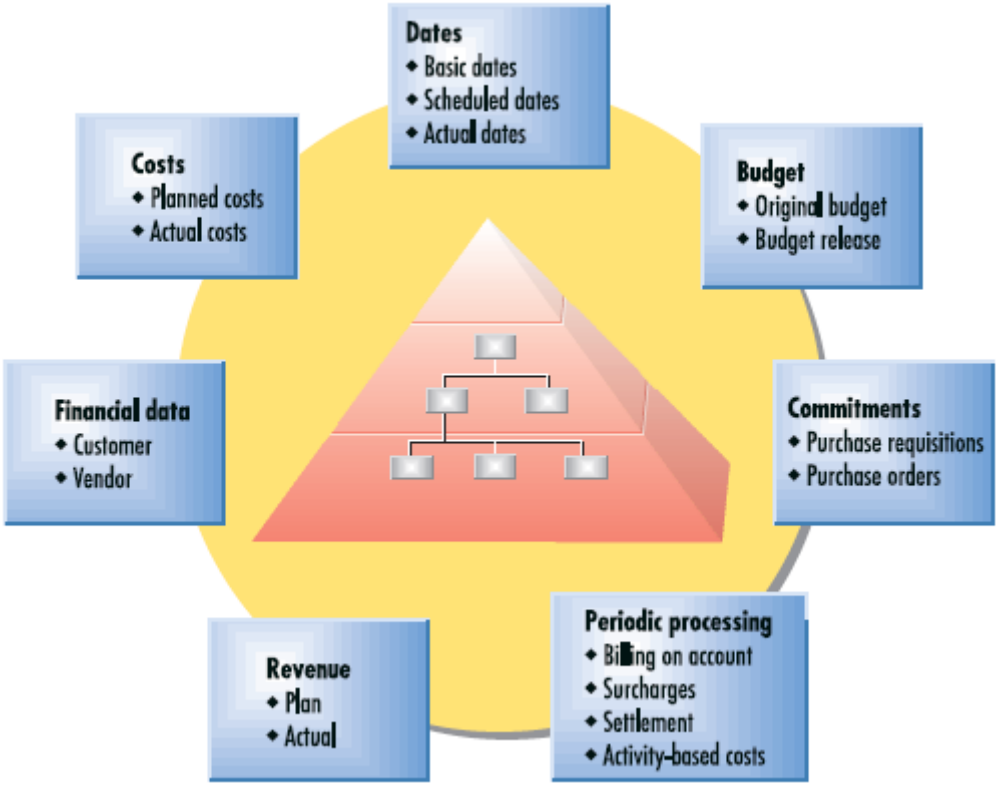


Figure 3.24. Functions of the Work Breakdown Structure [16].

The separate action tasks needed to manage the project tasks are called work breakdown structure elements (WBS elements). Depending on the project phase, it can be further break downed the work with secondary WBS elements [16].

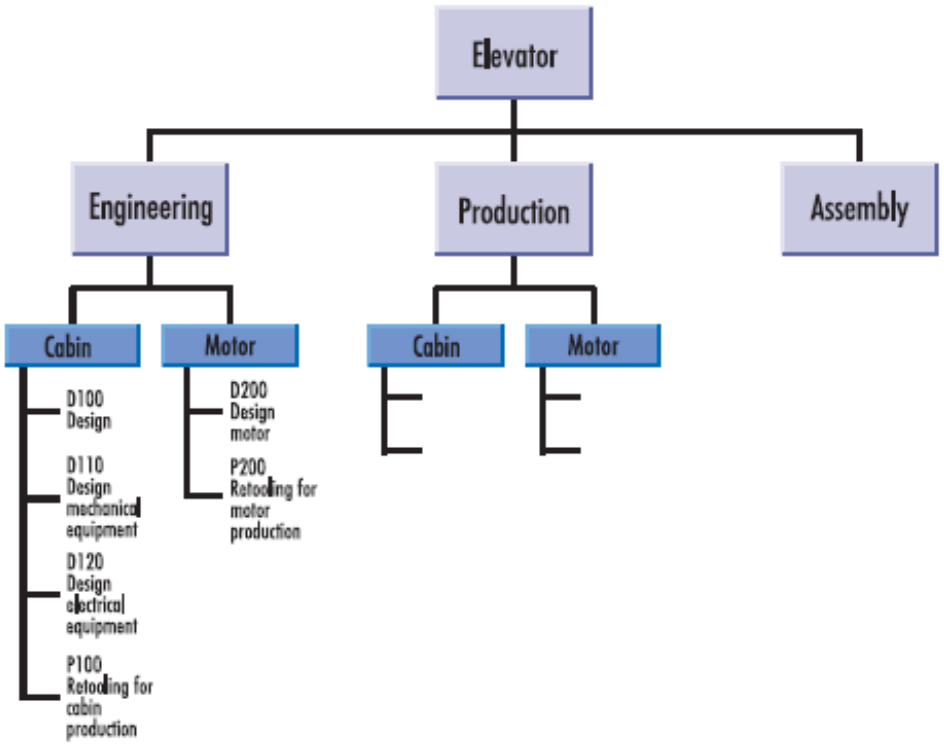


Figure 3.25. Example of a Work Breakdown Structure [16].

3.1.4. Network

The network defines project processing. The important units including a network are activities (task items) and their relationships and connections. Networks creates the basis for planning, analyzing, and monitoring and tracking time schedules, budgets, costs, and resources [16].

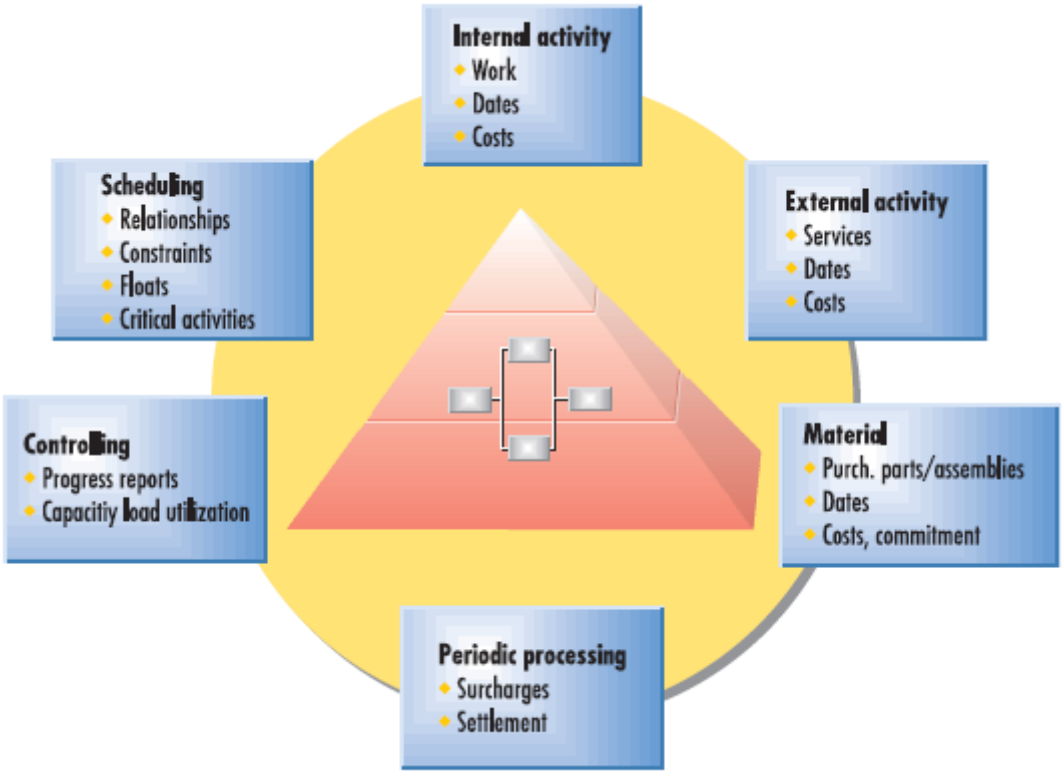


Figure 3.26. Network Functions [16].

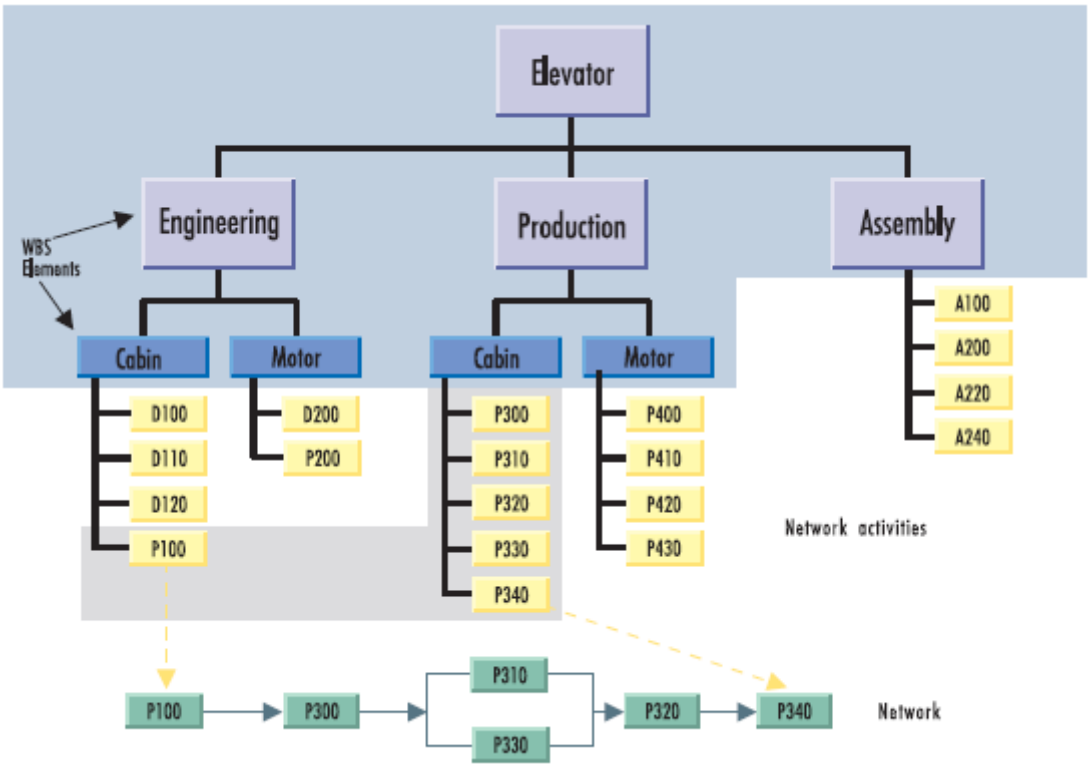


Figure 3.27. Detailing the Work Breakdown Structure Activities [16].

It can be used different activity types and the capacities of the activities can be defined. Also, purchasing data can be saved in the activities and SAP can directly create a procurement request based on the data in activities. The cost information of the activities can be recorded in the same way and expenses can be integrated with R/3 system [16].

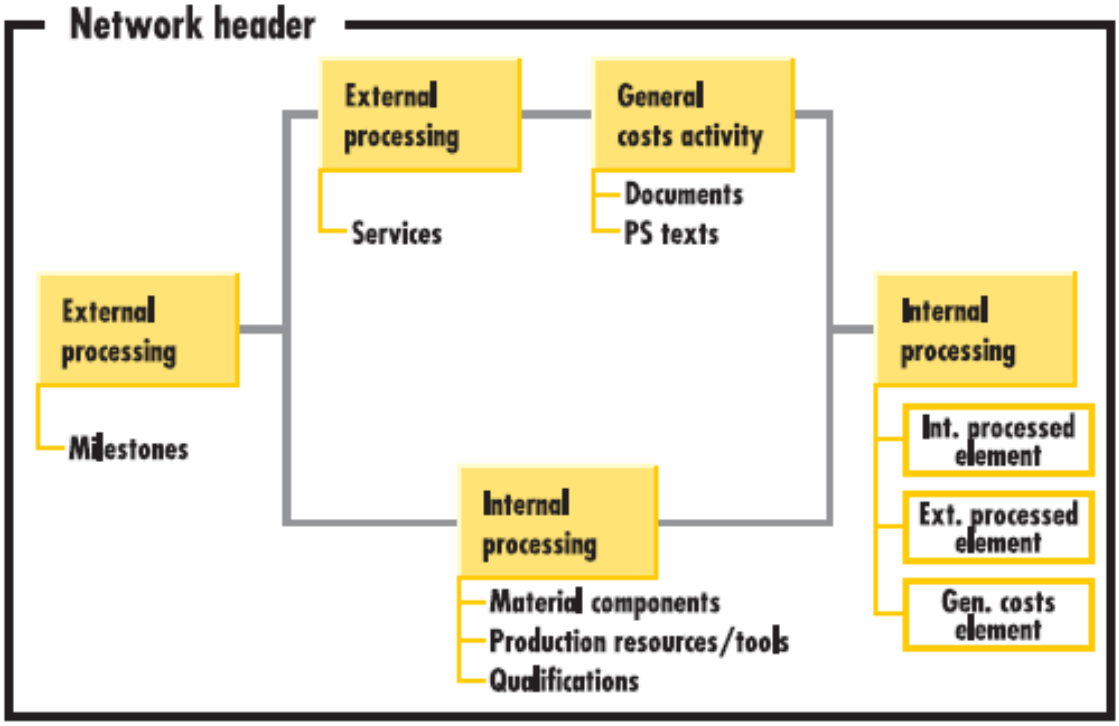


Figure 3.28. Network Structure [16].

It can be assigned some other information about the project for the activities, such as such as production details and elements [16].

Also, the relation and linkage between the activities can be created based on the type and chronology of the tasks [16].

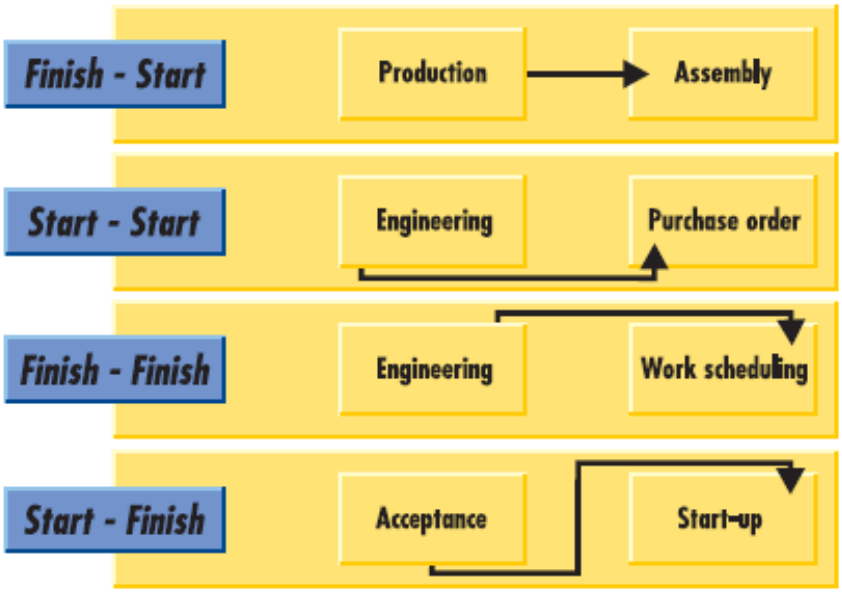


Figure 3.29. Relationships [16].

3.1.5. Milestones

Milestones are tasks or events in a project in order to start a predefined task and they can be allocated some activities and can be used for earned value analysis and procurement schedules. Also, milestones can be used for creating a billing plan [16].

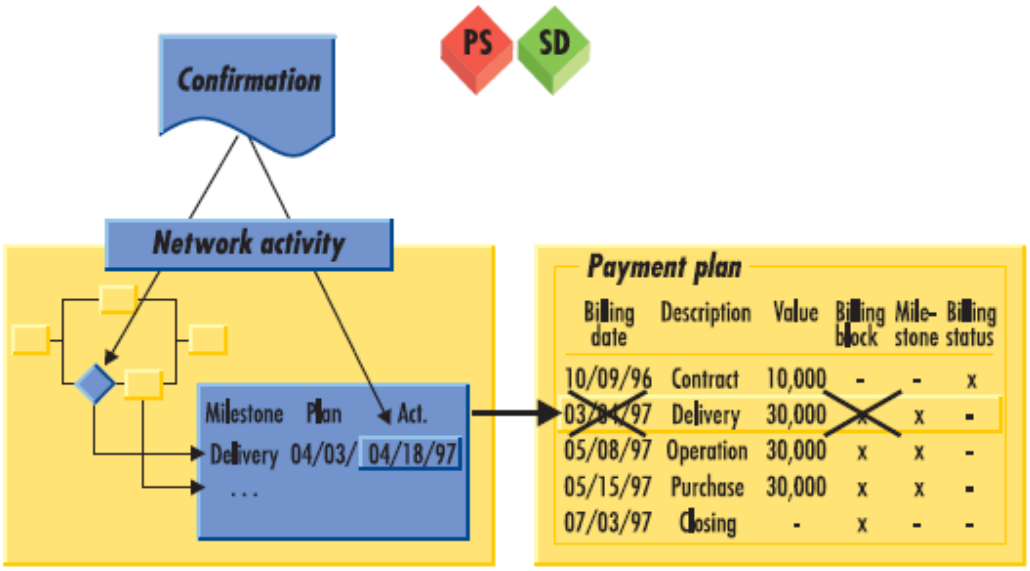


Figure 3.30. Milestone Billing [16].

3.1.6. Standard Structures and Templates

Though each project is unique, it is frequently likely to normalize work flows and procedures in order to use them again. It can be used some patterns to retain a record of structures and data unique to your production in order to decrease repetitive effort for further works [16].

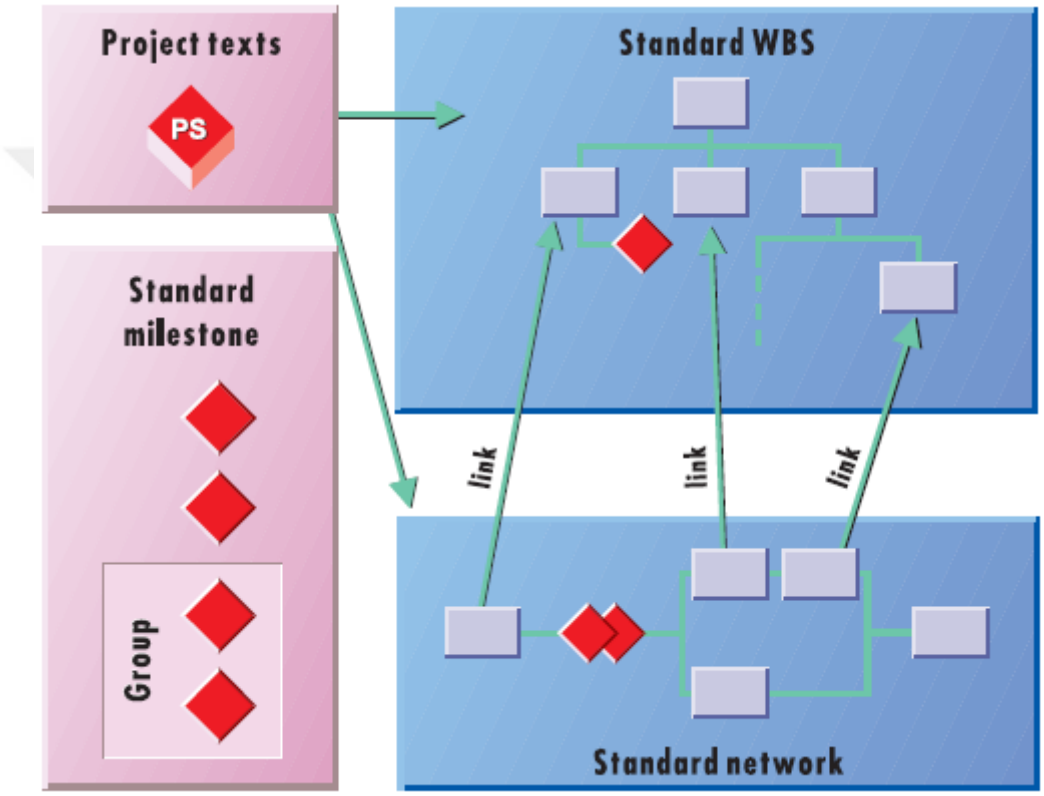


Figure 3.31. Standard Structures in the Project System [16].

A standard WBS can be used as a reference for generating a new project or growing a current one. Also, a standard network acts can be created as a template for generating a new network or for enlarging a current network [16].

3.1.7. Time Scheduling

Time scheduling is based on the project structure. While the WBS shows the structure of the project, it can be used for tasks and activities to plan the actual course of the project. Also, it should be created activities and their relationships between each other with

constraints and durations in order to run a project time schedule planning. The dates in the system can be planned and tracked as basic dates, forecasted dates and actual dates [16].

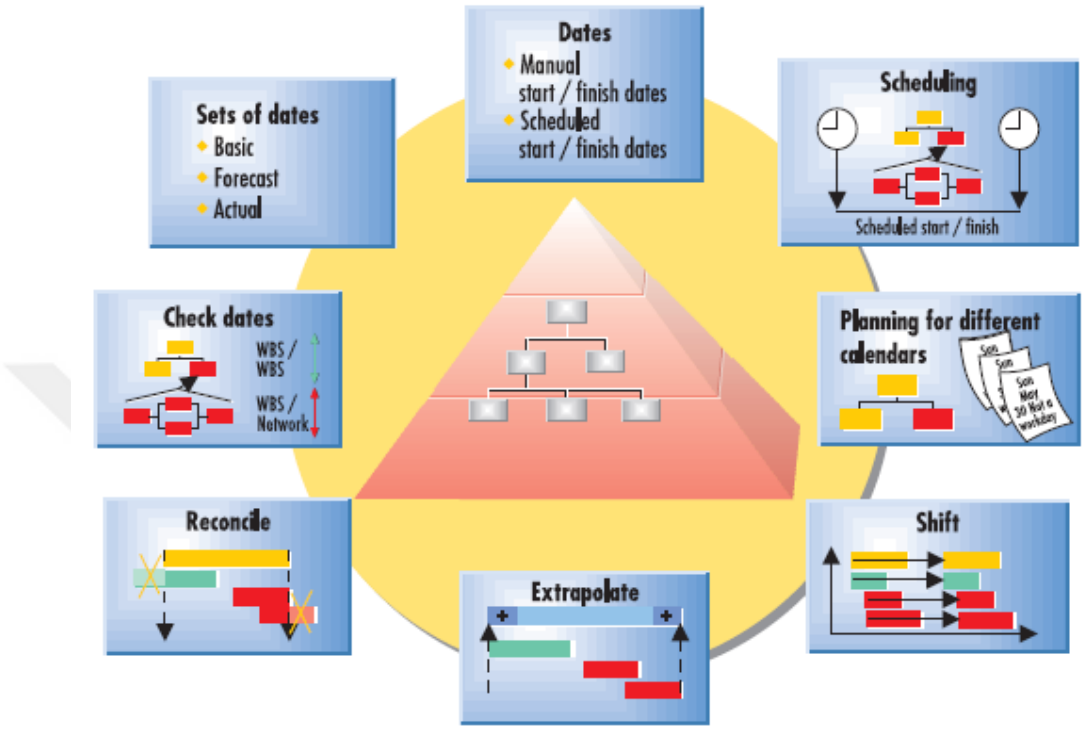


Figure 3.32. Dates in the Work Breakdown Structure [16].

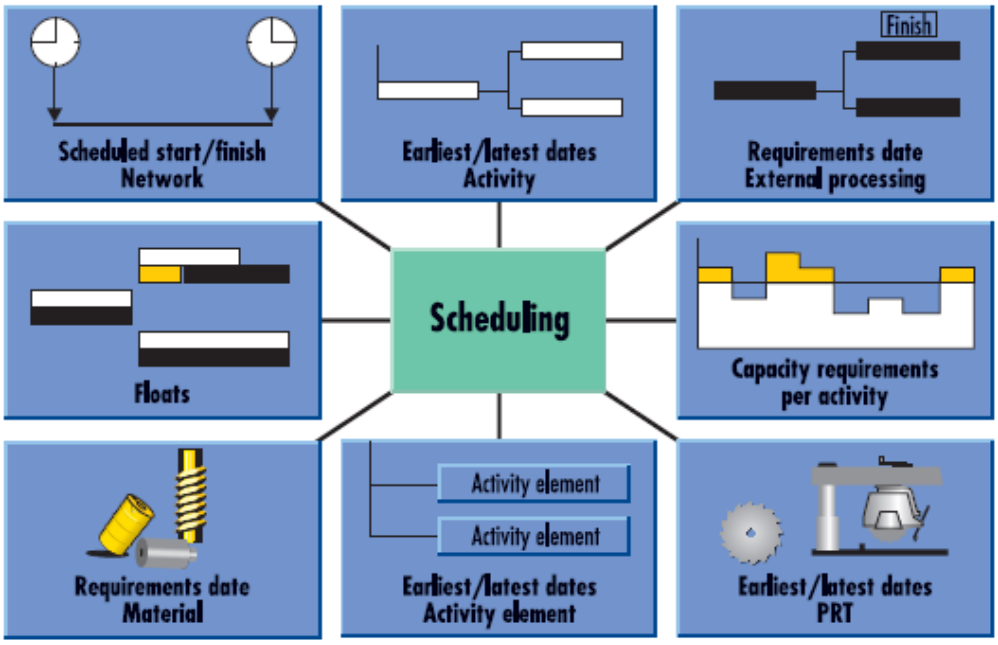


Figure 3.33. Scheduling Results [16].

In network scheduling, the SAP system governs the earliest and latest start and finish dates for each activity by calculating floats of the activities. Also, rescheduling is necessary if some of the activities are realized at some actual dates in order to find new planned/revised dates. The Project Information System at SAP ERP system helps to control the time schedules efficiently. It can be compared the planned dates, actual dates and forecasted dates. Also, variances, delays, late start and finish dates for each activity and WBS unit can be seen from the system [16].

3.1.8. Resource Planning

In the SAP system, it can be defined different kind of resources for each activity and it can be planned the capacities of each resources in different details [16].

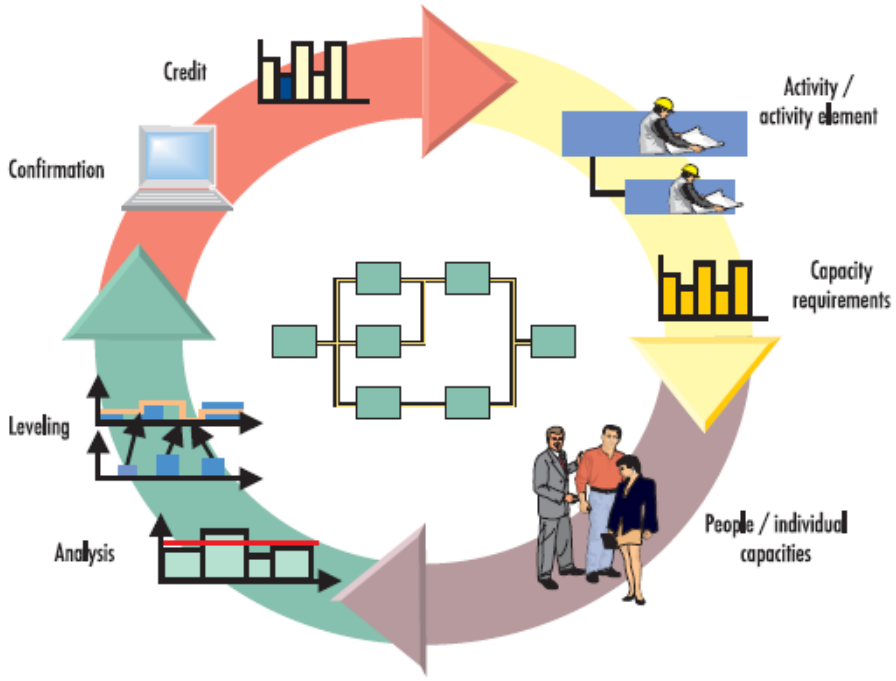


Figure 3.34. Resources [16].

The SAP R/3 system represents the resources for each activity at work center unit and record resource capacity information for each resource at this unit. Also, the cost of the resources saved at this unit [16]. The system can plan the capacities of the resources in this work unit and can record actual resources usage with respect to planned usage [16].

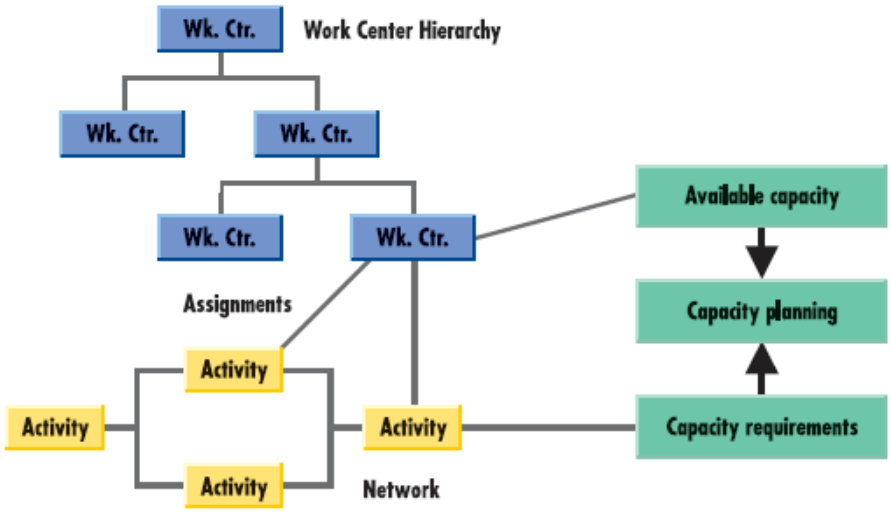


Figure 3.35. Available Capacity and Capacity Requirements [16].

Also, the capacity leveling and capacity evaluation can be made by using this module if necessary [16].

The purpose of capacity leveling is the best probable time forecasting and usage of existing resources. The capacity planning table shown in the figure contains tabular and graphical tools and allow users to edit the data [16].

3.2. MS DYNAMICS (NAVISION) ERP System for Construction Industry

In order to understand the current situation of C-ERP systems in the market, MS Dynamics (Navision) ERP System is also selected as one of the tier I ERP system in the world. One of the consultant and construction firm is selected in order to investigate MS Dynamics ERP system and all modules and sub-modules structures of the one of the running MS Dynamics (Navision) System has been investigated during the thesis.

In order to understand MS Dynamics (Navision) ERP systems, it is investigated both the literature on MS Dynamics Systems and its training documents, and also it is experienced live MS Dynamics System platform to see how it works.

During the investigation of MS Dynamics systems, all module and functions are listed as an MS Excel table. At the Table 3.1., it can be seen some part of the module list table of MS Dynamics systems. The whole list can be found at the Appendix B.

Table 3.1. Module List of MS Dynamics (Continued in Appendix B).

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	NO	WORK NO	MAIN MODULES	MODULES
01	01	00	01.01.00	1	01.01.00.1	Project Management	Quote Preparation
01	01	00	01.01.00	2	01.01.00.2	Project Management	Quote Preparation
01	01	00	01.01.00	3	01.01.00.3	Project Management	Quote Preparation
01	01	00	01.01.00	4	01.01.00.4	Project Management	Quote Preparation
01	01	00	01.01.00	5	01.01.00.5	Project Management	Quote Preparation
01	01	00	01.01.00	6	01.01.00.6	Project Management	Quote Preparation
01	01	00	01.01.00	7	01.01.00.7	Project Management	Quote Preparation
01	01	00	01.01.00	8	01.01.00.8	Project Management	Quote Preparation
01	01	00	01.01.00	9	01.01.00.9	Project Management	Quote Preparation
01	01	00	01.01.00	10	01.01.00.10	Project Management	Quote Preparation
01	01	00	01.01.00	11	01.01.00.11	Project Management	Quote Preparation
01	01	00	01.01.00	12	01.01.00.12	Project Management	Quote Preparation
01	01	00	01.01.00	13	01.01.00.13	Project Management	Quote Preparation
01	01	00	01.01.00	14	01.01.00.14	Project Management	Quote Preparation
01	01	00	01.01.00	15	01.01.00.15	Project Management	Quote Preparation
01	01	00	01.01.00	16	01.01.00.16	Project Management	Quote Preparation
01	01	00	01.01.00	17	01.01.00.17	Project Management	Quote Preparation
01	01	00	01.01.00	18	01.01.00.18	Project Management	Quote Preparation
01	01	00	01.01.00	19	01.01.00.19	Project Management	Quote Preparation
01	01	00	01.01.00	20	01.01.00.20	Project Management	Quote Preparation
01	01	00	01.01.00	21	01.01.00.21	Project Management	Quote Preparation
01	01	00	01.01.00	22	01.01.00.22	Project Management	Quote Preparation
01	01	00	01.01.00	23	01.01.00.23	Project Management	Quote Preparation
01	01	00	01.01.00	24	01.01.00.24	Project Management	Quote Preparation
01	01	00	01.01.00	25	01.01.00.25	Project Management	Quote Preparation
01	01	00	01.01.00	26	01.01.00.26	Project Management	Quote Preparation
01	01	00	01.01.00	27	01.01.00.27	Project Management	Quote Preparation
01	01	00	01.01.00	28	01.01.00.28	Project Management	Quote Preparation
01	01	00	01.01.00	29	01.01.00.29	Project Management	Quote Preparation
01	01	00	01.01.00	30	01.01.00.30	Project Management	Quote Preparation
01	01	00	01.01.00	31	01.01.00.31	Project Management	Quote Preparation
01	01	00	01.01.00	32	01.01.00.32	Project Management	Quote Preparation
01	01	00	01.01.00	33	01.01.00.33	Project Management	Quote Preparation
01	01	00	01.01.00	34	01.01.00.34	Project Management	Quote Preparation
01	01	00	01.01.00	35	01.01.00.35	Project Management	Quote Preparation
01	02	00	01.02.00	36	01.02.00.36	Project Management	Planning
01	02	00	01.02.00	37	01.02.00.37	Project Management	Planning
01	02	00	01.02.00	38	01.02.00.38	Project Management	Planning
01	02	00	01.02.00	39	01.02.00.39	Project Management	Planning
01	02	00	01.02.00	40	01.02.00.40	Project Management	Planning
01	02	00	01.02.00	41	01.02.00.41	Project Management	Planning
01	02	00	01.02.00	42	01.02.00.42	Project Management	Planning
01	02	00	01.02.00	43	01.02.00.43	Project Management	Planning
01	02	00	01.02.00	44	01.02.00.44	Project Management	Planning

It can be seen some real time MS Dynamics (Navision) system usage screenshots belong to main modules of it.

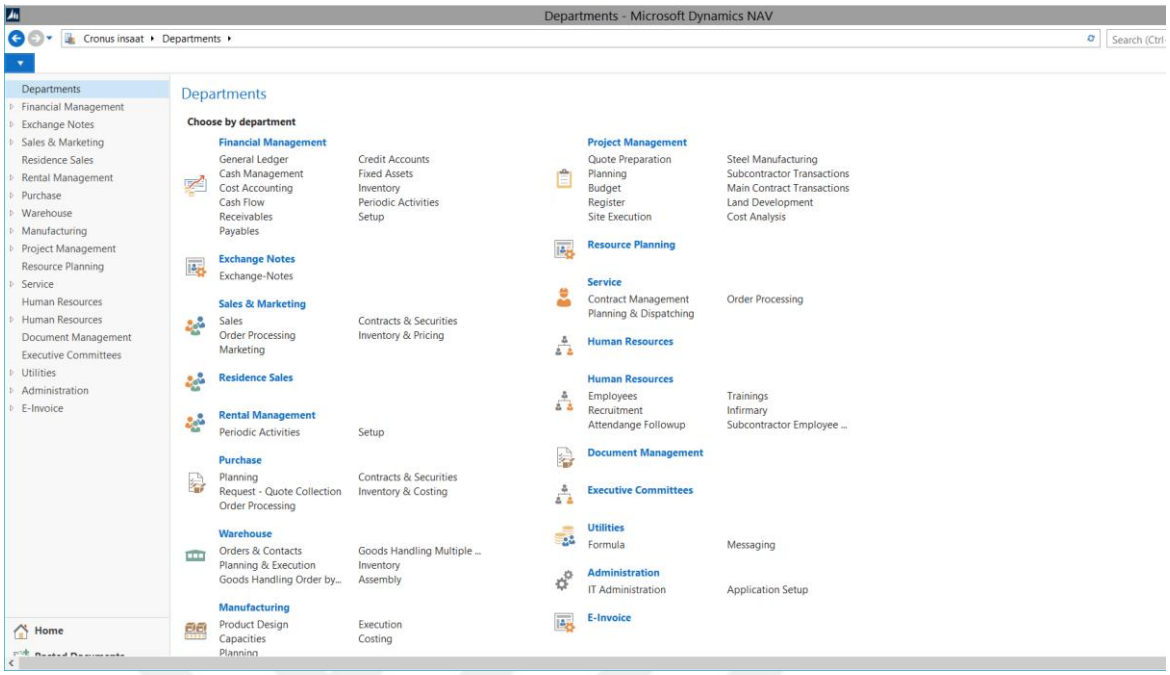


Figure 3.36. MS Dynamics Main Modules

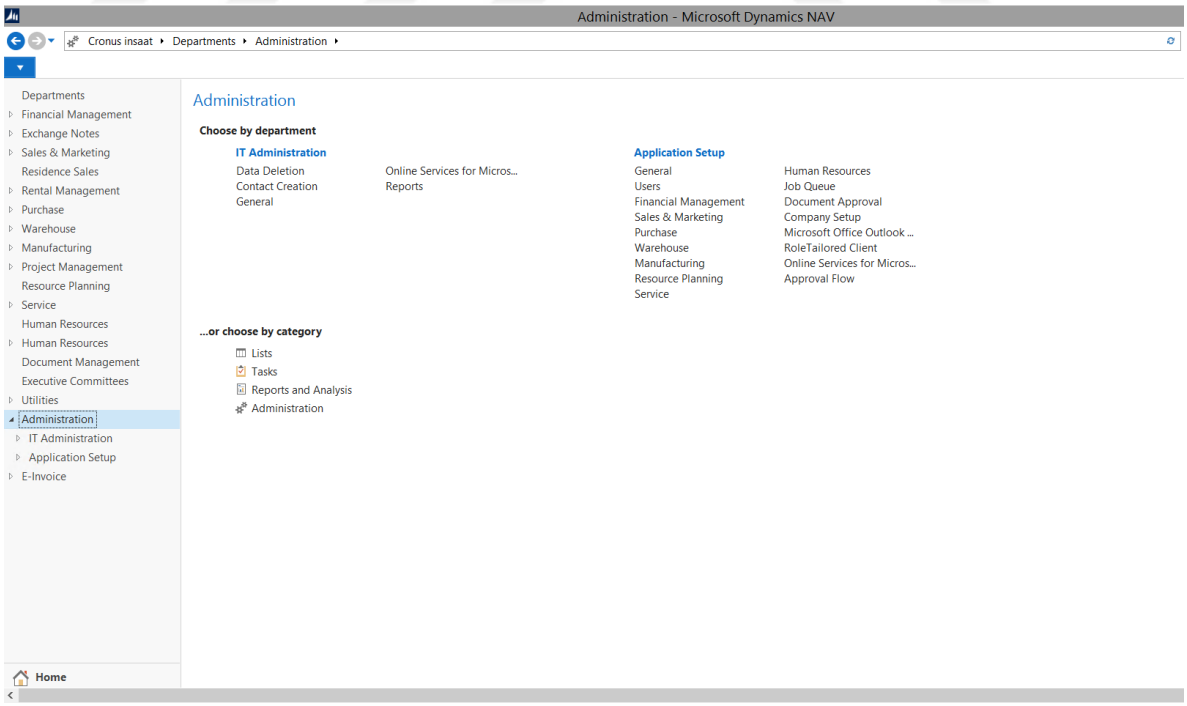


Figure 3.37. MS Dynamics Administration Module

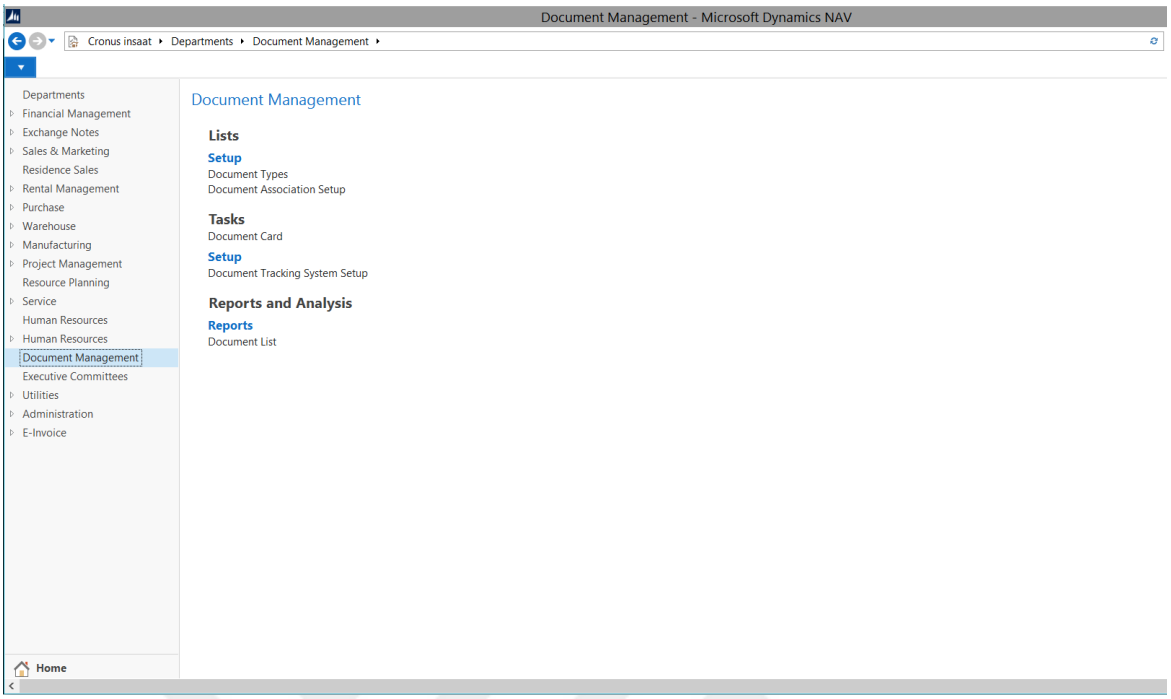


Figure 3.38. MS Dynamics Document Management Module

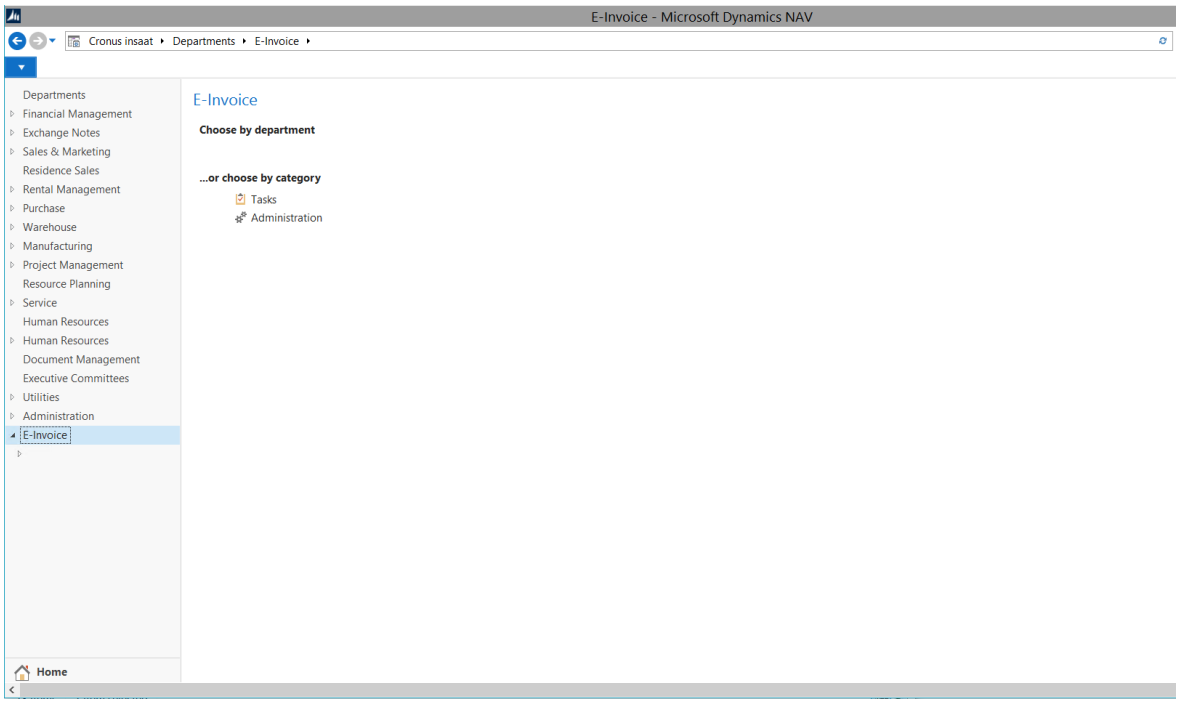


Figure 3.39. MS Dynamics E-Invoice Module

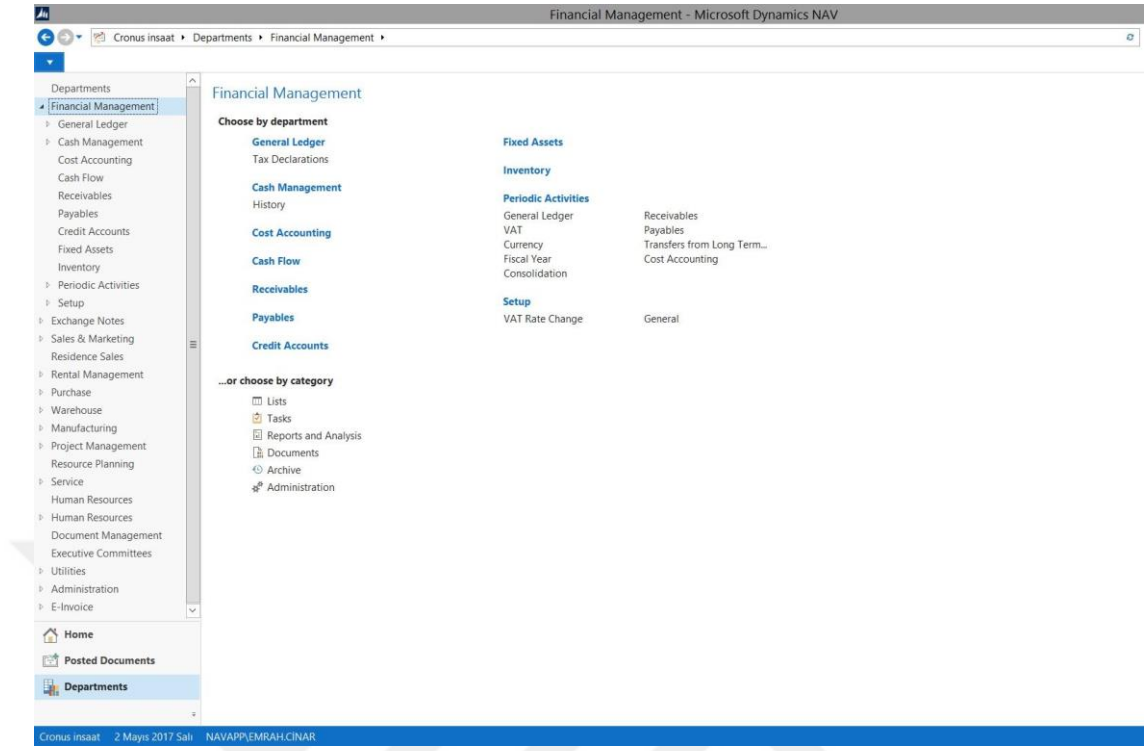


Figure 3.40. MS Dynamics Financial Management Main Module

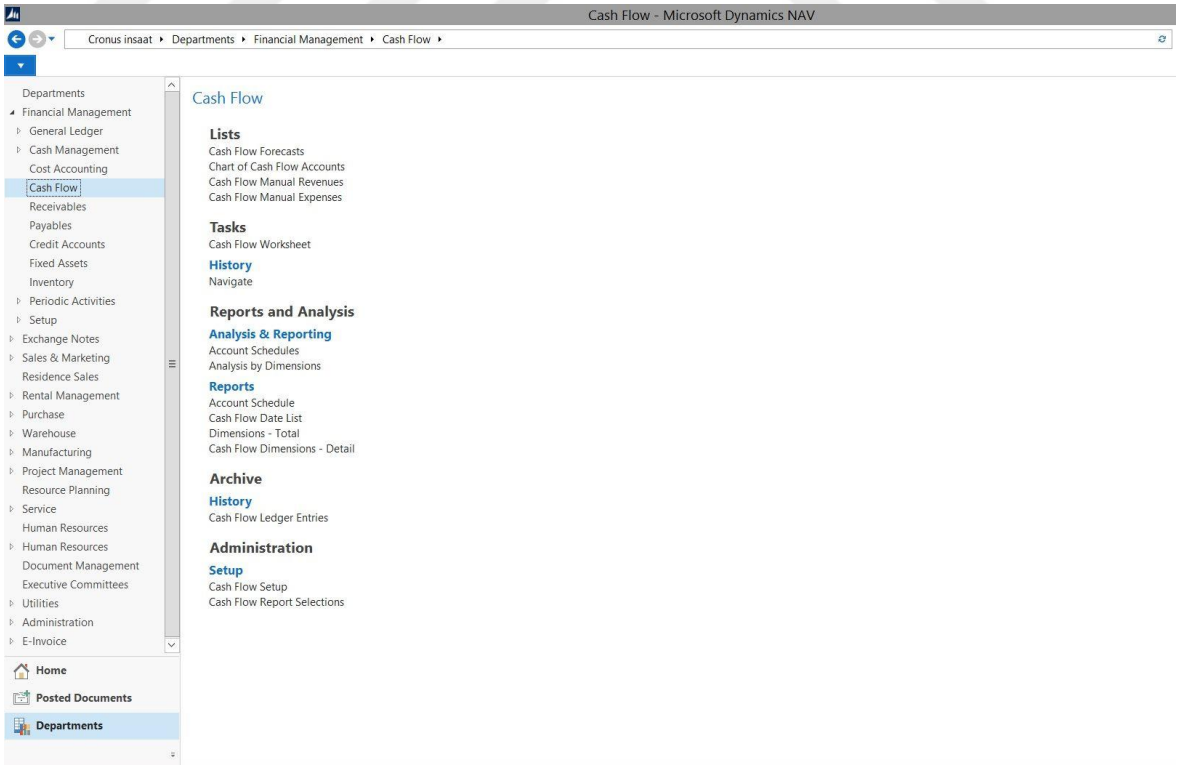


Figure 3.41. MS Dynamics Financial Management – Cash Flow Module

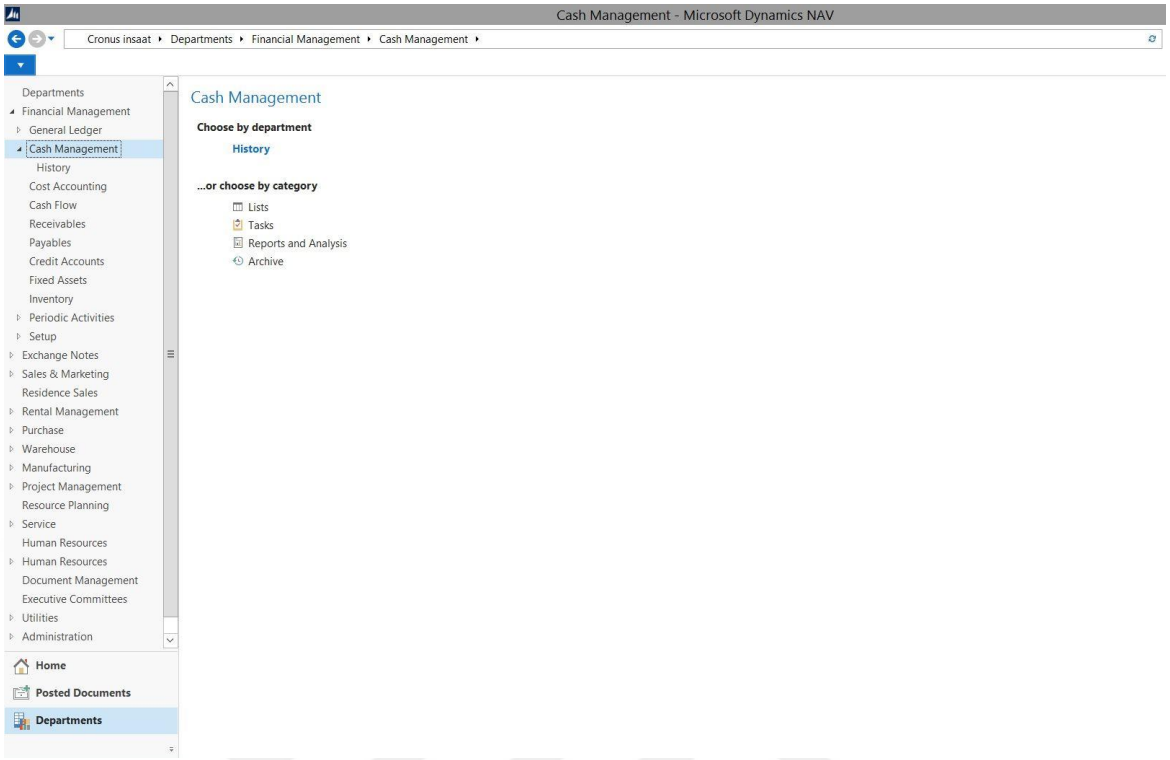


Figure 3.42. MS Dynamics Financial Management – Cash Management Module

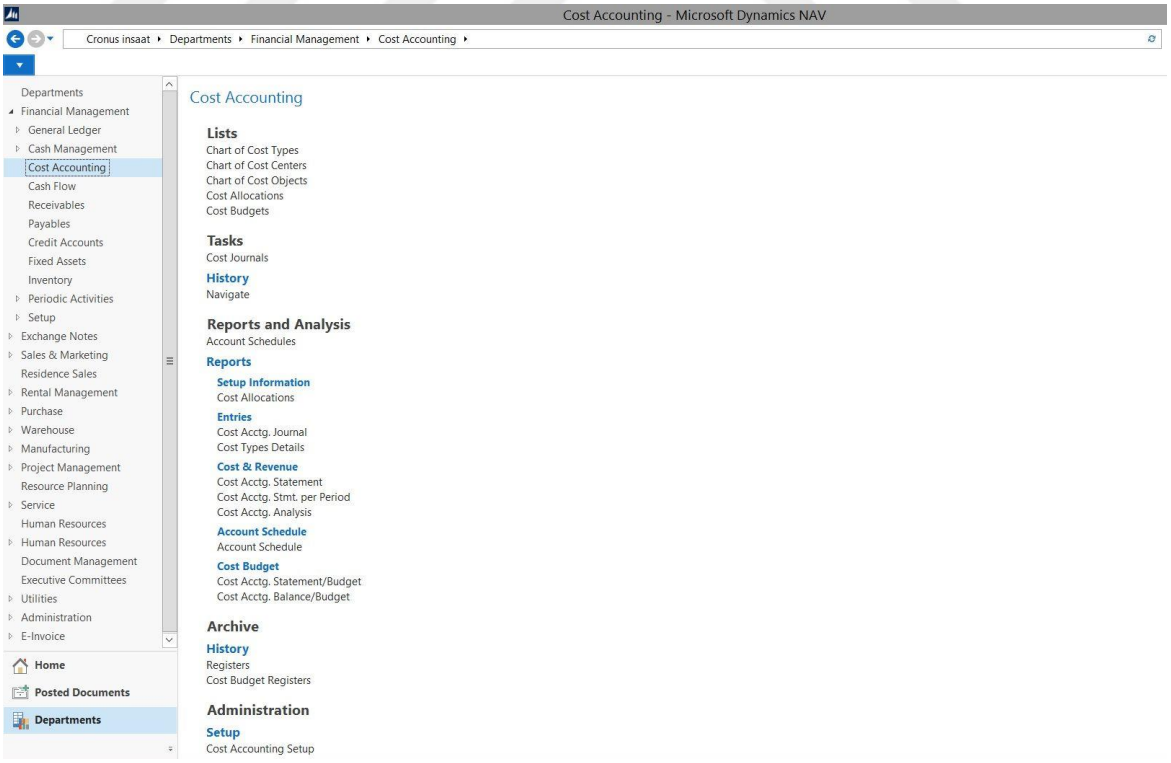


Figure 3.43. MS Dynamics Financial Management – Cost Accounting Flow

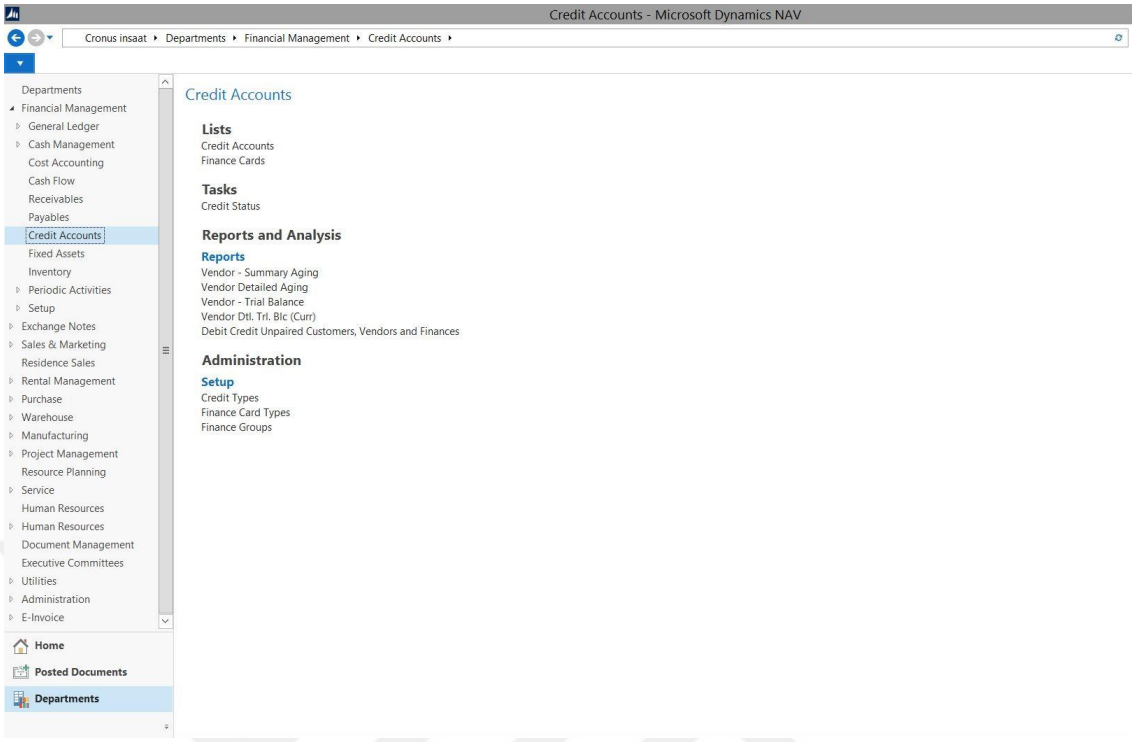


Figure 3.44. MS Dynamics Financial Management – Credit Accounts Module

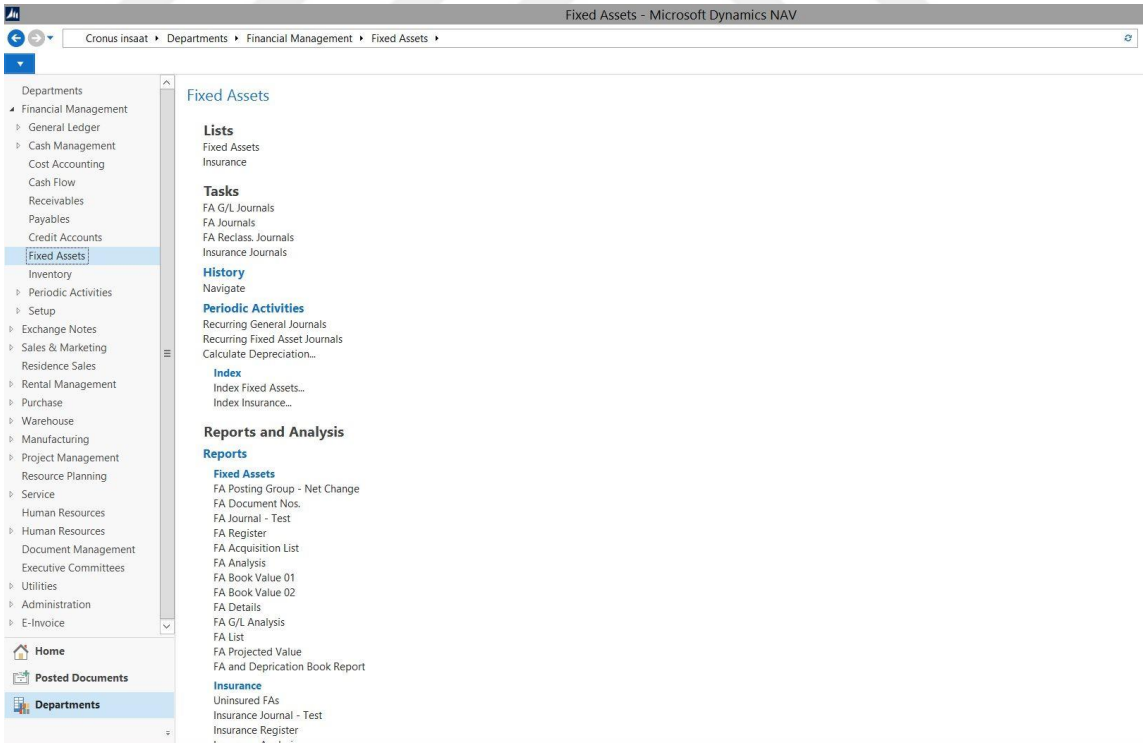


Figure 3.45. MS Dynamics Financial Management – Fixed Assets Module

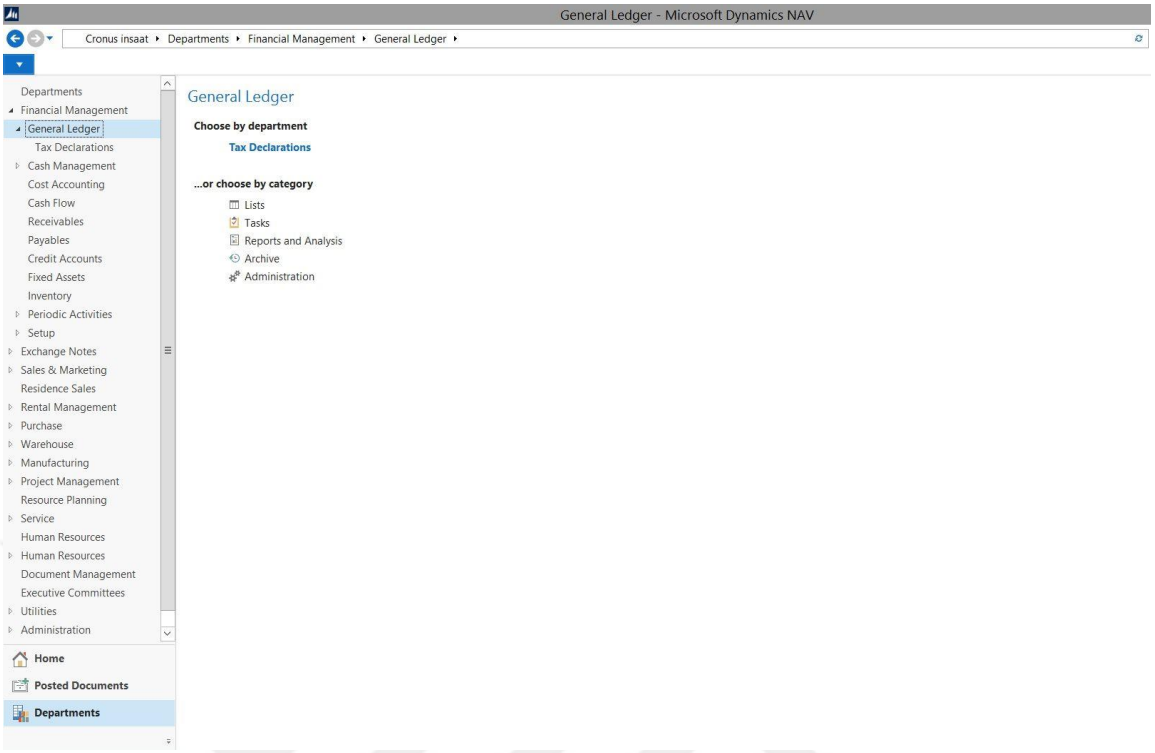


Figure 3.46. MS Dynamics (Navision) Financial Management – General Ledger Module

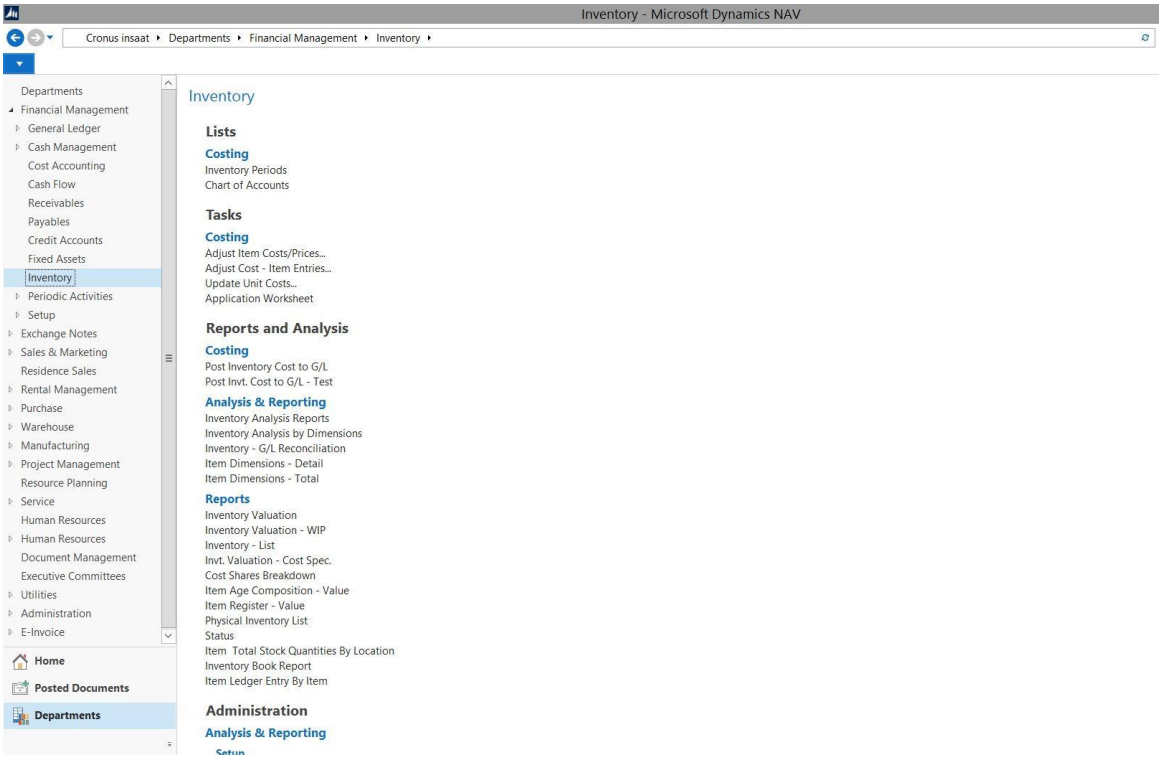


Figure 3.47. MS Dynamics (Navision) Financial Management – Inventory Management Module

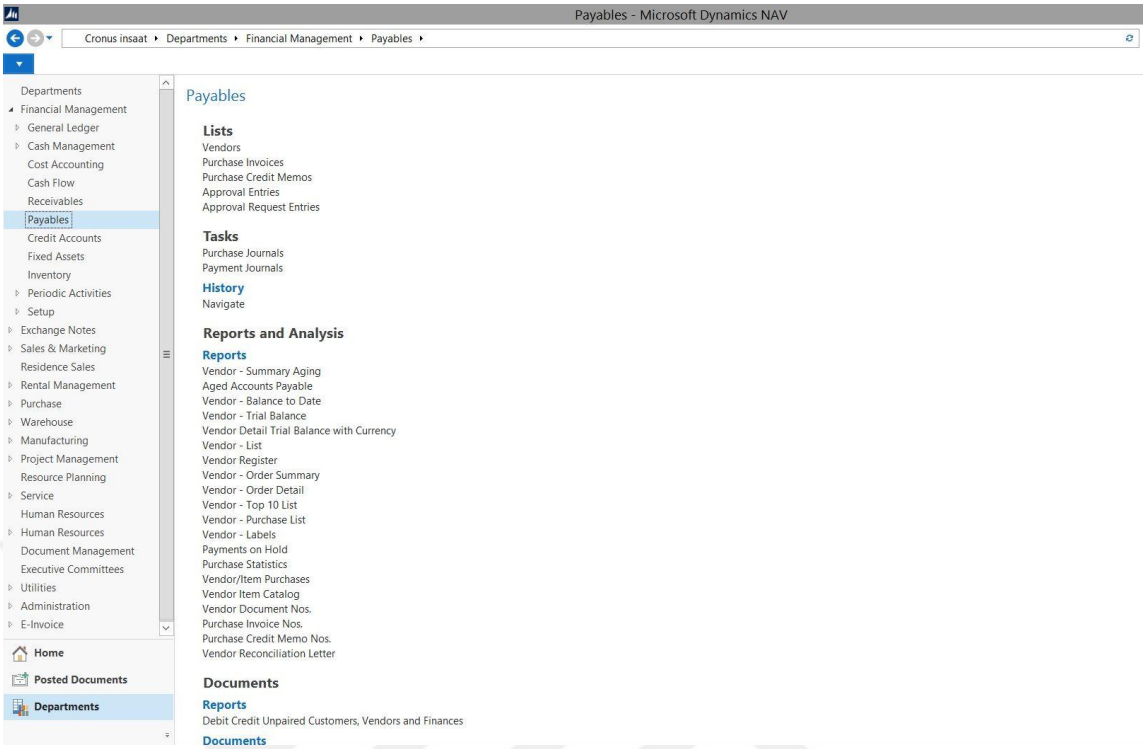


Figure 3.48. MS Dynamics Financial Management – Payables Module

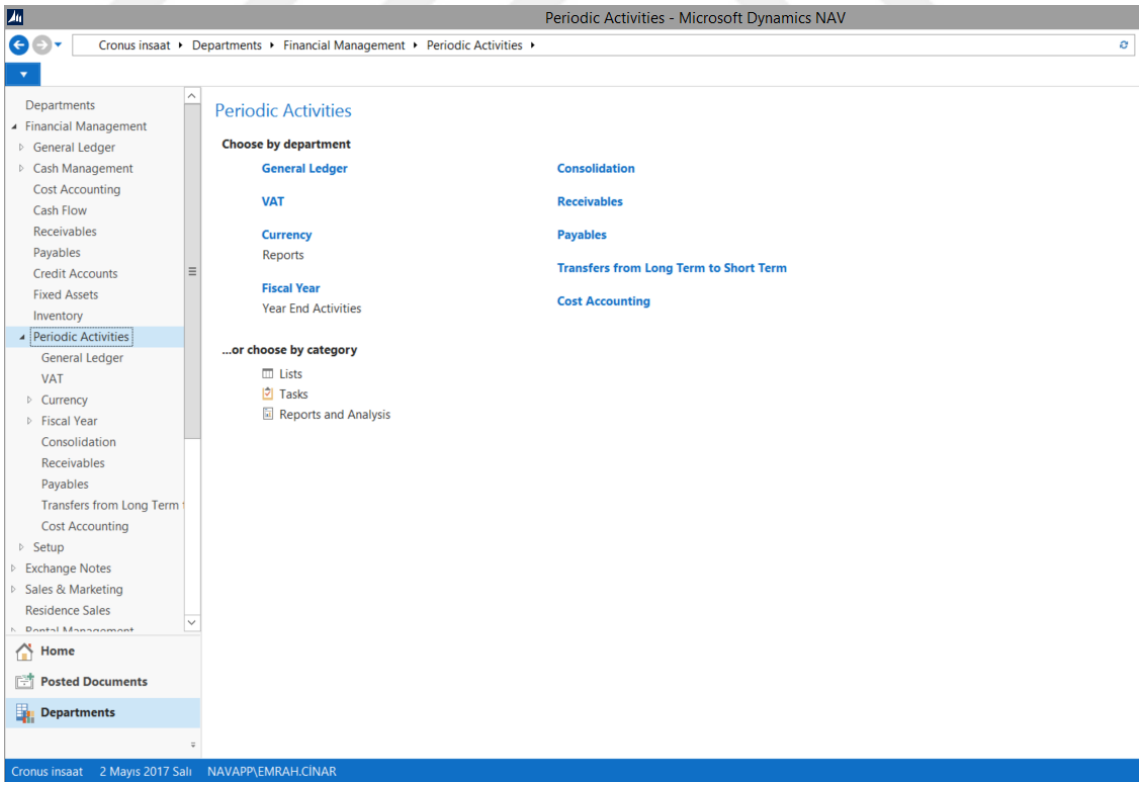


Figure 3.49. MS Dynamics Financial Management – Periodic Activities Module

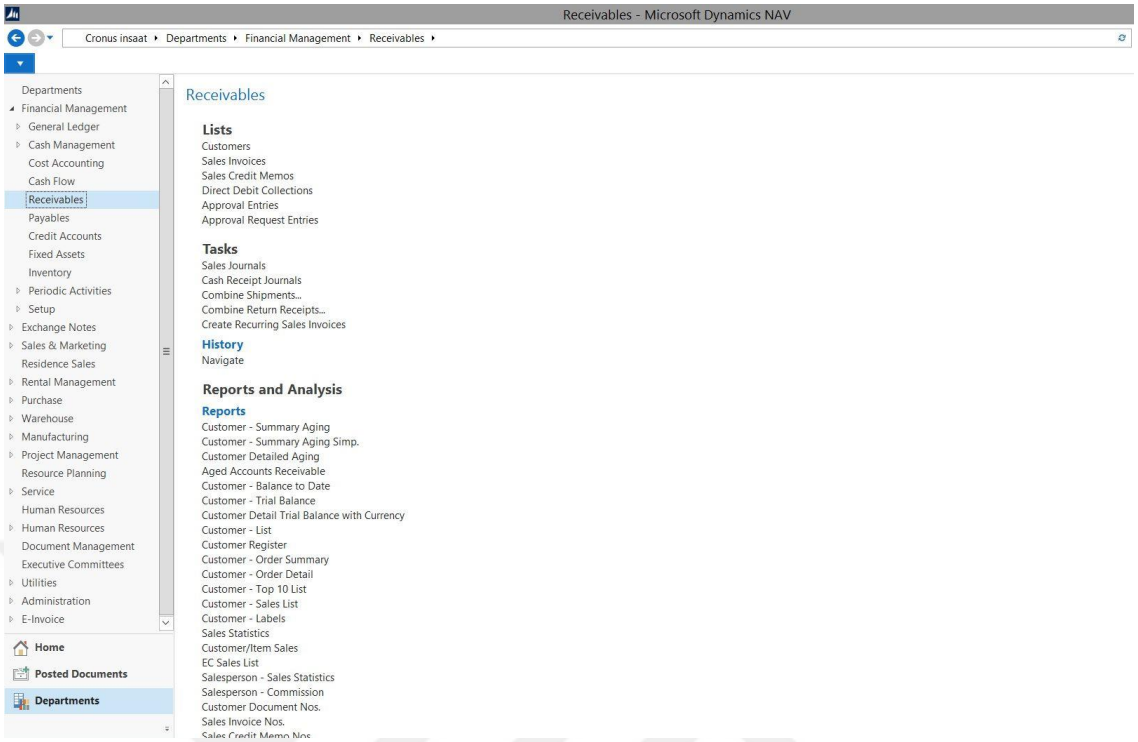


Figure 3.50. MS Dynamics Financial Management – Receivables Module

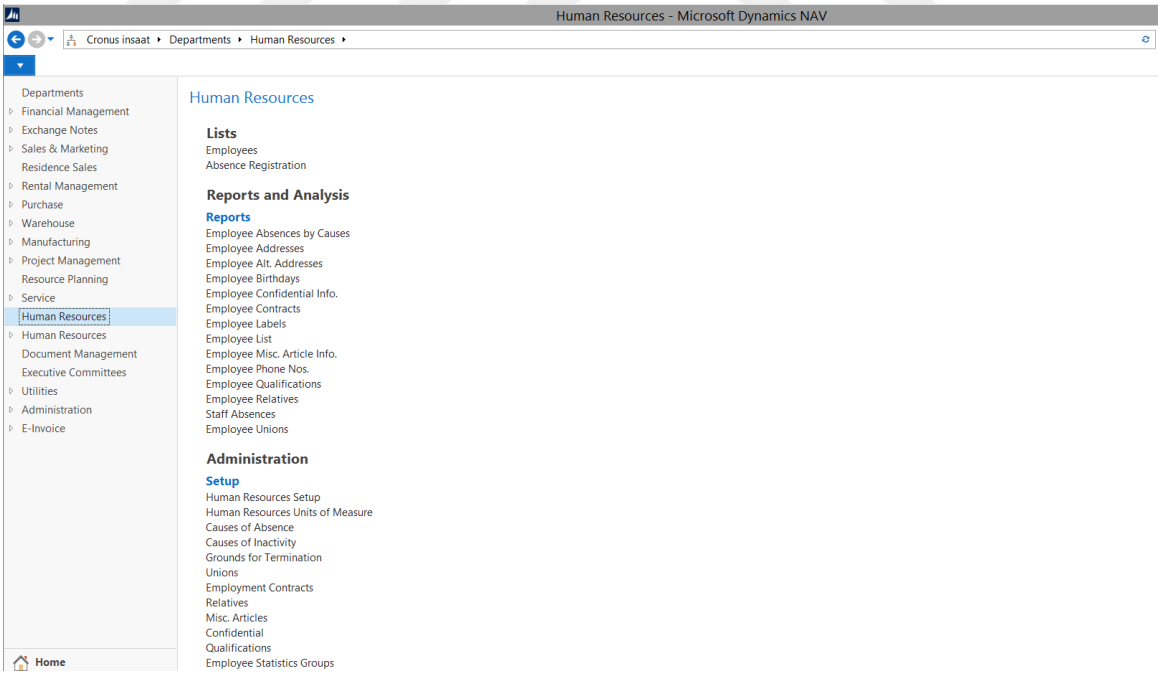


Figure 3.51. MS Dynamics Human Resources Module

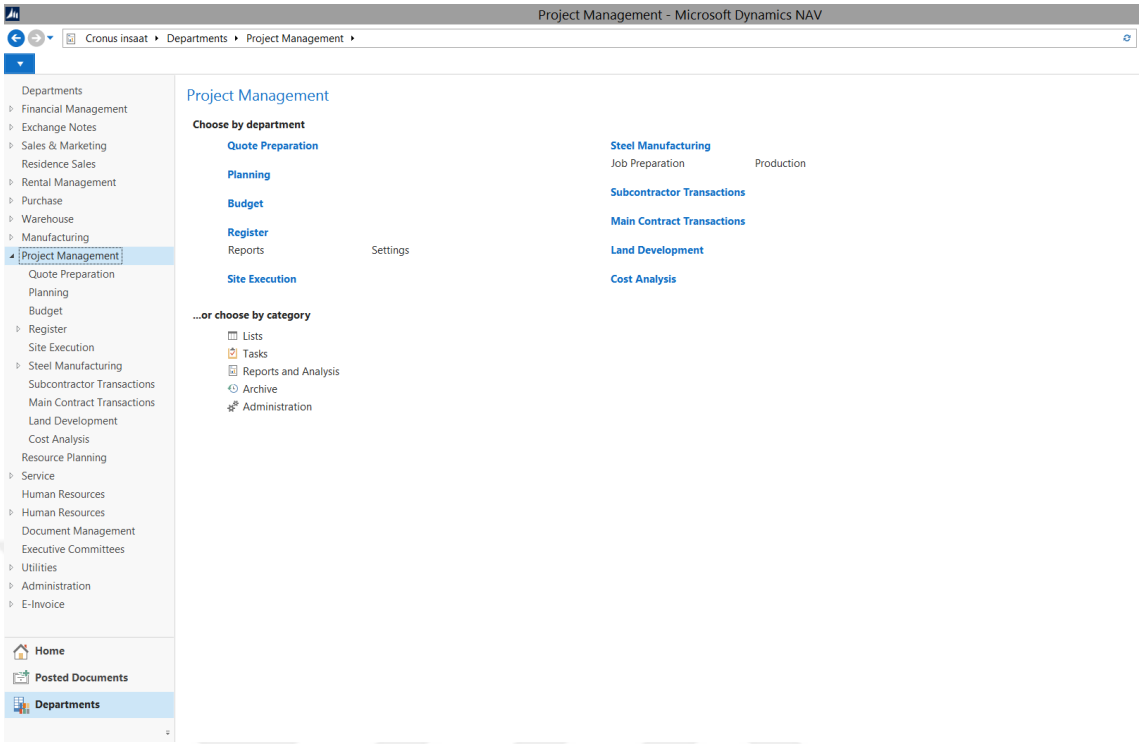


Figure 3.52. MS Dynamics Project Management Main Module

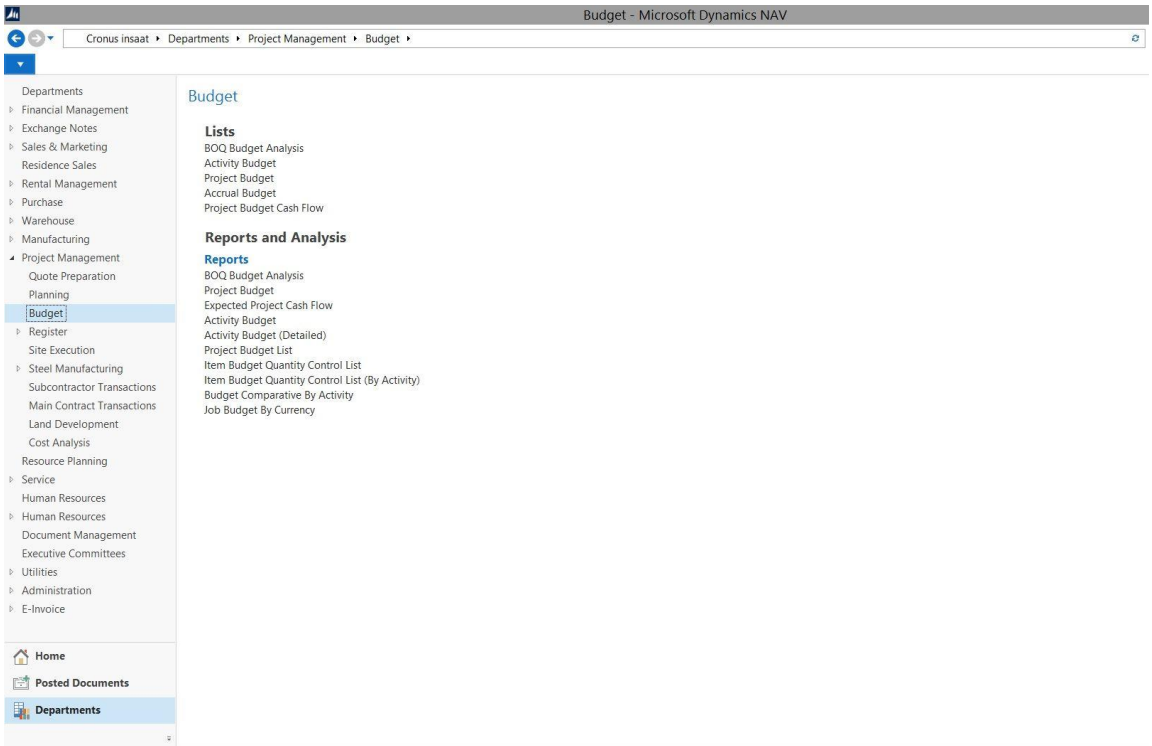


Figure 3.53. MS Dynamics Project Management – Budget Module

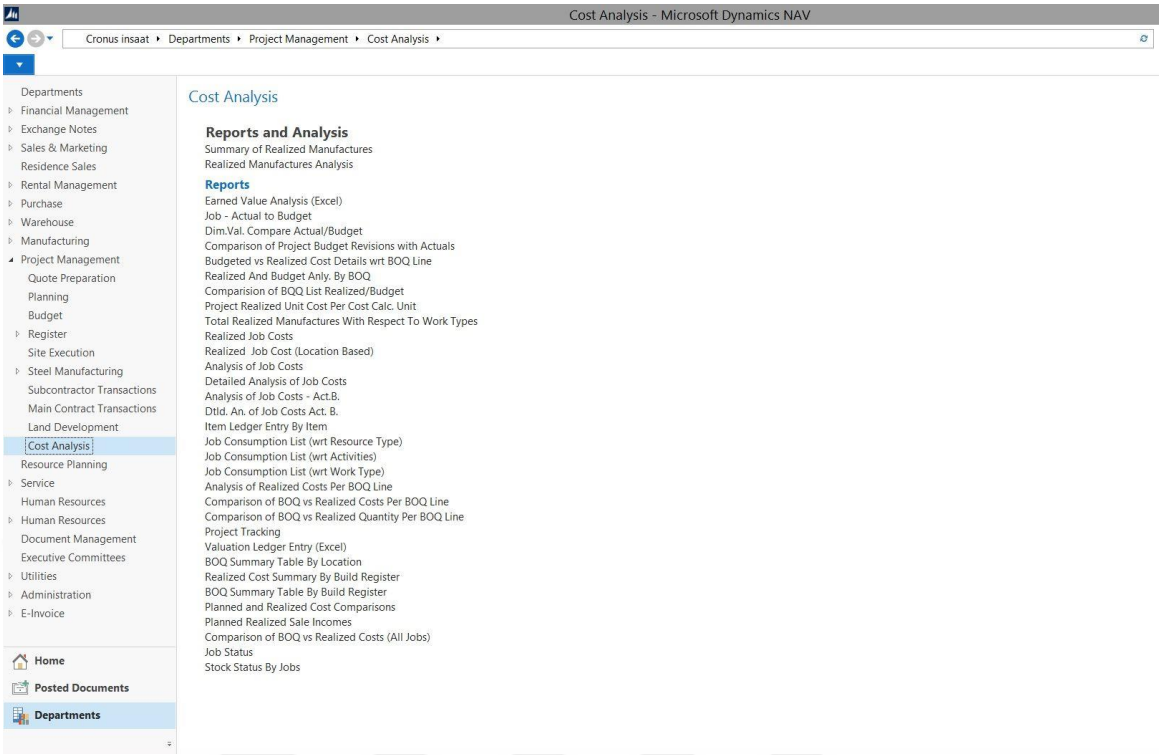


Figure 3.54. MS Dynamics Project Management – Cost Analysis Module

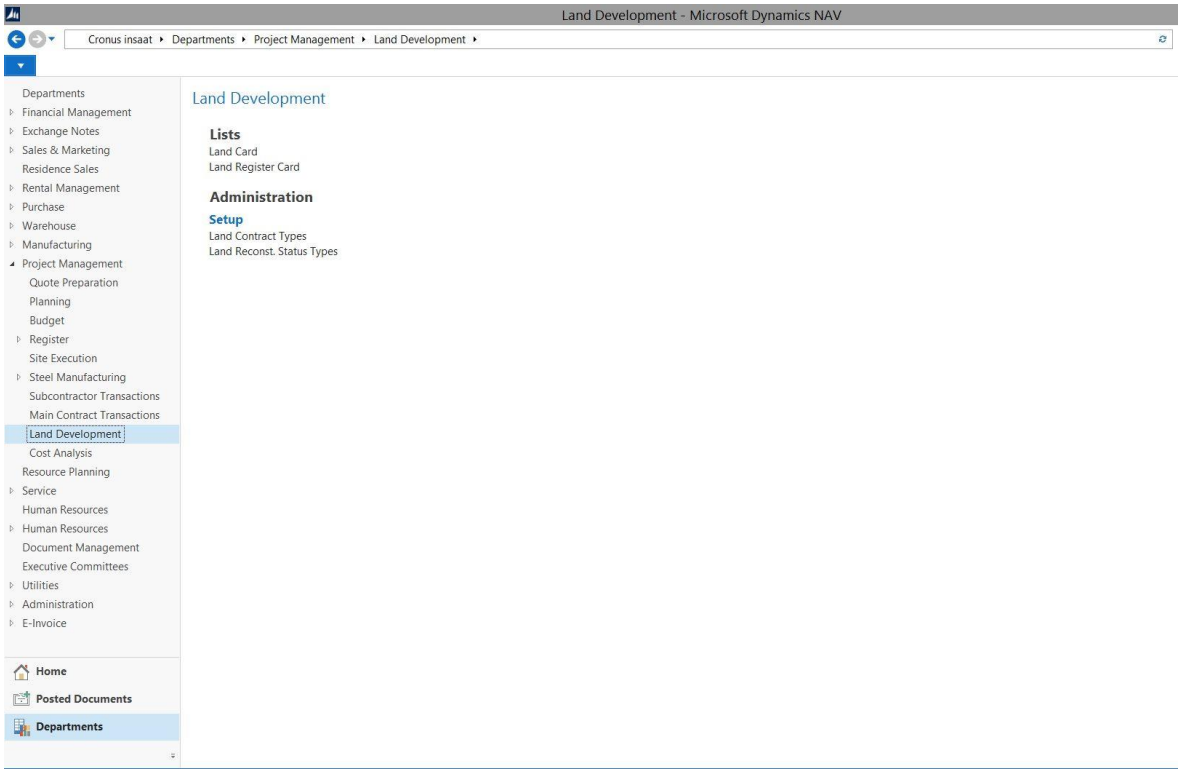


Figure 3.55. MS Dynamics Project Management – Land Development Module

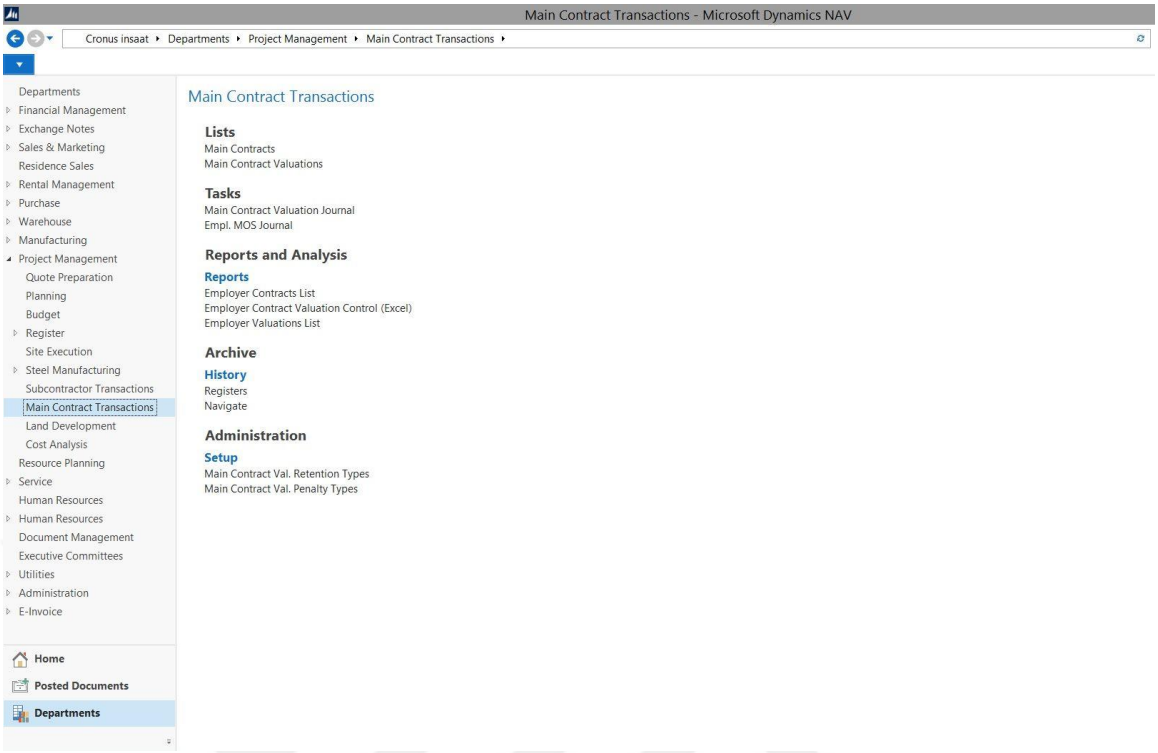


Figure 3.56. MS Dynamics Project Management – Contract Management Module

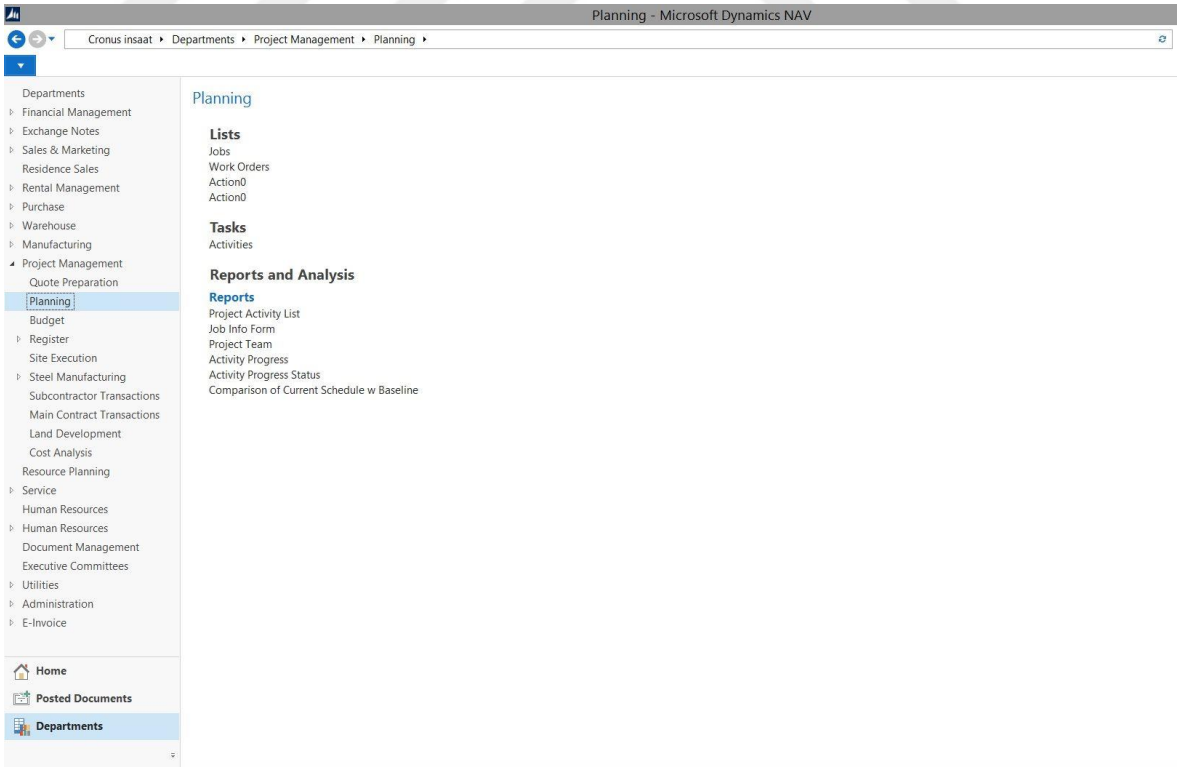


Figure 3.57. MS Dynamics Project Management – Planning Module

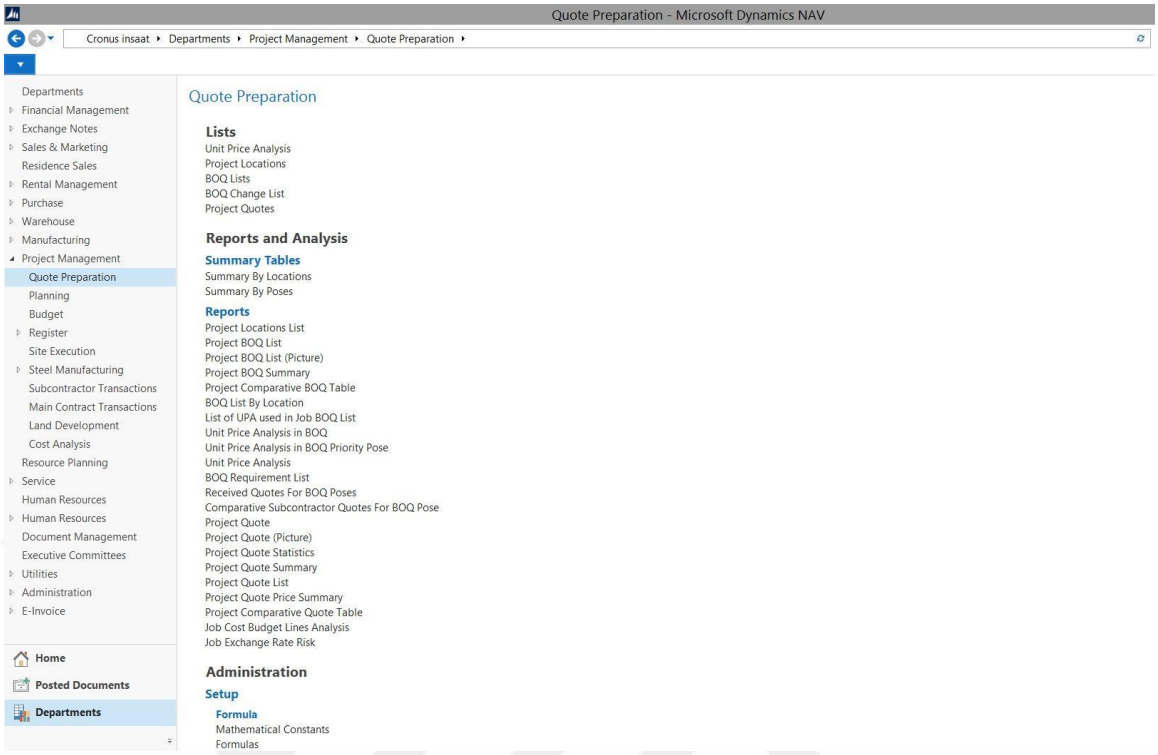


Figure 3.58. MS Dynamics Project Management – Quote Preparation Module

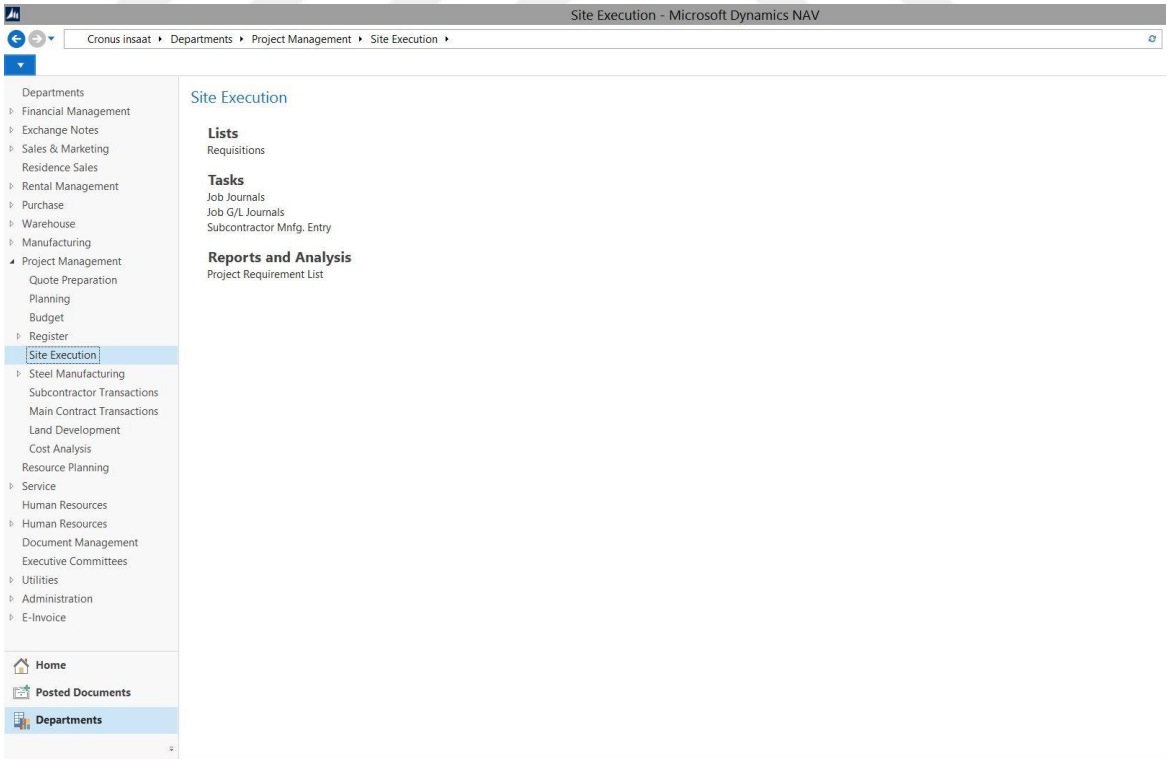


Figure 3.59. MS Dynamics Project Management – Site Execution Module

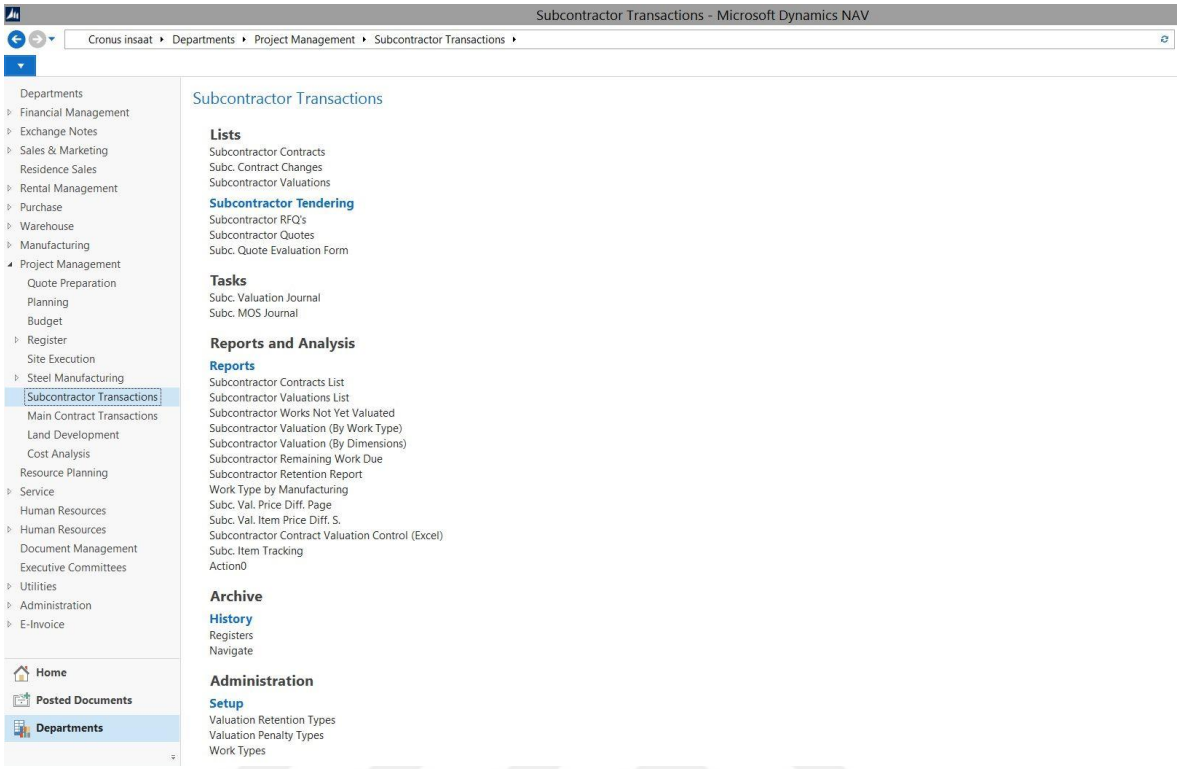


Figure 3.60. MS Dynamics Project Management – Subcontractor Management Module

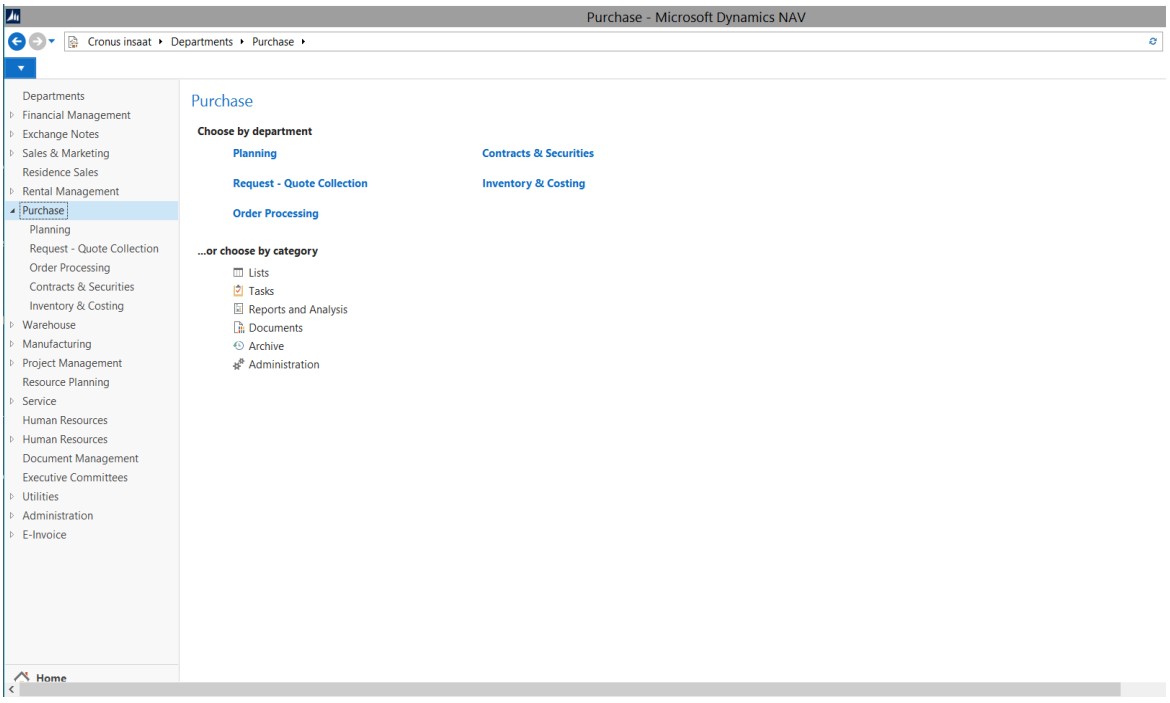


Figure 3.61. MS Dynamics Purchasing Main Module

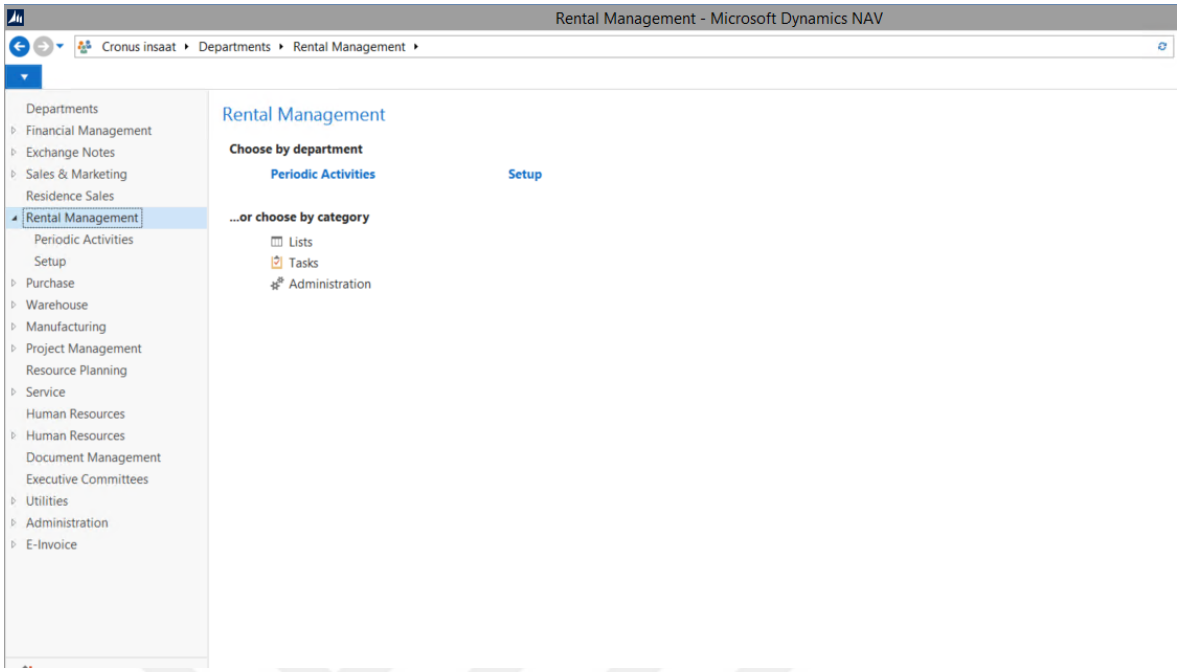


Figure 3.62. MS Dynamics Rental Management Main Module

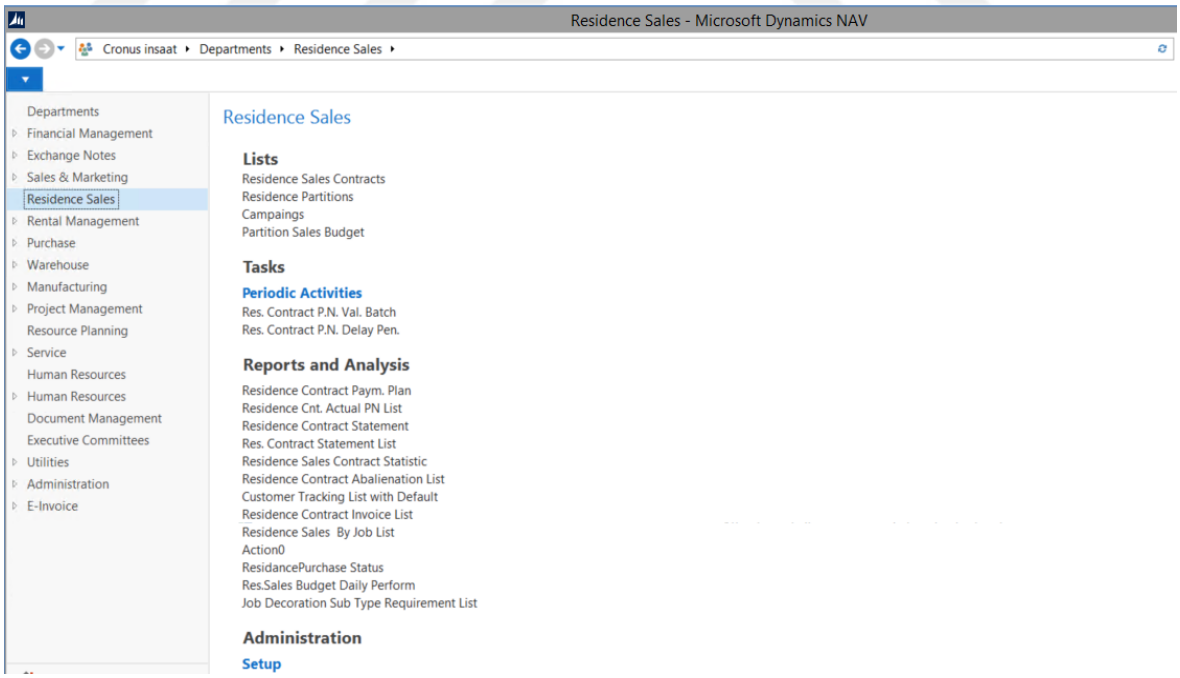


Figure 3.63. MS Dynamics Residence Sales Main Module

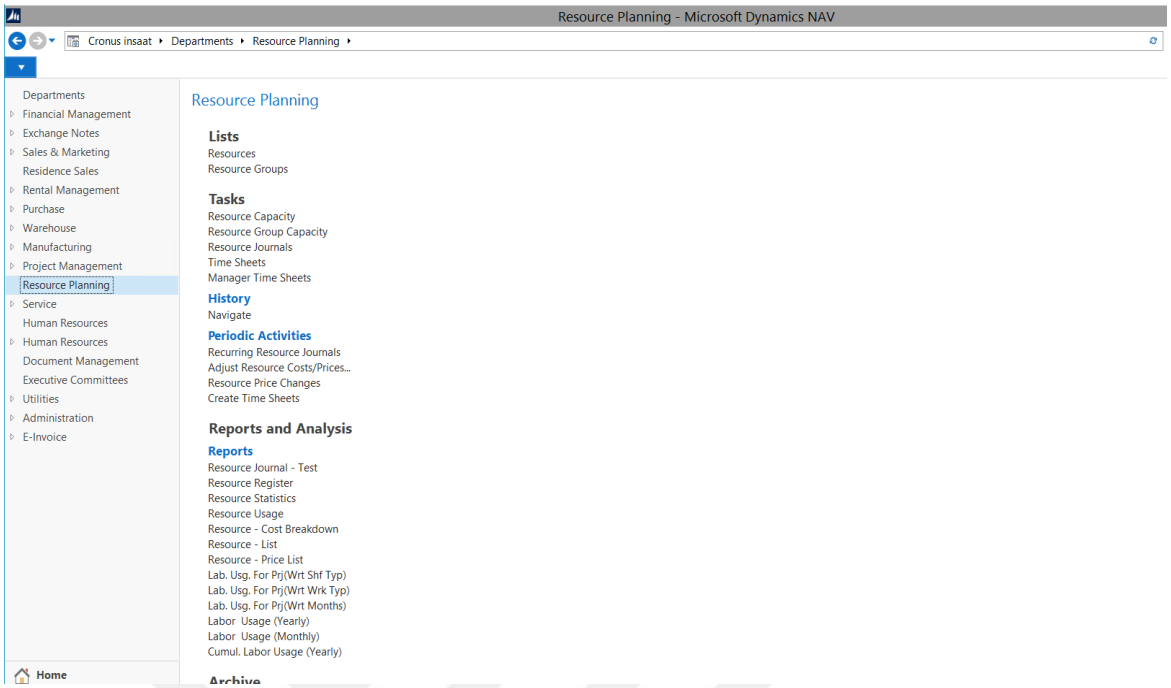


Figure 3.64. MS Dynamics Resource Planning Module

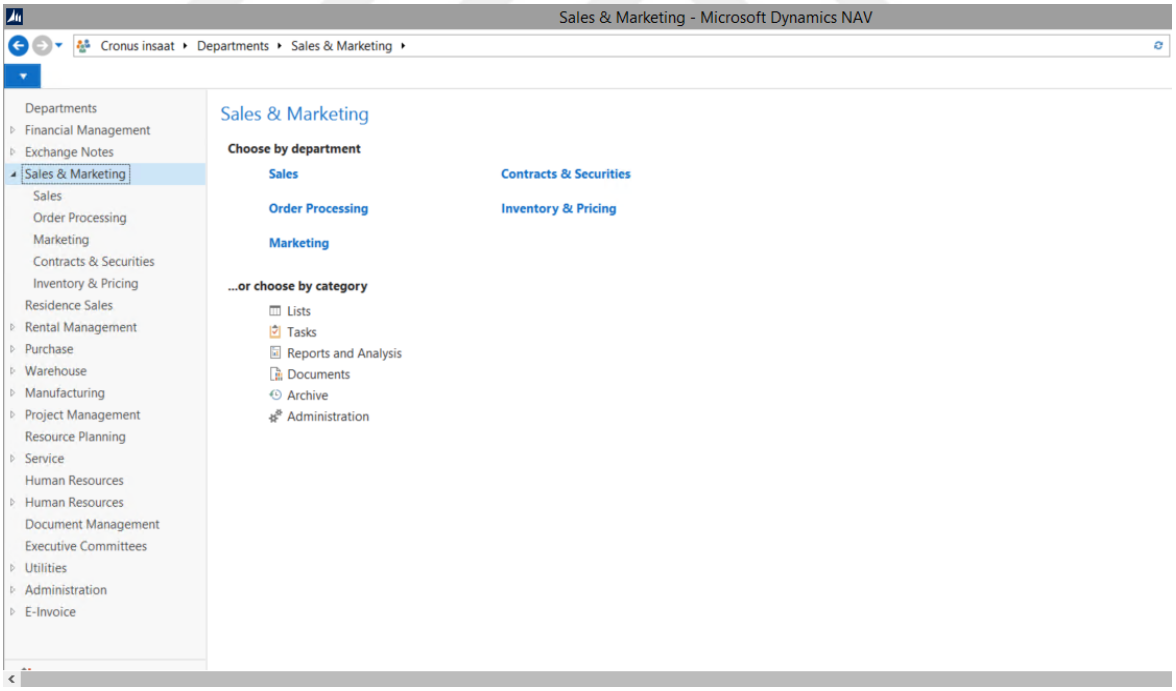


Figure 3.65. MS Dynamics Sales and Marketing Main Module

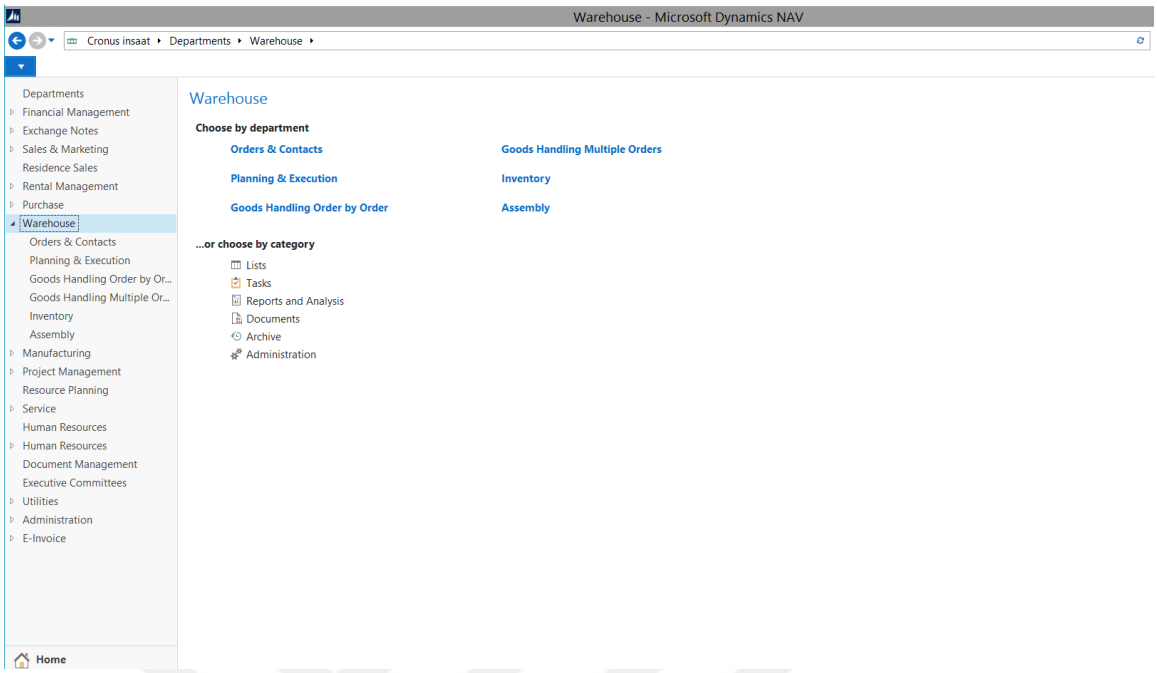


Figure 3.66. MS Dynamics Warehouse Main Module

3.3. YAPITAŞI ERP System for Construction Industry

In order to understand the current situation of C-ERP systems in the market, Yapitasi (Yapıtaşı in Turkish) ERP System is also selected as one of the leader ERP systems in Turkish construction industry. Yapıtaşı information technology firm itself has guided us to investigate their ERP system, and the investigation of main modules and sub-modules of the system has been investigated during the thesis.

In order to understand Yapıtaşı ERP systems, it is investigated training documents and also it is experienced live Yapıtaşı ERP System platform to see how it works.

During the investigation of Yapıtaşı ERP systems, all module and functions are listed as an MS Excel table. At the Table 3.2 below, it can be seen some part of the module list table of Yapıtaşı Systems. The whole list can be found at the Appendix C.

Table 3.2. Modules List of YAPITAŞI (Continued in Appendix C).

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	SIRA NO	WORK NO	MAIN MODULES	MODULES	SUB MODULES
01	01	01	01.01.01	1	01.01.01.1	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	01	01.01.01	2	01.01.01.2	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	01	01.01.01	3	01.01.01.3	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	02	01.01.02	4	01.01.02.4	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	02	01.01.02	5	01.01.02.5	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	02	01.01.02	6	01.01.02.6	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	02	01.01.02	7	01.01.02.7	PLANNING	PROJECT & CODES	ACTIVITY CODES
01	01	03	01.01.03	8	01.01.03.8	PLANNING	PROJECT & CODES	SITES & PROJECTS
01	01	04	01.01.04	9	01.01.04.9	PLANNING	PROJECT & CODES	COMPANIES
01	02	01	01.02.01	10	01.02.01.10	PLANNING	BUSINESS DEVELOPMENT	DEED OF REAL ESTATE
01	02	02	01.02.02	11	01.02.02.11	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS
01	02	02	01.02.02	12	01.02.02.12	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS
01	02	02	01.02.02	13	01.02.02.13	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS
01	02	02	01.02.02	14	01.02.02.14	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS
01	02	02	01.02.02	15	01.02.02.15	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS
01	02	03	01.02.03	16	01.02.03.16	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS
01	02	03	01.02.03	17	01.02.03.17	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS
01	02	03	01.02.03	18	01.02.03.18	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS
01	02	04	01.02.04	19	01.02.04.19	PLANNING	BUSINESS DEVELOPMENT	UNIT INFO
01	03	01	01.03.01	20	01.03.01.20	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	21	01.03.01.21	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	22	01.03.01.22	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	23	01.03.01.23	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	24	01.03.01.24	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	25	01.03.01.25	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	26	01.03.01.26	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	03	01	01.03.01	27	01.03.01.27	PLANNING	MASTER PLAN & BUDGETING	BUDGET
01	04	02	01.04.02	28	01.04.02.28	PLANNING	ANALYSIS & UNIT RATES	UNIT RATES
01	04	03	01.04.03	29	01.04.03.29	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)
01	04	03	01.04.03	30	01.04.03.30	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)
01	04	03	01.04.03	31	01.04.03.31	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)
01	05	01	01.05.01	32	01.05.01.32	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	33	01.05.01.33	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	34	01.05.01.34	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	35	01.05.01.35	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	36	01.05.01.36	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	37	01.05.01.37	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	01	01.05.01	38	01.05.01.38	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS
01	05	02	01.05.02	39	01.05.02.39	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	PROGRESS REPORTS
01	06	01	01.06.01	40	01.06.01.40	PLANNING	SITE PROGRESS	CURRENT SITUATION
01	06	01	01.06.01	41	01.06.01.41	PLANNING	SITE PROGRESS	CURRENT SITUATION
01	06	01	01.06.01	42	01.06.01.42	PLANNING	SITE PROGRESS	CURRENT SITUATION
01	06	02	01.06.02	43	01.06.02.43	PLANNING	SITE PROGRESS	PENDING APPROVAL

It can be seen some real time MS Dynamics (Navision) system usage screenshots belong to main modules of it.

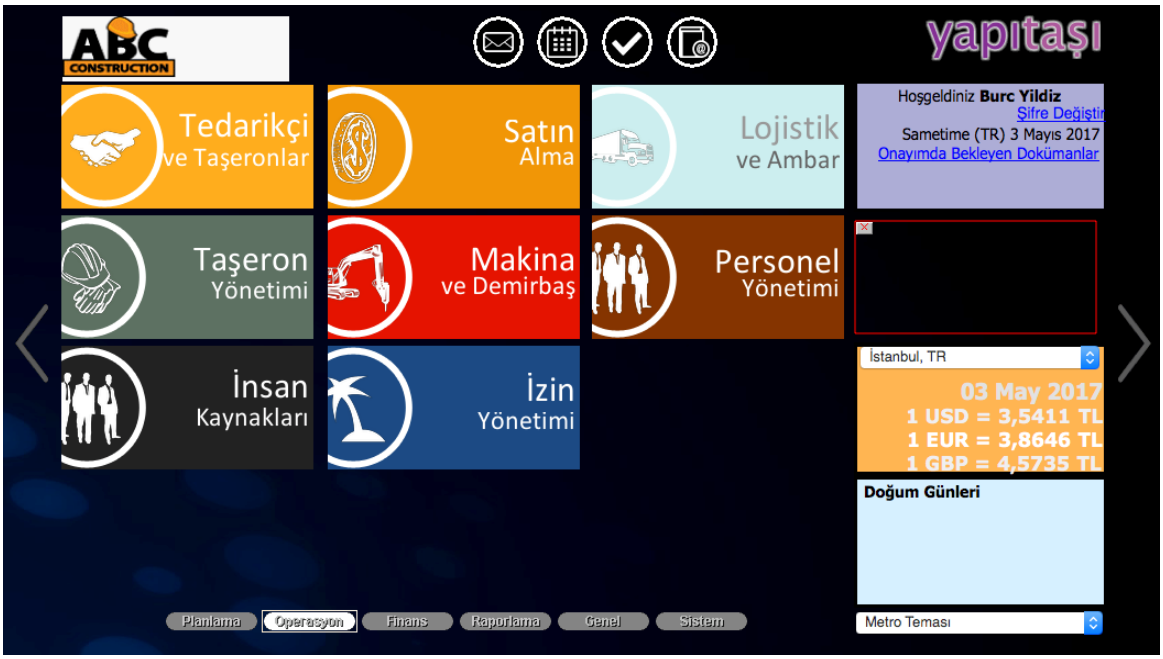


Figure 3.67. Yapıtaşı ERP Main Modules – Operation Main Module

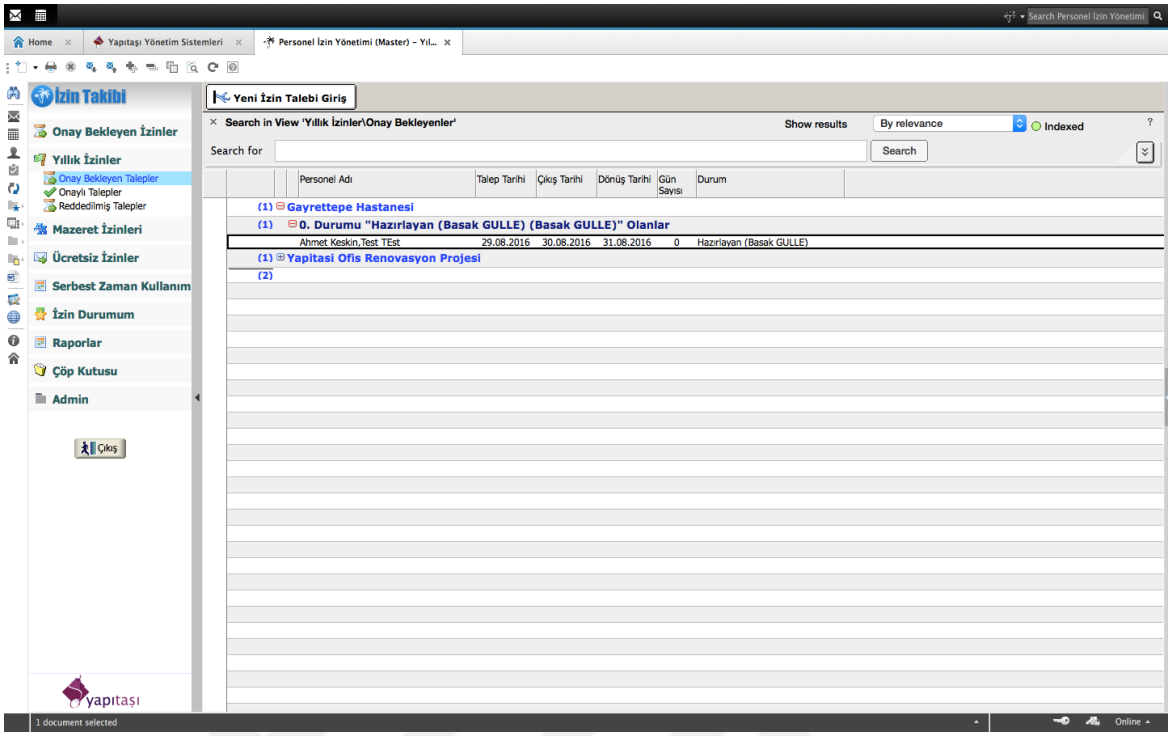


Figure 3.68. Yapıtaşı ERP Main Modules – Operation – Leave Management Module

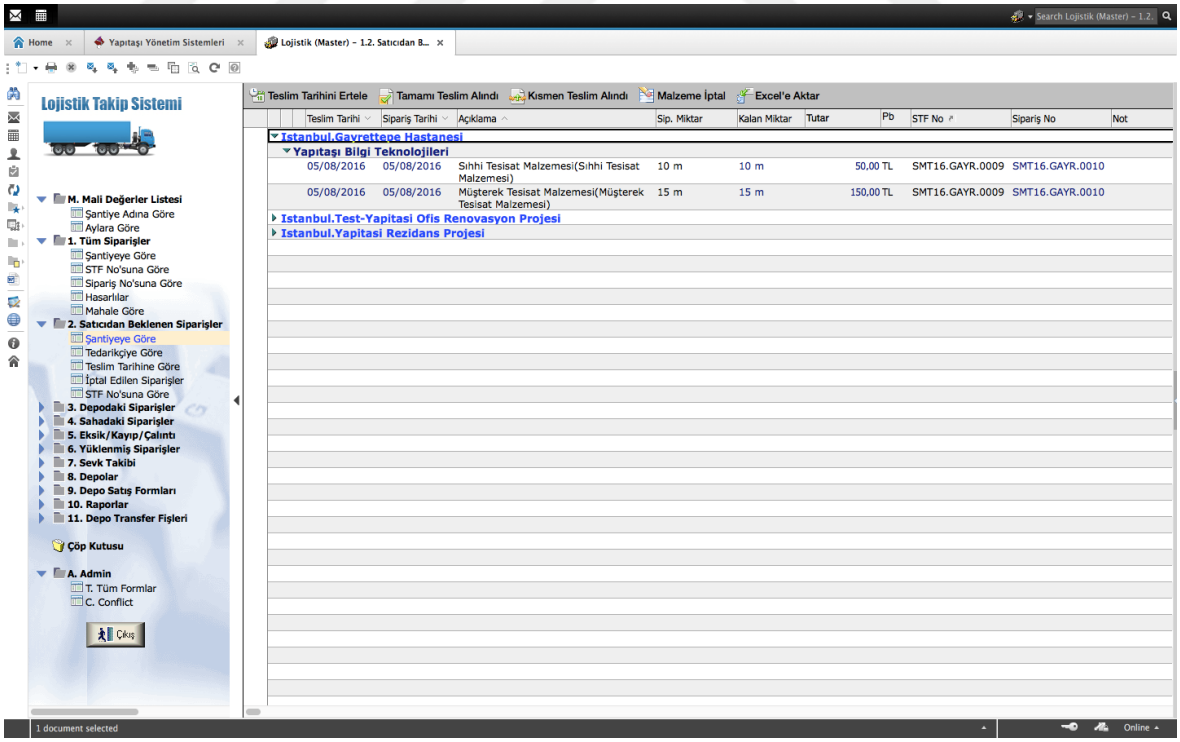


Figure 3.69. Yapıtaşı ERP Main Modules – Operation – Logistics & Warehouse Management Module

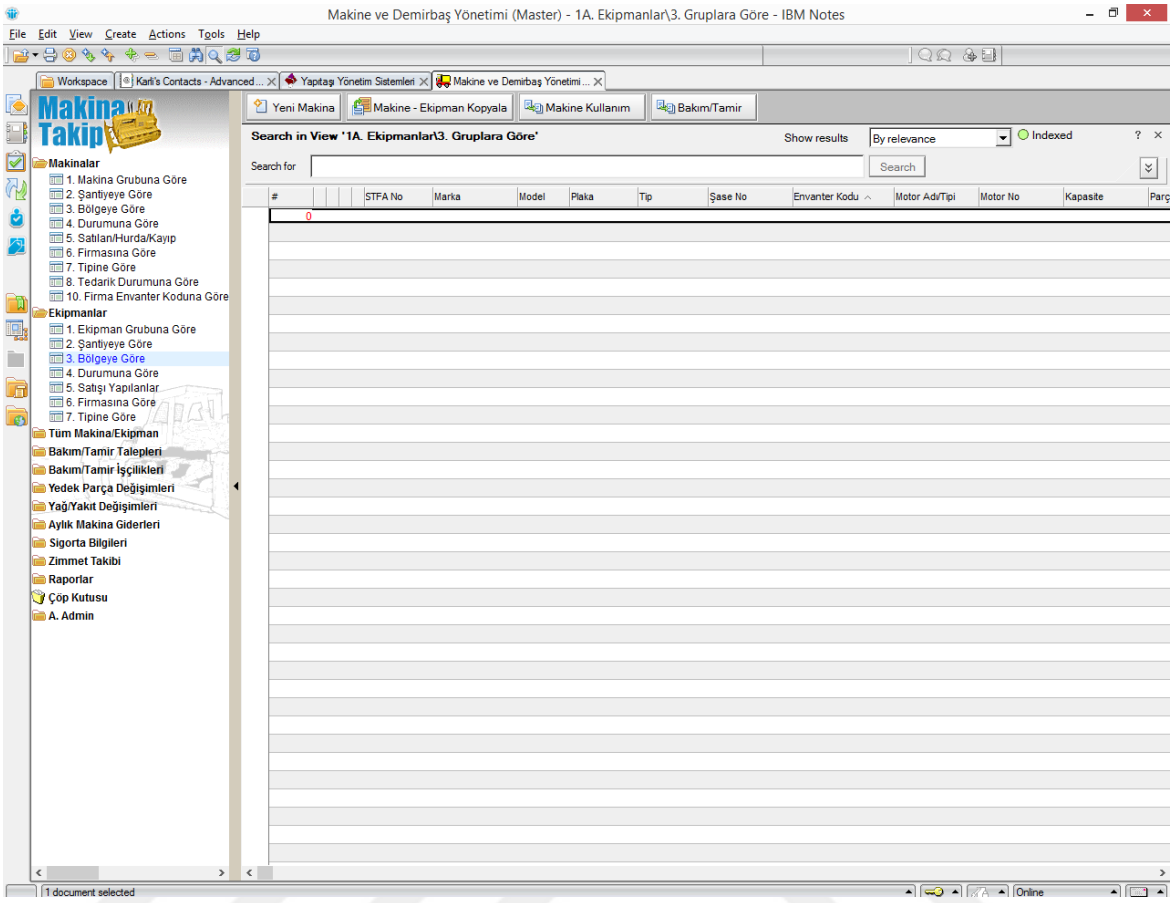


Figure 3.70. Yapıtaşı ERP Main Modules – Operation – Machine & Inventory Management Module

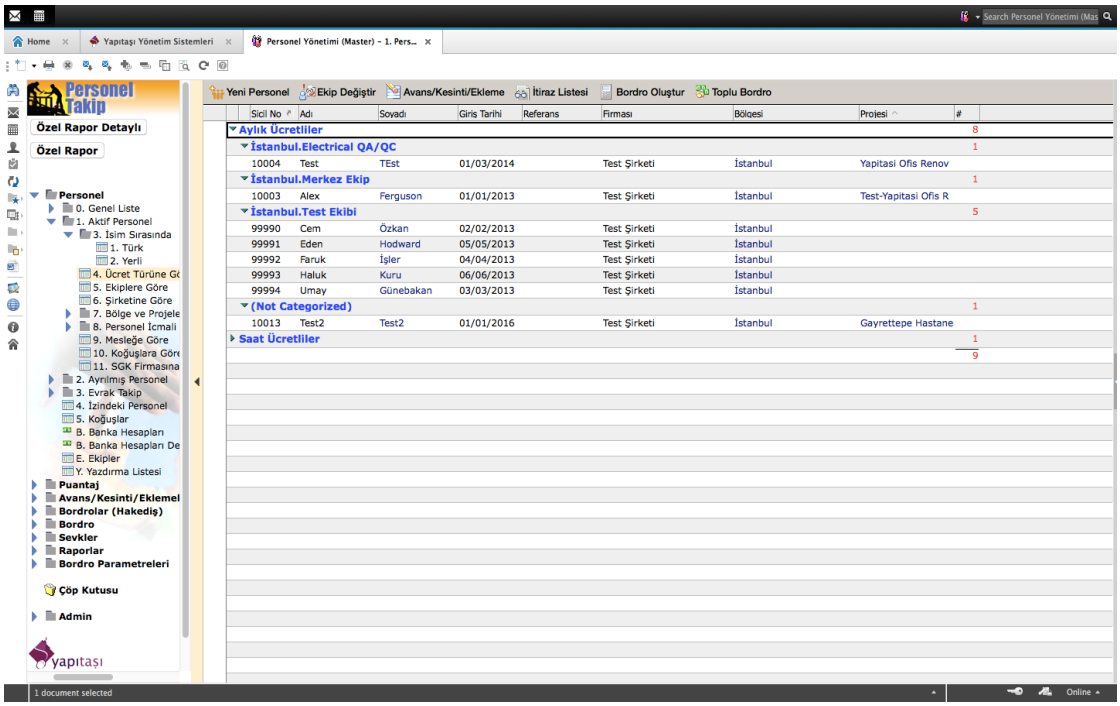


Figure 3.71. Yapıtaşı ERP Main Modules – Operation – HR Management Module

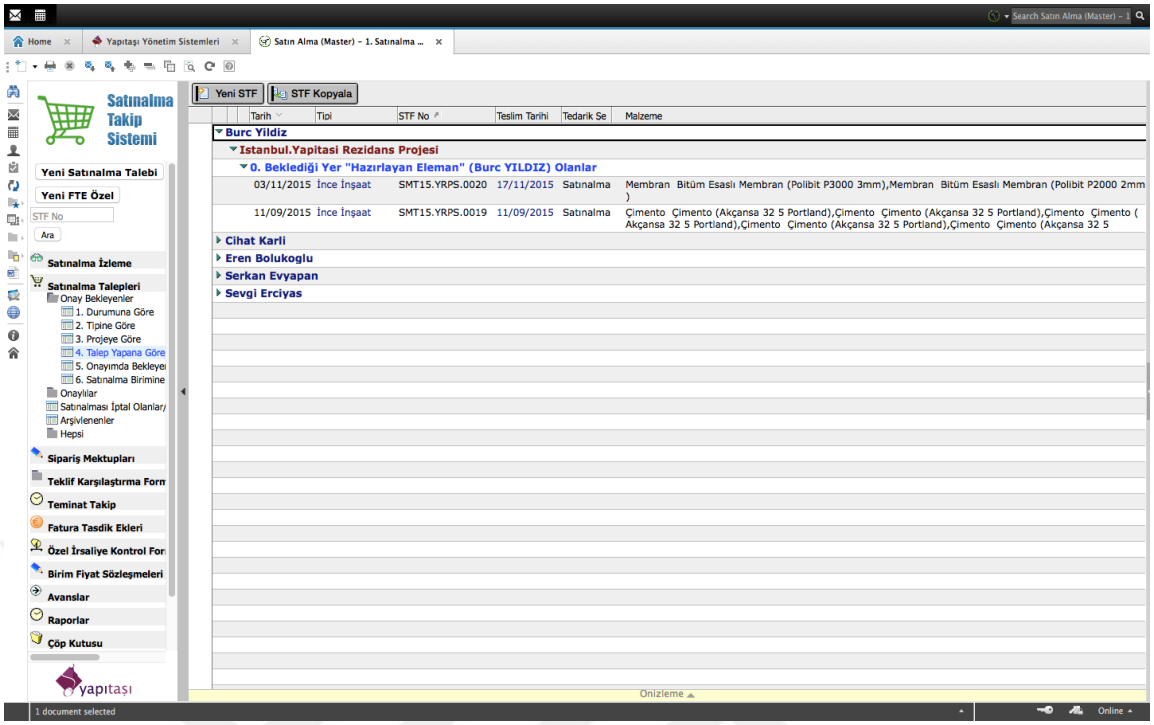


Figure 3.72. Yapıtaşı ERP Main Modules – Operation – Purchasing Module

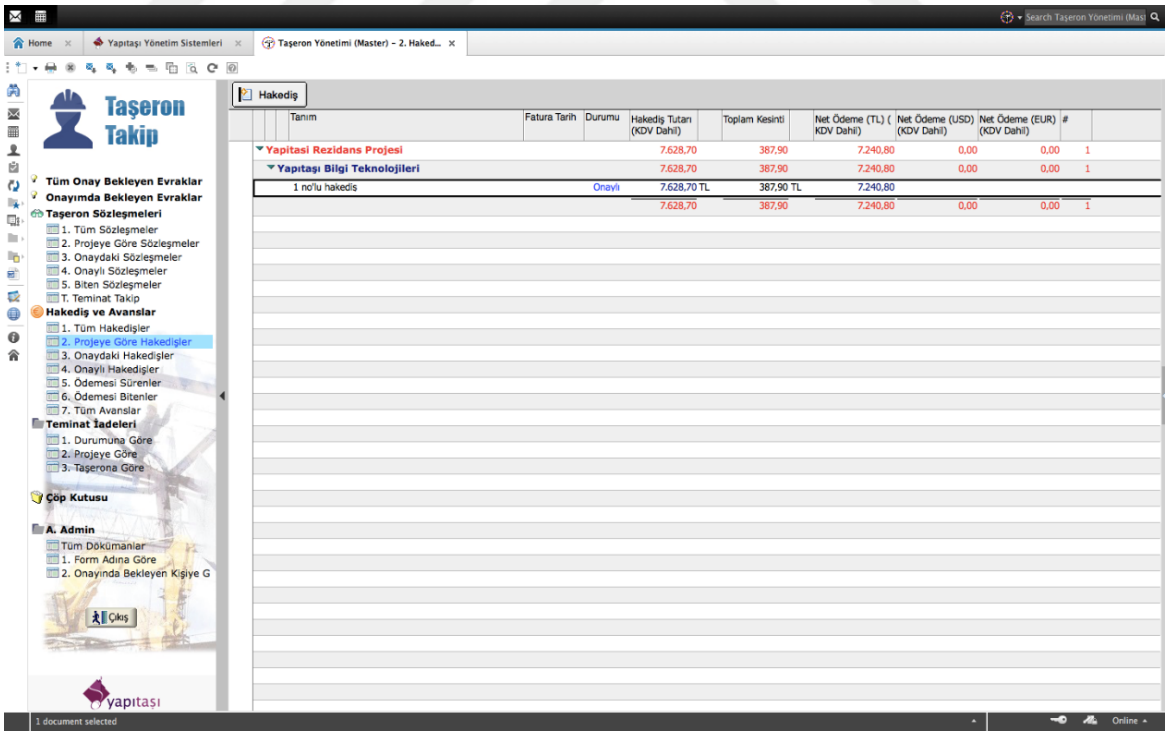
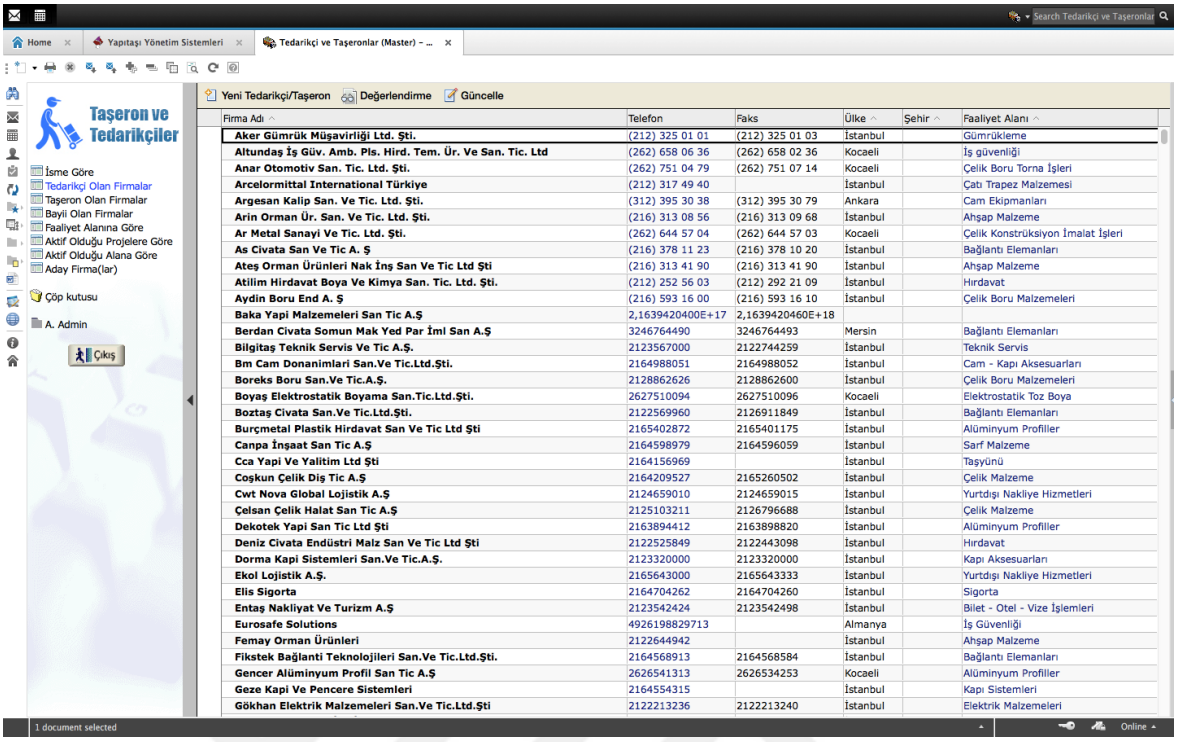


Figure 3.73. Yapıtaşı ERP Main Modules – Operation – Sub-Contractor Management Module



Firma Adı	Telefon	Faks	Ülke	Şehir	Faaliyet Alanı
Aker Gümrük Müşavirliği Ltd. Şti.	(212) 325 01 01	(212) 325 01 03	İstanbul		Gümrükleme
Altundaş İş Güv. Amb. Pls. Hird. Tem. Ür. Ve San. Tic. Ltd	(262) 658 06 36	(262) 658 02 36	Kocaeli		İş güvenliği
Anar Otomotiv San. Tic. Ltd. Şti.	(262) 751 04 79	(262) 751 07 14	Kocaeli		Çelik Boru Torna İşleri
Arcelormittal International Türkiye	(212) 317 49 40		İstanbul		Çatı Trapez Malzemesi
Argesan Kalip San. Ve Tic. Ltd. Şti.	(312) 395 30 38	(312) 395 30 79	Ankara		Cam Ekipmanları
Arin Orman Ür. San. Ve Tic. Ltd. Şti.	(216) 313 08 56	(216) 313 09 68	İstanbul		Ahşap Malzeme
Ar Metal Sanayi Ve Tic. Ltd. Şti.	(262) 644 57 04	(262) 644 57 03	Kocaeli		Çelik Konstrüksiyon İmalat İşleri
As Civata San Ve Tic A. Ş	(216) 378 11 23	(216) 378 10 20	İstanbul		Bağlantı Elemanları
Ateş Orman Ürünleri Nak İnş San Ve Tic Ltd Şti	(216) 313 41 90	(216) 313 41 90	İstanbul		Ahşap Malzeme
Atilim Hirdavat Boya Ve Kimya San. Tic. Ltd. Şti.	(212) 252 56 03	(212) 292 21 09	İstanbul		Hırdavat
Aydin Boru End A. Ş	(216) 593 16 00	(216) 593 16 10	İstanbul		Çelik Boru Malzemeleri
Baka Yapi Malzemeleri San Tic A.Ş	2,1639420400E+17	2,1639420460E+18			
Berdan Civata Somun Mak Yed Par İml San A.Ş	3246764490	3246764493	Mersin		Bağlantı Elemanları
Bilgitaş Teknik Servis Ve Tic A.Ş.	2123567000	2122744259	İstanbul		Teknik Servis
Bm Cam Donanimlari San.Ve Tic.Ltd.Şti.	2164988051	2164988052	İstanbul		Cam - Kapı Aksesuarları
Boreks Boru San.Ve Tic.A.Ş.	2128862626	2128862600	İstanbul		Çelik Boru Malzemeleri
Boyaş Elektrostatik Boyama San.Tic.Ltd.Şti.	2627510094	2627510096	Kocaeli		Elektrostatik Toz Boya
Boztaş Civata San.Ve Tic.Ltd.Şti.	2122569960	2126911849	İstanbul		Bağlantı Elemanları
Burçmetal Plastik Hirdavat San Ve Tic Ltd Şti	2165402872	2165401175	İstanbul		Alüminyum Profiller
Canpa İnşaat San Tic A.Ş	2164598979	2164596059	İstanbul		Sarf Malzeme
Cca Yapi Ve Yalitim Ltd Şti	2164156969		İstanbul		Taşyünü
Coşkun Çelik Diş Tic A.Ş	2164209527	2165260502	İstanbul		Çelik Malzeme
Cwt Nova Global Lojistik A.Ş	2124659010	2124659015	İstanbul		Yurtdışı Nakliye Hizmetleri
Çelsan Çelik Halat San Tic A.Ş	2125103211	2126796688	İstanbul		Çelik Malzeme
Dekotek Yapi San Tic Ltd Şti	2163894412	2163898820	İstanbul		Alüminyum Profiller
Deniz Civata Endüstri Malz San Ve Tic Ltd Şti	2122525849	2122443098	İstanbul		Hırdavat
Dorma Kapi Sistemleri San.Ve Tic.A.Ş.	2123320000	2123320000	İstanbul		Kapı Aksesuarları
Ekol Lojistik A.Ş.	2165643000	2165643333	İstanbul		Yurtdışı Nakliye Hizmetleri
Elis Sigorta	2164704262	2164704260	İstanbul		Sigorta
Entaş Nakliyat Ve Turizm A.Ş	2123542424	2123542498	İstanbul		Bilet - Otel - Vize İşlemleri
Eurosafe Solutions	4926198829713		Almanya		İş Güvenliği
Femay Orman Ürünleri	2122644942		İstanbul		Ahşap Malzeme
Fikstek Bağlanti Teknolojileri San.Ve Tic.Ltd.Şti.	2164568913	2164568584	İstanbul		Bağlantı Elemanları
Gencer Alüminyum Profil San Tic A.Ş	2626541313	2626534253	Kocaeli		Alüminyum Profiller
Geze Kapi Ve Pencere Sistemleri	2164554315		İstanbul		Kapı Sistemleri
Gökhan Elektrik Malzemeleri San.Ve Tic.Ltd.Şti	2122213236	2122213240	İstanbul		Elektrik Malzemeleri

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Figure 3.74. Yapıtaşı ERP Main Modules – Operation – Supplier Management Module

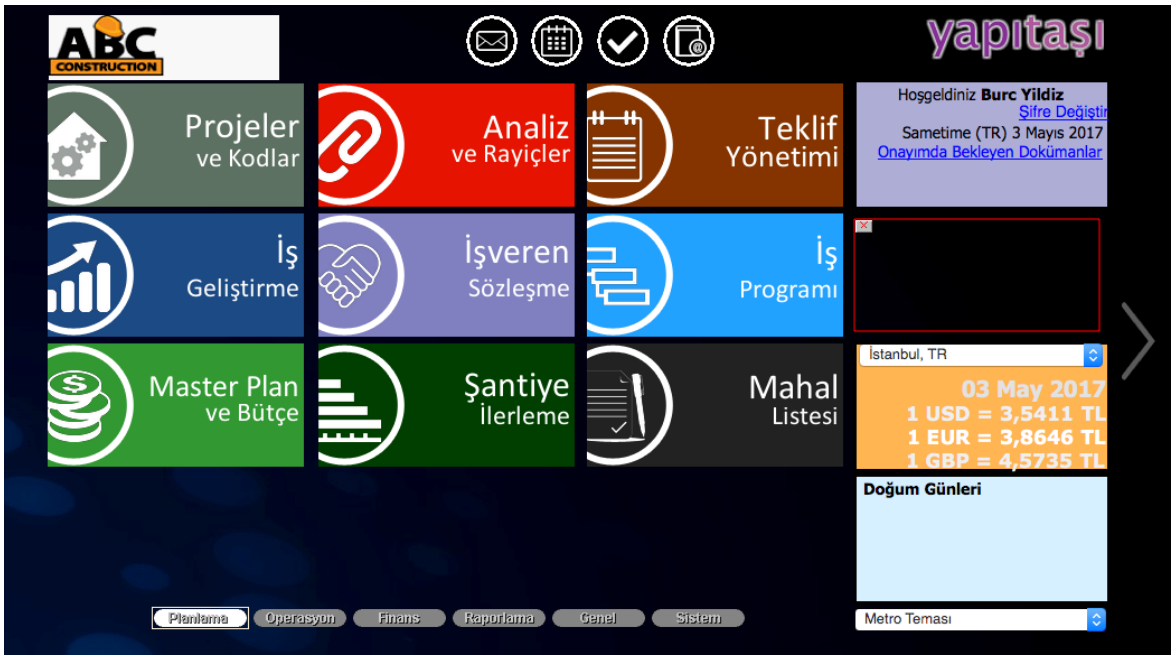


Figure 3.75. Yapıtaşı ERP Main Modules – Planning Main Module

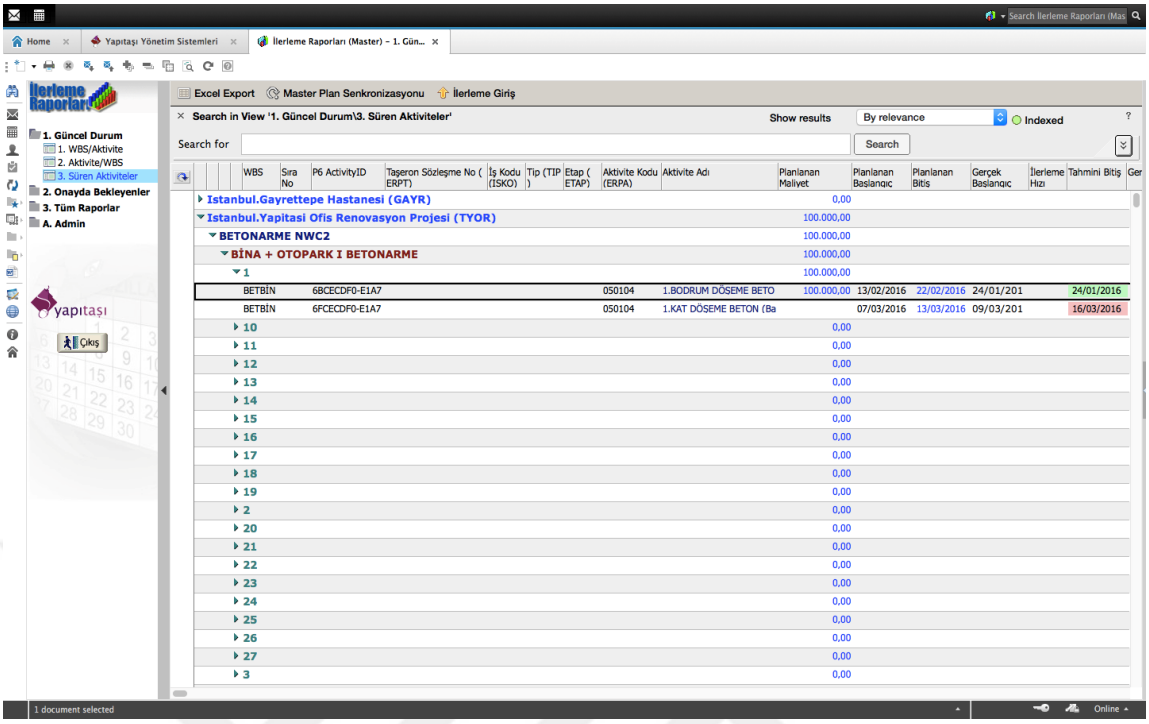


Figure 3.76. Yapıtaşı ERP Main Modules – Planning – Progress Tracking Module

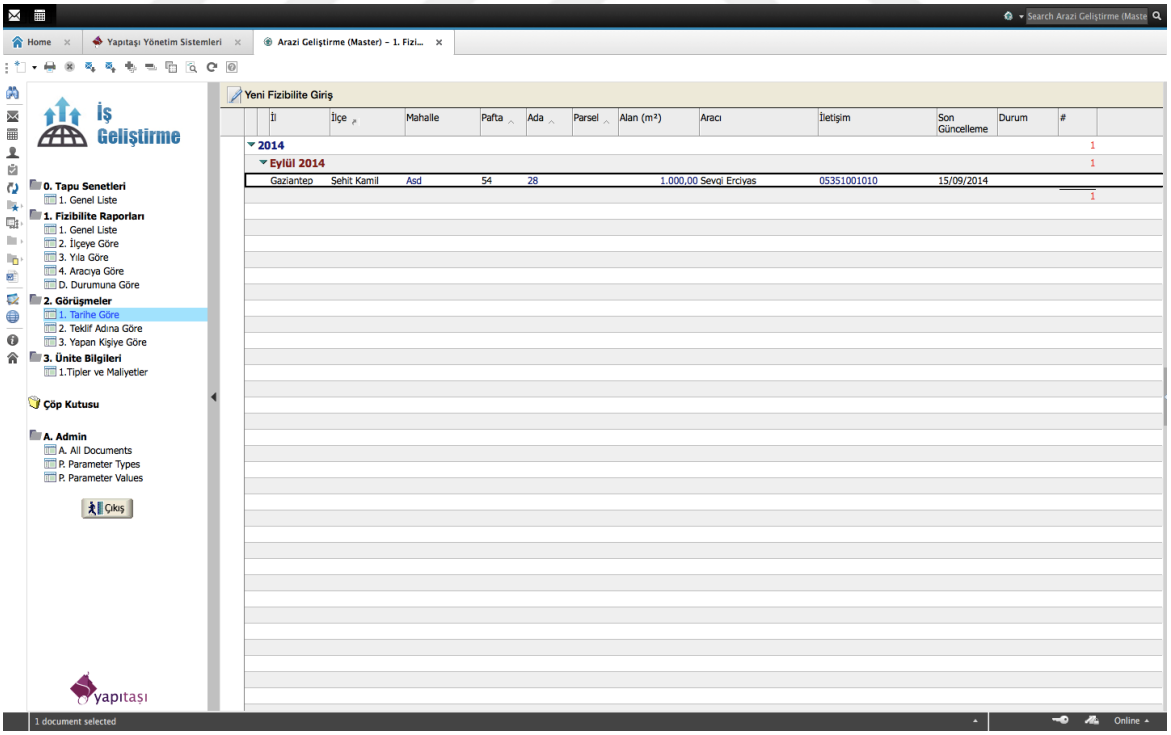


Figure 3.77. Yapıtaşı ERP Main Modules – Planning – Business Development Module

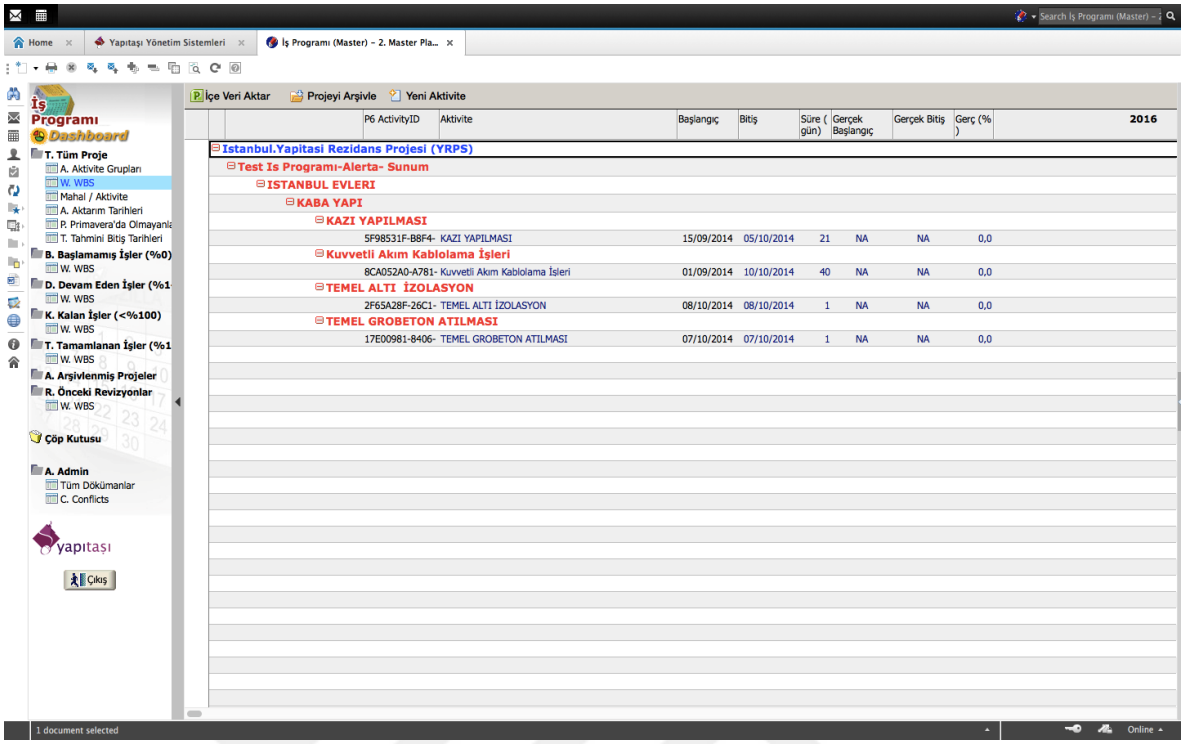


Figure 3.78. Yapıtaşı ERP Main Modules – Planning – Scheduling Module

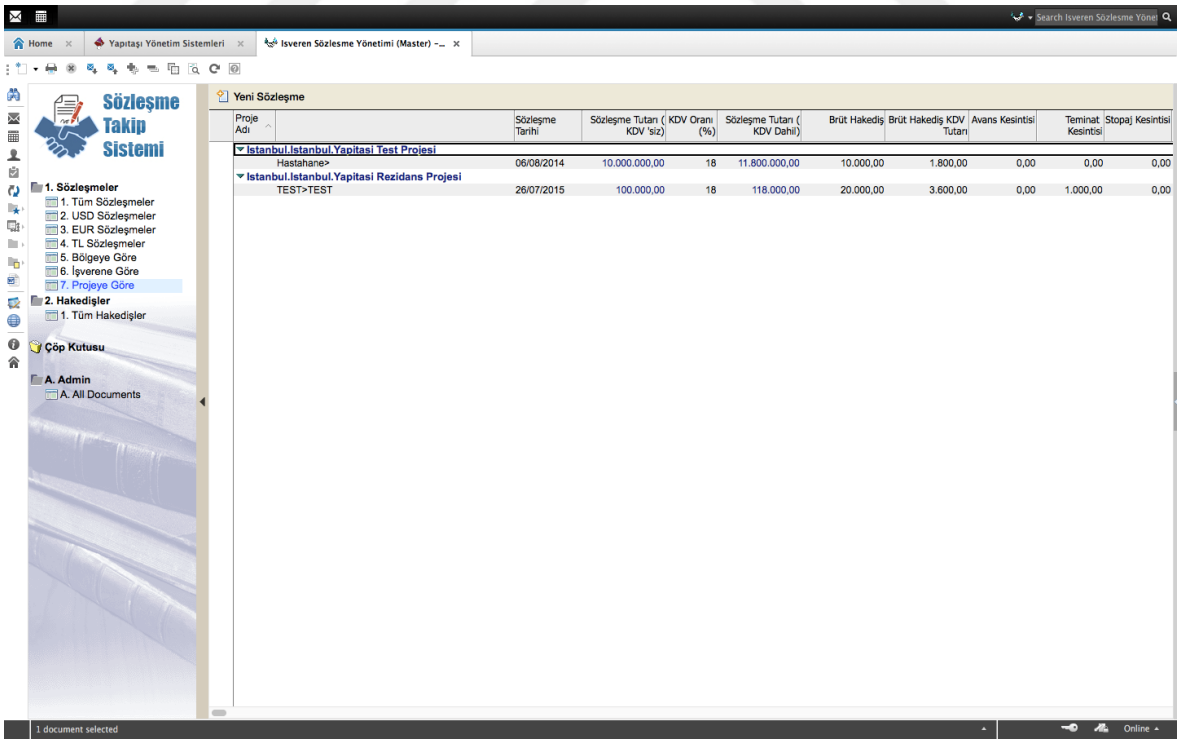


Figure 3.79. Yapıtaşı ERP Main Modules – Planning – (Owner) Contract Management Module

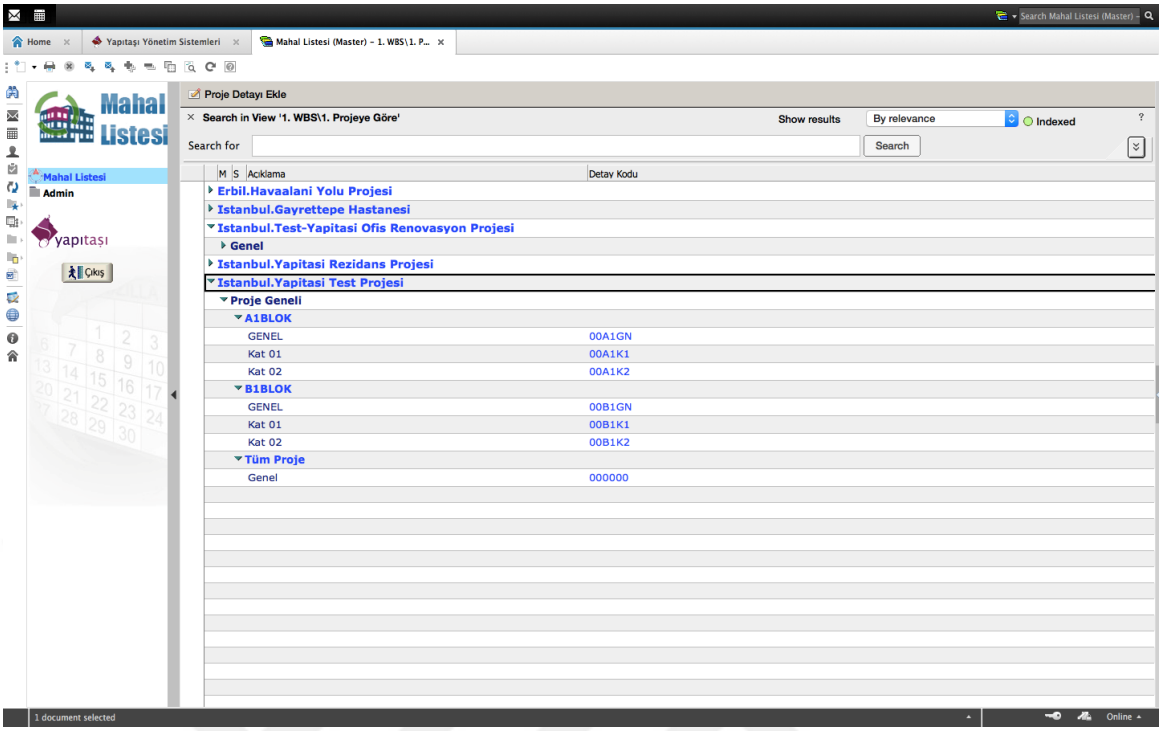


Figure 3.80. Yapıtaşı ERP Main Modules – Planning – Zone List Planning Module

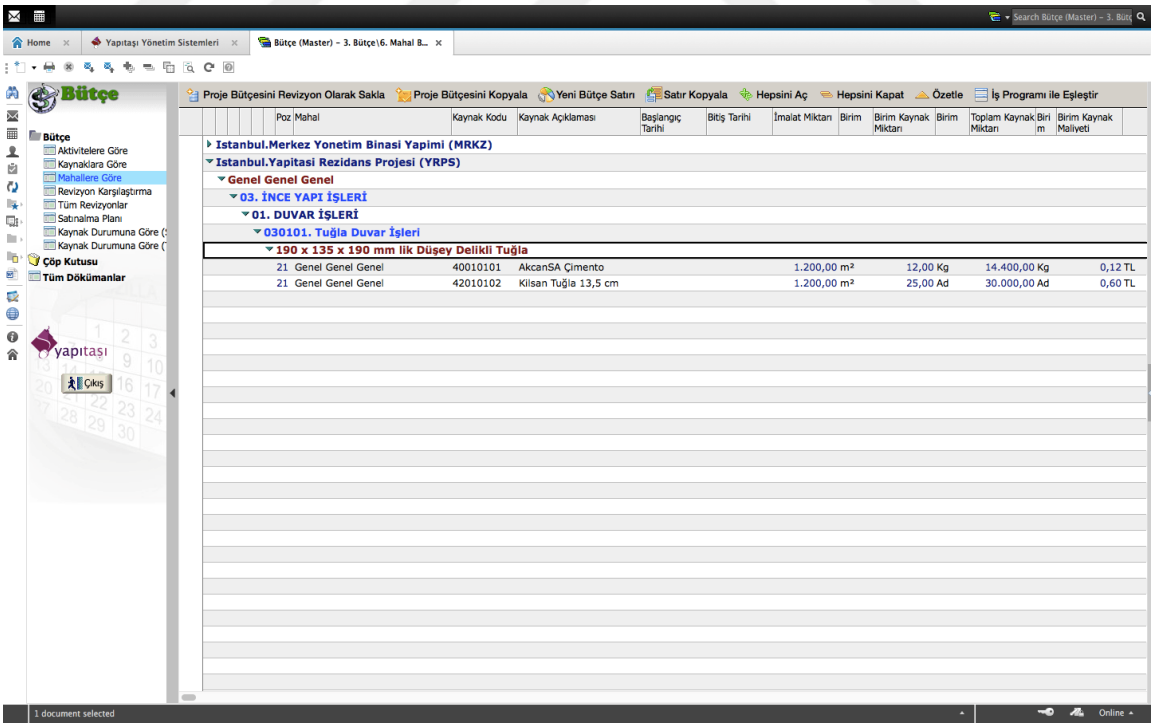


Figure 3.81. Yapıtaşı ERP Main Modules – Planning – Budgeting Module

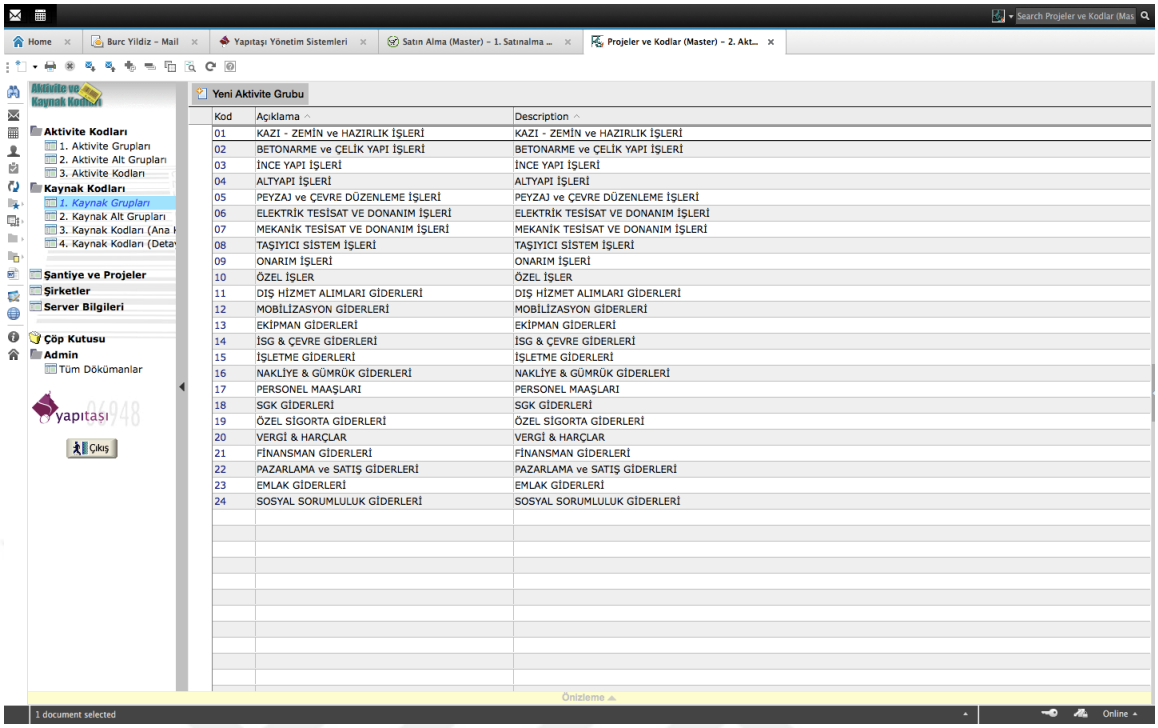


Figure 3.82. Yapıtaşı ERP Main Modules – Planning – Project Activity & Budgeting Codes Management Module

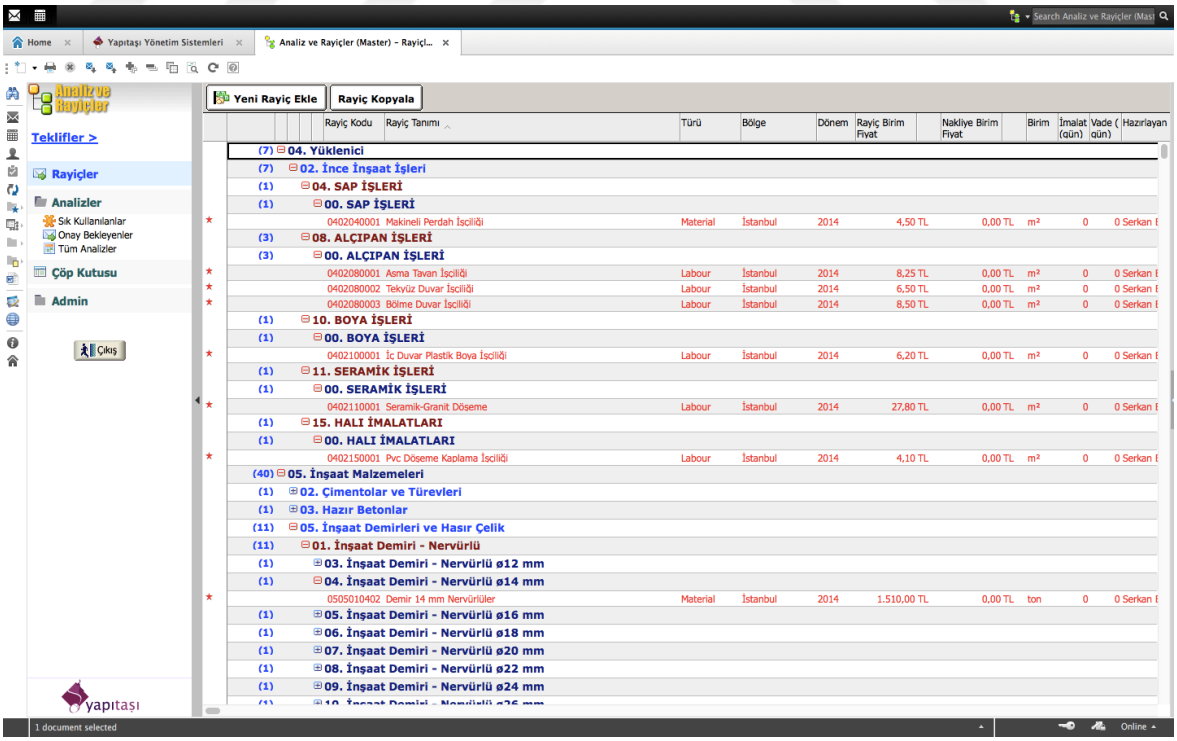


Figure 3.83. Yapıtaşı ERP Main Modules – Planning – Current & Unit Prices and Analysis Module

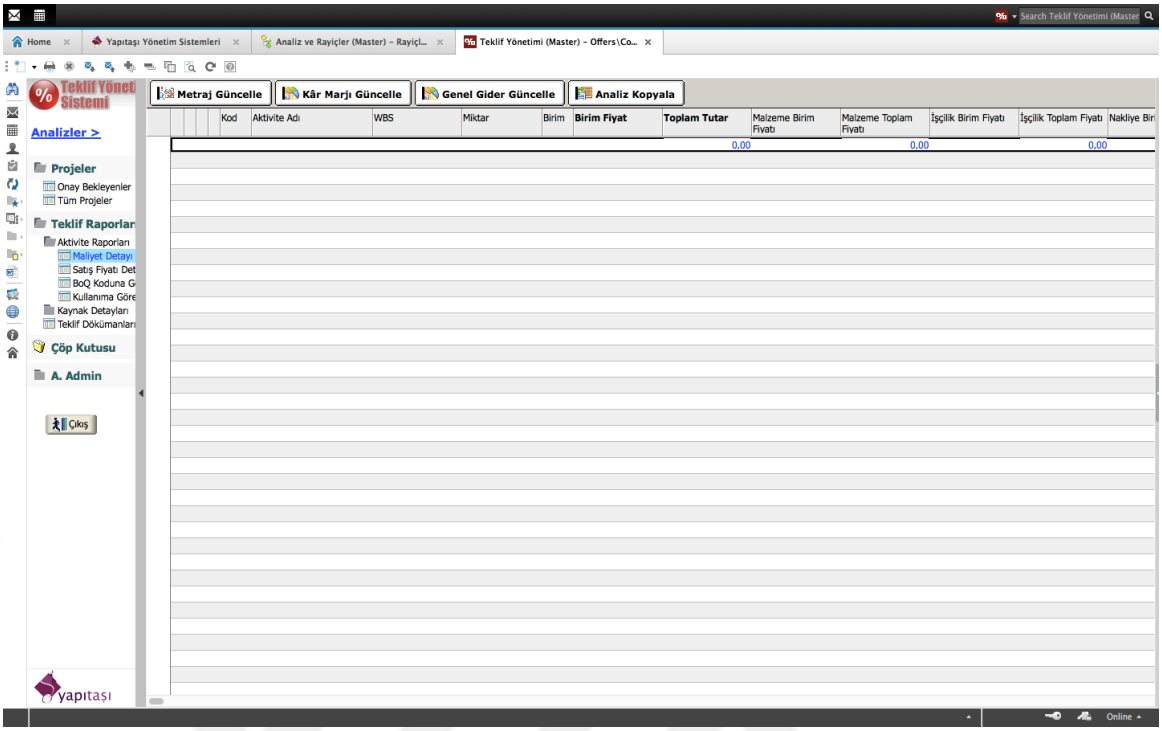


Figure 3.84. Yapıtaşı ERP – Planning – Quotation Management Module

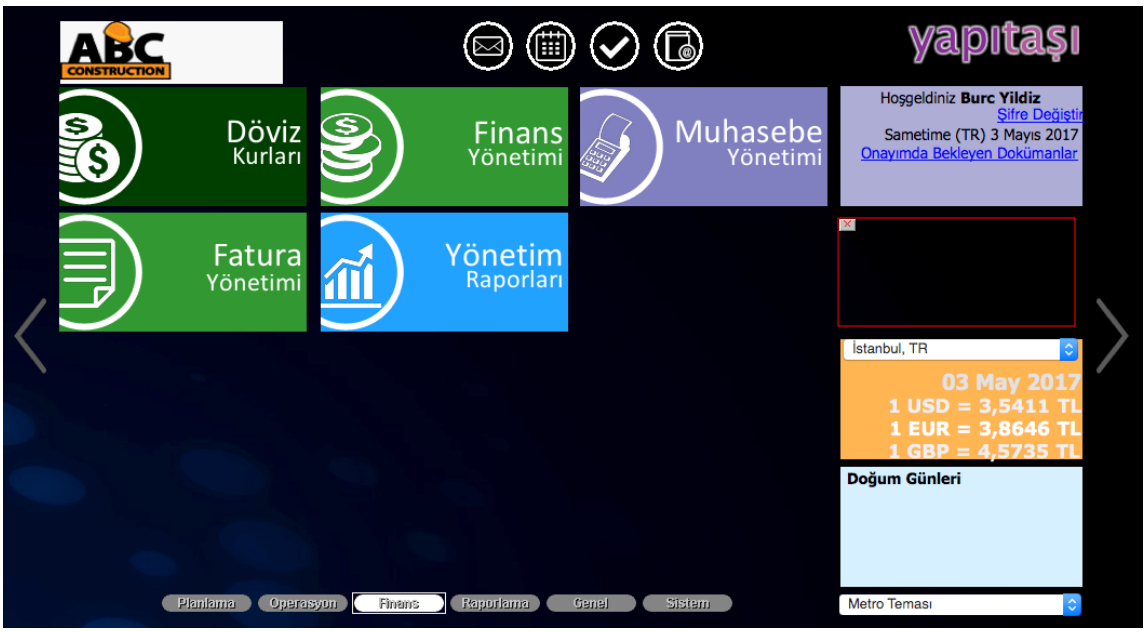


Figure 3.85. Yapıtaşı ERP Main Modules – Finance Main Module

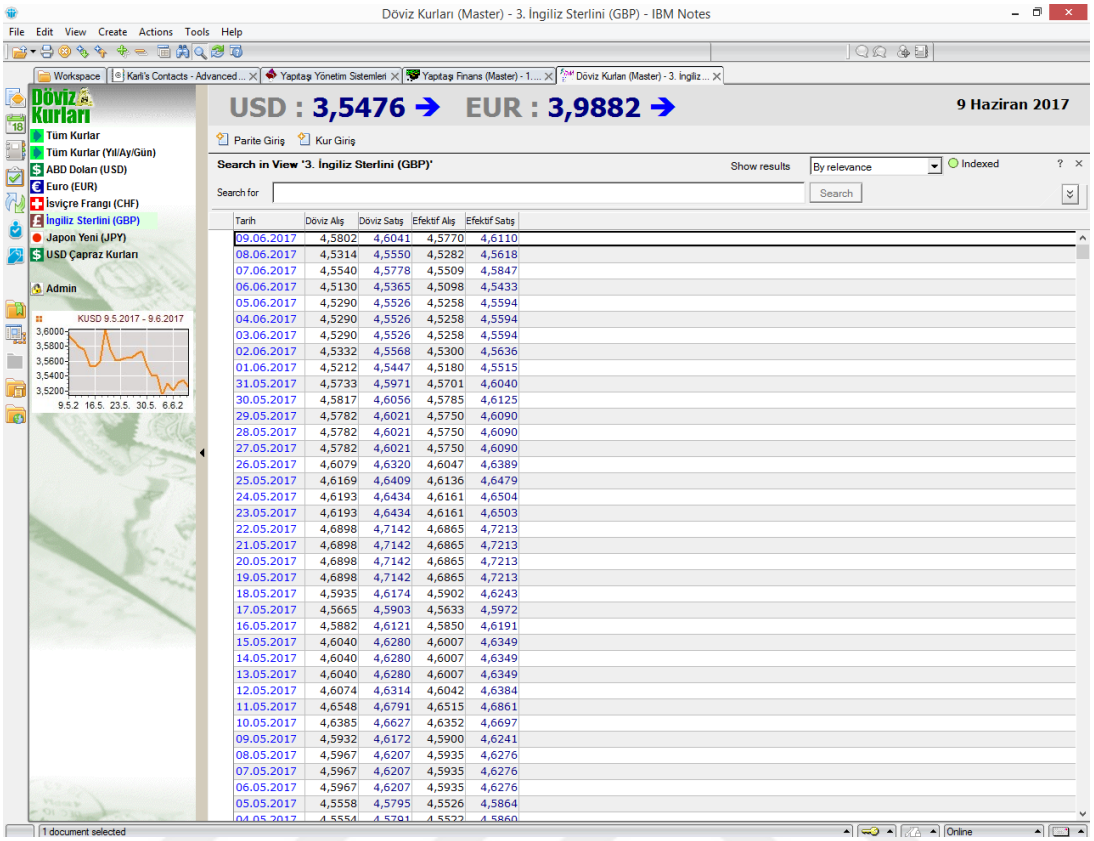


Figure 3.86. Yapıtaşı ERP – Finance – Exchange Rates Module

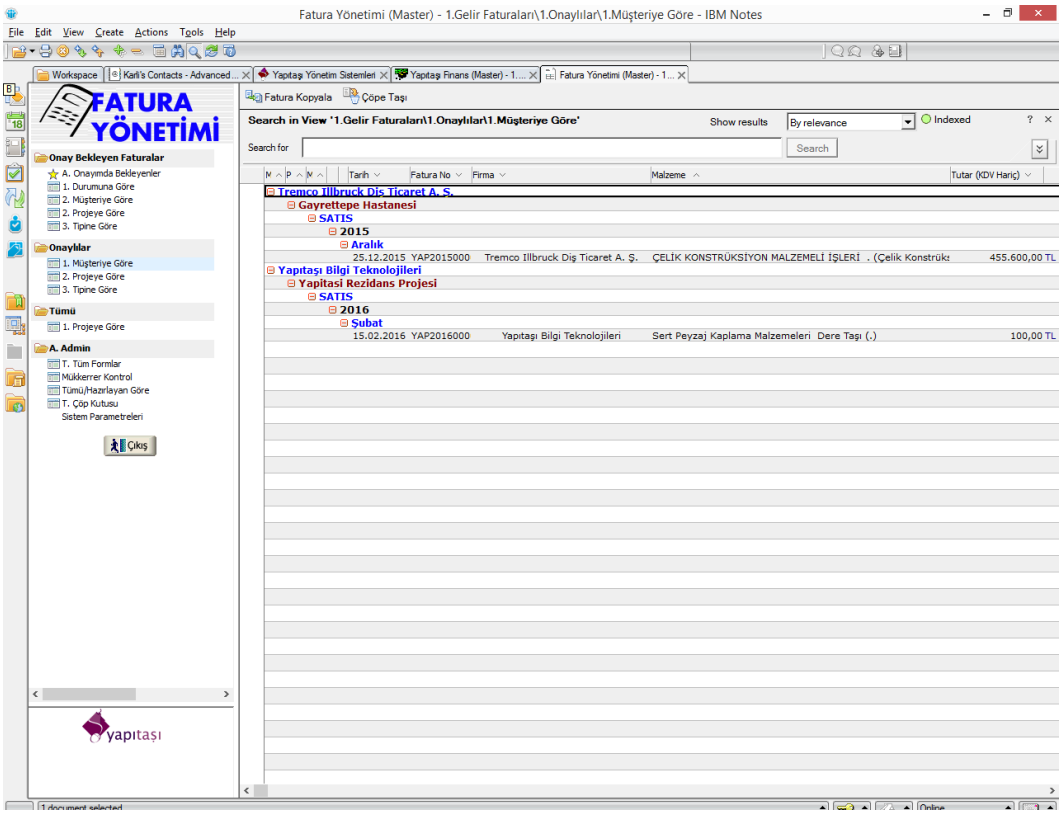


Figure 3.87. Yapıtaşı ERP – Finance – Invoice Management Module

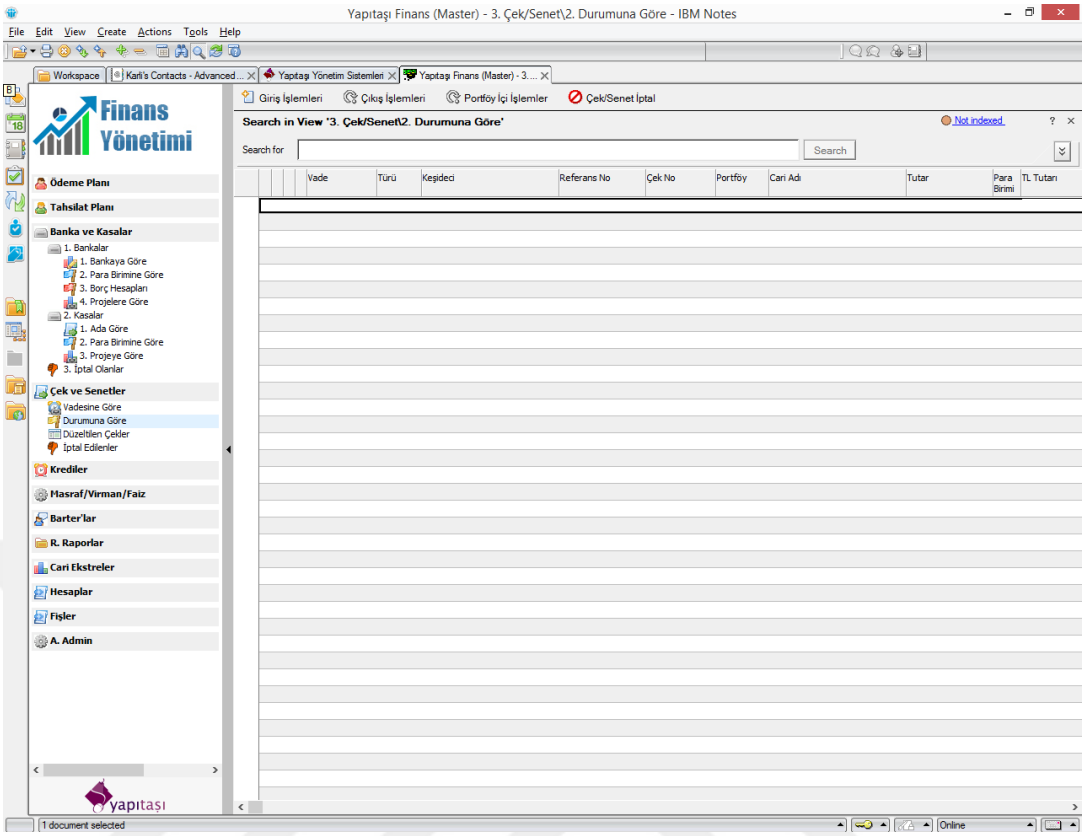


Figure 3.88. Yapıtaşı ERP – Finance – Finance Management Module

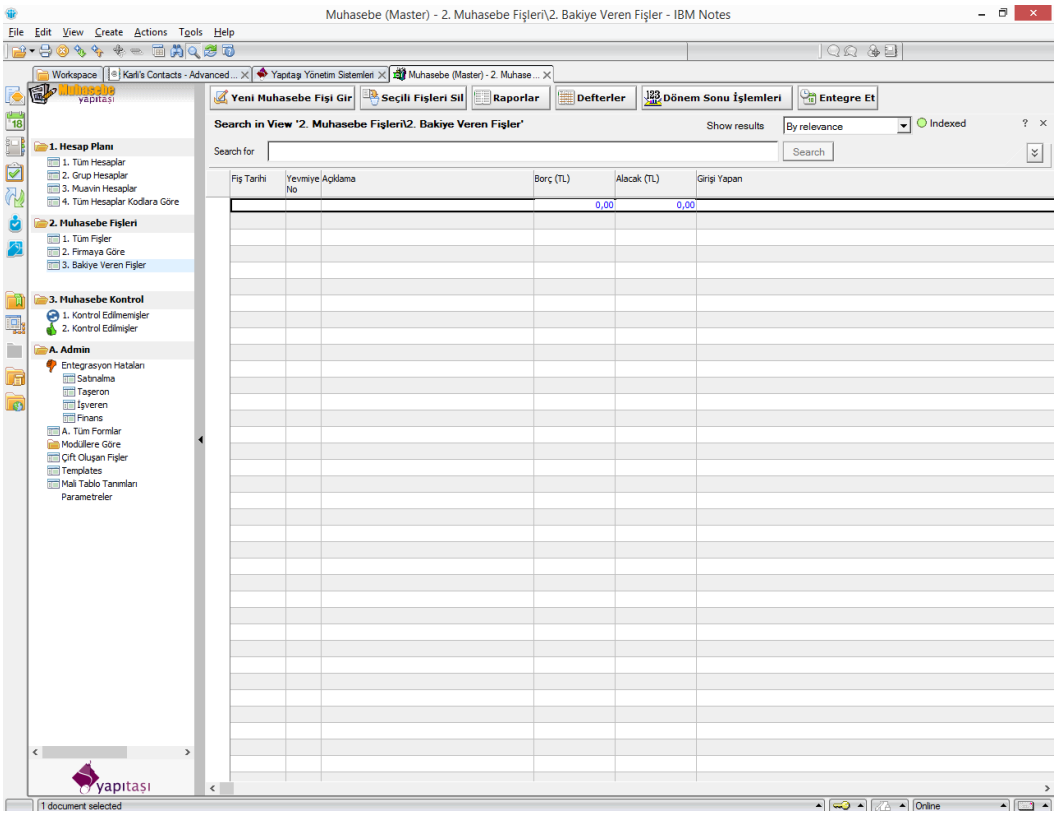


Figure 3.89. Yapıtaşı ERP – Finance – Accounting Management Module

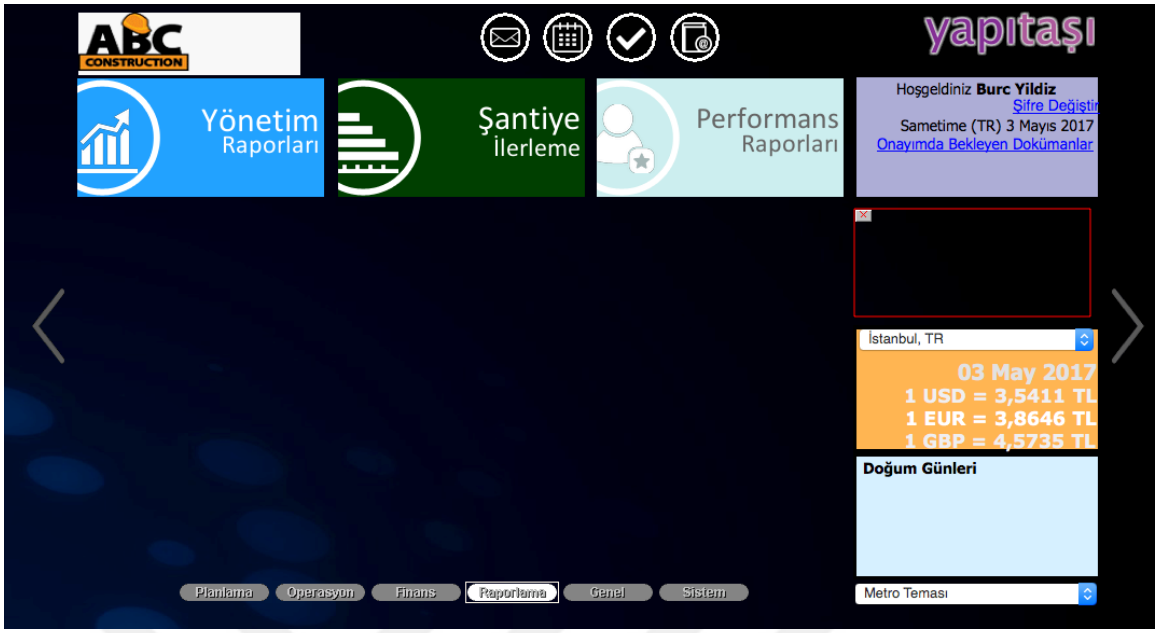


Figure 3.90. Yapıtaşı ERP Main Modules – Reporting Main Module

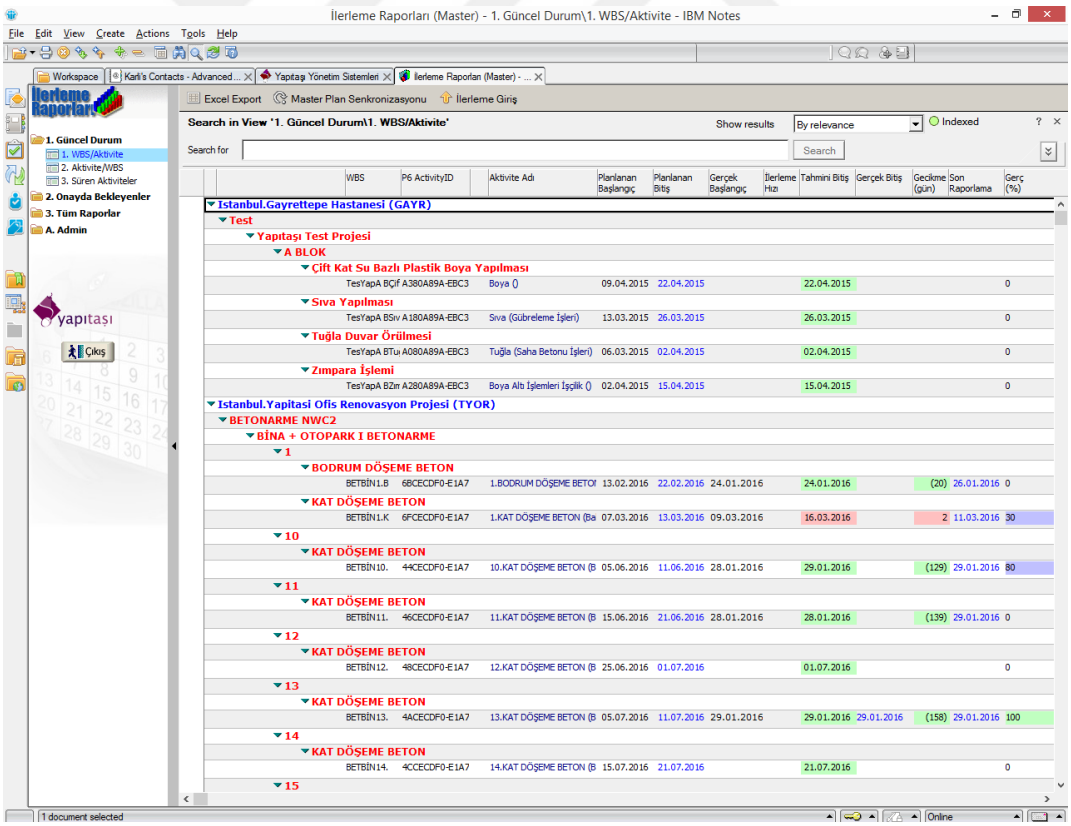


Figure 3.91. Yapıtaşı ERP – Reporting – Progress Reporting Module

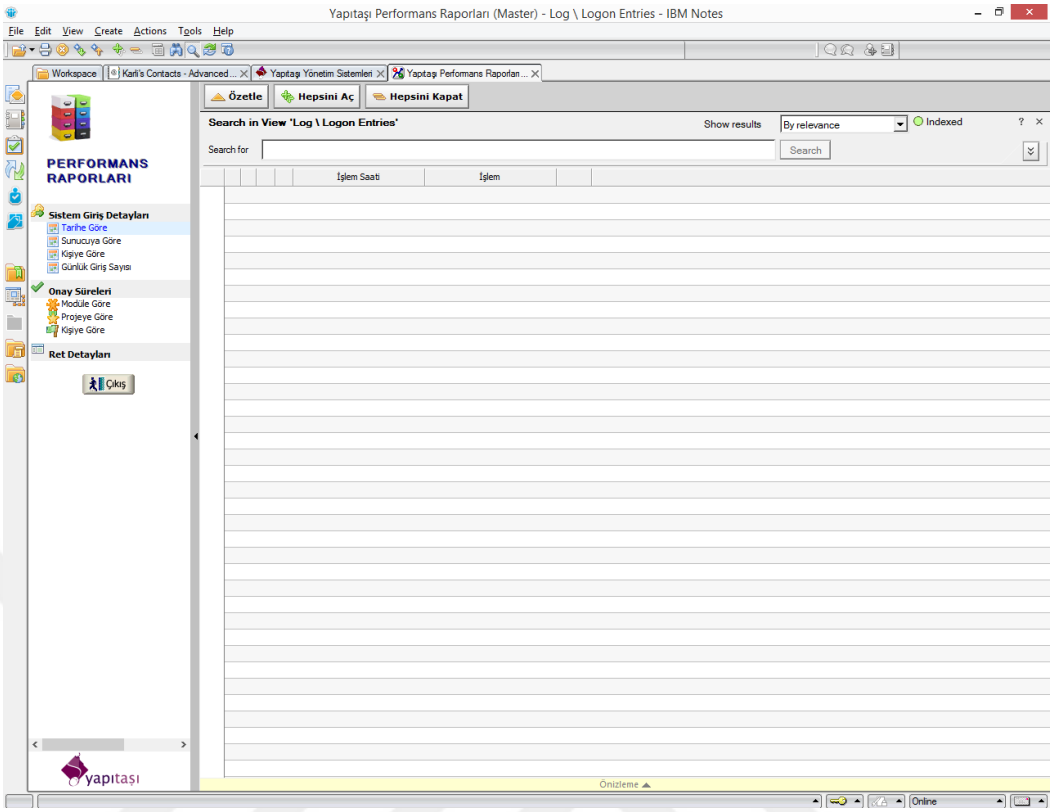


Figure 3.92. Yapıtaşı ERP – Reporting – Performance Reporting Module

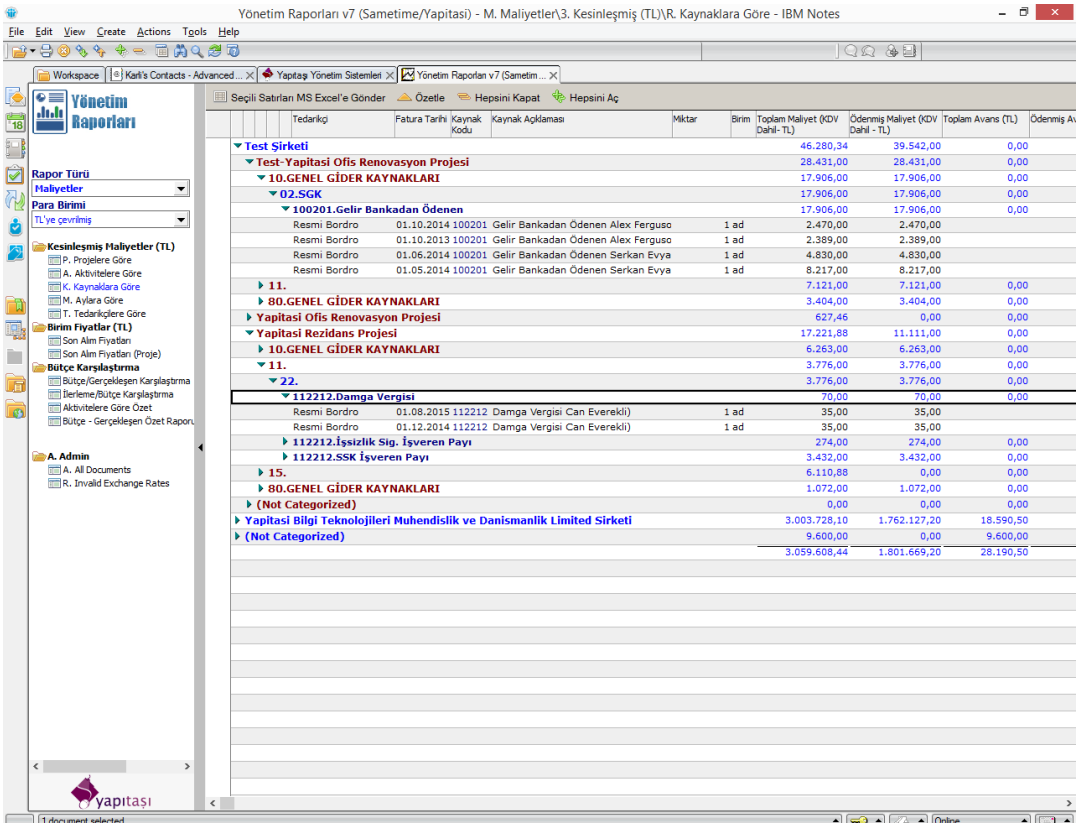


Figure 3.93. Yapıtaşı ERP – Reporting – Executive Reports Module



Figure 3.94. Yapıtaşı ERP Main Modules – General Main Module

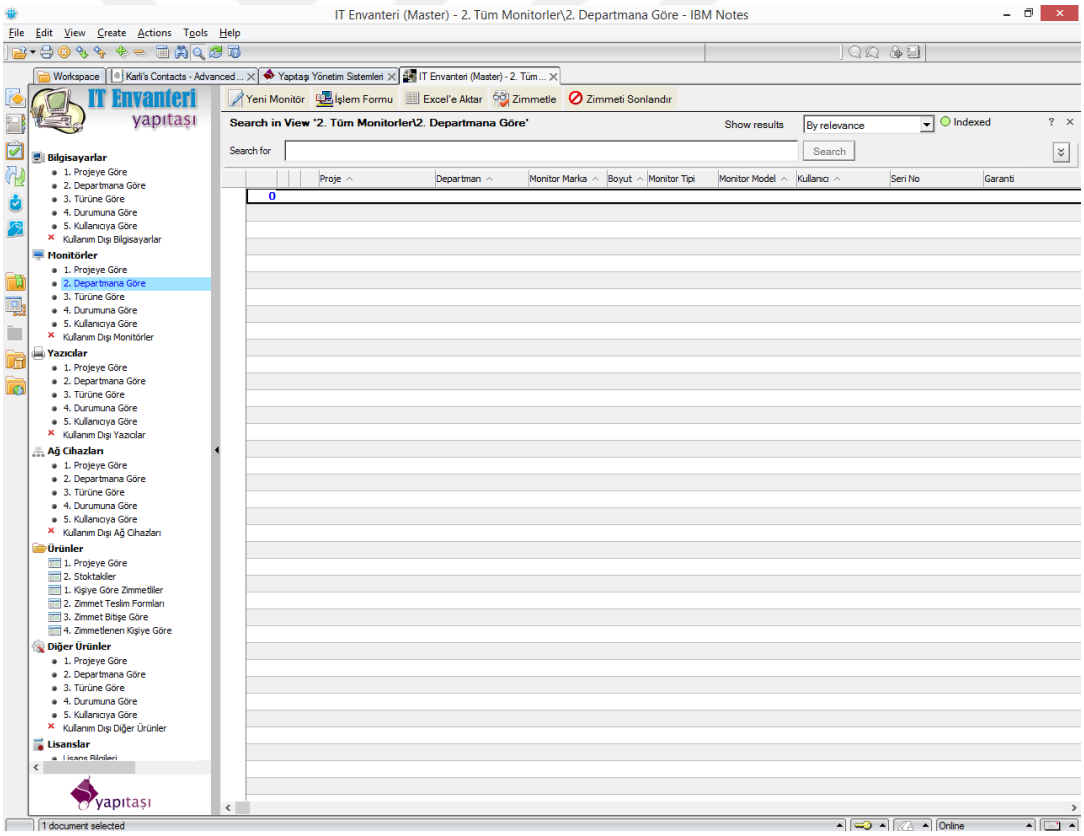


Figure 3.95. Yapıtaşı ERP – General – IT Inventory Management Module

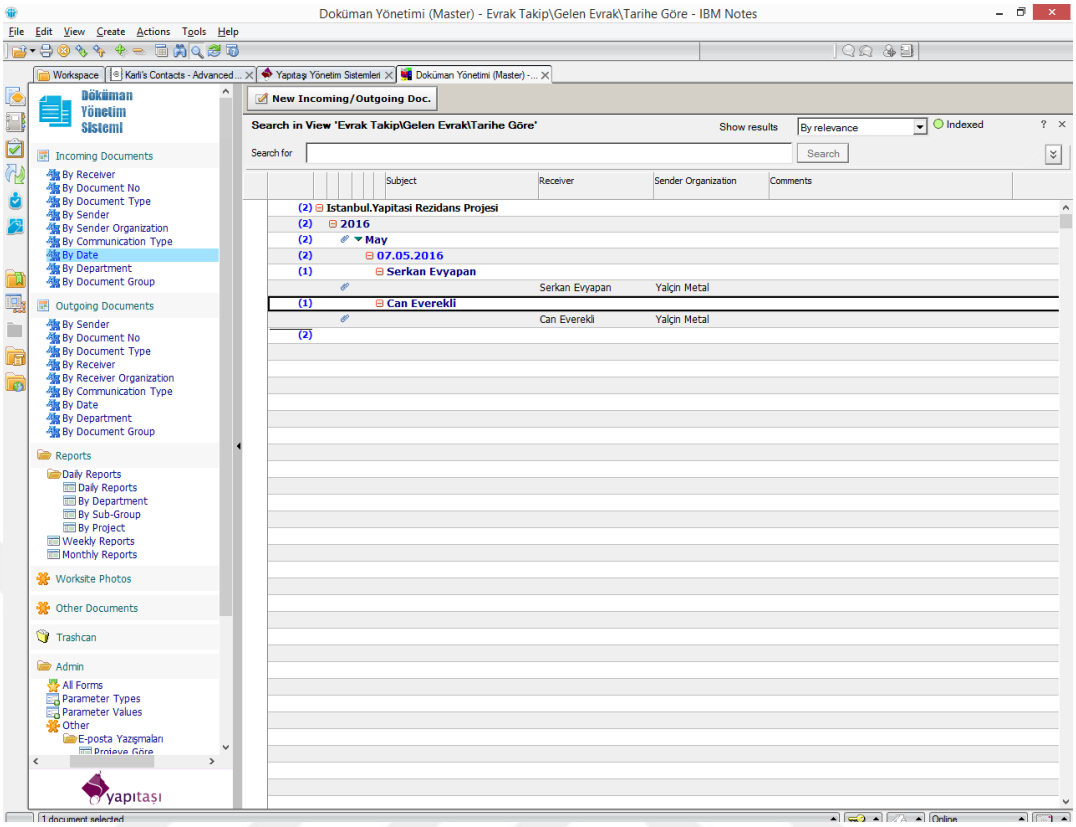


Figure 3.96. Yapıtaşı ERP – General – Document Management Module

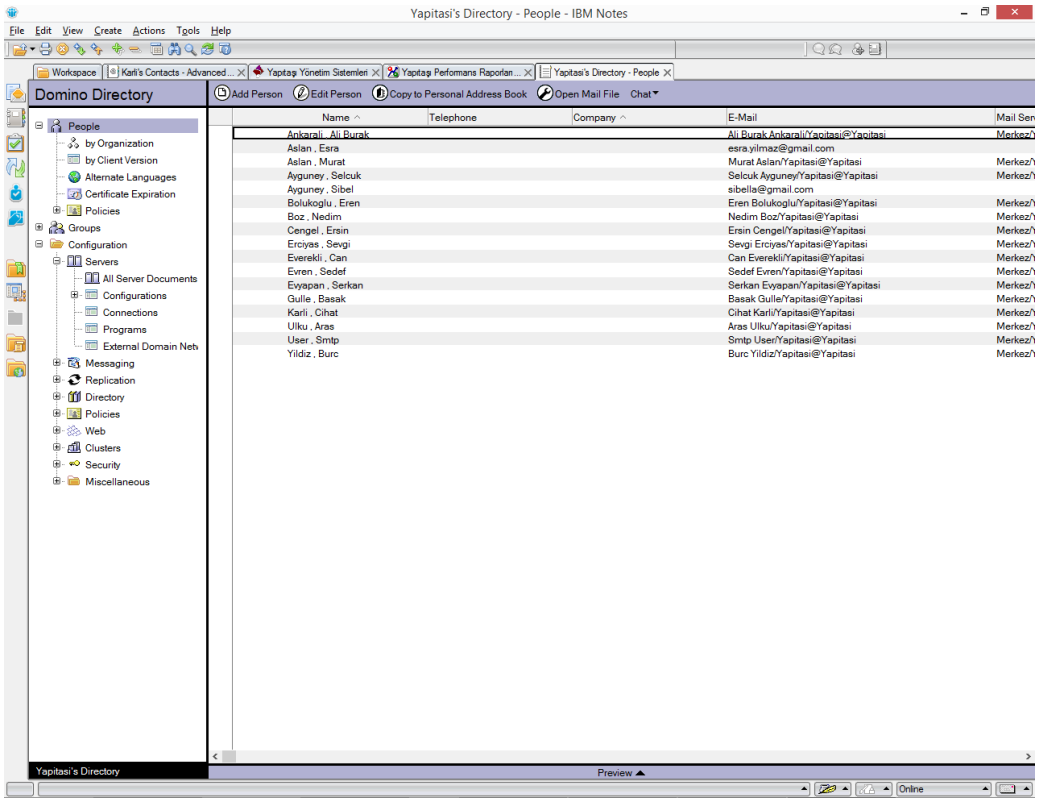


Figure 3.97. Yapıtaşı ERP – General – Address Book Module

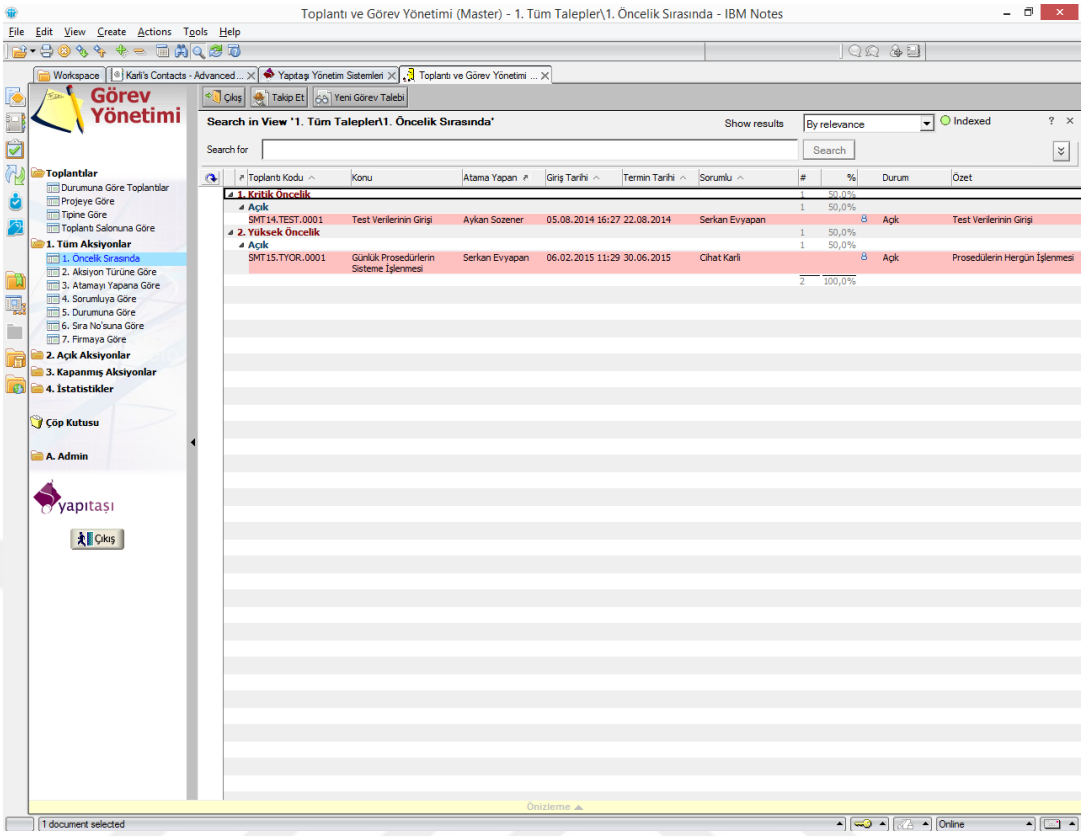


Figure 3.98. Yapıtaşı ERP – General – Task Management Module

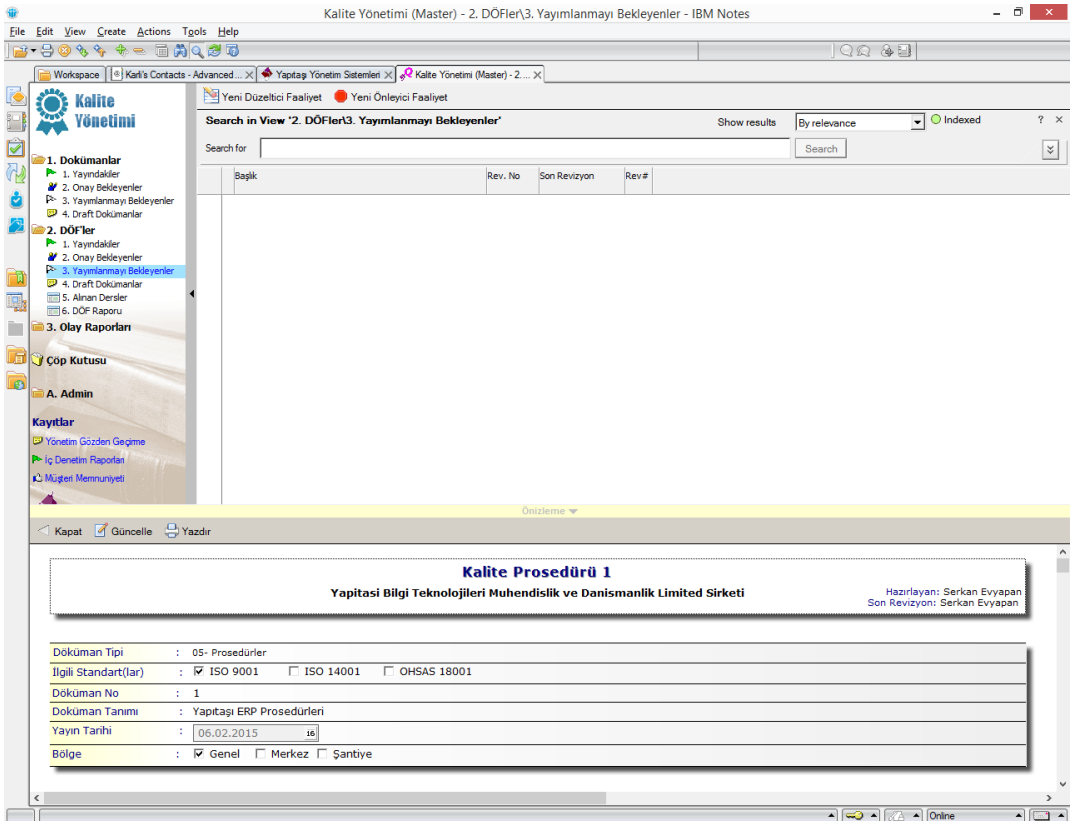


Figure 3.99. Yapıtaşı ERP – General – Quality Management Module

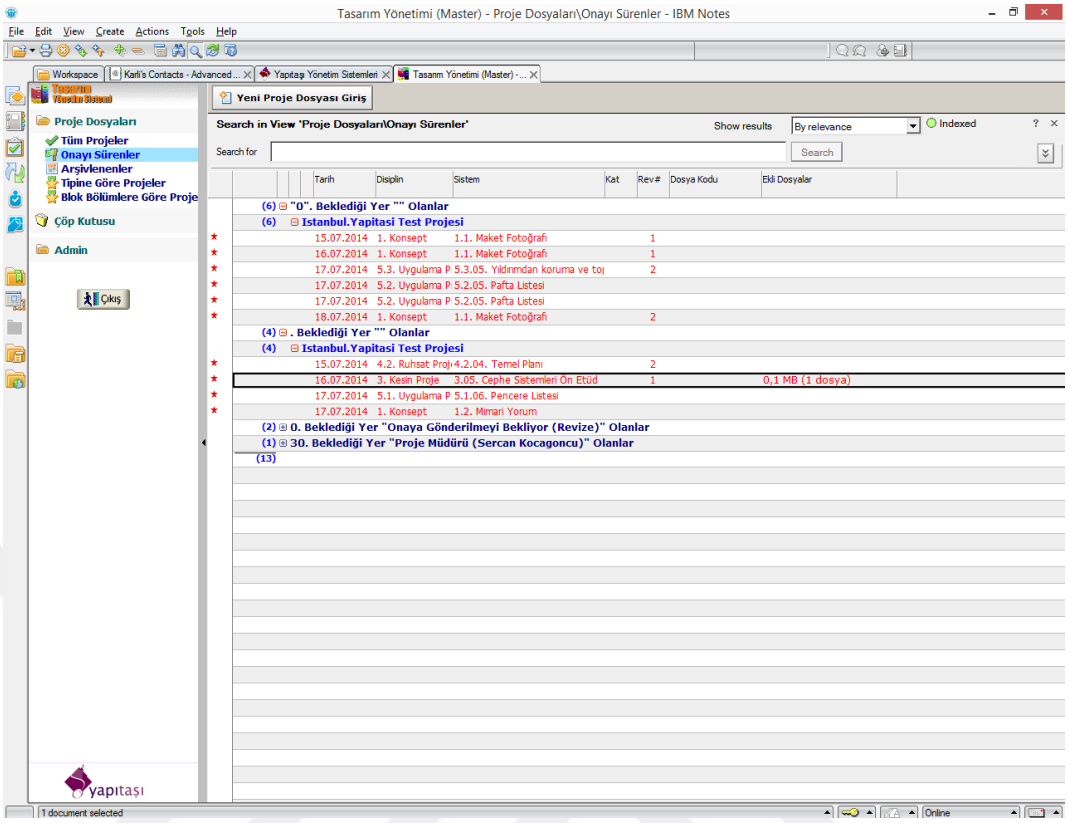


Figure 3.100. Yapıtaşı ERP – General – Design Management Module

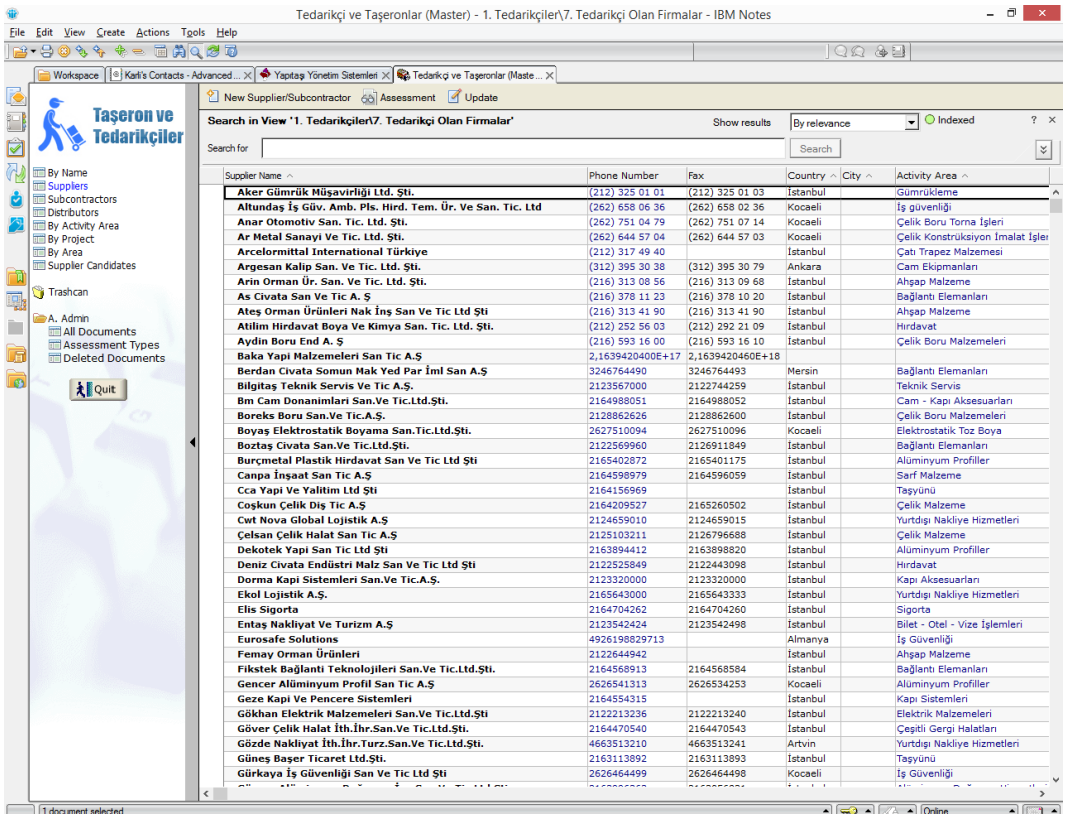


Figure 3.101. Yapıtaşı ERP – General – Suppliers & Subcontractors Lists Module

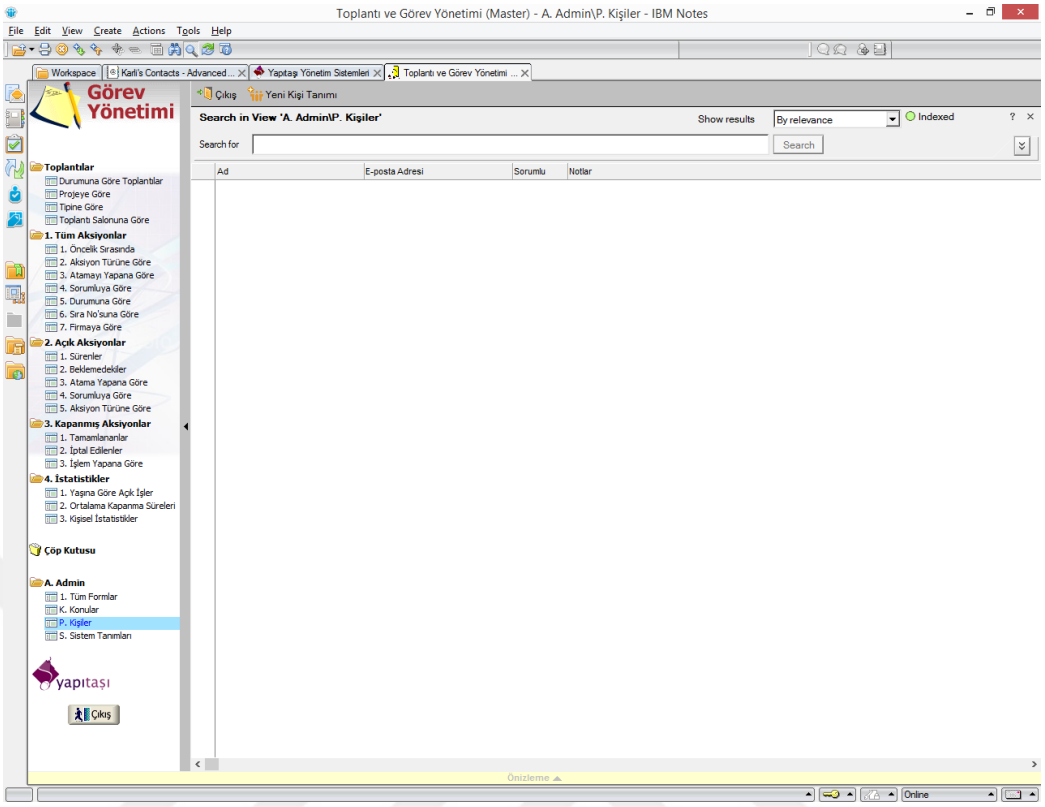


Figure 3.102. Yapıtaşı ERP – General – Meeting Minutes Module

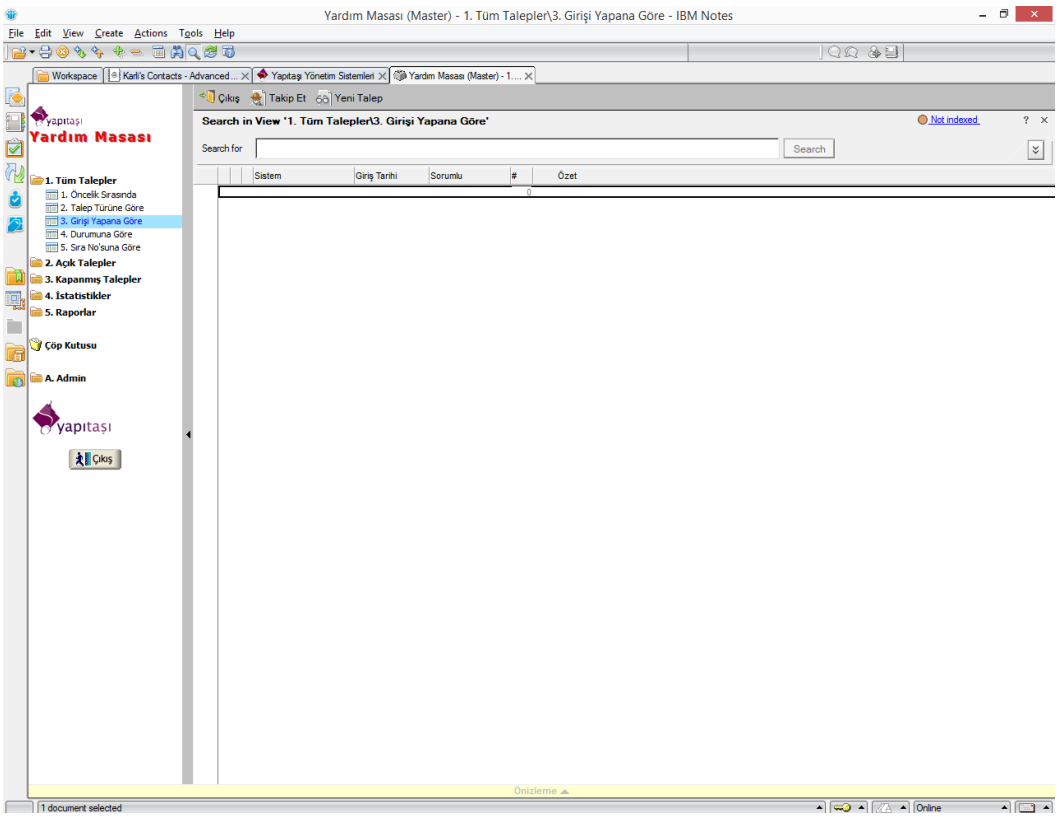


Figure 3.103. Yapıtaşı ERP – General – Help Desk Module

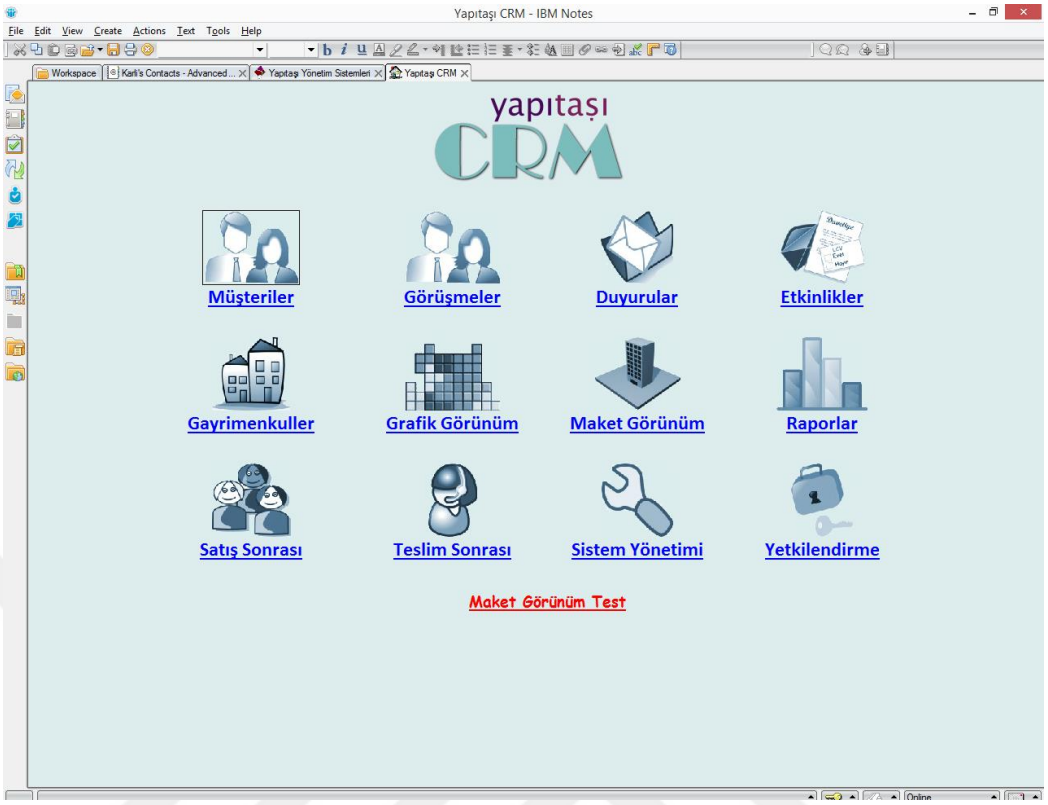


Figure 3.104. Yapıtaşı ERP – General – CRM Main Module

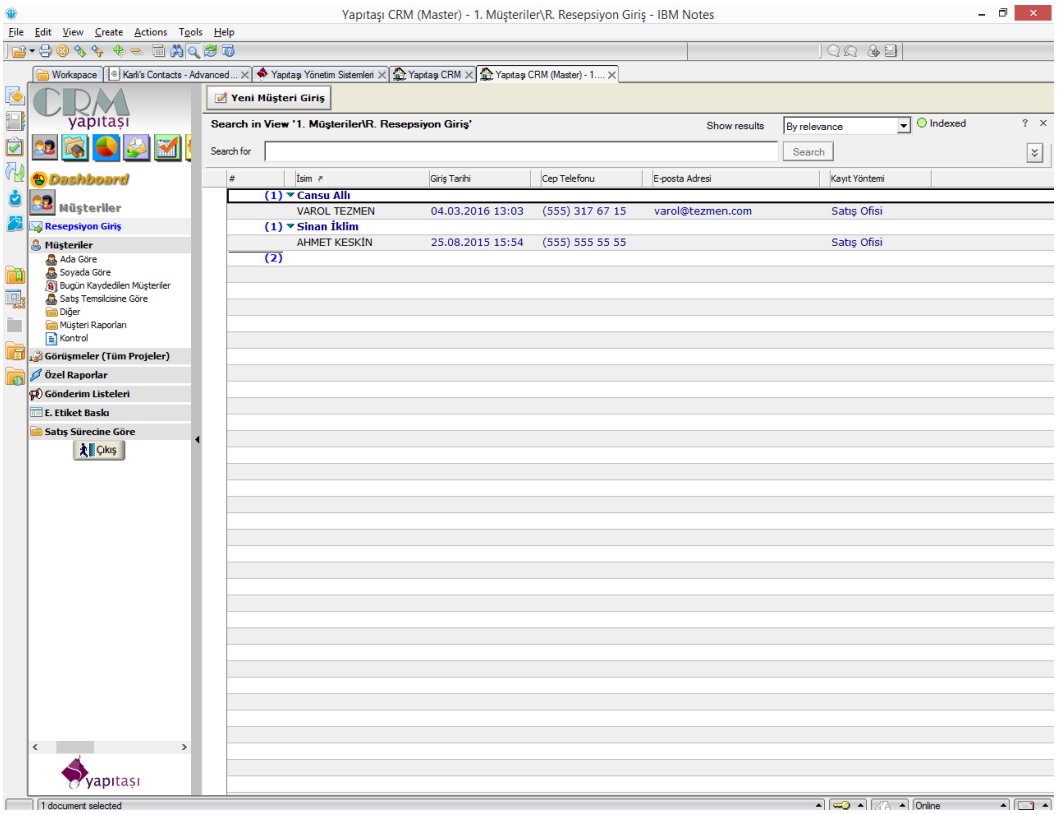


Figure 3.105. Yapıtaşı ERP – General – CRM – Customers & Meetings Modules

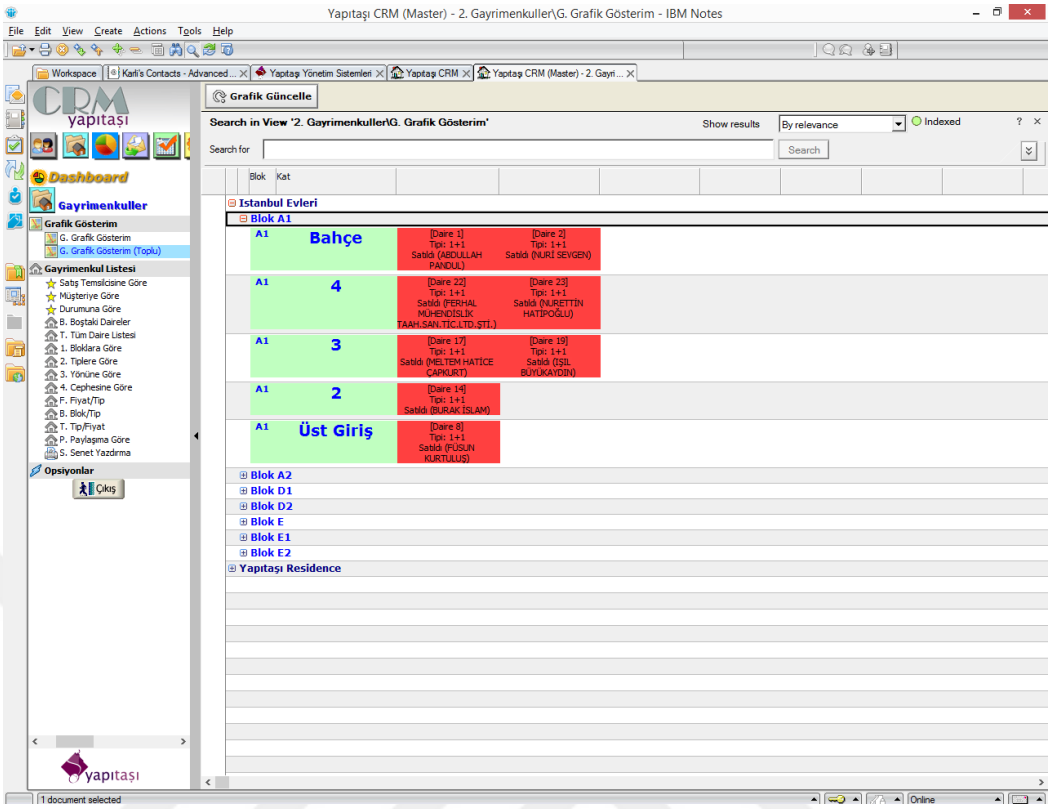


Figure 3.106. Yapıtaşı ERP – General – CRM – Graphical Unit Projection Modules

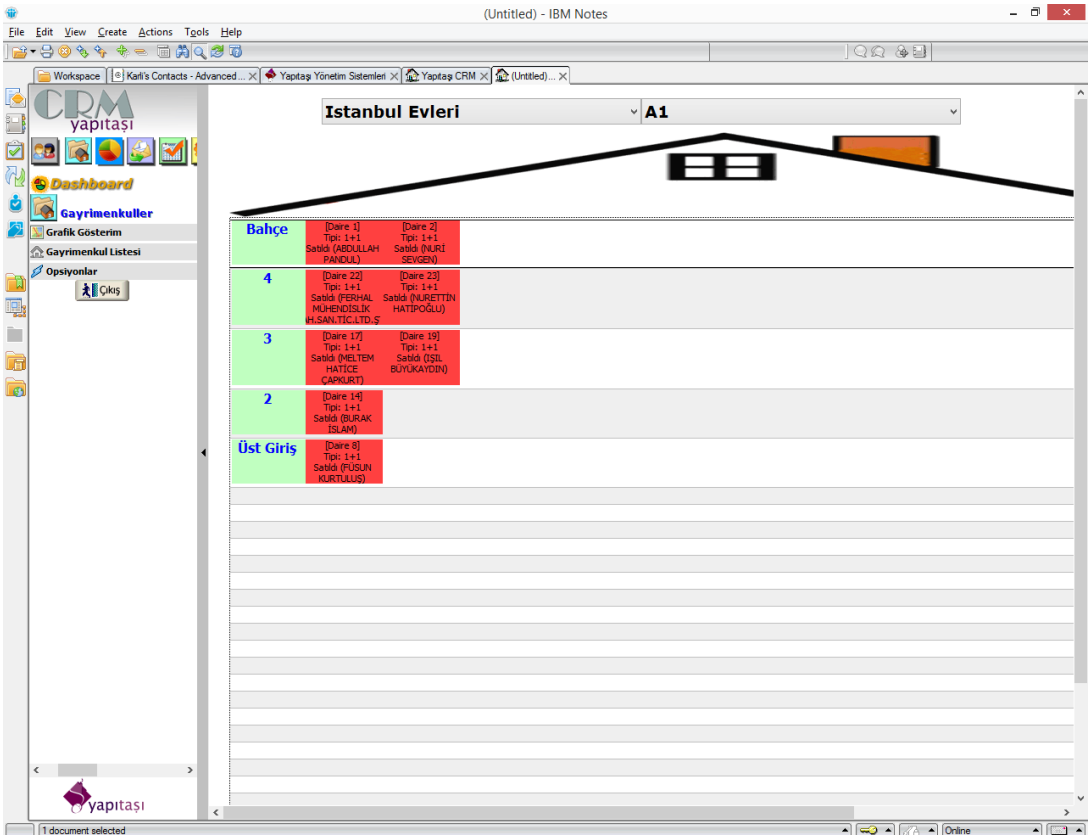


Figure 3.107. Yapıtaşı ERP – General – CRM – Graphical Unit Projection Modules.

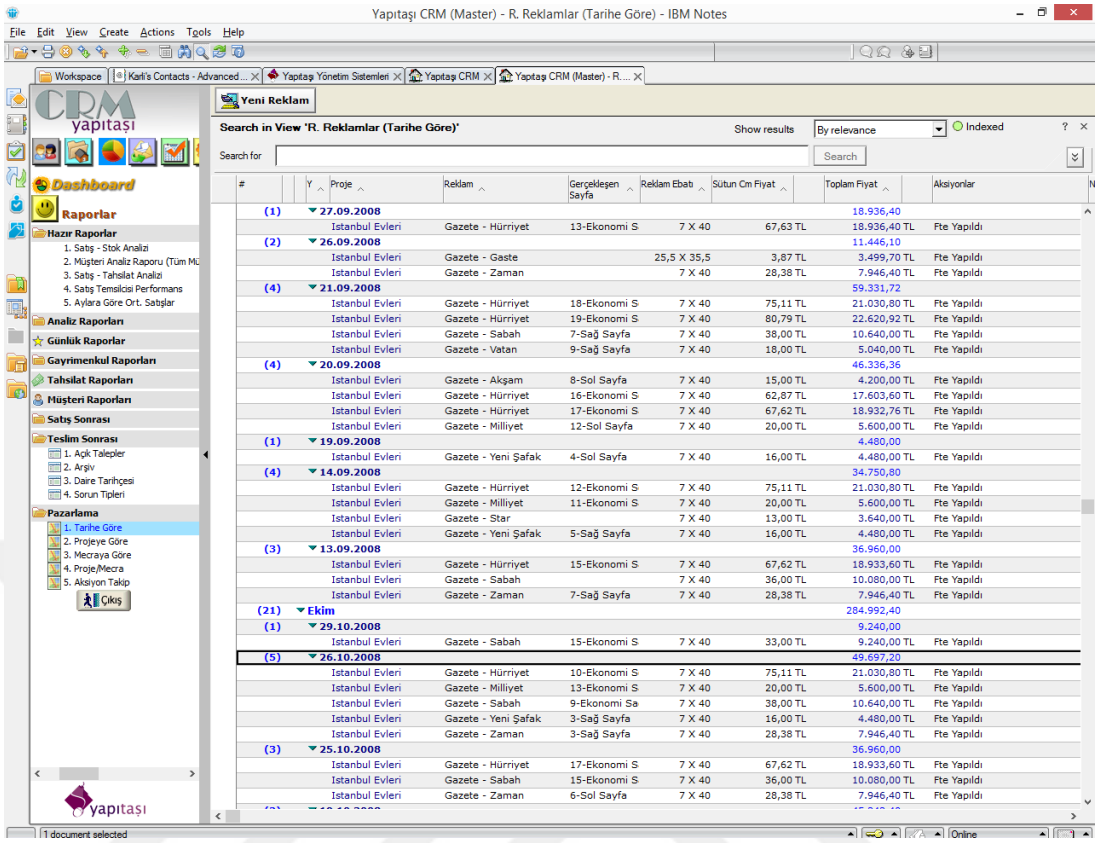


Figure 3.108. Yapıtaşı ERP – General – CRM – Marketing Modules.

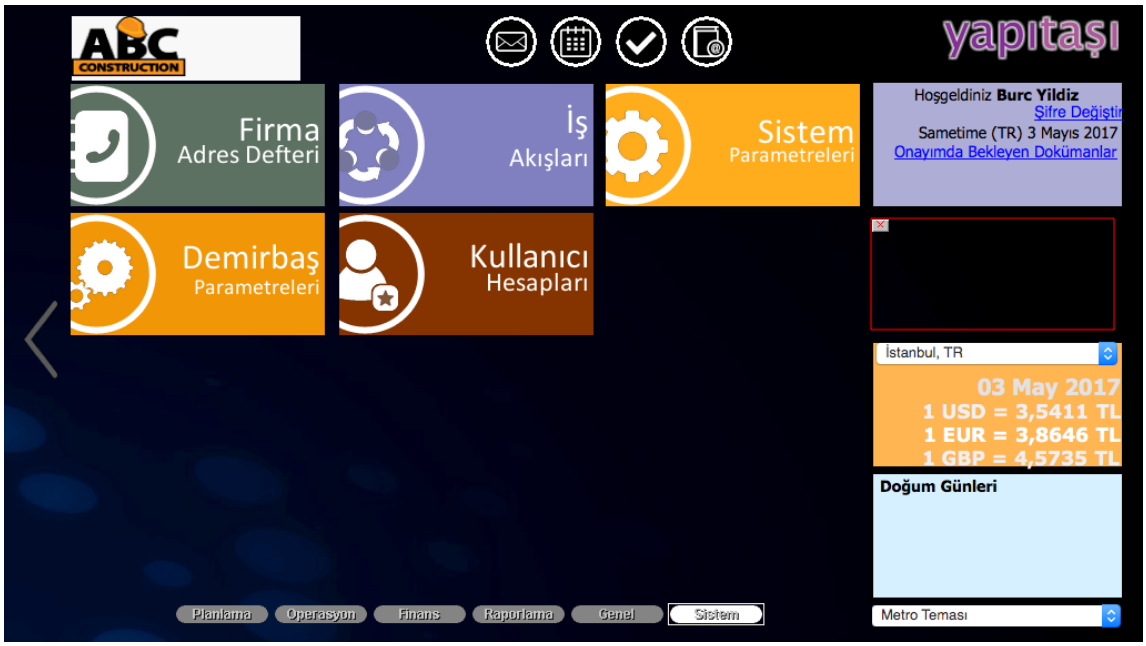


Figure 3.109. Yapıtaşı ERP Main Modules – System Main Module

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 and quantitative methods are two standard ways to carry out scientific researches. Generally, qualitative research has been utilized in the human and social science disciplines [36]. Denzin and Lincoln [36] 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 [36].

In this thesis, there are six 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 [36]. It is generally used in positivist studies to test hypotheses objectively or to test models that are built based on theories [69]. It is a robust and systematic way to examine and measure developed research models significantly [36]. The most common examples of quantitative methods include survey, laboratory and field experiments and mathematics modeling [135].

In this thesis, there is a questionnaire survey analysis to analyze user satisfaction level filled by 105 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 a face-to-face questionnaire would generate better and safer 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. Case Studies

In this section, answers of the respondent people in C-ERP vendor/development companies and/or 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 vendor/developer or construction companies and the interviewees.

Table 4.1. Case Study Interviewee Table.

Case Study	Company	Company Age	Title of the interviewee	The ERP System that Company Using and/or Implementing	Developer	Implementer	User
A	A	13	Project Coordinator	YAPITAŞI	X	X	X
B	A	13	Consultant	YAPITAŞI	X	X	X
C	B	3	Chairman and Chief Implementer	MS DYNAMICS (Navision)		X	X
D	C	22	Deputy General Manager	MS DYNAMICS (Navision)		X	X
E	D	24	Technical Office Chief	SAP			X
F	E	30	Chief Consultant	SAP		X	X

All interviewees were one of the key implementers and developers of ERP systems during ERP implementation phases of their companies or the companies they have been consulted.

4.1.1. Administration of the Case Studies

This research consists of six face-to-face interviews that were carried out in the companies with the interviewee respondents at the managerial level. Each case study took about 1 month. There was a case study form given at “the content of the case studies” part below. There are two construction companies and four ERP development/consultant companies participated in this study and six case studies are carried out with interviewees who are key developers, implementers or users of ERP system in their companies or the companies they have consulted. Thus, they know what was required from construction companies.

During each case study period, ERP system user manuals and procedures have been read. Also, each case study workshop took at least one month in order to understand how systems work, what kind of modules they have and how the modules of the system works. Also, what kind of functions and processes the systems perform have been identified.

The system modules of interviewees are used actively during case study workshop period and, the functionalities, the abilities and ARIS House components of the modules are investigated and understood by receiving guidance from the employees of the vendors or consultants. By using a main question list mentioned at the content of the case studies part below, also ARIS House components of the modules for each case study have been investigated.

Besides, about further functionality and abilities of the modules, any demand of the employees at case study companies are taken into consideration in order to enhance ARIS House methodology.

All five different companies use or develop three different ERP systems. Company A develops, implements and uses Yapıtaşı ERP system and it has many Turkish construction company references that they use Yapıtaşı ERP actively. Company A has also an advanced CRM software that can work with ERP system simultaneously. Company A has implemented its ERP systems to large scale and overseas construction companies.

Company B implements and uses MS Dynamics Navision and they have large scale references also. One of the company they consulted has uses all modules and functions of MS Dynamics Navision ERP Solution.

Company C uses MS Dynamics Navision but the company has implemented all modules of MS Dynamics more than five years ago. The company is a holding and contains a construction company, a Real Estate Investment Trust (REIT) company, a textile manufacturing company, a truism company, a hotel and other facility management company and a service company in itself. However, in the context of this thesis, it is only investigated construction company ERP modules and Real Estate Investment Trust (REIT) company ERP modules.

Company D is the members of the Turkish Contractors Association (TCA) and belong to one of the largest holding in Turkey. The holding company contains construction, facility management, real estate investment and management companies but largely works as a construction company. The company has figured in the "the Top 225 International Contractors" list which is published every year by Engineering News Record (ENR) for many years. The company uses SAP systems more than five years. They have implemented SAP system for 3 years period.

Company E implements and use SAP systems and it is one of the biggest and well-known SAP implementer company in the world. They give consulting services around the world for many sectors.

4.1.2. 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 are about the modules and Architecture of Integrated System (ARIS) House elements of ERP systems and they are presented in the Table 4.2. below.

Table 4.2. Case Study Questions.

Implementation of ERP System in Construction Sector **General Questions**	What is the name of ERP system implemented? What is the type of your company that implemented ERP system?: *Construction/Consultant/Project Management/… Company*
Modules	What modules of ERP system are implemented in your construction company? What modules does your vendor/developer company have been implemented or developed for your company or other construction companies? In your opinion, what modules a construction company should have?
Functions	What is the list of functions that the ERP system modules of your company performs? What functions in the modules that your companies have implemented for other construction companies? In your opinion, for each module, what functions a module in C-ERP system should have?
Organization	What kind of organizational units (departments) the modules of your implemented/consulted active C-ERP systems need or require when these systems work with all functions and data? What kind of organizational units the modules of your expected C-ERP system should need or require when an expected C-ERP system works with all functions and data? Please inform us about which function you defined earlier is related to which organizational units in your ERP system.
Data	What kind of data types and contents the modules of your implemented/consulted C-ERP systems use or require when these C-ERP system works with all functions? What kind of data types and contents the modules of your expected C-ERP system should use or require when this expected C-ERP system works with all functions? Please inform us about which function you defined earlier is related to what kind of data in your ERP system.
Control	What kind of control mechanisms the modules of your implemented/consulted C-ERP system run or performs when this C-ERP system works with all functions? What kind of control mechanisms the modules of your expected C-ERP system should run or performs when this expected C-ERP system works with all expected functions? Please inform us about which function you defined earlier is related to what kind of controls in your ERP system.

4.2. ARIS (Architecture of Integrated Information Systems) Methodology

4.2.1. ARIS Methodology

ARIS (Architecture of Integrated Information Systems) project has begun at University of Saarland as an academic research of August-Wilhelm Scheer in the beginning of 1990.

ARIS (Architecture of Integrated Information Systems) is a method for evaluation of an integrated information system model and a valuable approach to enterprise system modeling [6, 132]. This method proposes methods to evaluate processes of integrated information system models and providing a complete view for business processes, business process re-engineering design, work flow and management. The ARIS method offers a business process methodology, its framework, various tools and reports, functions to analyze and optimize all of ARIS processes and tools to document complex process analytically.

ARIS performs event-driven process chains (EPC) modelling language and EPC system links all views of ARIS each other. The ARIS-architecture separates four main views between each other. They are “Organization”, “Function”, Data” and “Control” views and in order to model data flow, it performs a graphical modelling system by using ARIS tools.

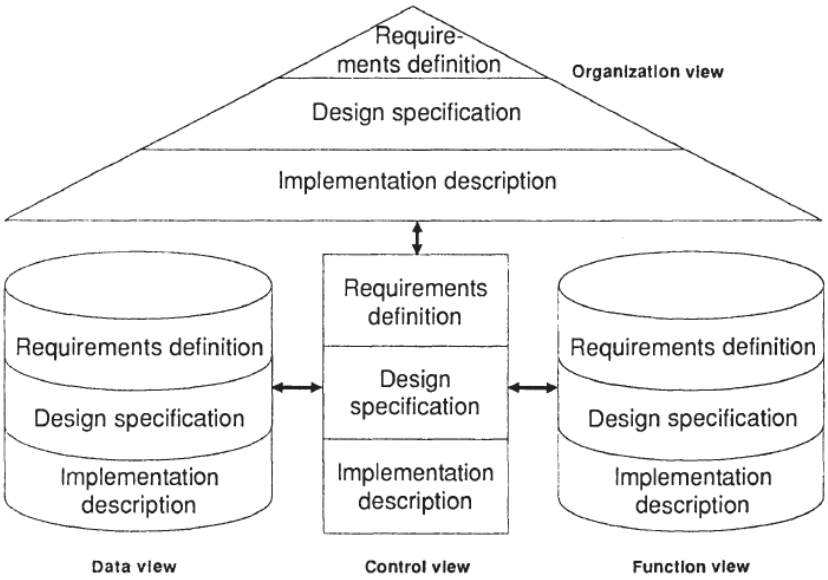


Figure 4.1. ARIS House Diagram [127, 130].

Additionally, ARIS methodology has been established to describe and implement business models and business process re-engineering models to IT systems and ensure meta structures for models by using ARIS Toolset programs.

ARIS methodology and toolset outputs are directly connected with SAP ERP systems and models of ARIS toolset can be used at SAP ERP systems directly [109, 110].

ARIS systems contain the following four elements and views; functions, organization, data, and control, and the Figure 4.1 is called as ARIS House [128, 129, 132]. Sheer [132] explains that the components of information technology resources are divided into three descriptive levels as the following that requirements definition, design specification and implementation description for all four views of ARIS House.

The ARIS methodology not only ensures a general framework but also a powerful business process engineering toolset. This toolset reinforces the whole process re-engineering system models during all life cycle phases [157].

For example, the ARIS House model architecture as described in Figure 4.1 “ARIS House Diagram”, concentrates on the investigation and requirements definition phases through the design of enterprise information systems. ARIS architecture has multi-layer and multi-view method concentrating on business-related issues separating between the organization, function, data and control views. Each views of ARIS House diagram is more detailed with the ARIS toolset software life cycle in the levels requirements definition, design specification and implementation description [157].

Function View shows us how and why processes transforming input into output. Events and functions create each other during processes and ERP systems are highly associated with functions, so that function view is very critical at the ARIS methodology [77].

Kozina [77] implies that organization view in the ARIS methodology contains organizational units and organizational breakdown structures. This view informs and runs the departments, positions, teams and roles in the system.

Data view contains whole data of the system that contains the environment of data processing and messages that triggers and triggered by functions. Control View associations with all of data, organization and function views are modelled and documented in control view [77].

Here below it is explained how the ARIS framework supports the development of workflow applications with the three layers of ARIS House.

Requirements Definition: The requirements definition shows non-technical and general business aims. Kozina [77] explains that the foundation point of this perception is the defining business strategy and strategic goals of business system. Also, this stage is related to business process modelling requirements, such as; hardware, software, databases, networks, etc.) This is the most significant stage of integral system development phase. Williams [157] explains that from the technical point of view, it is likely to investigate business process models with respect to what kind of data systems is essential in the requirement definition stage.

Design Specification: Kozina [77] explains that the design specification level plays an important role from the beginnings of regular transformation of business descriptions into Information and Communication Technology (ICT) objects. The logical Information System model is established with ICT elements in more detail (database models, hardware and network specifications, software modules, etc.) but exact IT inventories are still not defined precisely. Williams [157] implies that functions which will be computerized by the model workflow utilities have to be specified much more detailed. If functions are grabbed by a module software system, it is not necessary to define them in detailed.

Implementation Description: Kozina [77] explains that implementation description comprises descriptions of the technological model of the future systems. Also, the business requirements are applied into actual hardware and software elements, so it is called as “buildtime” phase. Afterward, the implemented system model turns as running operable system that is called as runtime phase. Therefore, this phase creates the physical association from strategic business model to IT model by operational level. Williams [157] explains that at the level of the implementation description, it is essential to implement the

information infrastructure obtained from ARIS into the model obtained from the design specification by using the workflow models in order to design graphical applications.

4.2.2. ARIS for New C-ERP

In order to use ARIS methodology in this thesis, first of all, a function list is needed to understand the core of the modules and the requirements of the ERP users and features of ERP module systems. Then, six case study is made and three ERP systems are investigated in detailed. 653 functions are determined at three ERP system and the following function table is created based on their availability and listed according to their most related C-ERP modules. “2” means function is available at that case study and the related ERP system, “1” means function is partially available at that case study and the related ERP system and “0” means function is not available at that case study and the related ERP system.

Whole list of functions can be found at Appendix D - Availability of Functions Table.

Table 4.3. Availability of Functions Table (Continued in Appendix D).

AVAILABILITY OF FUNCTIONS TABLE												
						AVAILABILITY OF THE FUNCTONS						
MAIN MODULE	MAIN MODULE NO	MODULE NO	MODULE	FUNCTION NO	FUNCTION	A	B	C	D	E	F
BUSINESS DEVELOPMENT	01											
	01	01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	2	2	1	1	0	1
				F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibility calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	0	0	0	0	0	0
				F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	1	1	1	1	0	1
				F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	0	0	0	0	0	0
				F05	This module has document management functions on business development documents.	2	2	2	2	0	2
				F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	2	2	1	1	0	1
				F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	1	1	0	0	0	1
				F08	This module has business development excel work calculation ability by using past project completion m2 costs.	0	0	0	0	0	0
				F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilties more accurately.	0	0	0	0	0	0
				F10	This module has Investment Brochures schemes and already maden invesment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.	0	0	0	0	0	0
				F11	This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module	1	1	0	0	0	0
				F12	This module has Commission Calculation functions that manage how much commission should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the project business development.	0	0	0	0	0	0

After determining the 24 modules and 653 functions lists that will be basis of ARIS House function view, it is decided to determine and create an organizational department list that will be the basis of organization view of ARIS House. By using case study information,

18 organization departments have been identified and the following table is created. Also, it can be seen from the following table that which function is related to which organizational department. The whole table can be found at Appendix E - Function vs. Organization Table.

Table 4.4. Function vs. Organization Table (Continued in Appendix E).

						ORGANIZATION															
						01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
MAIN MODULE	MAIN MODULE NO	MODULE NO	MODULE	FUNCTION NO	FUNCTION	O 01 - Business Development Department	O 02 - Technical Office [Project Management] Department	O 03 - Design Office Department	O 04 - SiteConstruction Department	O 05 - Quality Control Department	O 06 - HSE Department	O 07 - Finance Department	O 08 - Accounting Department	O 09 - Procurement Department	O 10 - HR Department	O 11 - Administration Department	O 12 - Logistic & Warehouse Management Department	O 13 - Sale& Marketing & CRM Department	O 14 - BIM Management Departmtani	O 15 - Risk Management Department	O 16 - IT Departmant	O 17 - ERP Departmant	O 18 - Claim ve Law Departmant
BUSINESS DEVELOPMENT	01																						
	01	01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X																	
				F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibilty calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	X																	
				F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X																	
				F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	X																	
				F05	This module has document management functions on business development documents.	X																	
				F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X																	
					This module can manage meetings and negotiations with respect to their																		

After determining the function and organization lists that will be basis of ARIS House function and organization views, it is decided to determine and create a data list that will be the basis of data view of ARIS House. By using case study information, 40 data types have been identified and the following table is created. Also, it can be seen from the following table that which function is related to what kind of data. The whole table can be found at Appendix F - Function vs. Data Table.

Table 4.5. Function vs. Data Table (Continued in Appendix F).

MAIN MODULE	MAIN MODULE NO	MODULE NO	MODULE	FUNCTION NO	FUNCTION	01	02	03	04	05	06	07	08	09	10	1
						D 01 - Data on the deeds of real estates, zone notes, planning notes, land notes at project development documents	D 02 - Data on work schedules, activities, resources and connection information	D 03 - Data on man x hours and BOQ values belong to work schedules	D 04 - Data on Unit Price, Unit Price Analysis, BOQ list with respect to Budget Codes	D 05 - Data on all sub-contractors and suppliers	D 06 - Data on all sub-contractor, contracts, unit prices and unit price analysis about past tenders	D 07 - Data on BOQ, Unit Price, Unit Price Analysis, Current Prices, Schedules, Cash flow and Realization Tables about Tender Bids	D 08 - Data on all contractual information about sub-contractor contracts	D 09 - Data on all contractual information about Owner contracts	D 10 - Data on sub-contractor progress report information such as; physical amount done, contractual data, warrantees and security deposits, deductions etc	D 11 - Data on owner progress report information such as; physical amount do
BUSINESS DEVELOPMENT	01															
	01	01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X										
				F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibilty calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	X										
				F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X										
				F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	X										
				F05	This module has document management finctions on business development documents.	X										
				F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X										
				F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	X										

After determining the function, organization and data lists that will be basis of ARIS House function, data and organization views, it is decided to determine and create a control list that will be the basis of control view of ARIS House.

By using case study information, 41 control processes have been identified and the following table is created. Also, it can be seen from the following table that which function is related to which control processes. The whole table can be found at Appendix G - Function vs. Control Table.

Table 4.6. Function vs. Control Table (Continued in Appendix G).

MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	C 01 - Controlling of feasibility report IRR, NPV, Benefit/Cost Ratio limits	C 02 - Controlling of schedule delays, activity baseline and actual date comparisons	C 03 - Controlling of baseline and actual man shours planned and spent, physical progress, delay calculations and controls.	C 04 - Controlling of budgeted BOQ amounts, unit price approved vs. realized comparisons, and budget revision comparisons	C 05 - Controlling of planned and realized cash flow and realization tables and alerting about financial negative cash flow quarters or months.	C 06 - Controlling of EVA analysis by using schedule, physical progress and budget data	C 07 - Controlling and cross check of past and current contracts based on their contractual classes and unit price comparisons with respect to unit price analysis, sub-contractors	C 08 - Controlling of past and current tender bids based on their BOQ values, unit price, unit price analysis, current prices, schedule, cash flows and realization flows, and determination of risks	C 09 - Controlling and cross check of past sub-contractor and current sub-contractor contracts based on their contractual classes and unit price comparisons with respect to unit price analysis, sub-contractors, deductions and warrantees	C 10 - Controlling and cross check of past owner and current owner contracts based on their contractual classes and unit price comparisons with respect to unit price analysis, owners, deductions and warrantees	C 11 - Controlling of sub-contractor progress reports with respect to their BOQ amounts, completed physical amount vs. budgeted amount in unity check, contractual classes vs. progress report, deductions, warrantees and other contractual classes unity checks.	C 12 - Controlling of owner progress reports with respect to their BOQ amounts, completed physical amount vs. budgeted amount in unity check, contractual classes vs. progress report, deductions, warrantees and other contractual classes unity checks.	C 13 - Controlling of site construction daily physical progress records with
BUSINESS DEVELOPMENT	01																
	01 01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X												
			F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibility calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	X												
			F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X												
			F04	This module has different investment scenarios for different investment options as excel on board system investment calculations.	X												
			F05	This module has document management functions on business development documents.	X												
			F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X												
			F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	X												
			F08	This module has business development excel work calculation ability by using past project completion m2 costs.	X												
			F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilities more accurately.	X												

All of ARIS House views lists are completed by using case study information. As a result, 653 functions, 18 organizational units (departments), 40 kinds of data and 41 control processes are determined and the correlation matrix tables are created.

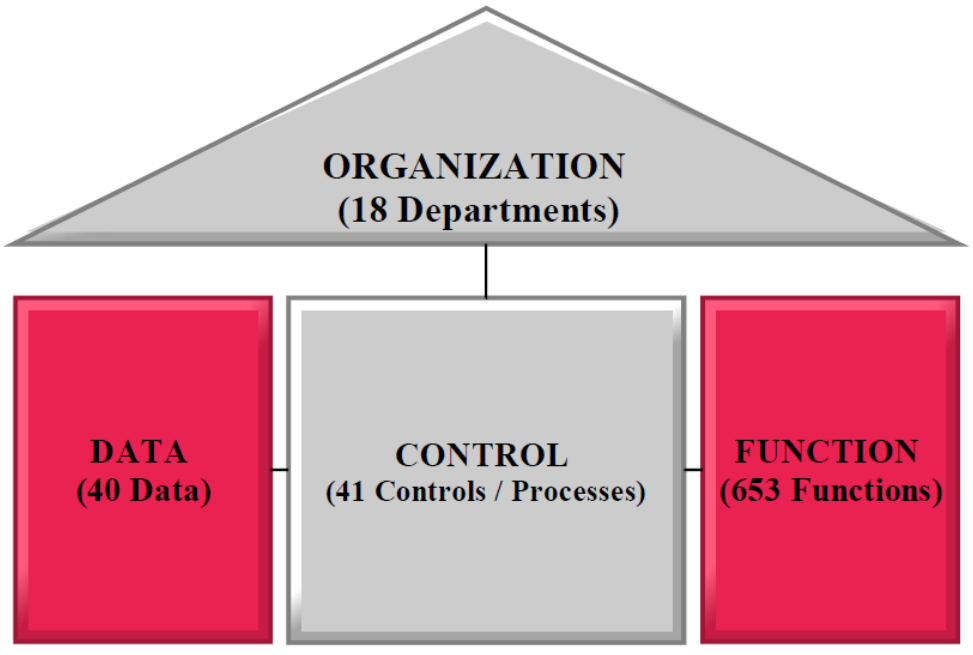


Figure 4.2. ARIS House Diagram of Case Studies

4.3. Analysis of the Case Studies

First of all, it is asked the respondents the name of ERP systems implemented in their companies or they developed and then it is asked what the type of their companies is. Answers can be seen at Table 4.1. Case Study Interviewee Table.

At the analysis of the case studies, it is asked the questions at the Table 4.2. Case Study Questions above. Some of the answers of the case study respondents were same or similar, so that all answers for all questions are listed and then a table that shows condition of availability is created based on “partially available”, “available” or “not available” for each ERP system of respondents.

4.3.1. Modules

At the module part, it is asked the companies what modules their companies use, what modules their companies develop for other construction companies or what modules their companies implement for other construction companies.

Many of the answers of the case study respondents were same or similar, so that all answers for all module questions are listed and then a table that shows condition of availability is created based on “partially available”, “available” or “not available” for each ERP system of respondents.

The table below (Appendix H - Module Availability) shows the answers of the respondents about availability of the modules at their own ERP systems as “0” means not available, “1” means partially available and “2” means available.

Table 4.7. Module Availability.

							CASE STUDY					
							A	B	C	D	E	F
MAIN MODULES	MBS 01	MBS 02	MODULES	MBS 03	SUB MODULES	MODULE NO						
BUSINESS DEVELOPMENT	01	00		00		01.00.00						
	01	01	BUSINESS DEVELOPMENT	00		01.01.00	2	2	1	1	0	1
	01	02	INVESTMENT CONTRACTS	00		01.02.00	1	1	1	1	1	1
PROJECT MANAGEMENT	02	01	PLANNING & TIME MANAGEMENT	01	PLANNING & TIME MANAGEMENT	02.01.01	2	2	2	2	2	2
	02	01	PLANNING & TIME MANAGEMENT	02	RESOURCE PLANNING (ONLY MANxHOURS PLANNING)	02.01.02	0	0	1	1	0	2
PROJECT MANAGEMENT	02	02	BUDGETING & COST CONTROL MANAGEMENT	01	BUDGETING & COST CONTROL MANAGEMENT	02.02.01	2	2	2	2	1	2
	02	02	BUDGETING & COST CONTROL MANAGEMENT	02	PROJECT MANAGEMENT - COST ANALYSIS	02.02.02	1	1	1	1	0	1
	02	03	SUB-CONTRACTOR TENDER MANAGEMENT	01	SUB-CONTRACTOR TENDER MANAGEMENT	02.03.01	2	2	2	2	0	1
	02	04	OWNER TENDERS MANAGEMENT (Quotation Module)	01	OWNER TENDERS MANAGEMENT (Quotation Module)	02.04.01	1	1	1	1	0	1
	02	04	OWNER TENDERS MANAGEMENT (Quotation Module)	02	QUOTATION	02.04.02	0	0	1	1	0	1
	02	05	CONTRACT MANAGEMENT	01	CONTRACT MANAGEMENT	02.05.01	2	2	2	2	2	2
	02	05	CONTRACT MANAGEMENT	02	SUBCONTRACTOR CONTRACTS	02.05.02	2	2	2	2	2	2
	02	05	CONTRACT MANAGEMENT	03	OWNER CONTRACTS	02.05.03	2	2	2	2	2	2
	02	06	PROGRESS REPORT (SUB-CONTRACTORS) MANAGEMENT	01	PROGRESS REPORT (SUB-CONTRACTORS) MANAGEMENT	02.06.01	2	2	2	2	0	1
	02	07	PROGRESS REPORT (OWNERS) MANAGEMENT	01	PROGRESS REPORT (OWNERS) MANAGEMENT	02.07.01	0	0	0	0	0	0
	02	08	SITE & SUB-CONTRACTOR MANAGEMENT	01	SITE & SUB-CONTRACTOR MANAGEMENT	02.08.01	1	1	1	1	0	0
	02	09	HEALTH & SECURITY & ENVIRONMENT MANAGEMENT	01	HEALTH & SECURITY & ENVIRONMENT MANAGEMENT	02.09.01	0	0	0	0	0	1
DESIGN MANAGEMENT	03	00		00		03.00.00						
	03	01	CONTRACT WORKS (FIRM OWN CONTRACTS)	00		03.01.00	1	1	0	0	0	0
	03	02	INVESTMENT PROJECTS - FEASIBILITY PROJECTS MODULE	00		03.02.00	1	1	0	0	0	0
	03	03	INVESTMENT PROIJECTS - DESIGN MANAGEMENT	00		03.03.00	1	1	0	0	0	0
FINANCE MANAGEMENT	04	00		00		04.00.00						
	04	01	EXCHANGE RATES MANAGEMENT	00		04.01.00	2	2	2	2	2	2
	04	02	E-INVOICE MANAGEMENT	00		04.02.00	2	2	2	2	2	2
	04	03	FINANCE MANAGEMENT	00		04.03.00	2	2	2	2	2	2
	04	04	BILL OF EXCHANGE (COMMERCIAL BILLS)	00		04.04.00	2	2	2	2	2	2
	04	05	RENT MANAGEMENT	00		04.05.00	2	2	2	2	2	2

Table 4.7. Module Availability (cont.).

	04	06	FINANCIAL REPORTS	00		04.06.00	2	2	2	2	2	2
ACCOUNTING MANAGEMENT	05	00		00		05.00.00						
	05	01	ACCOUNTING MANAGEMENT	00		05.01.00	2	2	2	2	2	2
	05	02	E-BALANCING MANAGEMENT	00		05.02.00	2	2	2	2	1	2
	05	03	E-ARCHIVE MANAGEMENT	00		05.03.00	2	2	2	2	1	2
	05	04	JOINT VENTURE MANAGEMENT	00		05.04.00	2	2	2	2	1	2
PROCUREMENT MANAGEMENT	06	00		00		06.00.00						
	06	01	PROCUREMENT MANAGEMENT	00		06.01.00	2	2	2	2	2	2
	06	02	PURCHASING / PROCUREMENT	00		06.02.00	2	2	2	2	2	2
HUMAN RESOURCES MANAGEMENT	07	00		00		07.00.00						
	07	01	EMPLOYEE LISTS & EMPLOYEE MANAGEMENT	00		07.01.00	2	2	2	2	2	2
	07	02	ABSENCE/LEAVE MANAGEMENT	00		07.02.00	2	2	2	2	2	2
	07	03	TIME KEEPING MANAGEMENT	00		07.03.00	1	1	1	1	1	1
	07	04	HR REPORTS	00		07.04.00	2	2	2	2	2	2
	07	05	INTERNAL PERFORMANCE REPORTS	00		07.05.00	1	1	1	1	2	2
	07	06	EVALUATION REPORTS	00		07.06.00	1	1	1	1	2	2
	07	07	INTERNAL ERP TRAINING MODULE (VIDEOS)	00		07.07.00	0	0	0	0	1	1
	07	08	INTERNAL TRAINING MODULE (VIDEOS)	00		07.08.00	0	0	0	0	1	1
QUALITY CONTROL MANAGEMENT	08	00		00		08.00.00						
	08	01	QUALITY CONTROL DOCUMENTS MANAGEMENT MODULE	00		08.01.00	2	2	2	2	2	2
	08	02	PROJECT QUALITY MANAGEMENT	00		08.02.00	2	2	2	2	2	2
SALES & MARKETING & CRM MANAGEMENTS	09	00		00		09.00.00						
	09	01	TASK MANAGEMENT	00		09.01.00	2	2	0	0	2	2
	09	02	CRM MODULE	00		09.02.00	2	2	2	2	0	1
	09	03	REAL ESTATE MODULE (RESIDENCE/OFFICE ETC. SALE MODULE)	00		09.03.00	1	1	2	2	0	1
	09	04	RESIDENCE SALE MODULE (SPECIALIZED MODULE)	00		09.04.00	2	2	2	2	0	0
	09	05	MARKETING MODULE	00		09.05.00	2	2	1	1	0	1
DOCUMENT MANAGEMENT	10	00		00		10.00.00						
	10	01	RECEIVED DOCUMENTS	00		10.01.00	2	2	2	2	1	2
	10	02	SENT DOCUMENTS	00		10.02.00	2	2	2	2	1	2
	10	03	DAILY REPORTS	00		10.03.00	2	2	1	1	0	1
	10	04	WEEKLY REPORTS	00		10.04.00	2	2	1	1	0	1

Table 4.7. Module Availability (cont.).

	10	05	PROJECT SITE PHOTOS	00		10.05.00	2	2	1	1	0	1
	10	06	EXECUTIVE REPORTS MODULE	00		10.06.00	1	1	1	1	0	1
	10	07	MEETING MINUTES MODULES	00		10.07.00	1	1	1	1	0	1
LOGISTICS & WAREHOUSE MANAGEMENT	11	00		00		11.00.00						
	11	01	LOGISTICS MANAGEMENT	01	LOGISTICS MANAGEMENT	11.01.01	2	2	1	1	0	2
	11	01	LOGISTICS MANAGEMENT	02	LOGISTIC REPORTING MODULE	11.01.02	2	2	1	1	0	2
	11	02	WAREHOUSE & INVENTORY MANAGEMENT	03	WAREHOUSE MANAGEMENT	11.02.03	2	2	2	2	2	2
	11	02	WAREHOUSE & INVENTORY MANAGEMENT	04	MACHINARY & EQUIPMENT MANAGEMENT	11.02.04	2	2	2	2	2	2
RISK MANAGEMENT	12	00		00		12.00.00						
	12	01	RISK MANAGEMENT	00		12.01.00	0	0	0	0	0	1
BIM MANAGEMENT	13	00		00		13.00.00						
	13	01	BIM MANAGEMENT	00		13.01.00	0	0	0	0	0	0
ERP & IT MANAGEMENT	14	00		00		14.00.00						
	14	01	IT INVENTORY & MANAGEMENT	00		14.01.00	2	2	2	2	2	2
	14	02	HELP DESK MODULE	00		14.02.00	0	0	0	0	0	0
GENERAL	15	00		00		15.00.00						
	15	01	ADDRESS BOOK	00		15.01.00	2	2	1	1	0	2
	15	02	TASK MANAGEMENT	00		15.02.00	2	2	0	0	0	0
CLAIM & LAW MANAGEMENT	16	00		00		16.00.00						
	16	01	CLAIM MANAGEMENT	00		16.01.00	1	1	0	0	0	0
	16	02	LITIGATION / TRIAL MANAGEMENT	00		16.02.00	2	2	0	0	0	0
	16	03	INTERNAL CONTRACT APPROVAL & PROCESS MANAGEMENT	00		16.03.00	0	0	0	0	2	2

4.3.2. Functions

At the function part, it is asked the companies what functions the modules of their ERP systems have or implemented for other construction companies. Some of the answers of the case study respondents were same or similar, so that all answers for all module questions are listed and then a table that shows condition of availability is created based on “partially available”, “available” or “not available” for each ERP system of respondents.

The table at Appendix D - Availability of Functions shows the answers of the respondents about availability of the functions at their own ERP systems as “0” means not available, “1” means partially available and “2” means available. Also, at the same table at

Appendix D - Availability of Functions, it is given the answers of the respondents to the question of that what is the proficiency level of modules by having these functions on 1 to 5 scales as 1 is for very low proficient and 5 is very high proficient.

4.3.3. Organization

At the organization part, it is asked the companies what kind of organizational units the modules of their ERP systems need or require when their system works with all functions and data. All of the answers of the case study respondents were combined and the following table is created.

Table 4.8. Organizational Units (Departments) of New C-ERP System.

No	Organization Department
O 01	Business Development Department
O 02	Technical Office (Project Management) Department
O 03	Design Office Department
O 04	Site/Construction Department
O 05	Quality Control Department
O 06	HSE Department
O 07	Finance Department
O 08	Accounting Department
O 09	Procurement Department
O 10	HR Departmant
O 11	Administration Department
O 12	Logistic & Warehouse Management Department
O 13	Sale & Marketing & CRM Department
O 14	BIM Management Departmanı
O 15	Risk Management Department
O 16	IT Departmant
O 17	ERP Departmant
O 18	Claim ve Law Departmant

Also, at the Appendix E - Functions vs. Organization Table, it can be seen that which function is related with which Organizational department.

4.3.4. Data

At the data part, it is asked the companies what kind of data types and contents the modules of their ERP systems use or require when their system works with all functions. All of the answers of the case study respondents were combined and the following table is created.

Table 4.9. Data Types and Data Contents of New C-ERP System.

NO	DATA TYPE / DATA CONTENTS
D 01	Data on the deeds of real estates, zone notes, planning notes, land notes and project development documents
D 02	Data on work schedules, activities, resources and connection information
D 03	Data on man x hours and BOQ values belong to work schedules
D 04	Data on Unit Price, Unit Price Analysis, BOQ list with respect to Budget Codes
D 05	Data on all sub-contractors and suppliers
D 06	Data on all sub-contractor, contracts, unit prices and unit price analysis about past tenders
D 07	Data on BOQ, Unit Price, Unit Price Analysis, Current Prices, Schedules, Cash flow and Realization Tables about Tender Bids
D 08	Data on all contractual information about sub-contractor contracts
D 09	Data on all contractual information about Owner contracts
D 10	Data on sub-contractor progress report information such as; physical amount done, contractual data, warrantees and security deposits, deductions etc.
D 11	Data on owner progress report information such as; physical amount done, contractual data, warrantees and security deposits, deductions etc.
D 12	Data on site photos and daily construction works done with their amount, location, floor information etc.
D 13	Data on near-miss, accident, work permit, control, regulatory&preventive activities report information about healt, security and environment management
D 14	Data on design documets and detailed sheet and zone lists about contractor, owner and feasibilty design projects
D 15	Data on exchange rate, invoice, receipt, cheque, promissory notes, barter and other financial management documents
D 16	Data on customer lists, all receivable accounts, payable accounts, invoices and return invoices, sales journals, balance sheets and return payment information
D 17	Data on supplier and sub-contractor lists, accounts payables, sales invoices, retun invoices and receipts
D 18	Data on accounts, banks, tax declarations, cost accounting, long term and short term records and general accounting transactions
D 19	Data on credit cards, finance cards, credit bank information and transactions

Table 4.9. Data Types and Data Contents of New C-ERP System (Contiuned).

D 20	Data on cost codes/centers and budget informations
D 21	Data on all owner and sub-contractor progress reports informations and information from accounts payables and account receivables
D 22	Data on fixed assets, general accouting journals, insurance journals, fixed asset journals, amortisation accounts etc. information
D 23	Data on warehouse information, warehouse budget codes and other warehouse material informations
D 24	Data on payment returns/collection informations on account payables, receivables, cheuqes, promissory notes
D 25	Data on real estate rent incomes, subscription payments, rent increase rates, price index statistical rates etc.
D 26	Data on chart of accounts, e-invoice system, invoice and receipt informations
D 27	Data on Procurement Request Forms, Order Evaluation Forms, approval durations, OEF budget codes, supplier lists, procurement employee informations including invoices
D 28	Data on employee lists, employee official records, salary net and gross calculations, team informations, assignment score cards, passport and vise informations, leave management informations, overtime informations, training records, internal performance evaluations
D 29	Data on company procedures, Regulatory and Preventive Activities (RPA), non-conformity reports, open and closed NCR records, method statements, control forms, test reports, leed reports, SOR site reports, HSE quality control forms, calibration documents, TSE EN standarts, internal quality control reports
D 30	Data on all customer representatives daily, weekly and monthly schedules, meeting minutes and notes
D 31	Data on customer information, candidate customers tracking records, news letter records, sales/stock reports, sales dates, customer problems and tracking, fixer teams and feedbacks
D 32	Data on layout sheets, sale availability of each unit, customer payments records and cash flow of each customer, technical specifications of sale contracts, sales price lists, campaigns, planned vs. realised sale price and amounts data, promissory notes delay interest records
D 33	Data on marketing and advertisement information and date, media, project information of advertisements
D 34	Data on received and sent all documents and their document number, date informations. Also, daily, weekly reports, site photos, executive reports, meeting minutes
D 35	Data on delivery conditions of all orders, all PRF information, warehouse material conditions, sub-contractor material delivery conditions, warehouse exit receipts, amortisation costs of each material, warehouse reports, warehouse journals, machinary/equipment fuel, oil consumption, maintenance records and costs, and performance records
D 36	Data on risk registrations, risk matrix, assessment of risk categories, risk tracking, risk reports, monte carlo simulation records, risk meeting minutes and other risk know-how documents

Table 4.9. Data Types and Data Contents of New C-ERP System (Contiuned).

D 37	Data on design, time and cost management information of BIM platform softwares and BIM documents, sheet lists and BIM model delay records
D 38	Data on IT inventories and their properties. Also, data on debit entries, IT team help records and statistics.
D 39	Data on general address book, to-do list information, all meeting minutes with action lists
D 40	Data on claims, trials and their documents

Also, at the Appendix F - Functions vs. Data Table, it can be seen that which function is related with what kind of data type.

4.3.5. Control

At the control part, it is asked the companies what kind of control mechanisms the modules of their ERP systems run or perform when their system works with all functions. All of the answers of the case study respondents were combined and the following table is created.

Table 4.10. Control Processes of New C-ERP System.

NO	CONTROL CONTENTS & CONTROL MECHANISMS
C 01	Controlling of feasibility report IRR, NPV, Benefit/Cost Ratio limits
C 02	Controlling of schedule delays, activity baseline and actual date comparisons
C 03	Controlling of baseline and actual man x hours planned and spent, physical progress, delay calculations and controls.
C 04	Controlling of budgeted BOQ amounts, unit price approved vs. realized comparisons, and budget revision comparisons
C 05	Controlling of planned and realized cash flow and realization tables and alerting about financial negative cash flow quarters or months
C 06	Controlling of EVA analysis by using schedule, physical progress and budget data
C 07	Controlling and cross check of past and current contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractor
C 08	Controlling of past and current tender bids based on their BOQ values, unit price, unit price analysis, current prices, schedule, cash flows and realization flows, and determination of risks
C 09	Controlling and cross check of past sub-contractor and current sub-contractor contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractors, deductions and warrantees

Table 4.10. Control Processes of New C-ERP System (cont.).

C 10	Controlling and cross check of past owner and current owner contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, owners, deductions and warrantees
C 11	Controlling of sub-contractor progress reports with respect to their BOQ amounts, completed physical amount vs. budgeted amounts sanity check, contractual clauses vs. progress report, deductions, warrantees and other contractual clauses sanity checks.
C 11	Controlling of owner progress reports with respect to their BOQ amounts, completed physical amount vs. budgeted amounts sanity check, contractual clauses vs. progress report, deductions, warrantees and other contractual clauses sanity checks.
C 13	Controlling of site construction daily physical progress records with BOQ amounts.
C 14	Controlling of project HSE score with company procedures HSE minimum limits and alerting HSE executives about project risk conditions.
C 15	Controlling of planned and realized design management schedules for each project, and alerting executives about design delays by comparing design sheet delivery dates in comparison with design schedules.
C 16	Controlling of user defined financial algorithms and standard financial alert systems (such as negative cash flow or near to negative cash flow etc.) by using financial data including exchange rates, receipts, invoices, cheques, promissory notes, accounts payables and receivables records, barter information etc.
C 17	Control and comparison of sales receipts, collection ledger, sales journals and account receivables, and alerting the executives to send payment letters to customers and requesting approval to send automatic news letters about payments.
C 18	Controlling of net present values of net cash flows based on all kind of income and expenses, so that the module can alert the executives both negative cash flows and negative investments.
C 19	Controlling of user defined financial algorithms and standard financial alert systems of periodic activities by using periodic activities financial data including cost accounting, long term and short term payments, accounts payables and receivables data.
C 20	Controlling of credit and finance card limits and if spending is getting close to user defined specific value, the module can alert finance department executives.
C 21	Controlling of budget cost codes and budgets according to matching realized expenses by invoices and controlling cost accounting reports with previous reports to check any sanity test.
C 22	Controlling of cash flow data by using progress reports, account receivables and payables and other financial records compare to cash flow prepared by technical office team at project site.
C 23	Controlling of amortisation calculations and prices by using fixed assets, accounting journals, warehouse records, fixed asset journals and alerting executives about amortisation cost load and warehouse amortisation costs due to not using materials by comparing leasing rent cost of inventories.
C 24	Controlling of amortisation cost distributions and stock valuations by using warehouse inventory and item data and unit price informations
C 25	Controlling of reeskont calculations, cheque and promissory note risk calculations by using account receivables accounts
C 26	Controlling of real estate rent and rent rise calculations with respect to rent contract clauses, consumer price indexes and comparing with rent invoices.
C 27	Controlling of e-invoices from beginning of system entrance to payment of e-invoices with approval of executives and reporting invoices to executives

Table 4.10. Control Processes of New C-ERP System (cont.).

C 28	Controlling of unit prices at Procurement Request Forms and Offer Evaluation Forms to compare with past OEF unit prices based on same budget code and alerting if any requested item at OEF is too much higher than past OEF items
C 29	Controlling of kept man x hours records of the company with PDKS (social security time keeping) system for sub-contractor and company employees to make sure payrolls of sub-contractors paid regularly and also, controlling of internal trainings to make sure employees have trained enough about HSE and other procedures.
D 30	Controlling of project quality control score by using all quality control documents (NCR, SOR, SIF etc.) and reports compared to minimum quality control scores defined at company procedures, and alerting QQ executives.
C 31	Controlling of sale representatives' performances by checking feedbacks from customers, daily, weekly and montly meeting schedules and meeting records along with sales volumes of sales representatives. Also, the module can control user defined algorithms and alert the executives.
C 32	Controlling of "after sale customer requests fixing durations" and the number of open customer requests, so that fixer team performance can be controlled and reported to the executives. Also, the module can control user defined algorithms and alert the executives.
C 33	Controlling of planned at the beginning of the project vs. realized sale performances of the projects based on sale incomes realizations, cheque and promissory notes maturities
C 34	Controlling of marketing expenses with respect to budgeted marketing expenses and how much money has been spent for which adversitement on which media.
C 35	Controlling and reporting of daily, weekly and montly reports of the projects and checking if there is any missing report that is not uploaded to the system by checking the document management module.
C 36	Controlling of performances of especially machinary and equipments based on their total working hours, total downtime, and also financial performances based on their total cost to the company based on fuel, oil consumptions, maintenance costs compared to leasing costs.
D 37	Controlling of project risk scores by using all risk management documents and risk tracking scores and alerting risk management executives.
C 38	Controlling of planned and realized BIM design management schedules for each project, and alerting executives about BIM design delays by comparing planned design model delivery and matury dates compared to design schedules. The module also can control clash detection and correction performances based on the number of clashes and their dates.
C 39	Controlling of IT team performances and reporting to the executives based on help request reaching and fixing durations, the number of opened requests and longest open help request time etc.
C 40	Controlling of employee performances based on action list completion durations at meeting minutes and to-do lists.
C 41	Controlling of trial and claim court dates along with important due dates and alerting them to law management department employees.

Also, at the Appendix G - Functions vs. Control Table, it can be seen that which function is related with which control processes.

4.4. Questionnaire Survey

In this thesis, a face-to-face questionnaire survey is prepared, which respondents can answer or fill during survey. Questionnaire survey has been performed by 105 professionals, that they are from mostly well-known Turkish construction companies and consultant companies, those are the members of Turkish Contractor Association (TCA) and Association of Turkish Consulting Engineers and Architects (ATCEA). Also, the questionnaire survey was performed by some construction related organizations like middle/large scale housing contractors.

Before the questionnaire was performed, 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 October and November 2017 and 105 interviews were performed. There were significant number of participants that were not used ERP system before. Only 51.43% of respondents were used ERP system before.

4.4.1. 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
- Main Business Areas of Their Companies
- Their Experience in The Construction Sector (Year)
- Turnover of Their Companies (Annual)
- The Number of Total Employee of Their Companies
- The Positions at Their Companies
- Departments
- ERP Usage (Yes or No)
- Which ERP System do They Use or being Implemented

- ERP System Implementation Phase at Their Company

The above questions are 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 being implemented” and “ERP system implementation phase at their company.”

Afterwards, user satisfaction questions of C-ERP modules on determining module proficiency come at the later pages. There are 15 main C-ERP main modules and 9 Project Management C-ERP modules. All respondents are answered according to the module proficiency of the modules from 1 to 5 Likert scales depended on how much requirements are satisfied with the function list that the module performs. The question that is asked to interviewees at every module is following that “In your opinion, to what extent a C-ERP module, whose functions and abilities are defined at below, satisfies your needs and meets the requirements of your C-ERP necessities?”

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

All of the questionnaire survey details can be seen at Appendix J - Questionnaire Survey.

4.4.2. Problems Encountered During Questionnaire

Only problem that was recognized by respondents that it took at least 1 hours to complete the questionnaire.

4.5. Analysis of the Questionnaire Survey

In the questionnaire part of the investigation, there are 105 input sets from 105 respondents. As mentioned before, in beginning of the survey, all respondents have replied general questions about them and their company. Later, the maturity of the modules and user satisfaction based on the functions of the modules 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.

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

- 1: Project & Construction Management
- 2: Contractor (Construction)
- 3: Consulting Firms
- 4: Project Design (Architectural / Structural / MEP) Firms
- 5: 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.

Yearly_Turnover number means average yearly turnover of the company that the respondents currently working for. Turnover numbers mean 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

Table 4.11. Descriptive Statistics.

Descriptive Statistics						
Variables	Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
age	105	28	55	38,69	6,151	37,833
business_type	105	1	4	2,37	0,763	0,582
comp_age	105	3	70	28,60	20,644	426,185
constr_experience_year	105	3	33	14,86	6,764	45,758
yearly_turnover	105	1	6	4,23	1,938	3,755
total_employee	105	1	6	3,86	2,110	4,451
comp_position	105	1	9	6,17	2,455	6,028
department	105	2	20	7,14	5,948	35,374
erp_usage_yes_no	105	0	1	0,51	0,502	0,252
which_erp_sys	54	1	10	2,61	2,078	4,318
erp_implmnt_phase	54	1	8	7,28	1,806	3,261
business_development_module	105	4	5	4,71	0,454	0,206
projectmng_planning_time_mngmt	105	4	5	4,94	0,233	0,054
projectmng_budget_cost_control	105	4	5	4,97	0,167	0,028
projectmng_subcontractor_tender	105	4	5	4,97	0,167	0,028
projectmng_owner_tender	105	4	5	4,97	0,167	0,028
projectmng_contract_mngmt	105	4	5	4,97	0,167	0,028
projectmng_subcontractor_progress_report	105	5	5	5,00	0,000	0,000
projectmng_owner_progress_report	105	4	5	4,94	0,233	0,054
projectmng_site_subcontractor_mngmt	105	4	5	4,91	0,281	0,079
projectmng_hse_mngmt	105	5	5	5,00	0,000	0,000
design_mngmt	105	3	5	4,77	0,486	0,236
finance_mngmt	105	4	5	4,94	0,233	0,054
accounting_mngmt	105	4	5	4,80	0,402	0,162
procurement_mngmt	105	4	5	4,91	0,281	0,079
hr_mngmt	105	4	5	4,86	0,352	0,124
qc_mngmt	105	4	5	4,97	0,167	0,028
sales_mrktng_crm_mngmt	105	4	5	4,86	0,352	0,124
document_mngmt	105	4	5	4,74	0,439	0,193
logistic_warehouse_mngmt	105	4	5	4,86	0,352	0,124
risk_mngmt	105	4	5	4,97	0,167	0,028
bim_mngmt	105	3	5	4,43	0,602	0,363
erp_it_mngmt	105	4	5	4,60	0,492	0,242
claim_law_mngmt	105	4	5	4,74	0,439	0,193
general_mngmt	105	3	5	4,57	0,552	0,305
Valid N (listwise)	54					

Table 4.12. List of Variables (Modules).

NO	SPSS Variable Name	Variables (Module Names)
1	business_development_module	Business Development Module
2	projectmng_planning_time_mngmt	Project Management - Planning and Time Management Module
3	projectmng_budget_cost_control	Project Management - Budgeting & Cost Control Management
4	projectmng_subcontractor_tender	Project Management - Sub-contractor Tender Management
5	projectmng_owner_tender	Project Management - Owner Tenders Management (quotation Module)
6	projectmng_contract_mngmt	Project Management - Contract Management
7	projectmng_subcontractor_progress_report	Project Management - Progress Report (sub-contractors) Management
8	projectmng_owner_progress_report	Project Management - Progress Report (owners) Management
9	projectmng_site_subcontractor_mngmt	Project Management - Site & Sub-contractor Management
10	projectmng_hse_mngmt	Project Management - Health & Security & Environment Management
11	design_mngmt	Design Management
12	finance_mngmt	Finance Management
13	accounting_mngmt	Accounting Management
14	procurement_mngmt	Procurement Management
15	hr_mngmt	Human Resources Management
16	qc_mngmt	Quality Control Management
17	sales_mrktng_crm_mngmt	Sales & Marketing & Crm Managements
18	document_mngmt	Document Management
19	logistic_warehouse_mngmt	Logistics & Warehouse Management
20	risk_mngmt	Risk Management
21	bim_mngmt	Bim Management
22	erp_it_mngmt	Erp & It Management
23	claim_law_mngmt	Claim & Law Management
24	general_mngmt	General

Total_employee means the number of total employee of respondent's company. Total employee numbers mean 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. Company position 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 / HR / Procurement / Business Development / Marketing / Finance etc.)
- 8: Chief Level (Construction Site / Planning / Mechanical / Electrical / Design / Business Development / HR / Procurement / Finance etc.)
- 9: Engineer & Architect etc.
- 10: Technician etc.
- 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 Department
- 5: Design (Architectural / Structural / Mechanical / Electrical) Department
- 6: Construction (Site)
- 7: Sale Department
- 8: Human Resources (HR) & Public Relations Department
- 9: Business Development Department
- 10: Marketing Department
- 11: Purchasing / Procurement Department
- 12: HSE (Health & Security & Environment) Department
- 13: Quality Control Department
- 14: Logistic Department
- 15: Warehouse Department
- 16: BIM Department

- 17: Risk Management Department
- 18: Law & Claim Management Department
- 19: ERP Department
- 20: IT Department
- 21: Other

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
- 4: Yapitasi ERP
- 5: IFS
- 6: Sage
- 7: NetSuit
- 8: OpenERP / Odoo
- 9: My Company has developed/is developing its own ERP system!
- 10: 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: At the primary stage of ERP system implementation
- 2: At the final stage (close to completion) of ERP system implementation
- 3: The implementation of ERP system has been completed about 1 year ago

- 4: ERP system has being used about 2 years
- 5: ERP system has being used about 3 years
- 6: ERP system has being used about 4 years
- 7: ERP system has being used about 5 years
- 8: ERP system has being used more than 5 years

According to descriptive table given above, the average age of the respondents is about 39. 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 4.13. Age Group.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30 or less	12	11,4	11,4	11,4
	31 - 40	63	60,0	60,0	71,4
	41 - 50	28	26,7	26,7	98,1
	51 or more	2	1,9	1,9	100,0
	Total	105	100,0	100,0	

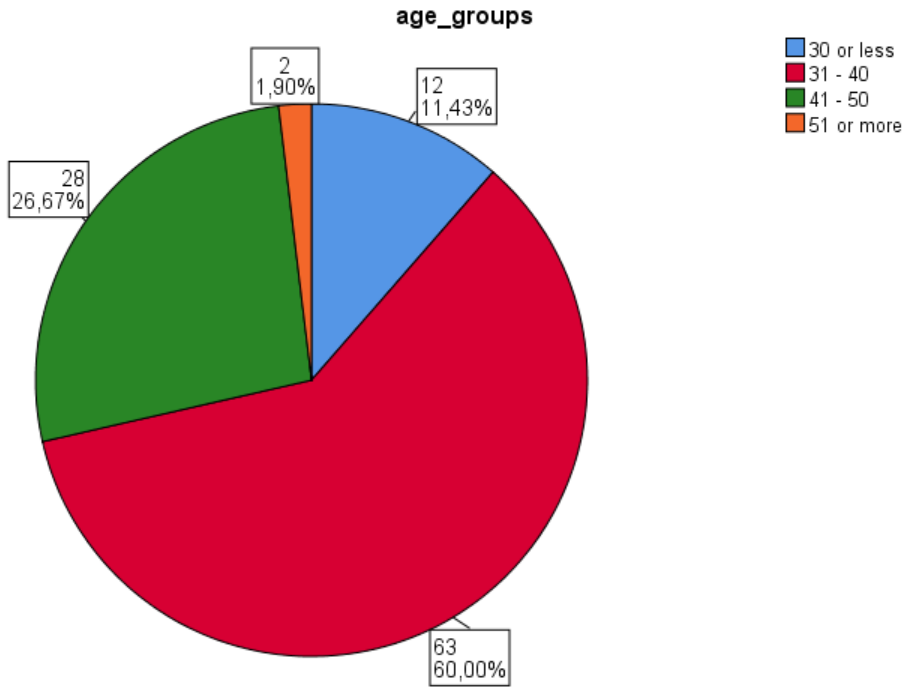


Figure 4.3. Age Group Pie Chart.

Mean of the company age is about 29 and average experience in construction sector of the respondents is about 15 years.

Table 4.14. Descriptive Statistics of Age, Company Age, Constr. Experience.

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
age	105	28	55	38,69	6,151	37,833
comp_age	105	3	70	28,60	20,644	426,185
constr_experience_year	105	3	33	14,86	6,764	45,758
Valid N (listwise)	105					

The mean of yearly turnover of the companies is close to number 4 (4.23) but this does not mean that most of the companies' turnover is about the range of 10 to 20 Million USD. It is only 2.9% of the companies have this turnover. 45.7% of the companies have yearly turnover more than 50 Million USD. There are not any companies that the respondents don't know total turnover of their own companies. The pie chart below; Figure 4.4 can give as a general idea about the company turnover profile.

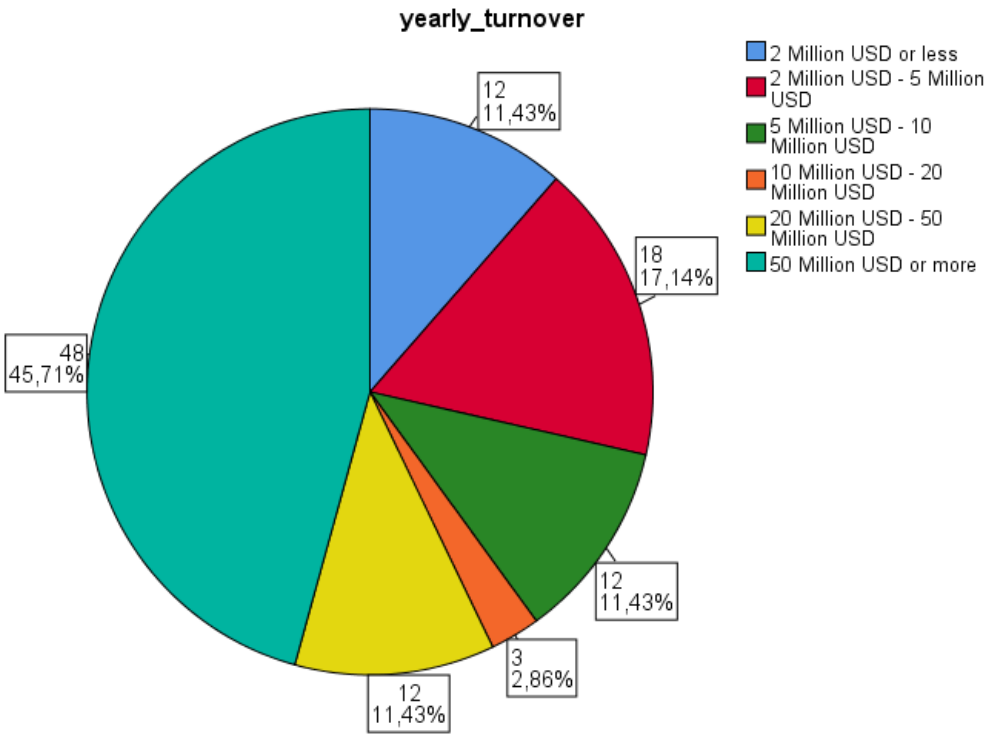


Figure 4.4. Turnover Pie Chart.

The mean of the total employee at the companies that respondents are working for is 3.86 and it can be seen at the Figure 4.5. This is the middle of number 3 and number 4. The number 3 refers to 51 – 100 and the number 4 refers to 101 – 200. It cannot be said exactly but may be indicated that number 3.86 refers the number of the employees about between 150 and 200.

It can be seen the position chart of the respondents at their companies as shown at Figure 4.6. 30 of the total respondents are chief level employees and this is the dominant group at the survey numerically. Secondly, the number of the respondents at managerial level is 27. These are two position groups of the employees that consist of 54.28% of all respondents' position level.

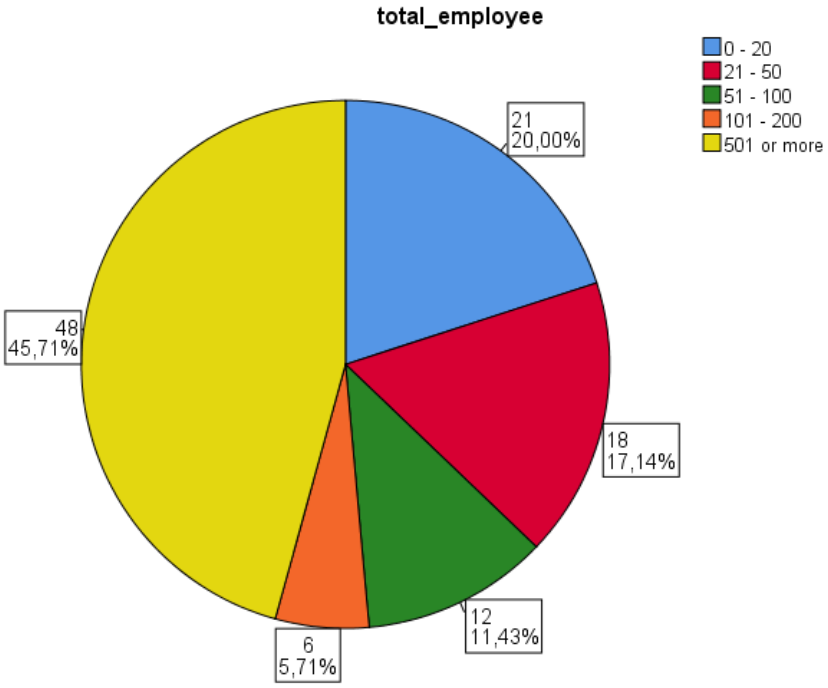


Figure 4.5. Total Employee Pie Chart.

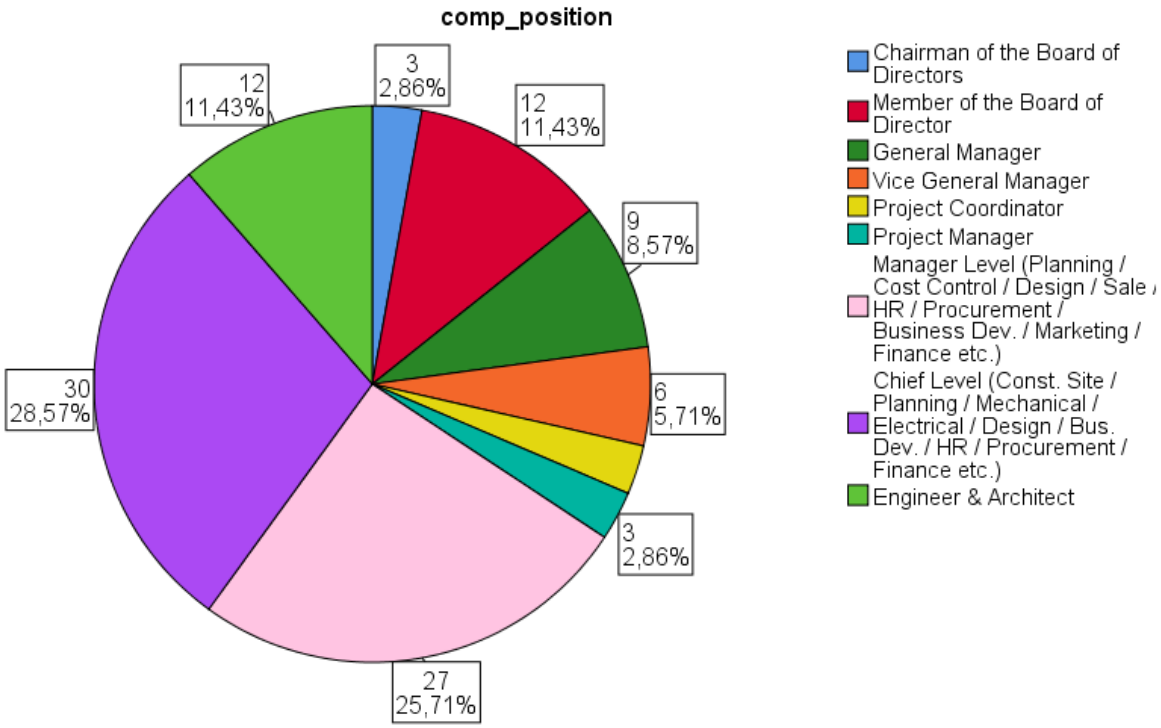


Figure 4.6. Position Pie Chart.

It can be seen the department chart of the respondents at Figure 4.7. It explains that at what department of the companies of the respondents they are working for. 45 of the total respondents are from Technical Office (Planning, Cost Control, Tender, Progress Payment etc.) Departments and 12 of them are from construction site. Also, 15 of the respondents are from ERP department and 12 of the respondents are from Business Development department.

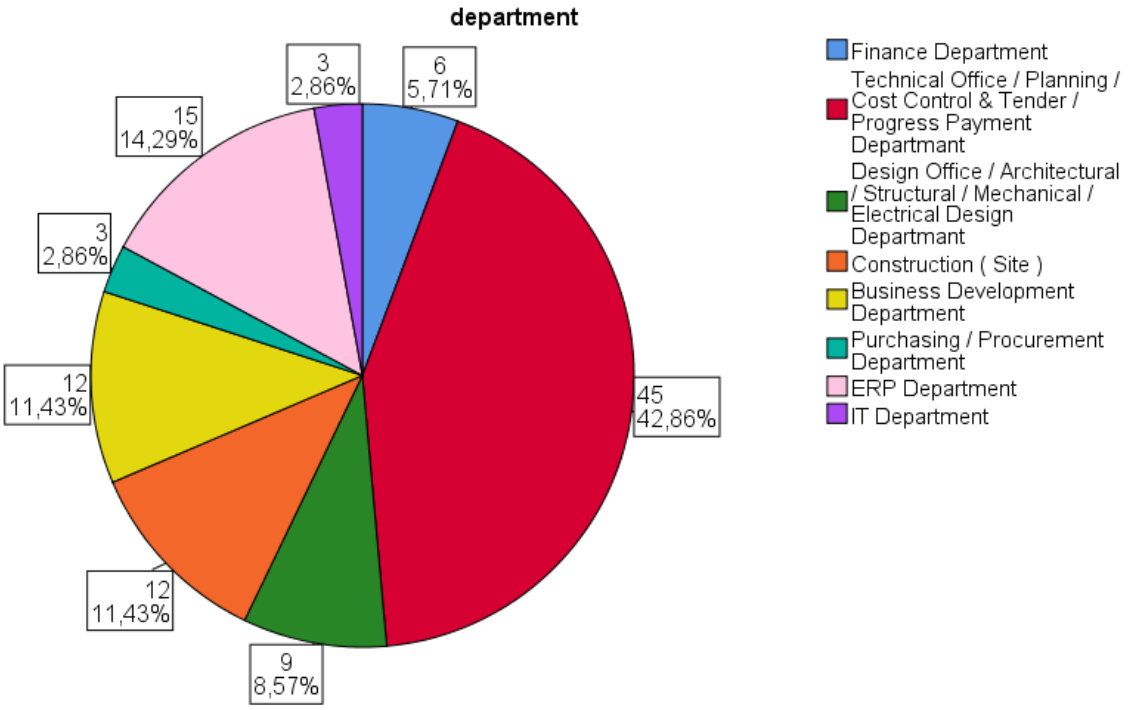


Figure 4.7. Department Pie Chart.

It can be seen the ERP usage chart of the respondents at Figure 4.8. 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, 51.43% of them answered this question as Yes.

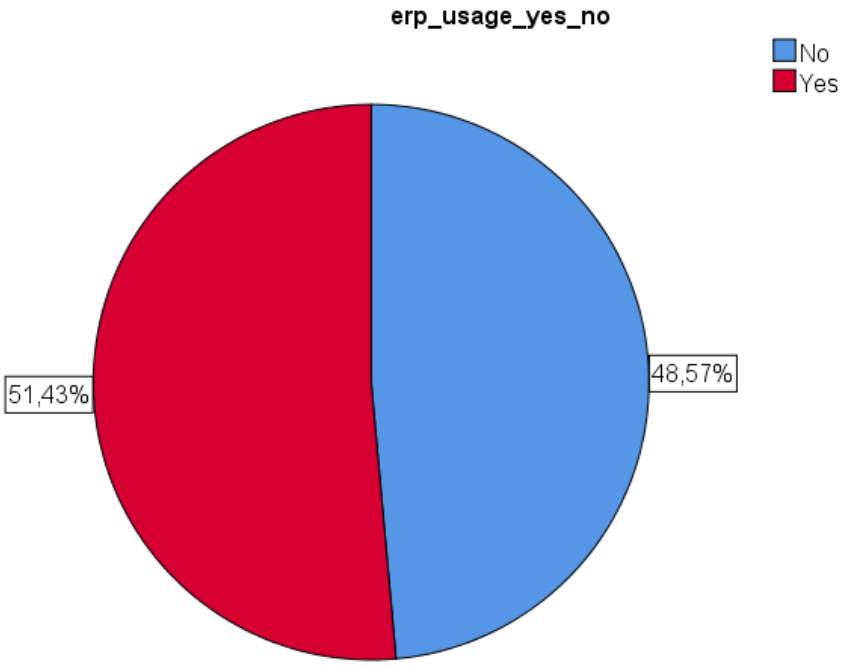


Figure 4.8. ERP Usage Pie Chart.

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 4.9 below that 33.33% of them have answered as “SAP” and secondly, it can be seen at Figure 4.9 below that 27.78% of them have answered as “MS Dynamics”. Also, about 6 percent of the respondents are replied as “My company has developed or developing its own ERP system”.

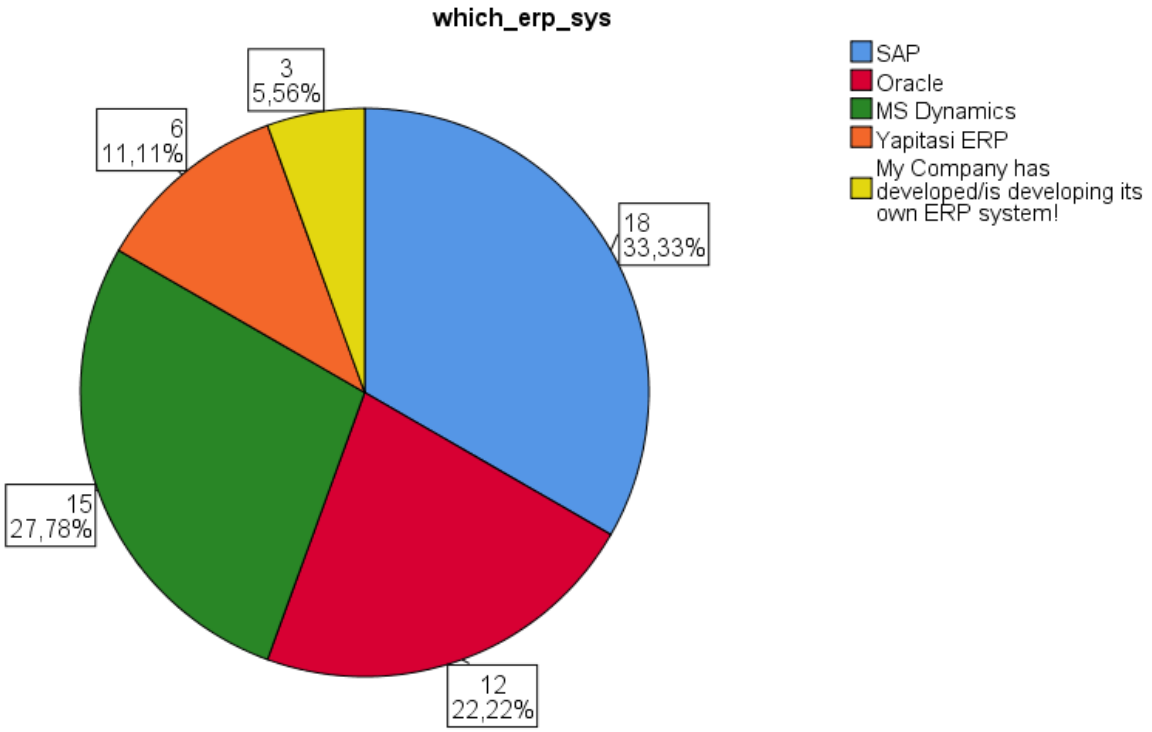


Figure 4.9. Which ERP System Pie Chart.

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 4.10 below that about 83% of the respondents have answered as that their ERP system in their companies has being used for more than 5 years.

About 11% of the respondents have answered as that their ERP system in their companies has being used for more than 3 years. About 3% of the respondents have answered as that the implementation of their ERP system has been at primary stage.

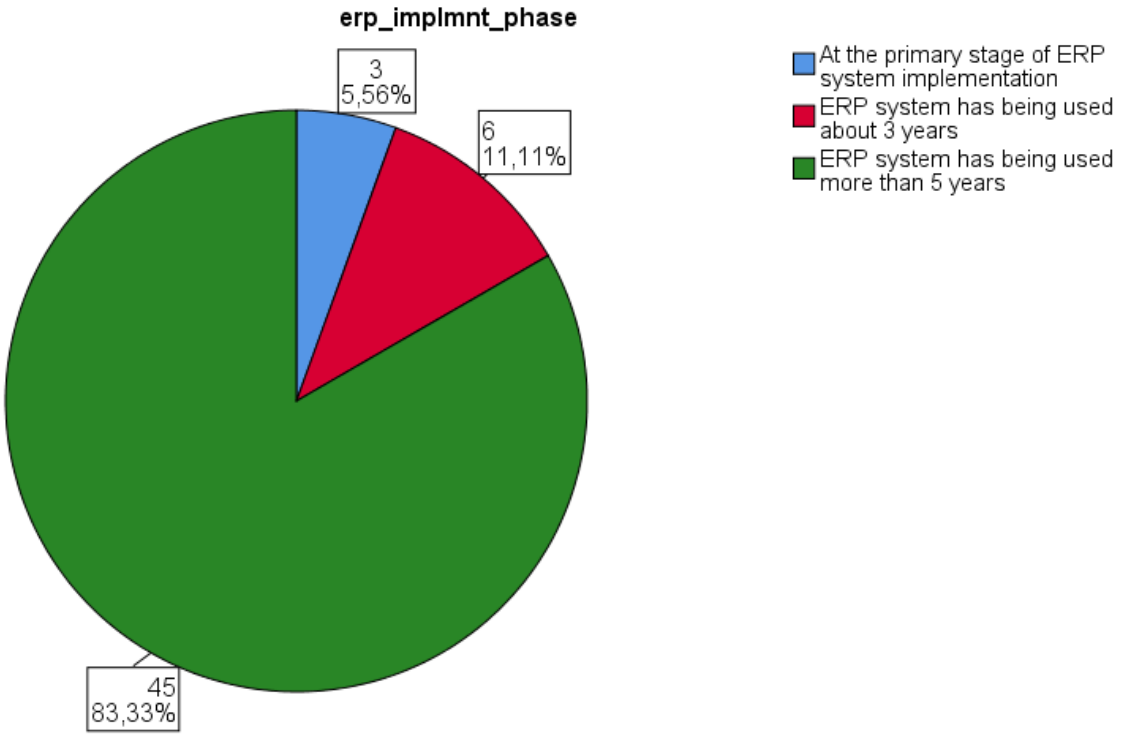


Figure 4.10. What Implementation Phase Pie Chart.

When ERP usage is examined based on how it is distributed by business type of the respondents, Figure 4.11 is obtained. When “Project & Construction Management companies” and “Project Design companies” are examined, it can be seen that none of them has been using any ERP system.

When “Contractor (Construction) companies” is examined, it can be seen that 59.1% of them has been using an ERP system in their companies. Also, when “Consulting firms” are examined, it can be seen that 71,4% of them has been using an ERP system in their companies because a great majority of the consulting companies are actually ERP Consulting firms and they are using their own developed or implemented systems in their companies.

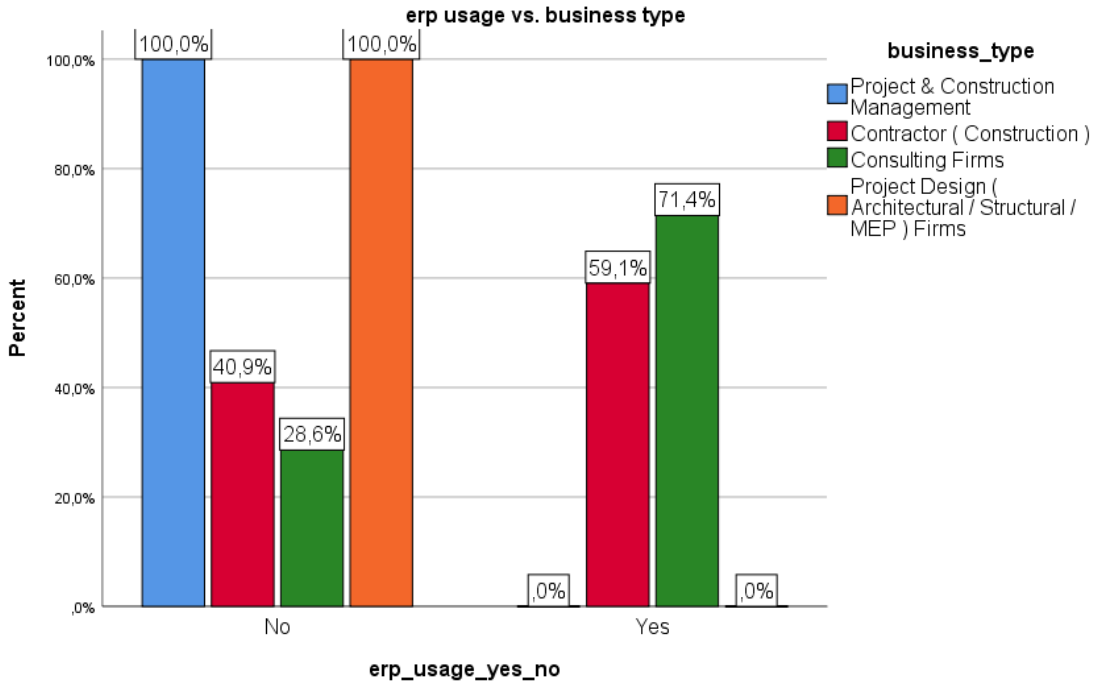


Figure 4.11. ERP Usage with respect to Business Type Bar Chart.

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 4.12 below. When “ERP Deparment” and “IT Department” is examined, it can be naturally seen that all of the respondents who are working at these departments have been using one of the 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 one of the ERP system. When “Technical Office department” is examined, it can be seen that only 53.3% of the respondents who are working at Technical Office department has been using an ERP system.

Additionally, when Construction Site is examined, it can be seen that only 75% of the respondents who are working at Construction Site has been using one of the ERP system.

When Business Development, Design Office and Procurement Departments are examined, it can be seen that none of the respondents have been using any ERP system.

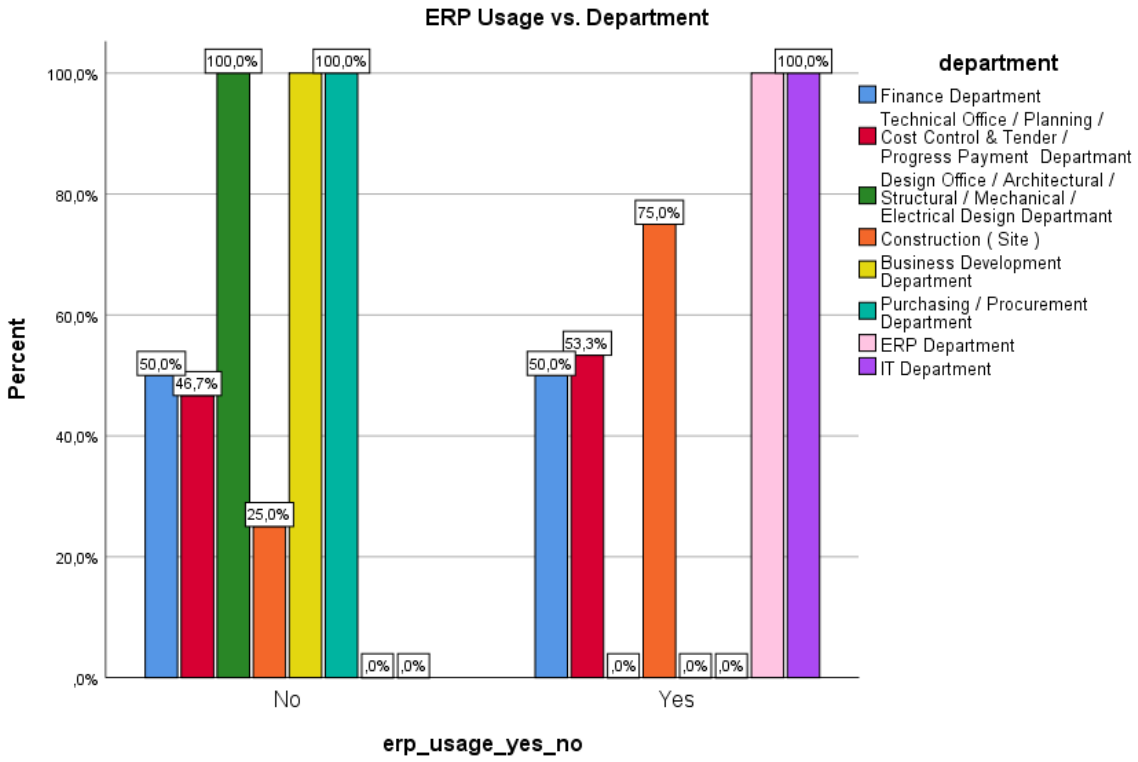


Figure 4.12. ERP Usage with respect to Department - Bar Chart.

Moreover, if what age groups the respondents who are not using any ERP system are belong to is examined, the following pie chart Figure 4.13 can be created.

According to the pie chart Figure 4.13 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.

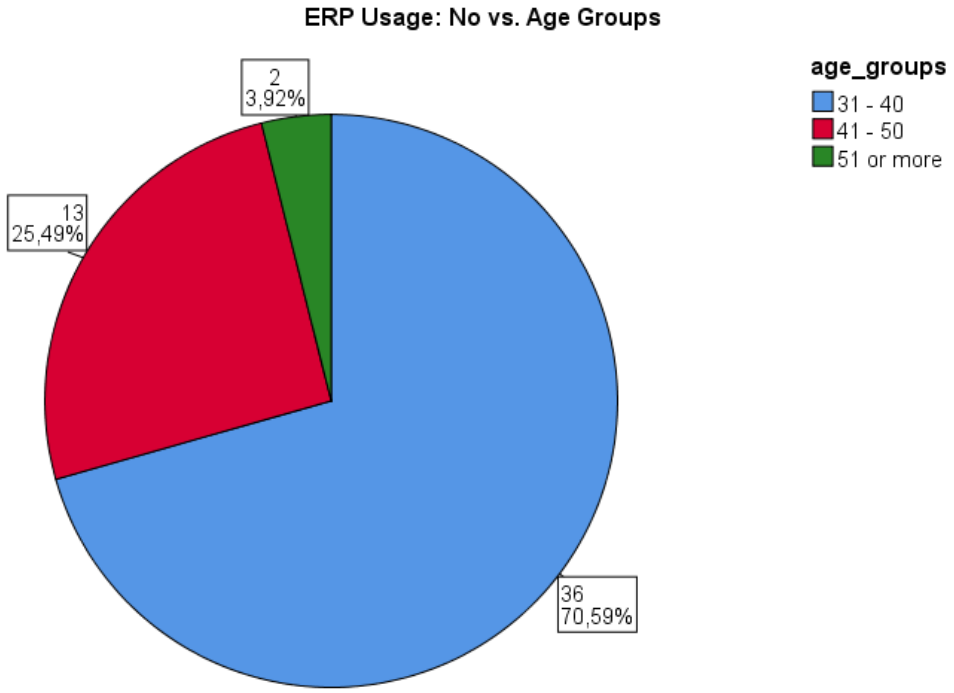


Figure 4.13. ERP Usage No vs. Age Group - Pie Chart.

Additionally, if what age group that the respondents who are using any ERP system is belong to is examined, the following pie chart Figure 4.14 can be created. According to the pie chart below, about 50% of the respondents who are using any ERP system before is in “between 31 and 40” age group, about 28% of the respondents who are using any ERP system before is in “between 41 and 50” age group and about 22% of the respondents who are using any ERP system before is in “30 or less” 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 4.15 can be created as below. According to the pie chart below, it can be seen that percentages of the age groups are very close, so that it can be seen that the age of the companies is not related with the ERP usage.

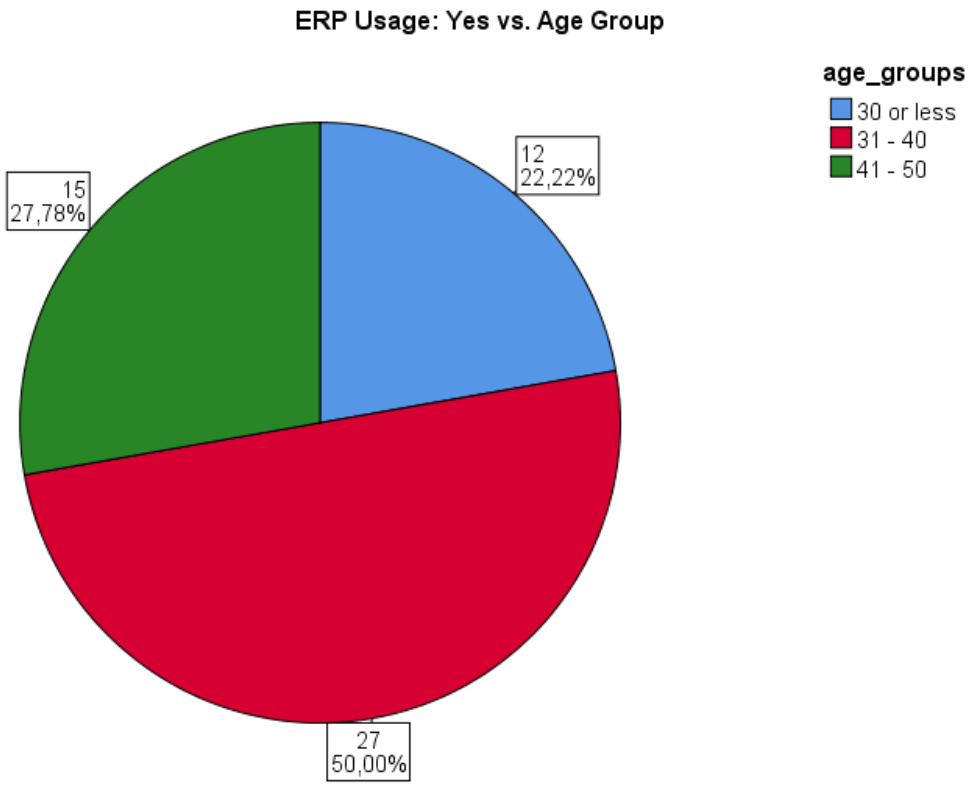


Figure 4.14. ERP Usage Yes vs. Age Group - Pie Chart.

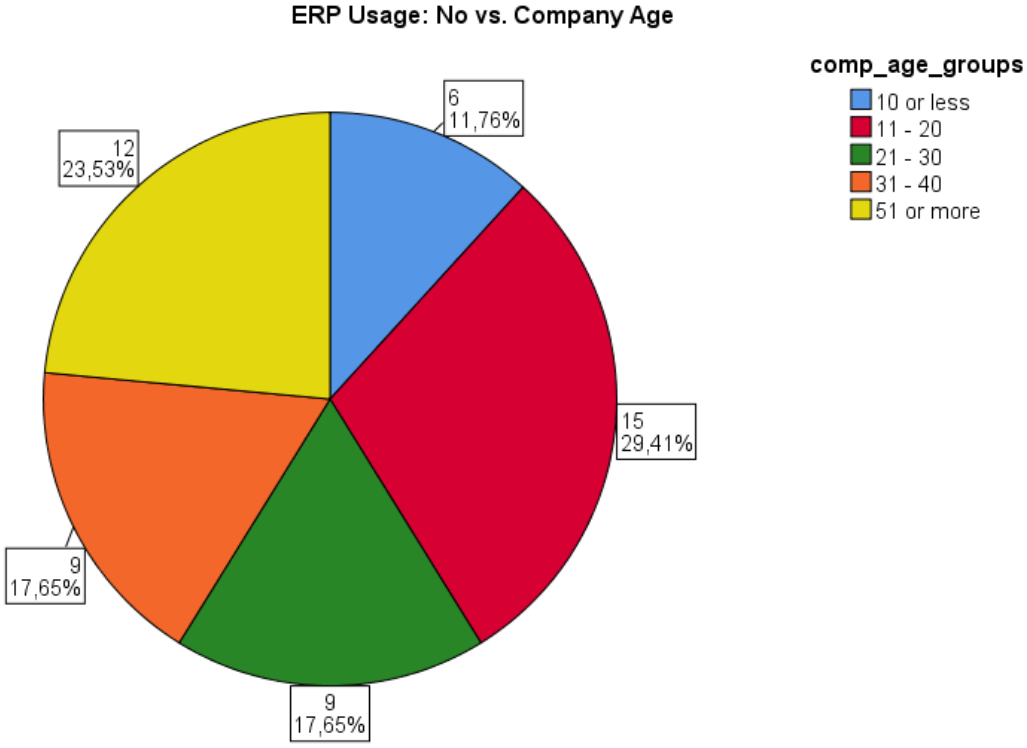


Figure 4.15. Company Age Groups with respect to ERP Usage No.

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 4.16 can be created as below. According to the pie chart below, about 17% of the companies that are using any ERP system before is in “10 or less” company age group, about 11% of the companies that are using any ERP system before is in “between 11 and 20” company age group, 50% of the companies that are using any ERP system before is in “between 21 and 30” company age group, about 6% of the companies that are using any ERP system before is in “between 41 and 50” company age group and about 17% of the companies that are using any ERP system before is in “51 or more” company age group.

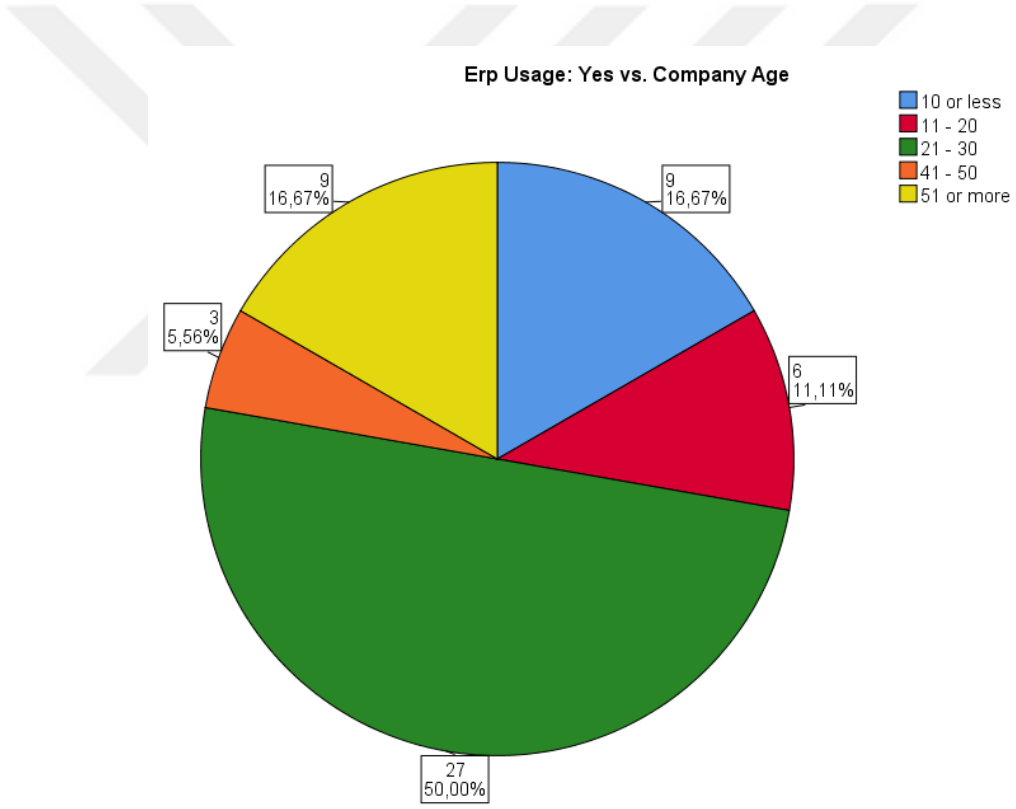


Figure 4.16. Company Age Groups with respect to ERP Usage Yes.

Furthermore, there are 24 ERP modules that are determined based on the case studies made reviewed by an academician.

The following table shows the modules, their variable name in SPSS analysis, and the mean value of their proficiency level based on user satisfaction questionnaire survey.

If following mean values are examined, it can be seen that all module proficiency levels are above “high level.”

Table 4.15. Mean Table of Module Proficiency at User Satisfaction Survey.

No	MODULE VARIABLE NAME	MODULE NAME	Mean	Proficiency Level FROM	Proficiency Level TO
1	*business_development_module*	Business Development Module	4,71	High	Very High
2	*projectmng_planning_time_mngmt*	Project Management - Planning and Time Management Module	4,94	High	Very High
3	*projectmng_budget_cost_control*	Project Management - Budgeting & Cost Control Management	4,97	High	Very High
4	*projectmng_subcontractor_tender*	Project Management - Sub-contractor Tender Management	4,97	High	Very High
5	*projectmng_owner_tender*	Project Management - Owner Tenders Management (quotation Module)	4,97	High	Very High
6	*projectmng_contract_mngmt*	Project Management - Contract Management	4,97	High	Very High
7	*projectmng_subcontractor_progress_report*	Project Management - Progress Report (sub-contractors) Management	5,00	Very High	Very High
8	*projectmng_owner_progress_report*	Project Management - Progress Report (owners) Management	4,94	High	Very High
9	*projectmng_site_subcontractor_mngmt*	Project Management - Site & Sub-contractor Management	4,91	High	Very High
10	*projectmng_hse_mngmt*	Project Management - Health & Security & Environment Management	5,00	Very High	Very High
11	*design_mngmt*	Design Management	4,77	High	Very High
12	*finance_mngmt*	Finance Management	4,94	High	Very High
13	*accounting_mngmt*	Accounting Management	4,80	High	Very High
14	*procurement_mngmt*	Procurement Management	4,91	High	Very High
15	*hr_mngmt*	Human Resources Management	4,86	High	Very High
16	*qc_mngmt*	Quality Control Management	4,97	High	Very High
17	*sales_mrktng_crm_mngmt*	Sales & Marketing & Crm Managements	4,86	High	Very High
18	*document_mngmt*	Document Management	4,74	High	Very High
19	*logistic_warehouse_mngmt*	Logistics & Warehouse Management	4,86	High	Very High
20	*risk_mngmt*	Risk Management	4,97	High	Very High
21	*bim_mngmt*	Bim Management	4,43	High	Very High
22	*erp_it_mngmt*	Erp & It Management	4,60	High	Very High
23	*claim_law_mngmt*	Claim & Law Management	4,74	High	Very High
24	*general_mngmt*	General	4,57	High	Very High

Also, Table 4.16 below shows the modules and their mean values in descending order, so that what modules are more proficient and satisfies user requirements can easily be seen.

Table 4.16. Descending Mean Value of Modules Table.

No	MODULE VARIABLE NAME	MODULE NAME	Mean	Proficiency Level FROM	Proficiency Level TO
7	*projectmng_subcontractor_progress_report*	Project Management - Progress Report (sub-contractors) Management	5,00	Very High	Very High
10	*projectmng_hse_mngmt*	Project Management - Health & Security & Environment Management	5,00	Very High	Very High
3	*projectmng_budget_cost_control*	Project Management - Budgeting & Cost Control Management	4,97	High	Very High
4	*projectmng_subcontractor_tender*	Project Management - Sub-contractor Tender Management	4,97	High	Very High
5	*projectmng_owner_tender*	Project Management - Owner Tenders Management (quotation Module)	4,97	High	Very High
6	*projectmng_contract_mngmt*	Project Management - Contract Management	4,97	High	Very High
16	*qc_mngmt*	Quality Control Management	4,97	High	Very High
20	*risk_mngmt*	Risk Management	4,97	High	Very High
8	*projectmng_owner_progress_report*	Project Management - Progress Report (owners) Management	4,94	High	Very High
2	*projectmng_planning_time_mngmt*	Project Management - Planning and Time Management Module	4,94	High	Very High
12	*finance_mngmt*	Finance Management	4,94	High	Very High
9	*projectmng_site_subcontractor_mngmt*	Project Management - Site & Sub-contractor Management	4,91	High	Very High
14	*procurement_mngmt*	Procurement Management	4,91	High	Very High
15	*hr_mngmt*	Human Resources Management	4,86	High	Very High
19	*logistic_warehouse_mngmt*	Logistics & Warehouse Management	4,86	High	Very High
17	*sales_mrktng_crm_mngmt*	Sales & Marketing & Crm Managements	4,86	High	Very High
13	*accounting_mngmt*	Accounting Management	4,80	High	Very High
11	*design_mngmt*	Design Management	4,77	High	Very High
23	*claim_law_mngmt*	Claim & Law Management	4,74	High	Very High
18	*document_mngmt*	Document Management	4,74	High	Very High
1	*business_development_mod*	Business Development Module	4,71	High	Very High
22	*erp_it_mngmt*	Erp & It Management	4,60	High	Very High
24	*general_mngmt*	General	4,57	High	Very High
21	*bim_mngmt*	Bim Management	4,43	High	Very High

4.5.1 Module Cross Tables

The easiest way to understand and compare user satisfaction questionnaire survey scores of module proficiencies is to investigate module cross tables. The module cross tables can inform us on the scores of user satisfaction survey with respect to age groups, business type, departments, company age, previous ERP usage or not, company turnover, the number of employee at companies etc.

For example, the following table shows us the score distribution of business development module based on age groups of the respondents at the user satisfaction survey.

It can be seen that 11.4% of the respondents are belong to “30 or less” age groups and 25% of this age group (2.9% of all respondents) has scored module satisfaction of business development module as “4 – High”, and 75% of this age group (8.6% of all respondents) has scored module satisfaction of business development module as “5 – Very High.”

Also, it can be seen that 60.0% of the respondents are belong to “31 – 40” age group and 28.6% of this age group (17.1% of all respondents) has scored module satisfaction of business development module as “4 – High”, and 71.4% of this age group (42.9% of all respondents) has scored module satisfaction of business development module as “5 – Very High.”

Also, it can be seen that 26.7% of the respondents are belong to “41 – 50” age group and 25% of this age group (6.7% of all respondents) has scored module satisfaction of business development module as “4 – High”, and 75% of this age group (20% of all respondents) has scored module satisfaction of business development module as “5 – Very High.”

Also, it can be seen that 1.9% of the respondents are belong to “51 or more” age group and all of this age group (1.9% of all respondents) has scored module satisfaction of business development module as “4 – High.”

To sum up, 28.6% of all respondents has scored module satisfaction of business development module as “4 – High” and 71.4% of all respondents has scored module satisfaction of business development module as “5 – Very High.”

Table 4.17. Age Groups vs. Business Development Module Cross Table.

age_groups * business_development_module Crosstabulation

			business_development_module		
			4	5	Total
age_groups	30 or less	Count	3	9	12
		% within age_groups	25,0%	75,0%	100,0%
		% within business_development_module	10,0%	12,0%	11,4%
		% of Total	2,9%	8,6%	11,4%
	31 - 40	Count	18	45	63
		% within age_groups	28,6%	71,4%	100,0%
		% within business_development_module	60,0%	60,0%	60,0%
		% of Total	17,1%	42,9%	60,0%
	41 - 50	Count	7	21	28
		% within age_groups	25,0%	75,0%	100,0%
		% within business_development_module	23,3%	28,0%	26,7%
		% of Total	6,7%	20,0%	26,7%
	51 or more	Count	2	0	2
		% within age_groups	100,0%	0,0%	100,0%
		% within business_development_module	6,7%	0,0%	1,9%
		% of Total	1,9%	0,0%	1,9%
Total		Count	30	75	105
		% within age_groups	28,6%	71,4%	100,0%
		% within business_development_module	100,0%	100,0%	100,0%
		% of Total	28,6%	71,4%	100,0%

All of other cross tables between some criteria at survey, such as; age groups, business type, departments, company age, previous ERP usage or not, company turnover, the number of employee at companies etc. versus 24 modules can be found Appendix I - Cross Tables – Survey Criteria vs. Modules.

4.5.2 ANOVA Analysis

Analysis of Variance (ANOVA) is used to compare the means among the three or more independent groups or categorical independent variables and specifies whether any of those means are statistically significantly different from each other or not [84].

One-way ANOVA use F-distribution test to compare two means between the independent groups and to check whether two means are equal or not, so that a significantly different result means that the two means of the groups are not equal and null hypothesis can be rejected [166]. This can be control by checking the p value of the analysis. If p value is less than or equal to 0.05, that means that there is a significant difference somewhere between the mean values about dependent variable for more than two groups.

ANOVA analysis can be used at this thesis in order to investigate the module proficiency at user satisfaction questionnaire survey results of respondents. It can be investigated whether some of specialties of the respondents are affecting their results or not.

4.5.3. The Convenience of ANOVA Analysis Method of the Questionnaire Survey

In order to use ANOVA analysis, the data of dependent variable should be distributed normally. In order to check the distribution of the data, it can be used The Kolmogorov-Smirnov Test (K-S test) or Shapiro-Wilks Normality Test for dependent variable.

In this thesis, the dependent variables are the “module proficiencies” and their user satisfaction level scores from 1 to 5. These data should be tested for normality and K-S or S-W tests should be performed to check the distribution of module satisfaction data set.

The tests reject the null hypothesis of normality when significance p value is less than or equal to 0.05 [167].

Table 4.18. Tests of Normality (K-S & S-W Tests)

Tests of Normality						
VARIABLES	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
business_development_module	0,450	105	0,000	0,566	105	0,000
projectmng_planning_time_mngmt	0,540	105	0,000	0,245	105	0,000
projectmng_budget_cost_control	0,539	105	0,000	0,156	105	0,000
projectmng_subcontractor_tender	0,539	105	0,000	0,156	105	0,000
projectmng_owner_tender	0,539	105	0,000	0,156	105	0,000
projectmng_contract_mngmt	0,539	105	0,000	0,156	105	0,000
projectmng_subcontractor_progress_report		105			105	
projectmng_owner_progress_report	0,540	105	0,000	0,245	105	0,000
projectmng_site_subcontractor_mngmt	0,534	105	0,000	0,313	105	0,000
projectmng_hse_mngmt		105			105	
design_mngmt	0,481	105	0,000	0,512	105	0,000
finance_mngmt	0,540	105	0,000	0,245	105	0,000
accounting_mngmt	0,491	105	0,000	0,490	105	0,000
procurement_mngmt	0,534	105	0,000	0,313	105	0,000
hr_mngmt	0,515	105	0,000	0,416	105	0,000
qc_mngmt	0,539	105	0,000	0,156	105	0,000
sales_mrktng_crm_mngmt	0,515	105	0,000	0,416	105	0,000
document_mngmt	0,464	105	0,000	0,544	105	0,000
logistic_warehouse_mngmt	0,515	105	0,000	0,416	105	0,000
risk_mngmt	0,539	105	0,000	0,156	105	0,000
bim_mngmt	0,314	105	0,000	0,734	105	0,000
erp_it_mngmt	0,392	105	0,000	0,622	105	0,000
claim_law_mngmt	0,464	105	0,000	0,544	105	0,000
general_mngmt	0,381	105	0,000	0,677	105	0,000
a. Lilliefors Significance Correction						

It can be seen that for all both K-S and S-W Normality tests, all significant p values for all modules is zero and that means that none of the module proficiency data comes from user satisfaction survey distributes normally.

Therefore, ANOVA analysis cannot be performed for these data set and Non-Parametric Analysis should be used. Also, it can be seen that "*projectmng_subcontractor_ progress_ report*" and "*projectmng_hse_mngmt*" modules do not have any significance value because of the fact that their mean is 5 – Very High, so there is not any distribution.

4.5.4. Non-Parametric ANOVA Analysis (Kruskal-Wallis H Test)

Because of the non-normal distribution data sets of module proficiencies, it should be used non-parametric analysis techniques. Kruskal-Wallis H test is the non-parametric analysis to investigate variances between-groups.

K-W test allows the researchers to compare the values of some continuous variable for more than two groups. In this context, it can be thought as K-W Test is non-parametric version of ANOVA test.

Values at the data set are transformed to ranks and the mean rank for each independent group is compared. Therefore, Kruskal-Wallis H Test is one of the best suitable test for data sets of user satisfaction survey in this thesis.

4.5.4.1. Kruskal-Wallis Test with Respect To "Age Groups". Here below at Table 4.19 Hypothesis Test Summary (Age Group) Table, it can be seen Kruskal-Wallis test results of all modules with respect to "age groups."

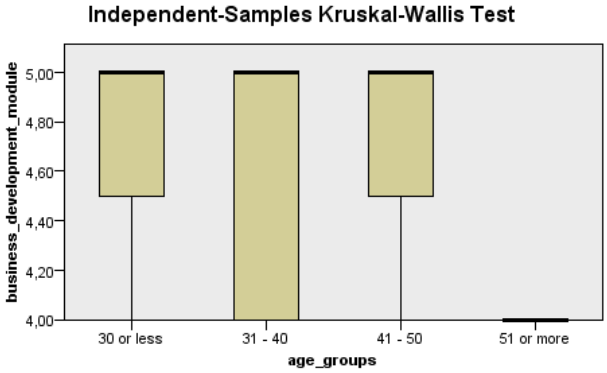
It can be seen from the table that Planning and Time Management, Budget and Cost Control Management, Accounting Management, HR Management and Logistic & Warehouse Management modules user satisfaction survey scores changes with respondent "age groups".

Table 4.19. Hypothesis Test Summary (Age Groups).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,158	Retain the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,004	Reject the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,564	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,564	Retain the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,564	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,240	Retain the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,073	Retain the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,085	Retain the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,526	Retain the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,037	Reject the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,133	Retain the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,003	Reject the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,564	Retain the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,325	Retain the null hypothesis.
18	The distribution of document_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,129	Retain the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,009	Reject the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,564	Retain the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,099	Retain the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,433	Retain the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,119	Retain the null hypothesis.
24	The distribution of general_mngmt is the same across categories of age_groups.	Independent-Samples Kruskal-Wallis Test	0,355	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is ,05.				

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to “age groups” of the respondents in details.

According to the figure below, it can be seen that “Business Development” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	5,200
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,158

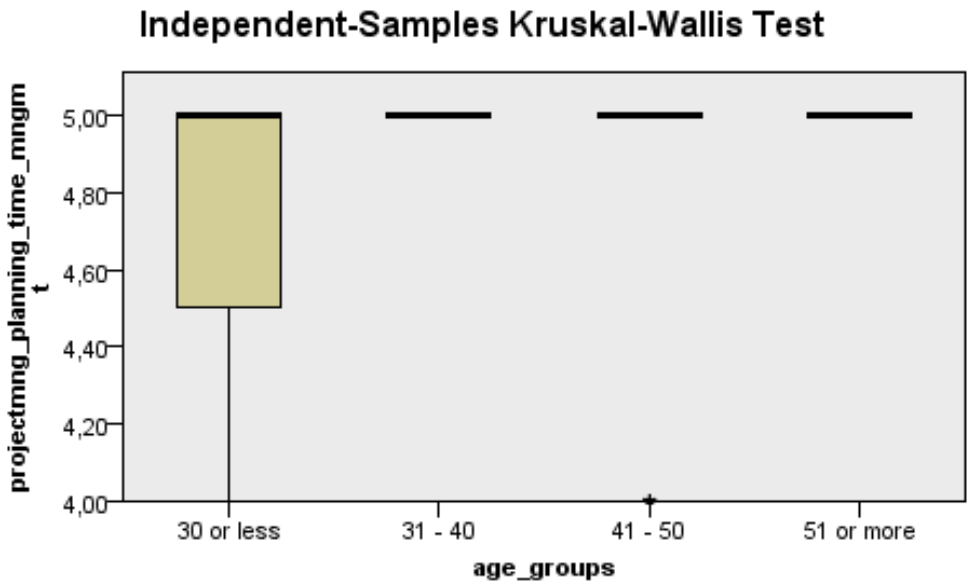
1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.17. Kruskal-Wallis Test with respect to Age Groups (Business Development Module).

According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do change with respect to “age groups.” It can be seen that the answers of “30 or less” age group respondents are significantly different than “31 – 40“ age group respondents.

According to Appendix L – Cross Tables Between Factors, %100 of “30 or less” age group members have “10 or less” construction sector experiences but %75 of “31-40” age group members have “11 – 20” construction sector experiences. The more experienced professionals scored the proficiency of the module as 100% “5 – Very High”. Also, 100% of the “30 or less” are from technical office department, all of the members of this age group have been using ERP system and “Project Management – Planning & Time Management” module is actively used by this department, so 25% of “30 or less” group members are scored

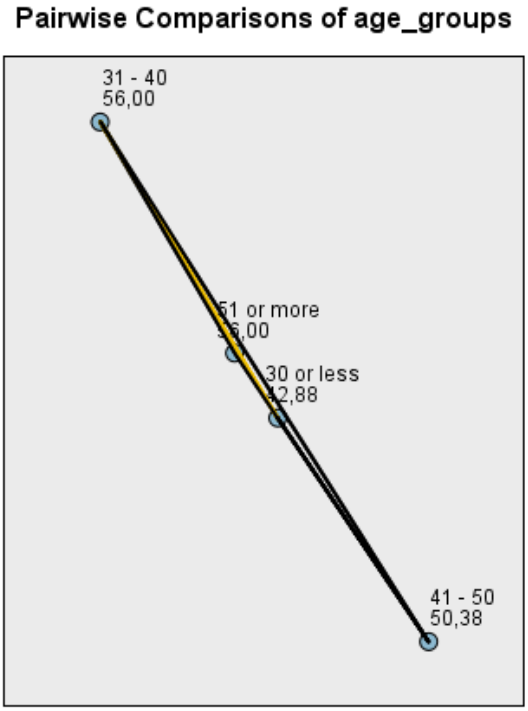
the module as “4 – High” and others as “5 – Very High”. Thus, the less experienced young professionals request much more ability from the module.



Total N	105
Test Statistic	13,394
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,004

1. The test statistic is adjusted for ties.

Figure 4.18. Kruskal-Wallis Test with respect to Age Groups (Planning & Time Management).

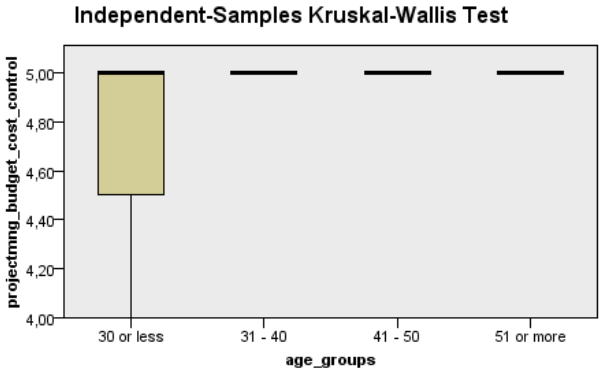


Each node shows the sample average rank of age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
30 or less-41 - 50	-7,500	4,225	-1,775	,076	,455
30 or less-31 - 40	-13,125	3,857	-3,403	,001	,004
30 or less-51 or more	-13,125	9,352	-1,403	,160	,963
41 - 50-31 - 40	5,625	2,781	2,023	,043	,259
41 - 50-51 or more	-5,625	8,962	-,628	,530	1,000
31 - 40-51 or more	,000	8,795	,000	1,000	1,000

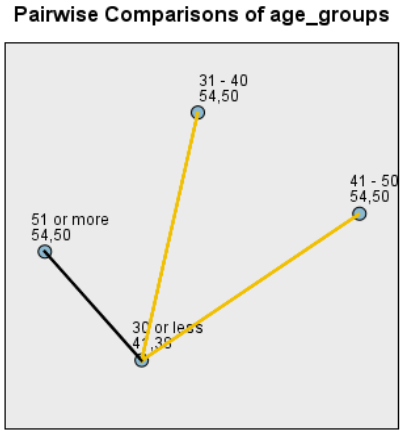
Figure 4.19. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Planning & Time Management).

According to the figure below, it can be seen that “Project Management – Budget & Cost Control Management” module user satisfaction scores do change with respect to “age groups.” It can be seen that the answers of “30 or less” age group respondents are significantly different than “31 – 40“ and “41 – 50” age group respondents.



Total N	105
Test Statistic	23,706
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

Figure 4.20. Kruskal-Wallis Test with respect to Age Groups (Budget & Cost Control).



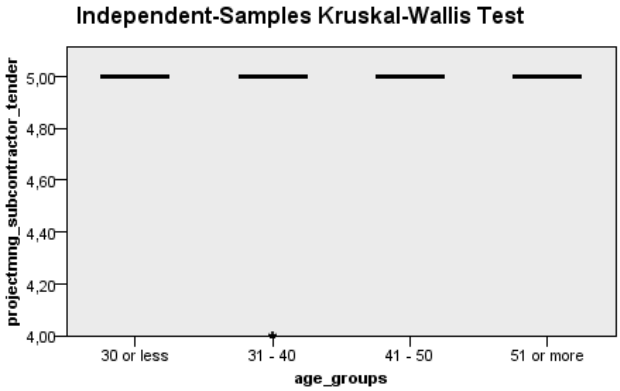
Each node shows the sample average rank of age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
30 or less-31 - 40	-13,125	2,768	-4,742	,000	,000
30 or less-41 - 50	-13,125	3,032	-4,328	,000	,000
30 or less-51 or more	-13,125	6,712	-1,955	,051	,303
31 - 40-41 - 50	,000	1,996	,000	1,000	1,000
31 - 40-51 or more	,000	6,312	,000	1,000	1,000
41 - 50-51 or more	,000	6,432	,000	1,000	1,000

Figure 4.21. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Budget & Cost Control).

According to Appendix L – Cross Tables Between Factors, %100 of "30 or less" age group members have "10 or less" construction sector experiences but %75 of "31-40" and 60% of "41-50" age group members have "11 – 20" years and "21-30" years construction sector experiences. The more experienced professionals scored the proficiency of the module as 100% "5 – Very High". Also, "30 or less" age group members are mostly working at "Engineer & Architect" position but others age groups are working mostly at chief and managerial level. For higher company positions, the module proficiency level is much higher.

According to the figure below, it can be seen that "Project Management – Sub-Contractor Tender Management" module user satisfaction scores do not change with respect to "age groups."

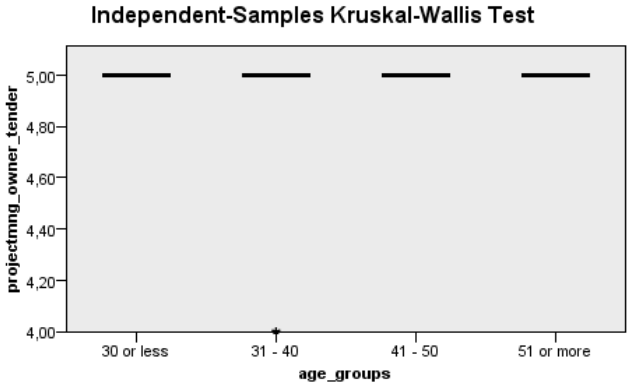


Total N	105
Test Statistic	2,039
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,564

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.22 Kruskal-Wallis Test with respect to Age Groups (Sub-Contractor Tender Management).

According to the figure below, it can be seen that “Project Management – Owner Tender Management” module user satisfaction scores do not change with respect to “age groups.”

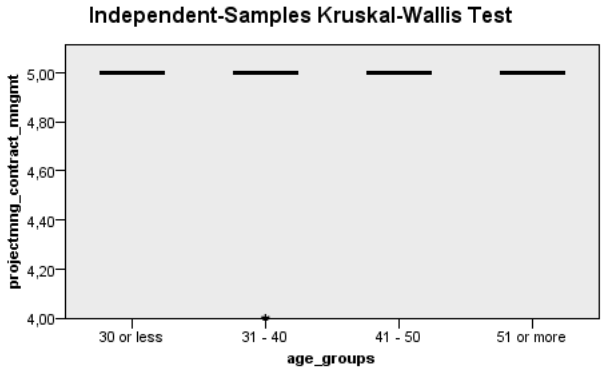


Total N	105
Test Statistic	2,039
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,564

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.23. Kruskal-Wallis Test with respect to Age Groups (Owner Tender Management Module).

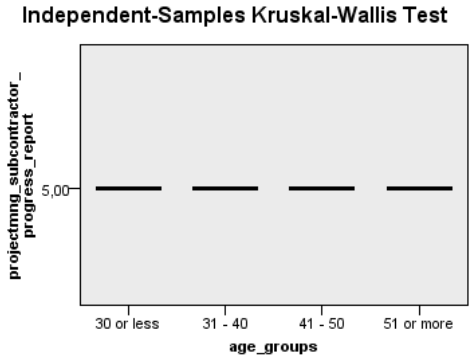
According to the figure below, it can be seen that “Project Management – Contract Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	2,039
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,564

Figure 4.24. Kruskal-Wallis Test with respect to Age Groups (Contract Management).

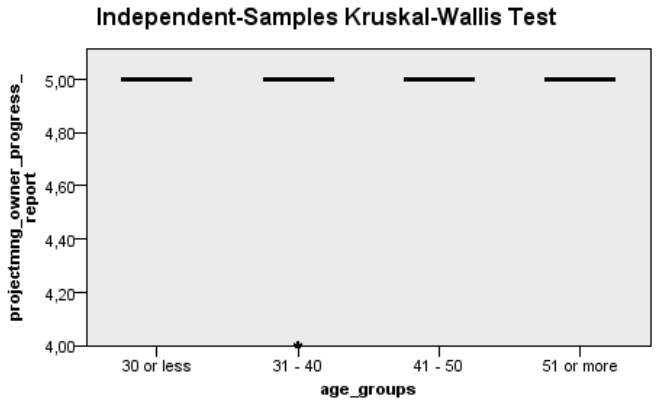
According to the figure below, it can be seen that “Project Management – Sub-Contractor Progress Report Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	,000
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	1,000

Figure 4.25. Kruskal-Wallis Test with respect to Age Groups (Sub-Contractor Progress Report Management).

According to the figure below, it can be seen that “Project Management – Owner Progress Report Management” module user satisfaction scores do not change with respect to “age groups.”

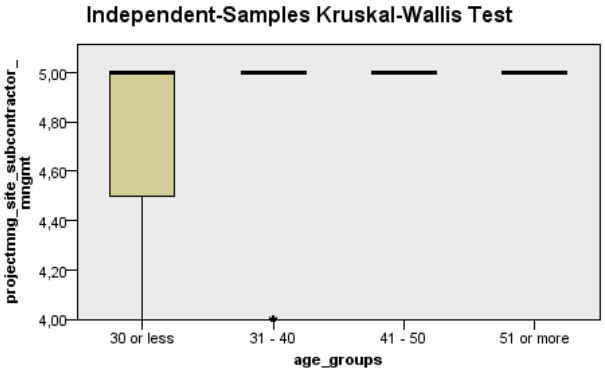


Total N	105
Test Statistic	4,202
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,240

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.26. Kruskal-Wallis Test with respect to Age Groups (Owner Progress Report Management).

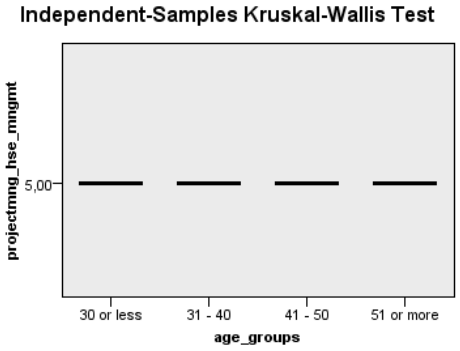
According to the figure below, it can be seen that “Project Management – Site & Subcontractor Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	6,951
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,073

Figure 4.27. Kruskal-Wallis Test with respect to Age Groups (Site & Subcontractor Management).

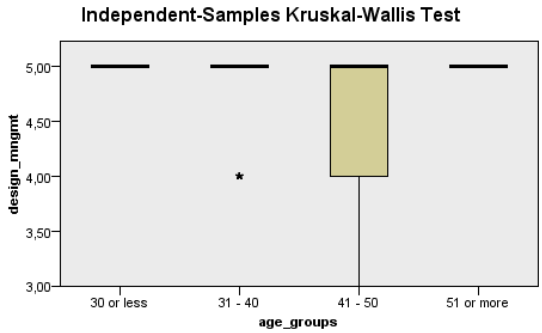
According to the figure below, it can be seen that "Project Management – HSE Management" module user satisfaction scores do not change with respect to "age groups."



Total N	105
Test Statistic	,000
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	1,000

Figure 4.28. Kruskal-Wallis Test with respect to Age Groups (HSE Management Module).

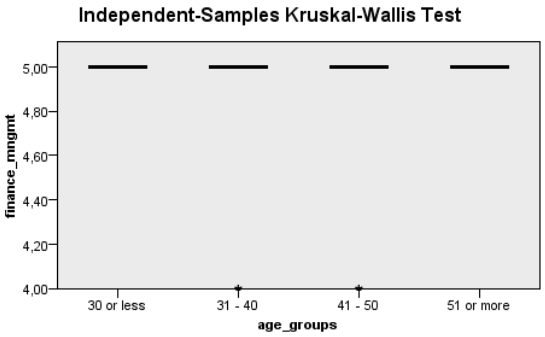
According to the figure below, it can be seen that “Design Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	6,611
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,085

Figure 4.29. Kruskal-Wallis Test with respect to Age Groups (Design Management Module).

According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do not change with respect to “age groups.”

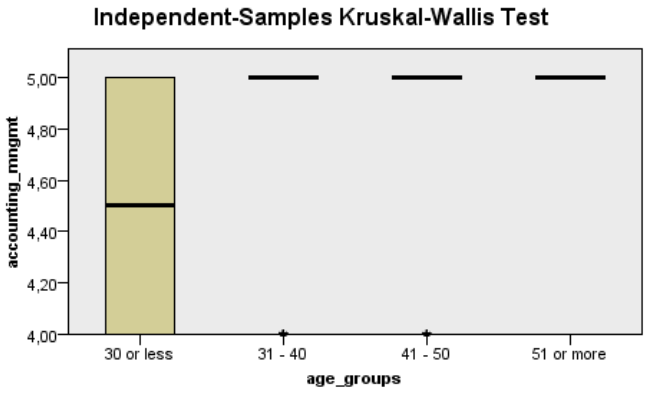


Total N	105
Test Statistic	2,232
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,526

Figure 4.30. Kruskal-Wallis Test with respect to Age Groups (Finance Management Module).

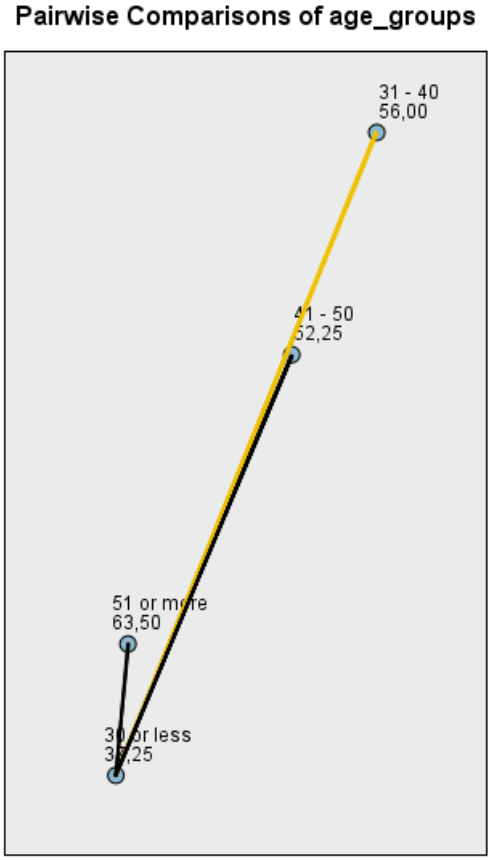
According to the figure below, it can be seen that “Accounting Management” module user satisfaction scores do change with respect to “age groups.” It can be seen that the answers of “30 or less” age group respondents are significantly different than “31 – 40“ age group respondents.

According to Appendix L – Cross Tables Between Factors, %100 of “30 or less” age group members have “10 or less” construction sector experiences but %75 of “31-40” age group members have “11 – 20” construction sector experiences. The more experienced professionals scored the proficiency of the module as 100% “5 – Very High”. Also, 100% of the “30 or less” are from technical office department and they are not actively using accounting module but 50% of “30 or less” group members are scored the module as “4 – High” and others as “5 – Very High”. However, 85.7% of “31-40” age group members scored the proficiency level of accounting module as “5 – Very High”.



Total N	105
Test Statistic	8,490
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,037

Figure 4.31. Kruskal-Wallis Test with respect to Age Groups (Accounting Management Module).

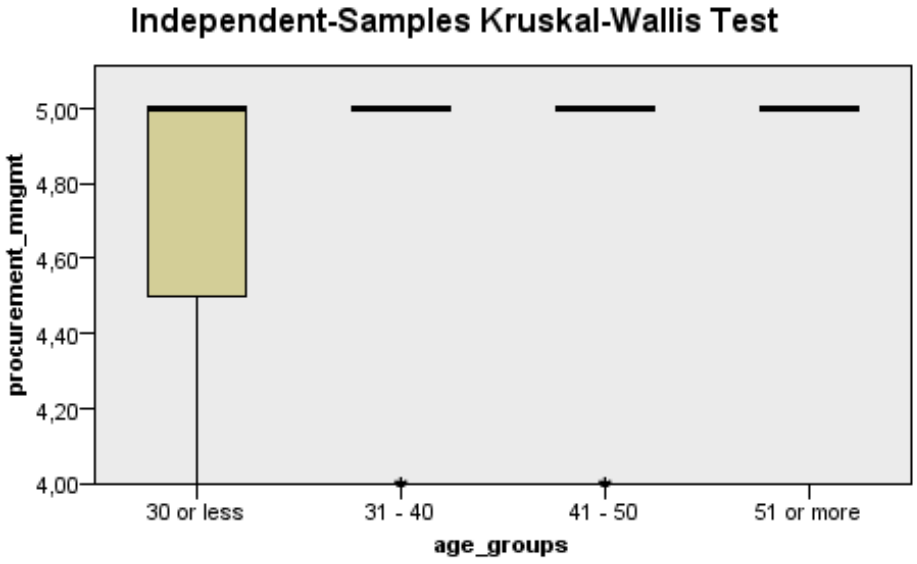


Each node shows the sample average rank of age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
30 or less-41 - 50	-15,000	7,280	-2,060	,039	,236
30 or less-31 - 40	-18,750	6,646	-2,821	,005	,029
30 or less-51 or more	-26,250	16,116	-1,629	,103	,620
41 - 50-31 - 40	3,750	4,793	,782	,434	1,000
41 - 50-51 or more	-11,250	15,444	-,728	,466	1,000
31 - 40-51 or more	-7,500	15,155	-,495	,621	1,000

Figure 4.32. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Accounting Management Module).

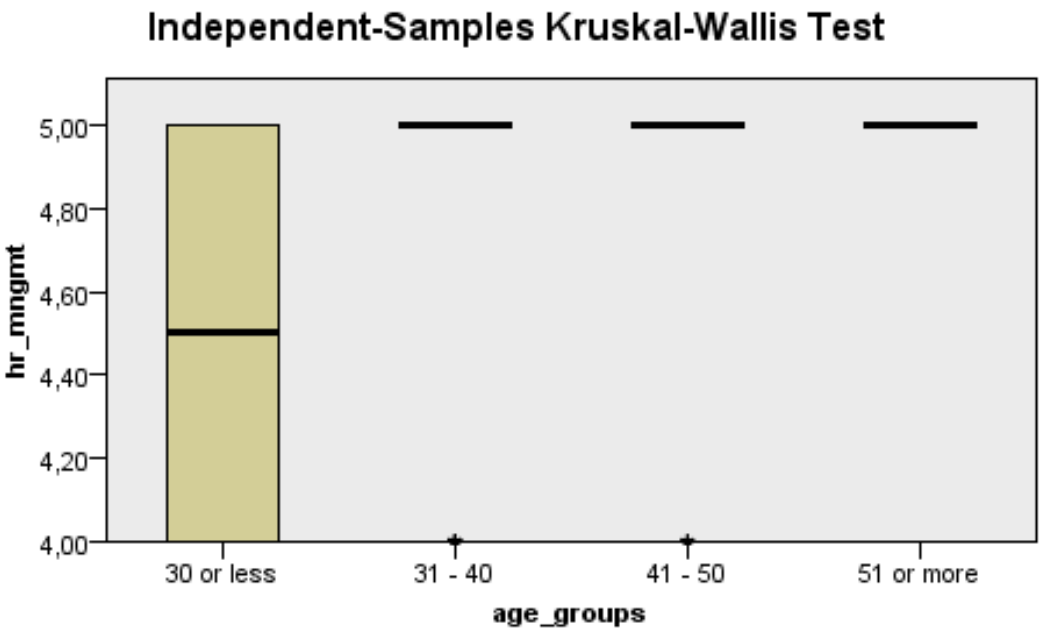
According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	5,597
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,133

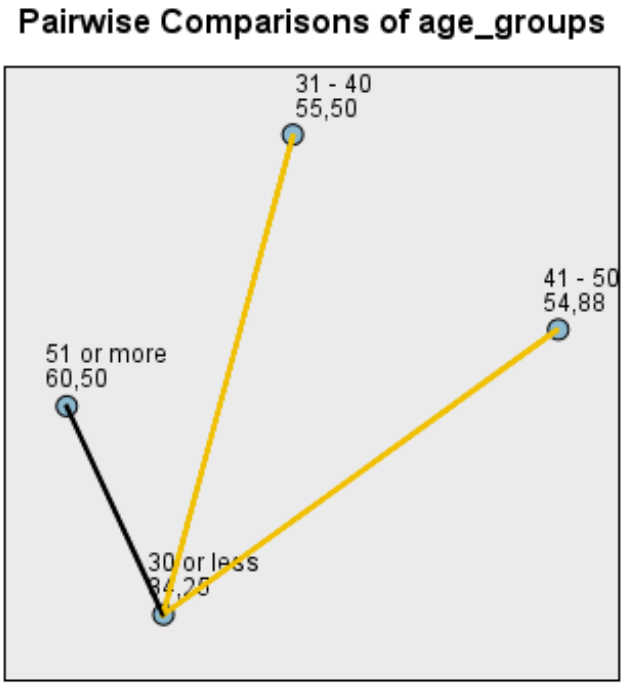
Figure 4.33. Kruskal-Wallis Test with respect to Age Groups (Procurement Management Module).

According to the figure below, it can be seen that “Human Resources Management” module user satisfaction scores do change with respect to “age groups.” It can be seen that the answers of “30 or less” age group respondents are significantly different than “31 – 40” and “41 – 50” age group respondents. According to Appendix L – Cross Tables Between Factors, it can be said that the experienced age groups scored the proficiency of the module as much higher. 75% of “30 or less” scored the module proficiency as 5 – Very High but 95.2% of “31-40” age group members and 89,3% of “41-50” age group members scored the module proficiency as 5-Very High.



Total N	105
Test Statistic	14,156
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,003

Figure 4.34. Kruskal-Wallis Test with respect to Age Groups (Human Resources Management Module).

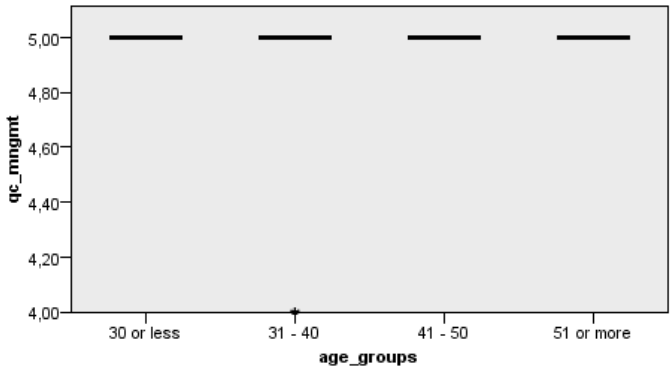


Each node shows the sample average rank of age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
30 or less-41 - 50	-20,625	6,369	-3,238	,001	,007
30 or less-31 - 40	-21,250	5,814	-3,655	,000	,002
30 or less-51 or more	-26,250	14,099	-1,862	,063	,376
41 - 50-31 - 40	,625	4,193	,149	,881	1,000
41 - 50-51 or more	-5,625	13,511	-,416	,677	1,000
31 - 40-51 or more	-5,000	13,258	-,377	,706	1,000

Figure 4.35. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Human Resources Management Module).

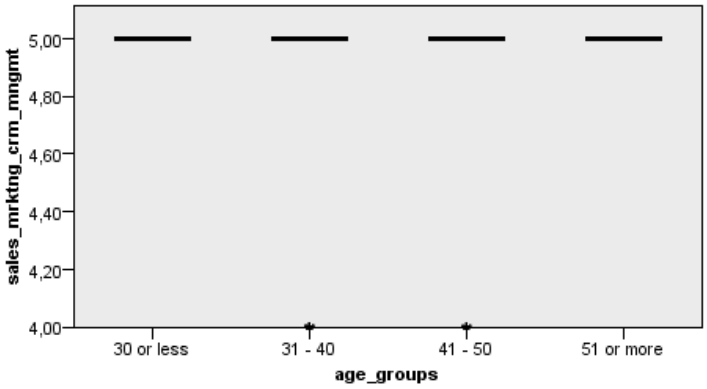
According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	2,039
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,564

Figure 4.36. Kruskal-Wallis Test with respect to Age Groups (Quality Control Management Module).

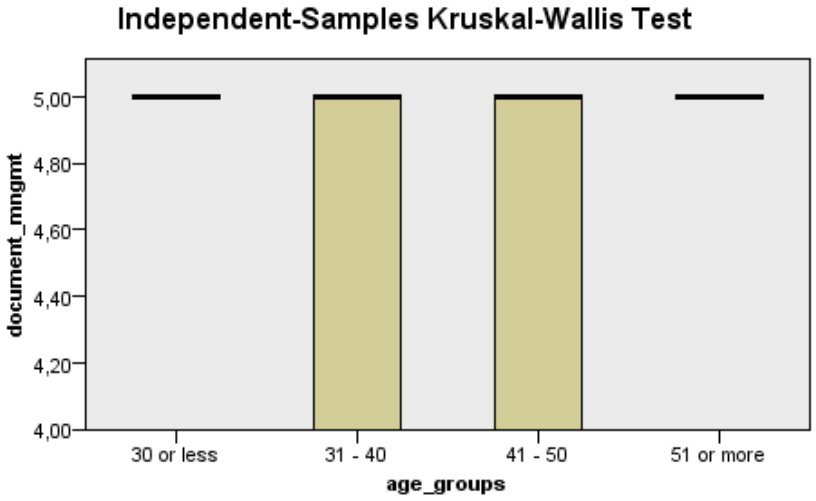
According to the figure below, it can be seen that "Sales & Marketing & CRM Management" module user satisfaction scores do not change with respect to "age groups."



Total N	105
Test Statistic	3,467
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,325

Figure 4.37. Kruskal-Wallis Test with respect to Age Groups (Sales & Marketing & CRM Management Module).

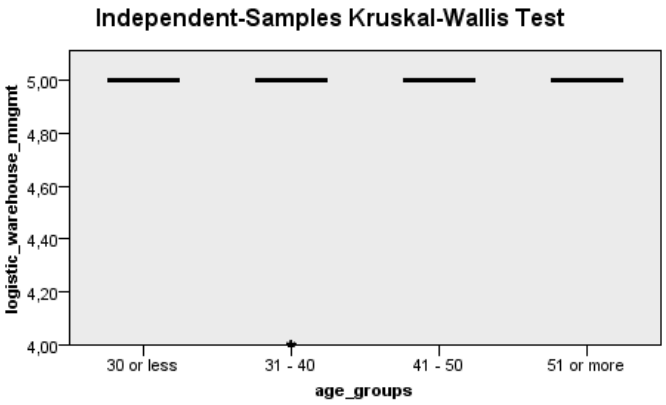
According to the figure below, it can be seen that “Document Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	5,667
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,129

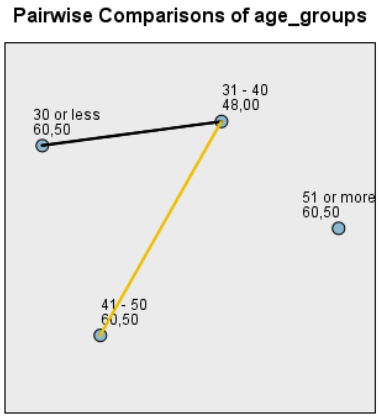
Figure 4.38. Kruskal-Wallis Test with respect to Age Groups (Document Management Module).

According to the figure below, it can be seen that “Logistics & Warehouse Management” module user satisfaction scores do change with respect to “age groups.” It can be seen that the answers of “31 – 40” age group respondents are significantly different than “41 – 50“ age group respondents. Some of the “31-40” age group members have scored as “4 – High” but other members of “31-40” age group members and most of the “41-50” age group members have scored the module proficiency as 5 – Very High.



Total N	105
Test Statistic	11,556
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,009

Figure 4.39. Kruskal-Wallis Test with respect to Age Groups (Logistics & Warehouse Management Module).

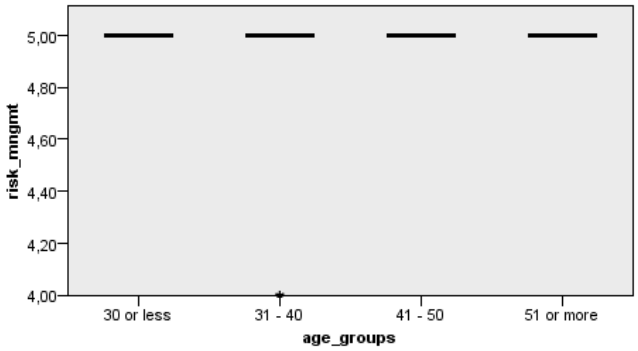


Each node shows the sample average rank of age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
31 - 40-30 or less	12,500	5,814	2,150	,032	,189
31 - 40-41 - 50	-12,500	4,193	-2,981	,003	,017
31 - 40-51 or more	-12,500	13,258	-,943	,346	1,000
30 or less-41 - 50	,000	6,369	,000	1,000	1,000
30 or less-51 or more	,000	14,099	,000	1,000	1,000
41 - 50-51 or more	,000	13,511	,000	1,000	1,000

Figure 4.40. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Logistics & Warehouse Management Module).

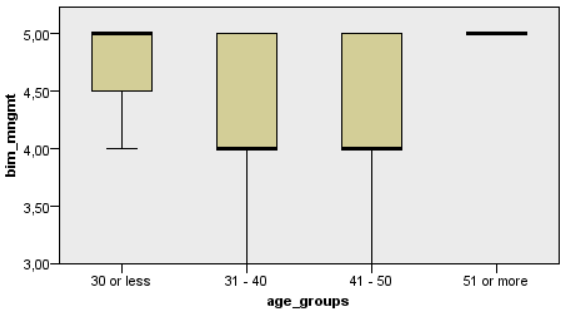
According to the figure below, it can be seen that “Risk Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	2,039
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,564

Figure 4.41. Kruskal-Wallis Test with respect to Age Groups (Risk Management Module).

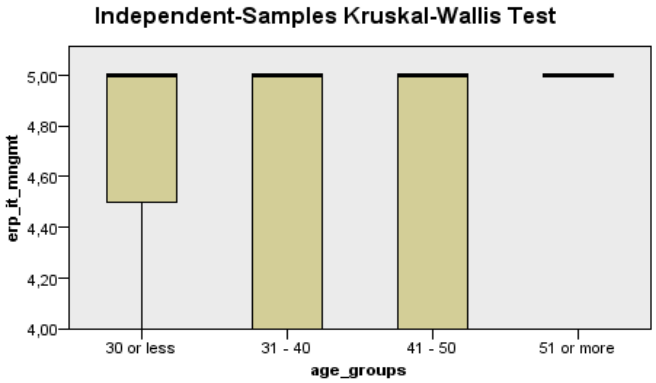
According to the figure below, it can be seen that “BIM Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	6,285
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,099

Figure 4.42. Kruskal-Wallis Test with respect to Age Groups (BIM Management Module).

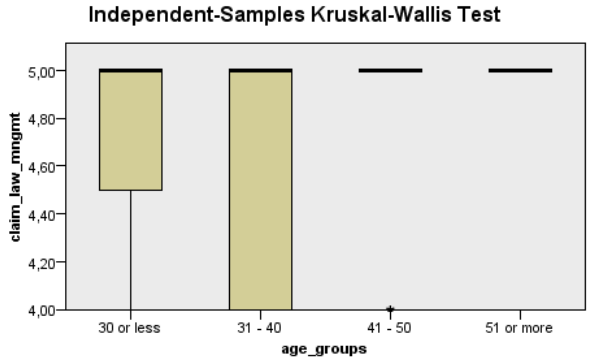
According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	2,741
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,433

Figure 4.43. Kruskal-Wallis Test with respect to Age Groups (ERP & IT Management Module).

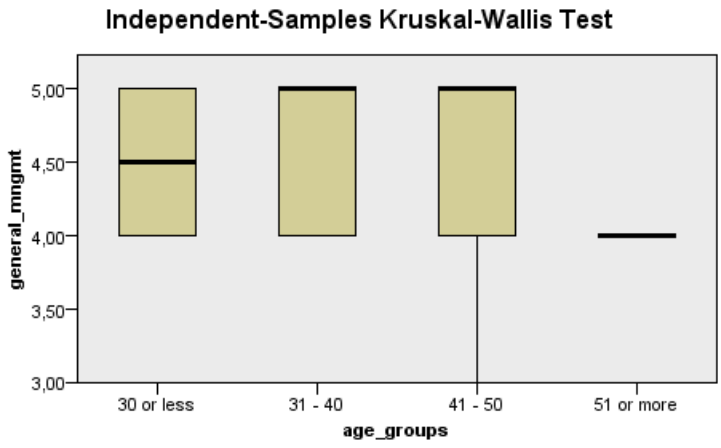
According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	5,852
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,119

Figure 4.44. Kruskal-Wallis Test with respect to Age Groups (Claim & Law Management Module).

According to the figure below, it can be seen that “General Management” module user satisfaction scores do not change with respect to “age groups.”



Total N	105
Test Statistic	3,247
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,355

Figure 4.45. Kruskal-Wallis Test with respect to Age Groups (General Management Module).

4.5.4.2. Kruskal-Wallis Test with Respect To “Business Type”. Here below at Table 4.20 Hypothesis Test Summary (Business Type) Table, it can be seen Kruskal-Wallis test results of all modules with respect to “business type.”

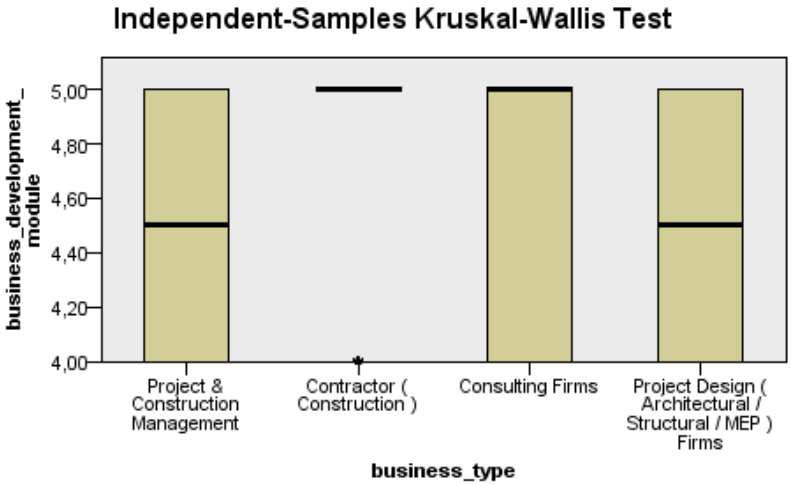
It can be seen from the table that Design Management, Accounting Management, HR Management and Quality Control Management, Sales & Marketing & CRM Managements, Logistic & Warehouse Management, Risk Management, BIM Management, ERP & IT Management and General Management modules user satisfaction survey scores changes with respondent “business type”.

Table 4.20. Hypothesis Test Summary (Business Type).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,164	Retain the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,293	Retain the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,613	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,613	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,613	Retain the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,613	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,293	Retain the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,124	Retain the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,253	Retain the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,029	Reject the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,124	Retain the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,017	Reject the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,033	Reject the null hypothesis.
18	The distribution of document_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,342	Retain the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,006	Reject the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,065	Retain the null hypothesis.
24	The distribution of general_mngmt is the same across categories of business_type.	Independent-Samples Kruskal-Wallis Test	0,010	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is ,05.				

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to “business type” of the respondents in details.

According to the figure below, it can be seen that “Business Development” module user satisfaction scores do not change with respect to “business type.”

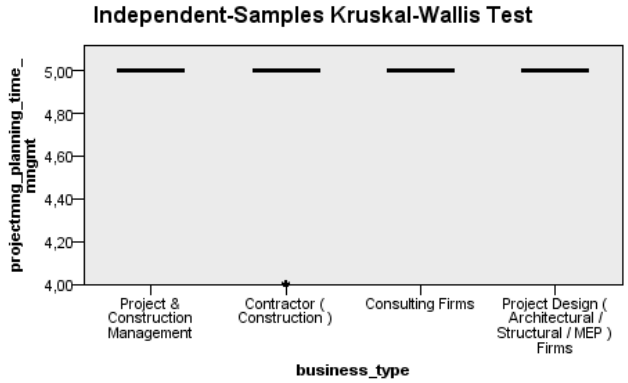


Total N	105
Test Statistic	5,105
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,164

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.46. Kruskal-Wallis Test with respect to Business Type (Business Development Module).

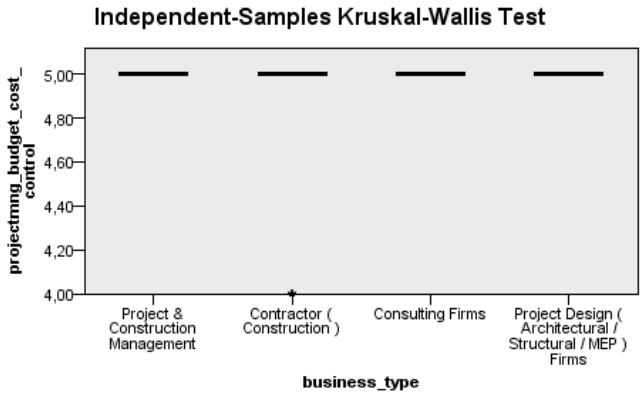
According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do not change with respect to “business type.”



Total N	105
Test Statistic	3,725
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,293

Figure 4.47 Kruskal-Wallis Test with respect to Business Type (Planning & Time Management Module)

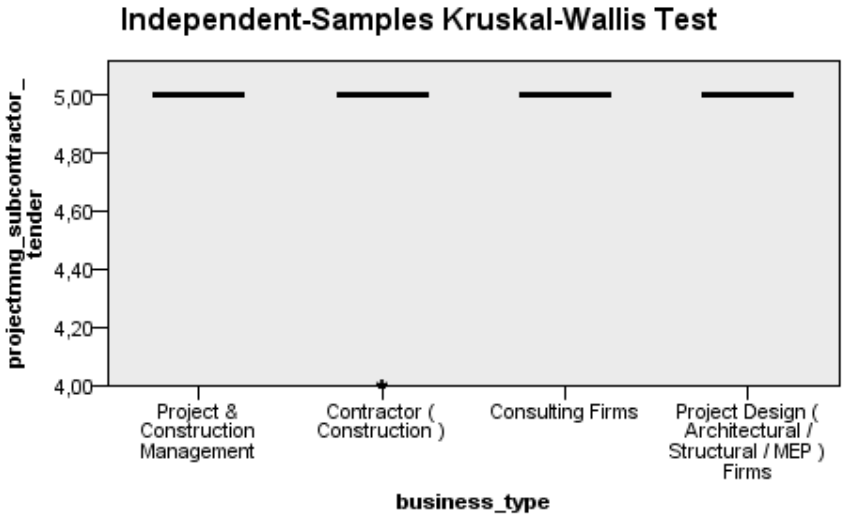
According to the figure below, it can be seen that "Project Management – Budget & Cost Control Management" module user satisfaction scores do not change with respect to "business type."



Total N	105
Test Statistic	1,807
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,613

Figure 4.48. Kruskal-Wallis Test with respect to Business Type (Budget & Cost Control Management Module).

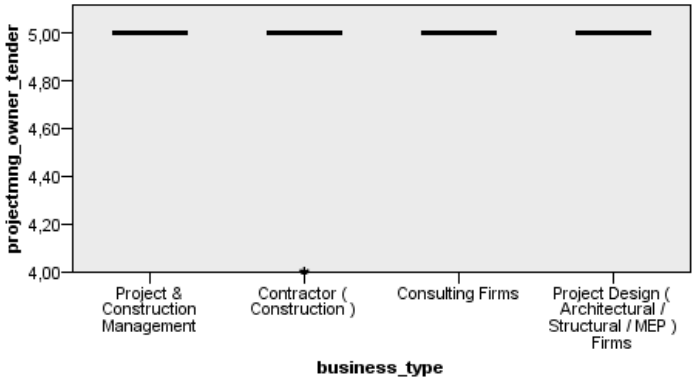
According to the figure below, it can be seen that “Project Management – Sub-Contractor Tender Management” module user satisfaction scores do not change with respect to “business type.”



Total N	105
Test Statistic	1,807
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,613

Figure 4.49. Kruskal-Wallis Test with respect to Business Type (Sub-Contractor Tender Management Module).

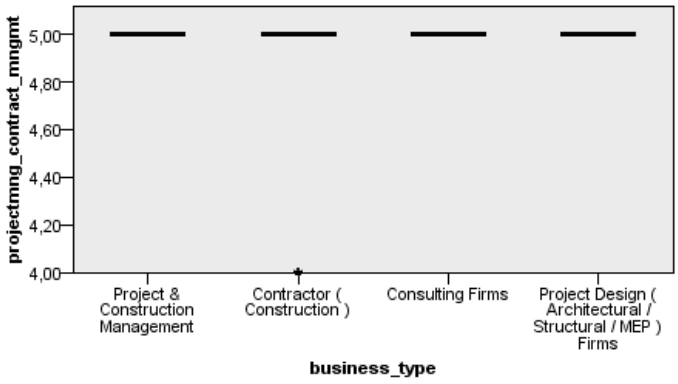
According to the figure below, it can be seen that “Project Management – Owner Tender Management” module user satisfaction scores do not change with respect to “business type.”



Total N	105
Test Statistic	1,807
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,613

Figure 4.50. Kruskal-Wallis Test with respect to Business Type (Owner Tender Management Module).

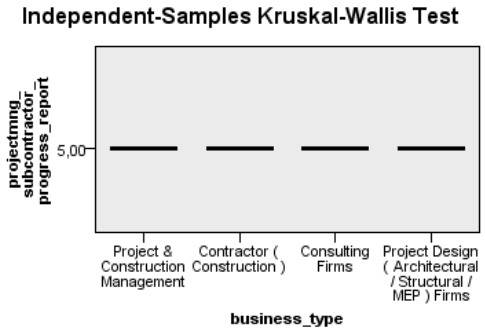
According to the figure below, it can be seen that "Project Management – Contract Management" module user satisfaction scores do not change with respect to "business type."



Total N	105
Test Statistic	1,807
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,613

Figure 4.51. Kruskal-Wallis Test with respect to Business Type (Contract Management Module).

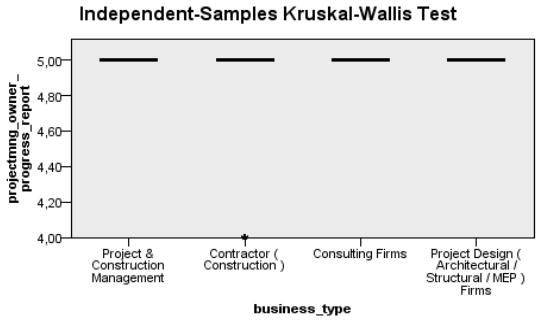
According to the figure below, it can be seen that “Project Management – Sub-Contract Management” module user satisfaction scores do not change with respect to “business type.”



Total N	105
Test Statistic	,000
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	1,000

Figure 4.52. Kruskal-Wallis Test with respect to Business Type (Sub-Contract Management Module).

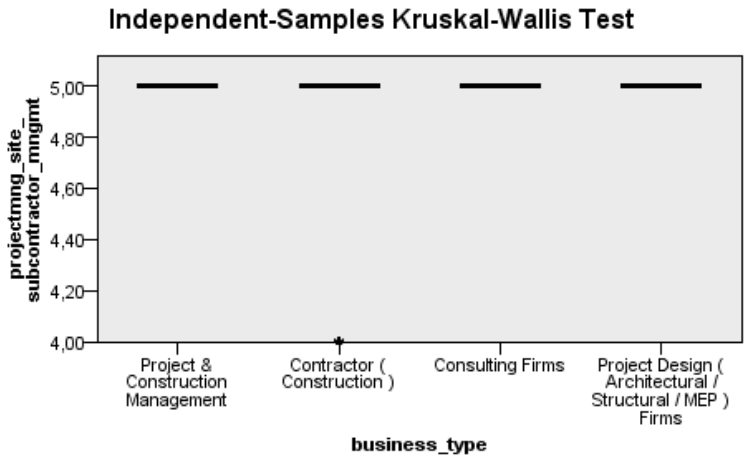
According to the figure below, it can be seen that “Project Management – Owner Progress Report Management” module user satisfaction scores do not change with respect to “business type.”



Total N	105
Test Statistic	3,725
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,293

Figure 4.53. Kruskal-Wallis Test with respect to Business Type (Owner Progress Report Management Module).

According to the figure below, it can be seen that “Project Management – Site & Subcontractor Management” module user satisfaction scores do not change with respect to “business type.”

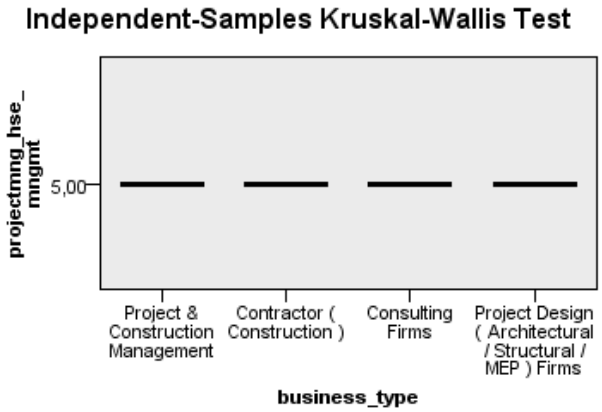


Total N	105
Test Statistic	5,761
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,124

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.54. Kruskal-Wallis Test with respect to Business Type (Site & Subcontractor Management Module).

According to the figure below, it can be seen that “Project Management – HSE Management” module user satisfaction scores do not change with respect to “business type.”

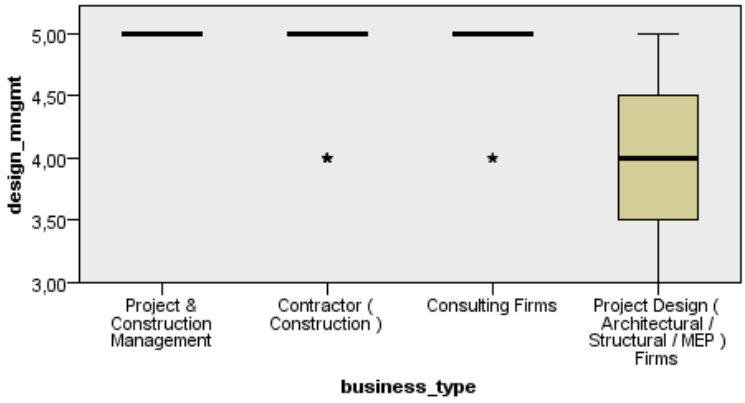


Total N	105
Test Statistic	,000
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	1,000

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

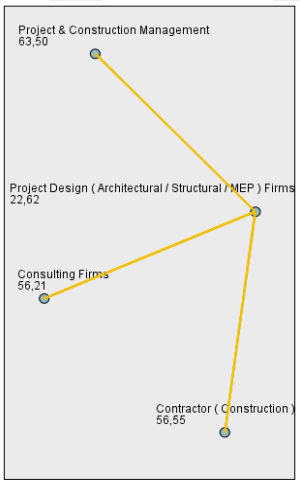
Figure 4.55. Kruskal-Wallis Test with respect to Business Type (HSE Management Module).

According to the figure below, it can be seen that "Design Management" module user satisfaction scores do change with respect to "business type." It can be seen that the answers of "Project Design Firms" business type respondents are significantly different than "Consulting", "Contractor (Construction)" and "Project & Construction Management" business type respondents. According to Appendix I – Cross Tables, 100% of Project & Construction Management firms, 86.4% of Contractor firms and 85.7% of Consulting Firms members scored the proficiency of the module as 5 – Very High. However, 25% of Project Design firms scored the proficiency of the module as 5 – Very High, 50% of them scored as 4 – High and remaining 25% of them scored as 3 – Medium. It can be said that Project Design firms demand much more advanced Design Management module but at the overall 97,1% from different business type have scored the module proficiency as 4-High or higher than 4-High level.



Total N	105
Test Statistic	28,528
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

Figure 4.56. Kruskal-Wallis Test with respect to Business Type (Design Management Module).

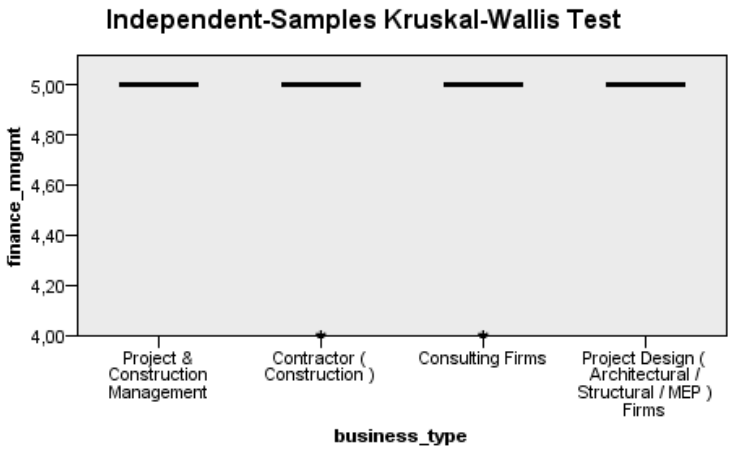


Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	33,589	7,659	4,386	,000	,000
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	33,920	6,642	5,107	,000	,000
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	40,875	10,583	3,862	,000	,001
Consulting Firms-Contractor (Construction)	,331	5,303	,062	,950	1,000
Consulting Firms-Project & Construction Management	7,286	9,798	,744	,457	1,000
Contractor (Construction)-Project & Construction Management	6,955	9,025	,771	,441	1,000

Figure 4.57. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Design Management Module).

According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do not change with respect to “business type.”

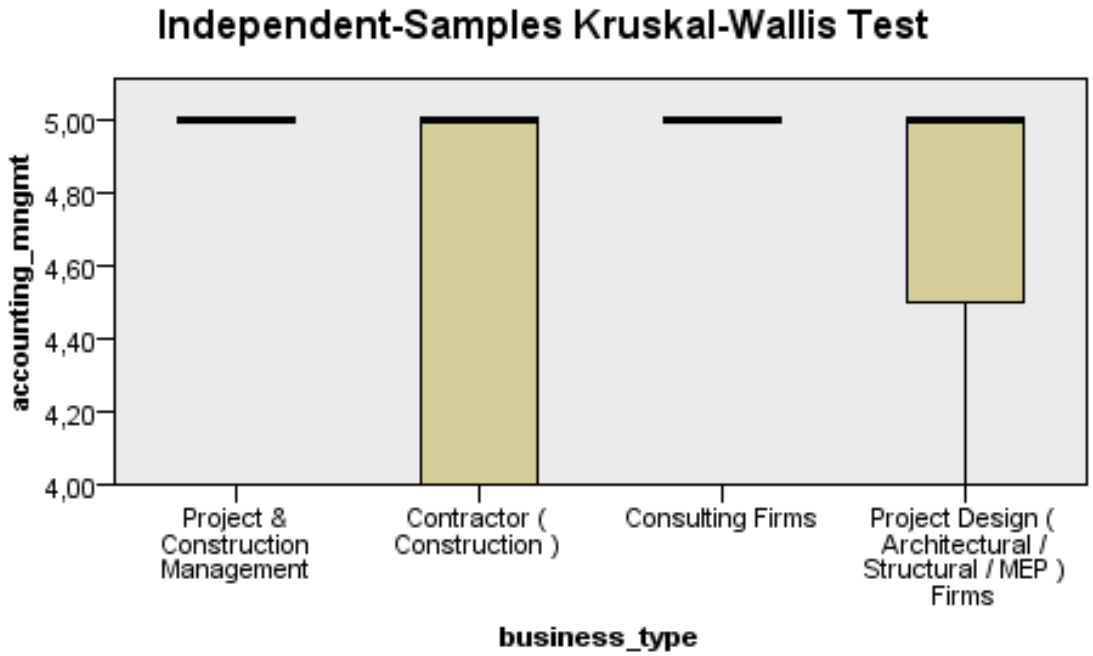


Total N	105
Test Statistic	4,083
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,253

Figure 4.58. Kruskal-Wallis Test with respect to Business Type (Finance Management Module).

According to the figure below, it can be seen that “Accounting Management” module user satisfaction scores do change with respect to “business type.”

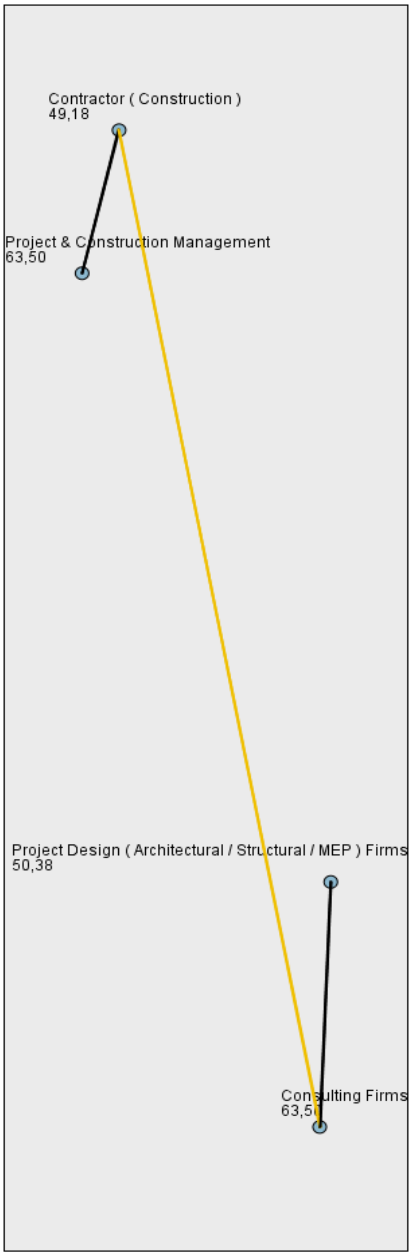
It can be seen that the answers of “Contractor (Construction)” business type respondents are significantly different than “Consulting” business type respondents. 72.7% of Contractor professionals have scored the module proficiency as 5-Very High, but 100% of consulting firms scored the module proficiency as 5 – Very High. Accounting department of Contractor firms may demand much more advanced module proficiency with respect to Consulting firms.



Total N	105
Test Statistic	9,032
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,029

1. The test statistic is adjusted for ties.

Figure 4.59. Kruskal-Wallis Test with respect to Business Type (Accounting Management Module).

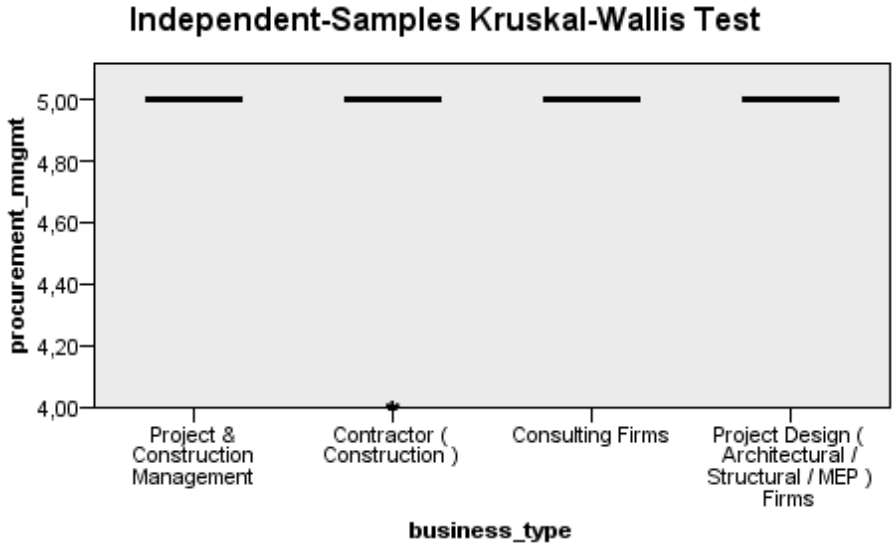


Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Contractor (Construction)-Project Design (Architectural / Structural / MEP) Firms	-1,193	6,622	-,180	,857	1,000
Contractor (Construction)-Project & Construction Management	14,318	8,997	1,591	,112	,669
Contractor (Construction)-Consulting Firms	-14,318	5,287	-2,708	,007	,041
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	13,125	10,550	1,244	,213	1,000
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	13,125	7,636	1,719	,086	,514
Project & Construction Management-Consulting Firms	,000	9,768	,000	1,000	1,000

Figure 4.60. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Accounting Management Module).

According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do not change with respect to “business type.”

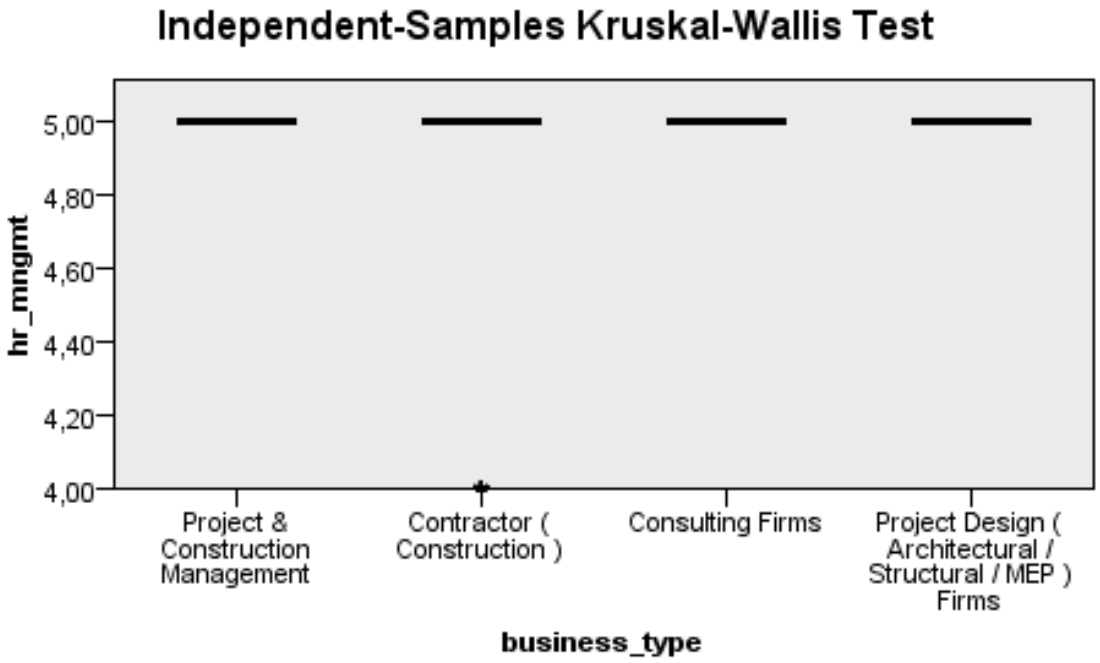


Total N	105
Test Statistic	5,761
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,124

Figure 4.61. Kruskal-Wallis Test with respect to Business Type (Procurement Management Module).

According to the figure below, it can be seen that “Human Resources Management” module user satisfaction scores do change with respect to “business type.” It can be seen that the answers of “Contractor (Construction)” business type respondents are significantly different than “Consulting” business type respondents.

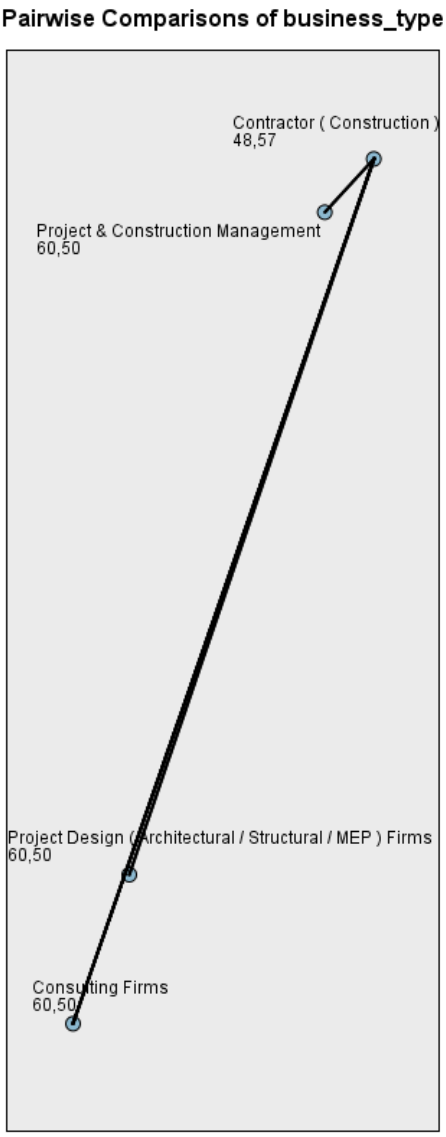
77.3% of Contractor professionals have scored the module proficiency as 5-Very High, but 100% of consulting firms scored the module proficiency as 5 – Very High. Human Resources department of Contractor firms may demand much more advanced module proficiency with respect to Consulting firms.



Total N	105
Test Statistic	10,242
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,017

1. The test statistic is adjusted for ties.

Figure 4.62. Kruskal-Wallis Test with respect to Business Type (Human Resources Management Module).



Each node shows the sample average rank of business_type.

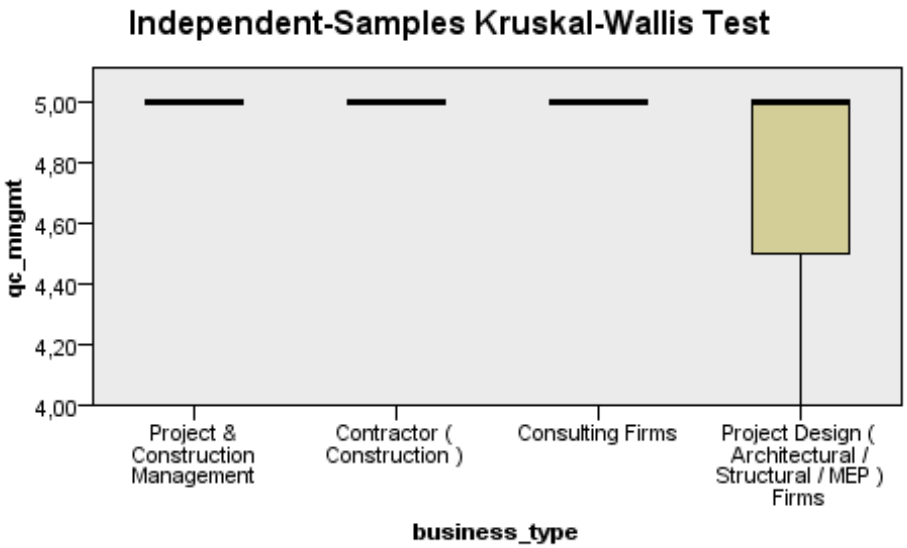
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Contractor (Construction)-Project & Construction Management	11,932	7,871	1,516	,130	,777
Contractor (Construction)-Consulting Firms	-11,932	4,625	-2,580	,010	,059
Contractor (Construction)-Project Design (Architectural / Structural / MEP) Firms	-11,932	5,793	-2,060	,039	,237
Project & Construction Management-Consulting Firms	,000	8,545	,000	1,000	1,000
Project & Construction Management-Project Design (Architectural / Structural / MEP) Firms	,000	9,230	,000	1,000	1,000
Consulting Firms-Project Design (Architectural / Structural / MEP) Firms	,000	6,680	,000	1,000	1,000

Figure 4.63. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Human Resources Management Module).

According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores do change with respect to “business type.”

It can be seen that the answers of “Project Design Firms” business type respondents are significantly different than “Consulting”, “Contractor (Construction)” and “Project & Construction Management” business type respondents.

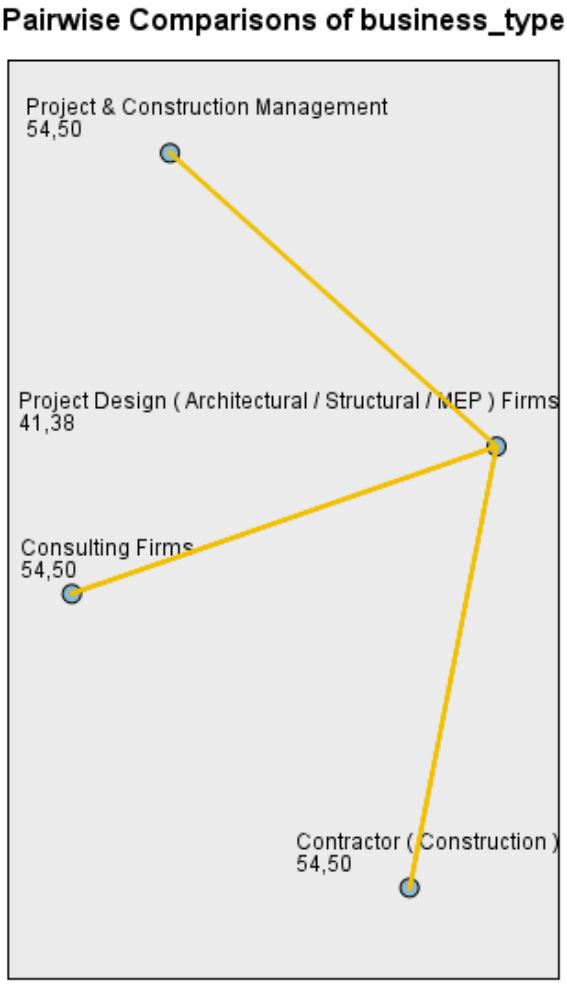
75% of Project Design professionals have scored the module proficiency as 5-Very High, but 100% of Consulting, Contractor and Project & Construction Management firms scored the module proficiency as 5 – Very High.



Total N	105
Test Statistic	23,706
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.64. Kruskal-Wallis Test with respect to Business Type (Quality Control Management Module).



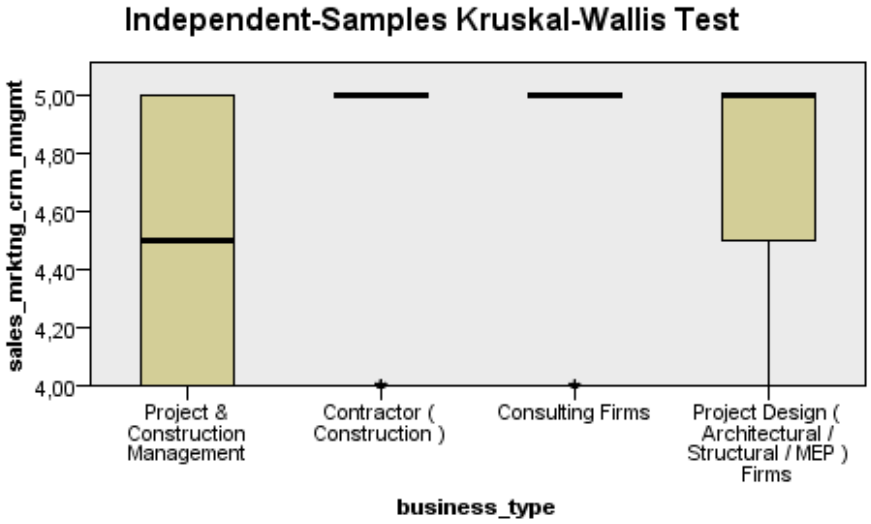
Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	13,125	4,394	2,987	,003	,017
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	13,125	2,758	4,759	,000	,000
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	13,125	3,180	4,127	,000	,000
Project & Construction Management-Contractor (Construction)	,000	3,747	,000	1,000	1,000
Project & Construction Management-Consulting Firms	,000	4,068	,000	1,000	1,000
Contractor (Construction)-Consulting Firms	,000	2,202	,000	1,000	1,000

Figure 4.65. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Quality Control Management Module).

According to the figure below, it can be seen that “Sales & Marketing & CRM Management” module user satisfaction scores change with respect to “business type.” It can be seen that the answers of “Project & Construction Management” business type respondents are significantly different than “Contractor (Construction)” business type respondents.

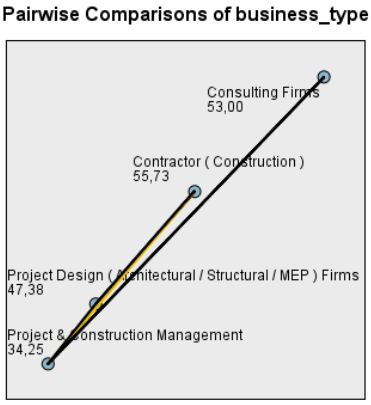
50% of Project & Construction Management professionals have scored the module proficiency as 5-Very High, but 90,9% of Contractor firms scored the module proficiency as 5 – Very High. Project & Construction Management professionals consist of only about 6% of total interviewees and they are not actively using CRM modules but Contractors consist of about 63% of total interviewees and they are actively using CRM and related modules. There is inconsistency at this part of data.



Total N	105
Test Statistic	8,745
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,033

1. The test statistic is adjusted for ties.

Figure 4.66. Kruskal-Wallis Test with respect to Business Type (Sales & Marketing & CRM Management Module).

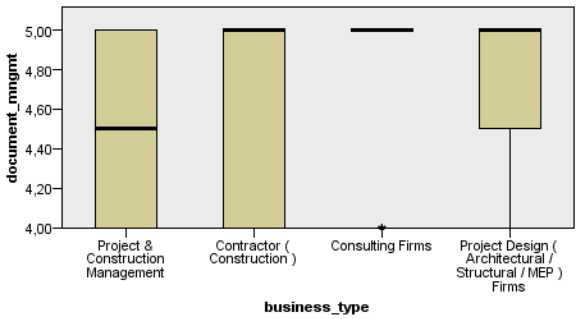


Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project & Construction Management-Project Design (Architectural / Structural / MEP) Firms	-13,125	9,230	-1,422	,155	,930
Project & Construction Management-Consulting Firms	-18,750	8,545	-2,194	,028	,169
Project & Construction Management-Contractor (Construction)	-21,477	7,871	-2,729	,006	,038
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	5,625	6,680	,842	,400	1,000
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	8,352	5,793	1,442	,149	,896
Consulting Firms-Contractor (Construction)	2,727	4,625	,590	,555	1,000

Figure 4.67. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Sales & Marketing & CRM Management Module).

According to the figure below, it can be seen that “Document Management” module user satisfaction scores do not change with respect to “business type.”



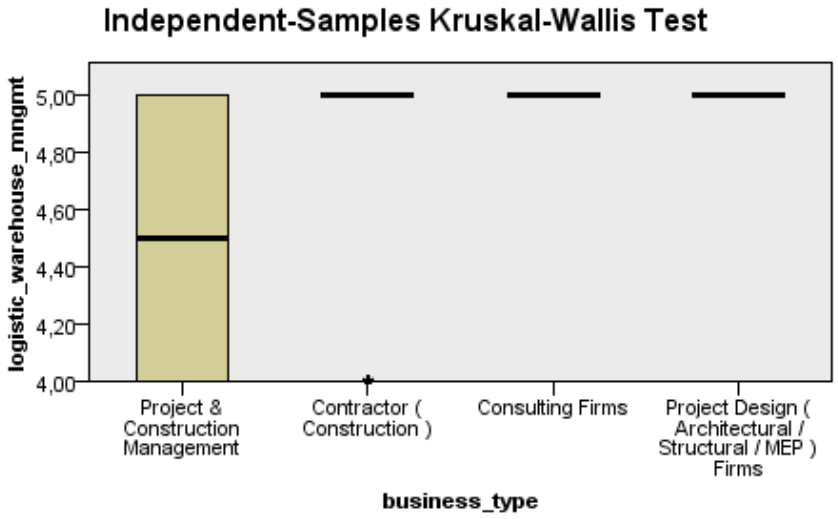
Total N	105
Test Statistic	3,343
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,342

Figure 4.68. Kruskal-Wallis Test with respect to Business Type (Document Management Module).

According to the figure below, it can be seen that “Logistics & Warehouse Management” module user satisfaction scores change with respect to “business type.”

It can be seen that the answers of “Project & Construction Management” business type respondents are significantly different than “Consulting” and “Project Design Firms” business type respondents.

50% of Project & Construction Management professionals have scored the module proficiency as 5-Very High and other 50% of them as 4 – High, but 100% of Consulting and Project Design firms scored the module proficiency as 5 – Very High. However, 85.7% of total interviewees have scored as 5 – Very High.

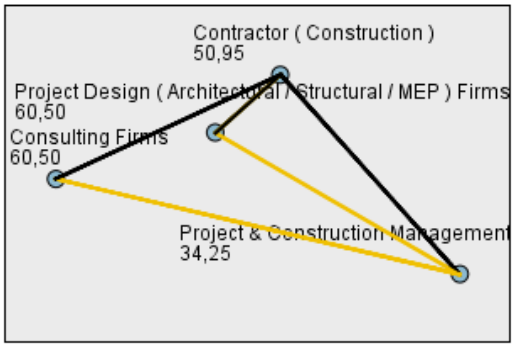


Total N	105
Test Statistic	12,448
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,006

1. The test statistic is adjusted for ties.

Figure 4.69. Kruskal-Wallis Test with respect to Business Type (Logistics & Warehouse Management Module).

Pairwise Comparisons of business_type



Each node shows the sample average rank of business_type.

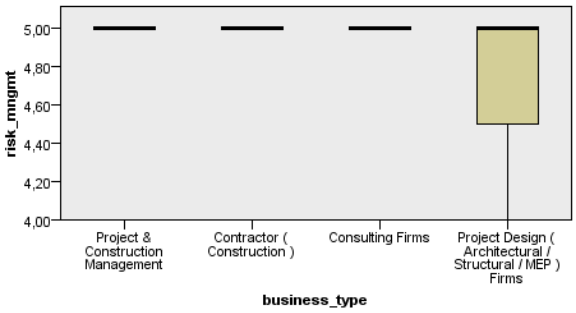
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project & Construction Management-Contractor (Construction)	-16,705	7,871	-2,122	,034	,203
Project & Construction Management-Consulting Firms	-26,250	8,545	-3,072	,002	,013
Project & Construction Management-Project Design (Architectural / Structural / MEP) Firms	-26,250	9,230	-2,844	,004	,027
Contractor (Construction)-Consulting Firms	-9,545	4,625	-2,064	,039	,234
Contractor (Construction)-Project Design (Architectural / Structural / MEP) Firms	-9,545	5,793	-1,648	,099	,596
Consulting Firms-Project Design (Architectural / Structural / MEP) Firms	,000	6,680	,000	1,000	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Figure 4.70. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Logistics & Warehouse Management Module).

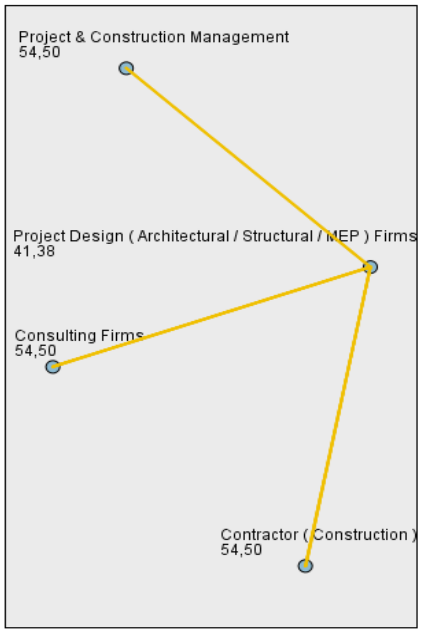
According to the figure below, it can be seen that “Risk Management” module user satisfaction scores do change with respect to “business type.” It can be seen that the answers of “Project Design Firms” business type respondents are significantly different than “Consulting”, “Contractor (Construction)” and “Project & Construction Management” business type respondents.

75% of Project Design professionals have scored the module proficiency as 5 – Very High and other 25% of them as 4 – High, but 100% of Consulting, Contractor and Project Management firms scored the module proficiency as 5 – Very High.



Total N	105
Test Statistic	23,706
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

Figure 4.71. Kruskal-Wallis Test with respect to Business Type (Risk M. Module).



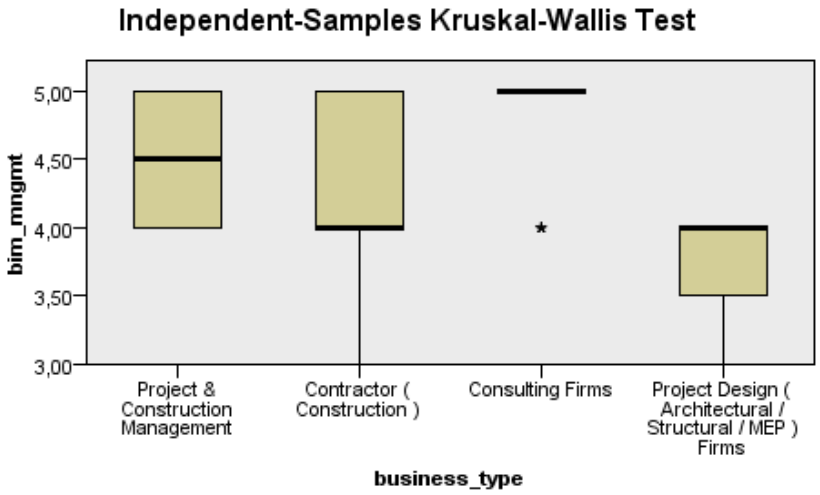
Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	13,125	4,394	2,987	,003	,017
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	13,125	2,758	4,759	,000	,000
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	13,125	3,180	4,127	,000	,000
Project & Construction Management-Contractor (Construction)	,000	3,747	,000	1,000	1,000
Project & Construction Management-Consulting Firms	,000	4,068	,000	1,000	1,000
Contractor (Construction)-Consulting Firms	,000	2,202	,000	1,000	1,000

Figure 4.72. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (Risk Management Module).

According to the figure below, it can be seen that “BIM Management” module user satisfaction scores do change with respect to “business type.” It can be seen that the answers of “Project Design Firms” business type respondents are significantly different than “Consulting” and “Contractor (Construction)” business type respondents, and also the answers of “Contractor (Construction)” business type respondents are significantly different than “Consulting” business type respondents.

75% of Project & Construction Management professionals have scored the module proficiency as 4 – High and other 25% of them as 3 – Middle, but 85.7% of Consulting firms and 45.5% of Contractor firms scored the module proficiency as 5 – Very High. Also, 4.5% of Contractor professionals have scored the module proficiency as 3 – Middle. However, 94.3% of total interviewees have scored as 4 – High or higher. It can be said that especially for Project Design firms, BIM Management module can be improved because Project Design firms will actively use this module.



Total N	105
Test Statistic	25,579
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

Figure 4.73. Kruskal-Wallis Test with respect to Business Type (BIM Management Module).

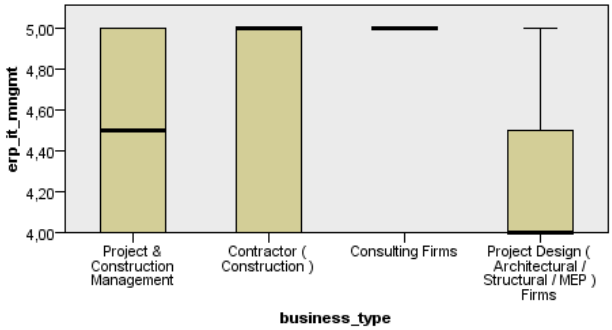
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	28,023	8,494	3,299	,001	,006
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	31,500	13,532	2,328	,020	,120
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	49,179	9,794	5,021	,000	,000
Contractor (Construction)-Project & Construction Management	3,477	11,540	,301	,763	1,000
Contractor (Construction)-Consulting Firms	-21,156	6,781	-3,120	,002	,011
Project & Construction Management-Consulting Firms	-17,679	12,529	-1,411	,158	,949

Figure 4.74. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (BIM Management Module).

According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores change with respect to “business type.”

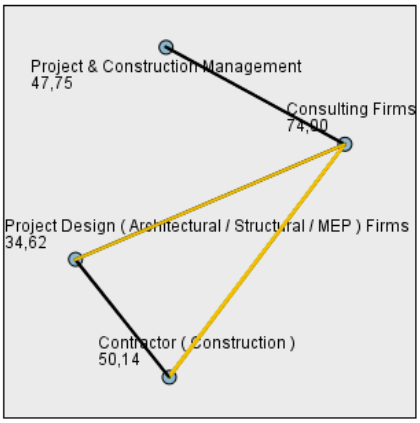
It can be seen that the answers of “Project Design Firms” business type respondents are significantly different than “Consulting”, and the answers of “Contractor” business type respondents are significantly different than “Consulting” business type respondents.

100% of Consulting firm professionals have scored the module proficiency as 5-Very High, but 75% of Project Design firms professionals and 45.5% scored the module proficiency as 4 – High.



Total N	105
Test Statistic	20,991
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,000

Figure 4.75. Kruskal-Wallis Test with respect to Business Type (ERP & IT Management Module).

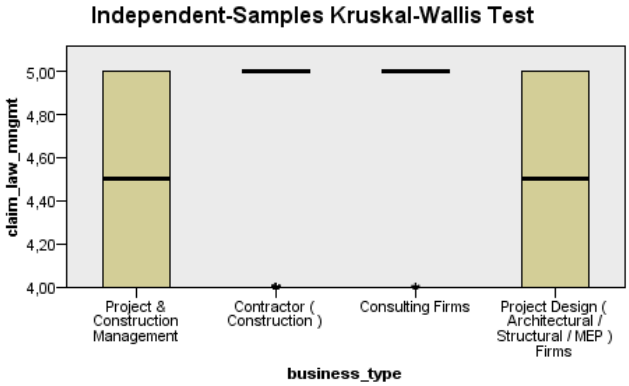


Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	13,125	12,921	1,016	,310	1,000
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	15,511	8,110	1,913	,056	,335
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	39,375	9,352	4,210	,000	,000
Project & Construction Management-Contractor (Construction)	-2,386	11,019	-,217	,829	1,000
Project & Construction Management-Consulting Firms	-26,250	11,963	-2,194	,028	,169
Contractor (Construction)-Consulting Firms	-23,864	6,475	-3,686	,000	,001

Figure 4.76. Kruskal-Wallis Pairwise Comparison Test with respect to Business Type (ERP & IT Management Module).

According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores do not change with respect to “business type.”



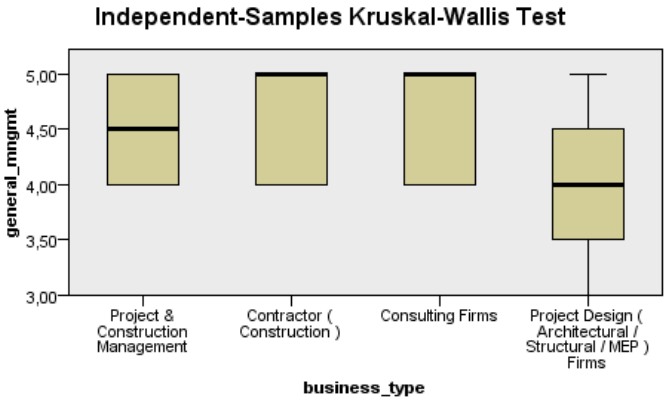
Total N	105
Test Statistic	7,232
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,065

Figure 4.77. Kruskal-Wallis Test with respect to Business Type (Claim & Law Management Module).

According to the figure below, it can be seen that “General Management” module user satisfaction scores do change with respect to “business type.” It can be seen that the answers of “Project Design Firms” business type respondents are significantly different than “Contractor (Construction)” business type respondents.

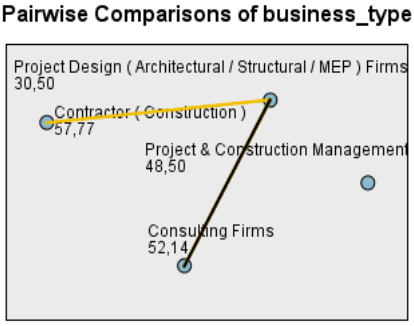
68.2% of Contractor professionals have scored the module proficiency as 5-Very High and 31.8% of them as 4 – High, but 25% of Project Design firm professionals scored the module proficiency as 5 – Very High and 50% of them as 4 – High.

It can be said that General Management module is needed mostly for Contractor firms due to high number of employees and they scored much higher than Project Design firms that they are generally much small offices with respect to other business types.



Total N	105
Test Statistic	11,352
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,010

Figure 4.78. Kruskal-Wallis Test with respect to Business Type (General Management Module).



Each node shows the sample average rank of business_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Project Design (Architectural / Structural / MEP) Firms-Project & Construction Management	18,000	13,035	1,381	,167	1,000
Project Design (Architectural / Structural / MEP) Firms-Consulting Firms	21,643	9,434	2,294	,022	,131
Project Design (Architectural / Structural / MEP) Firms-Contractor (Construction)	27,273	8,182	3,333	,001	,005
Project & Construction Management-Consulting Firms	-3,643	12,068	-,302	,763	1,000
Project & Construction Management-Contractor (Construction)	-9,273	11,117	-,834	,404	1,000
Consulting Firms-Contractor (Construction)	5,630	6,532	,862	,389	1,000

Figure 4.79. Kruskal-Wallis Test with respect to Business Type (General Management Module).

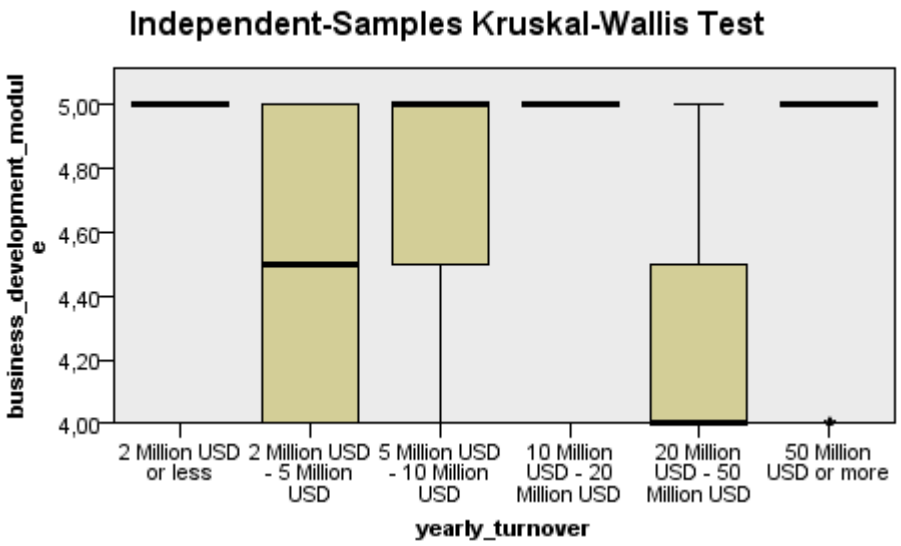
4.5.4.3. Kruskal-Wallis Test with Respect To "Yearly Turnover". Here below at Table 4.21 Hypothesis Test Summary (Yearly Turnover) Table, it can be seen Kruskal-Wallis test results of all modules with respect to "yearly turnover." It can be seen from the table that Business Development, Owner Tender, Design Management, Quality Control Management, Risk Management, BIM Management, ERP & IT Management, Claim & Law Management and General Management modules user satisfaction survey scores changes with respondent company "yearly turnover".

Table 4.21. Hypothesis Test Summary (Yearly Turnover).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,187	Retain the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,603	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,603	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,603	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,053	Retain the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,101	Retain the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,053	Retain the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,056	Retain the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,101	Retain the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,052	Retain the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,011	Reject the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,052	Retain the null hypothesis.
18	The distribution of document_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,265	Retain the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,052	Retain the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,011	Reject the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,004	Reject the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,008	Reject the null hypothesis.
24	The distribution of general_mngmt is the same across categories of yearly_turnover.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to "yearly turnover" of the companies of respondents in details.

According to the figure below, it can be seen that "Business Development" module user satisfaction scores change with respect to "yearly turnover" of the respondent's companies. It can be seen that the answers of "20 – 50 Million USD" yearly turnover respondents are significantly different than "50 Million USD or more" and "2 Million USD or less" yearly turnover respondents. Also, the answers of "2 – 5 Million USD" yearly turnover respondents are significantly different than "2 Million USD or less" yearly turnover respondents.

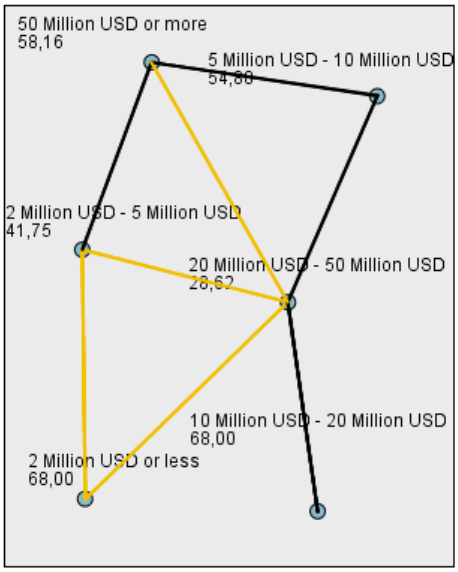


Total N	105
Test Statistic	24,830
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.80. Kruskal-Wallis Test with respect to Yearly Turnover (Business Development Module)

Pairwise Comparisons of yearly_turnover

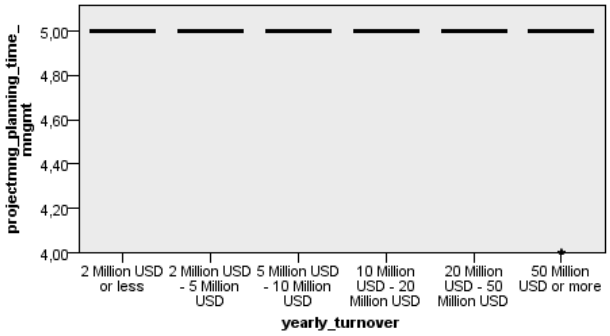


Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
20 Million USD - 50 Million USD-2 Million USD - 5 Million USD	13,125	8,881	1,478	,139	1,000
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	26,250	9,729	2,698	,007	,105
20 Million USD - 50 Million USD-50 Million USD or more	-29,531	7,691	-3,840	,000	,002
20 Million USD - 50 Million USD-2 Million USD or less	39,375	9,729	4,047	,000	,001
20 Million USD - 50 Million USD-10 Million USD - 20 Million USD	39,375	15,383	2,560	,010	,157
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-13,125	8,881	-1,478	,139	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-16,406	6,586	-2,491	,013	,191
2 Million USD - 5 Million USD-2 Million USD or less	26,250	8,881	2,956	,003	,047
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-26,250	14,861	-1,766	,077	1,000
5 Million USD - 10 Million USD-50 Million USD or more	-3,281	7,691	-,427	,670	1,000
5 Million USD - 10 Million USD-2 Million USD or less	13,125	9,729	1,349	,177	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	-13,125	15,383	-,853	,394	1,000
50 Million USD or more-2 Million USD or less	9,844	7,691	1,280	,201	1,000
50 Million USD or more-10 Million USD - 20 Million USD	9,844	14,182	,694	,488	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	15,383	,000	1,000	1,000

Figure 4.81. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Business Development Module).

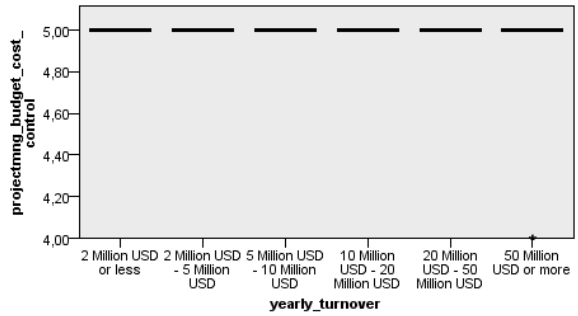
According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	7,485
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,187

Figure 4.82. Kruskal-Wallis Test with respect to Yearly Turnover (Planning & Time Management Module).

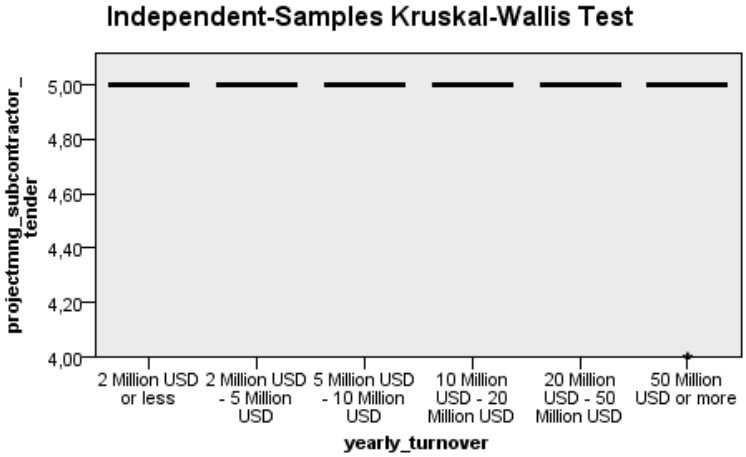
According to the figure below, it can be seen that “Project Management – Budget & Cost Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	3,632
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,603

Figure 4.83. Kruskal-Wallis Test with respect to Yearly Turnover (Budget & Cost Management Module).

According to the figure below, it can be seen that “Project Management – Subcontractor Tender Management” module user satisfaction scores do not change with respect to “yearly turnover.”



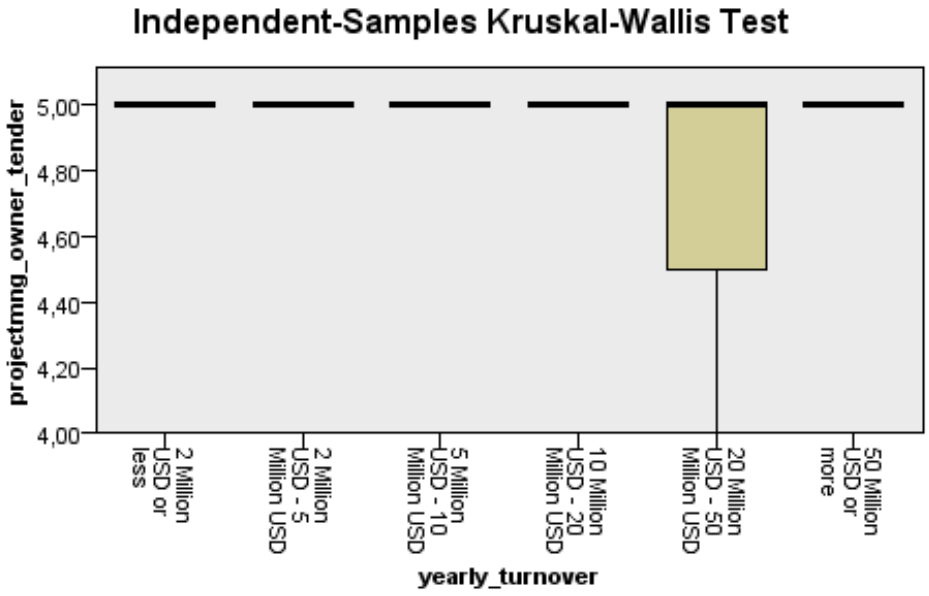
Total N	105
Test Statistic	3,632
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,603

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.84. Kruskal-Wallis Test with respect to Yearly Turnover (Subcontractor Tender Management Module).

According to the figure below, it can be seen that “Project Management – Owner Tender Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “20 – 50 Million USD” yearly turnover respondents are significantly different than “2 – 5 Million USD” and “2 Million USD or less” yearly turnover respondents. Also, the answers of “20 – 50 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more” yearly turnover respondents.

Only 25% of “20 Million – 50 Million USD” annual turnover company professionals have scored the proficiency level of the module as 4 – High and other remaining part of them and 100% other annual turnover company professionals scored as 5 – Very High.

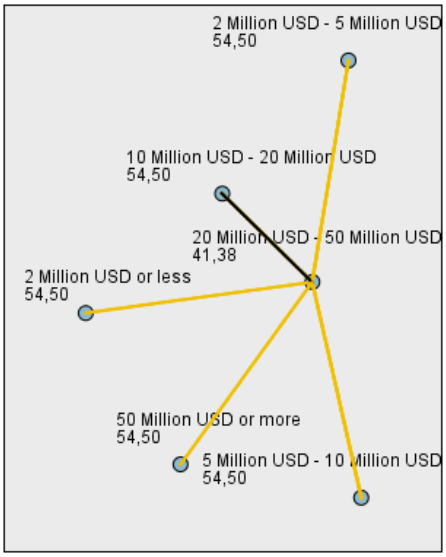


Total N	105
Test Statistic	23,706
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.85. Kruskal-Wallis Test with respect to Yearly Turnover (Owner Tender Management Module).

Pairwise Comparisons of yearly_turnover

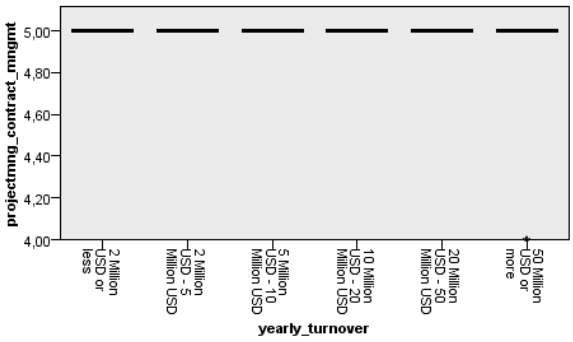


Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
20 Million USD - 50 Million USD-2 Million USD or less	13,125	3,588	3,658	,000	,004
20 Million USD - 50 Million USD-2 Million USD - 5 Million USD	13,125	3,275	4,007	,000	,001
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	13,125	3,588	3,658	,000	,004
20 Million USD - 50 Million USD-10 Million USD - 20 Million USD	13,125	5,673	2,314	,021	,310
20 Million USD - 50 Million USD-50 Million USD or more	-13,125	2,836	-4,627	,000	,000
2 Million USD or less-2 Million USD - 5 Million USD	,000	3,275	,000	1,000	1,000
2 Million USD or less-5 Million USD - 10 Million USD	,000	3,588	,000	1,000	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
2 Million USD or less-50 Million USD or more	,000	2,836	,000	1,000	1,000
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	,000	3,275	,000	1,000	1,000
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	,000	5,481	,000	1,000	1,000
2 Million USD - 5 Million USD-50 Million USD or more	,000	2,429	,000	1,000	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
5 Million USD - 10 Million USD-50 Million USD or more	,000	2,836	,000	1,000	1,000
10 Million USD - 20 Million USD-50 Million USD or more	,000	5,230	,000	1,000	1,000

Figure 4.86. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Owner Tender Management Module).

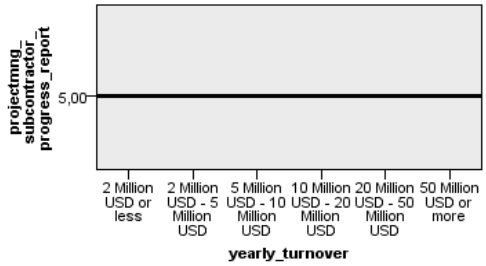
According to the figure below, it can be seen that “Project Management – Contract Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	3,632
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,603

Figure 4.87. Kruskal-Wallis Test with respect to Yearly Turnover (Contract Management Module).

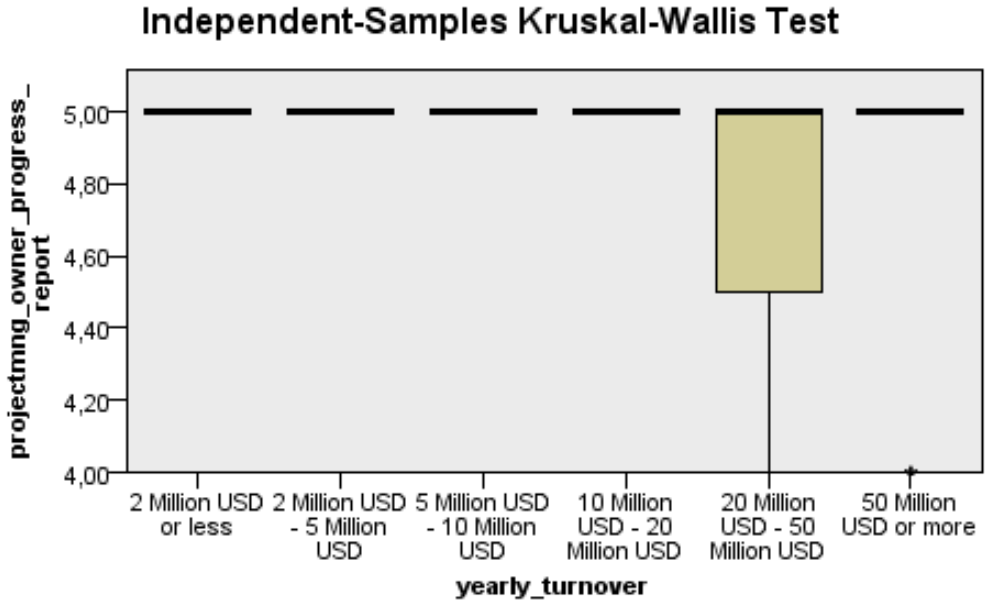
According to the figure below, it can be seen that “Project Management – Sub-Contractor Progress Report Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	,000
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	1,000

Figure 4.88. Kruskal-Wallis Test with respect to Yearly Turnover (Sub-Contractor Progress Report Management Module).

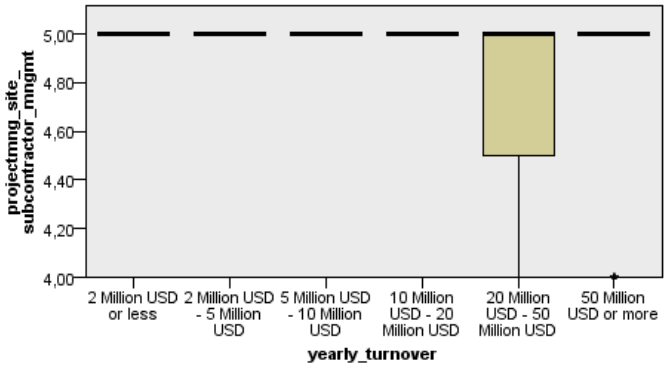
According to the figure below, it can be seen that “Project Management – Owner Progress Report Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	10,932
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,053

Figure 4.89. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Owner Progress Report Management Module).

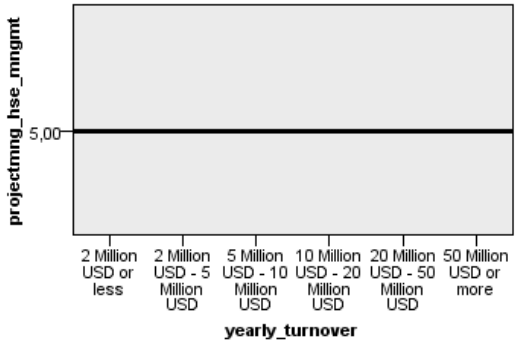
According to the figure below, it can be seen that “Project Management – Site & Subcontractor Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	9,208
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,101

Figure 4.90. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Site & Subcontractor Management Module).

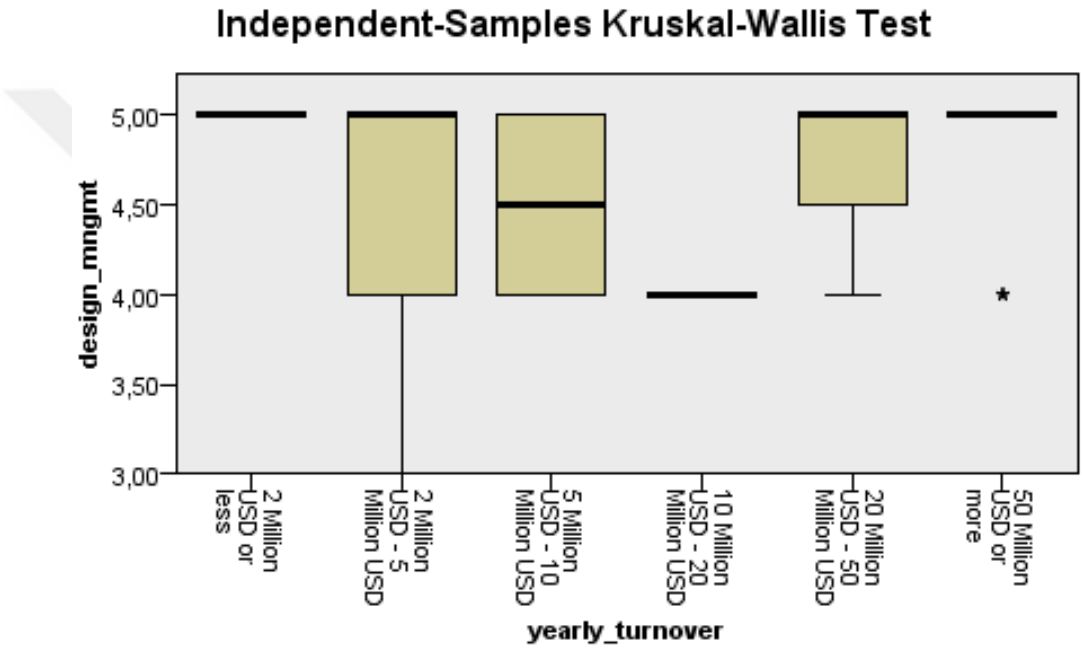
According to the figure below, it can be seen that "Project Management – HSE Management" module user satisfaction scores do not change with respect to "yearly turnover."



Total N	105
Test Statistic	,000
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	1,000

Figure 4.91. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (HSE Management Module).

According to the figure below, it can be seen that “Design Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “10 – 20 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more” and “2 Million USD or less” yearly turnover respondents. Also, the answers of “5 – 10 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more” and “2 Million USD or less” yearly turnover respondents.



Total N	105
Test Statistic	28,565
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.92. Kruskal-Wallis Test with respect to Yearly Turnover (Design Management Module).

Pairwise Comparisons of yearly_turnover

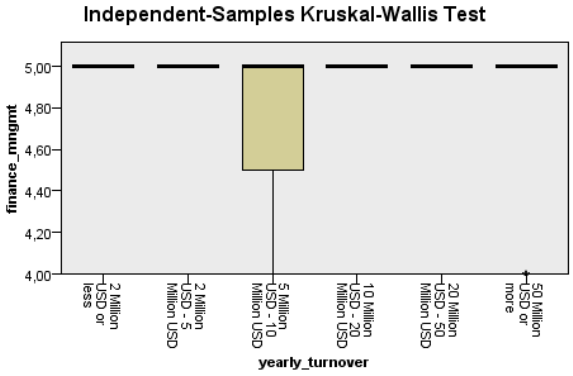


Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
10 Million USD - 20 Million USD-5 Million USD - 10 Million USD	25,500	13,662	1,866	,062	,930
10 Million USD - 20 Million USD-2 Million USD - 5 Million USD	32,250	13,199	2,443	,015	,218
10 Million USD - 20 Million USD-20 Million USD - 50 Million USD	-38,250	13,662	-2,800	,005	,077
10 Million USD - 20 Million USD-50 Million USD or more	-47,812	12,596	-3,796	,000	,002
10 Million USD - 20 Million USD-2 Million USD or less	51,000	13,662	3,733	,000	,003
5 Million USD - 10 Million USD-2 Million USD - 5 Million USD	6,750	7,888	,856	,392	1,000
5 Million USD - 10 Million USD-20 Million USD - 50 Million USD	-12,750	8,641	-1,476	,140	1,000
5 Million USD - 10 Million USD-50 Million USD or more	-22,312	6,831	-3,266	,001	,016
5 Million USD - 10 Million USD-2 Million USD or less	25,500	8,641	2,951	,003	,047
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-6,000	7,888	-,761	,447	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-15,562	5,850	-2,660	,008	,117
2 Million USD - 5 Million USD-2 Million USD or less	18,750	7,888	2,377	,017	,262
20 Million USD - 50 Million USD-50 Million USD or more	-9,562	6,831	-1,400	,162	1,000
20 Million USD - 50 Million USD-2 Million USD or less	12,750	8,641	1,476	,140	1,000
50 Million USD or more-2 Million USD or less	3,188	6,831	,467	,641	1,000

Figure 4.93. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Design Management Module).

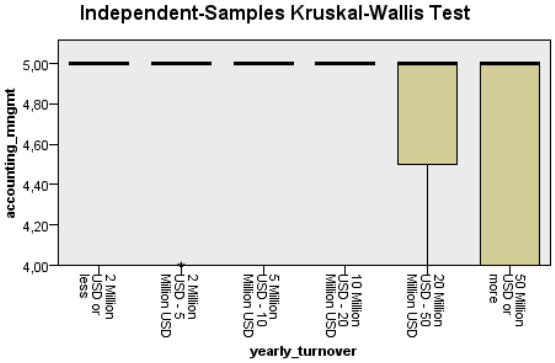
According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	10,932
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,053

Figure 4.94. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Finance Management Module).

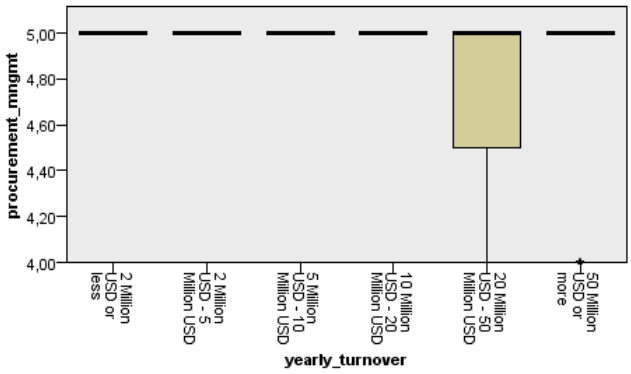
According to the figure below, it can be seen that “Accounting Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	10,756
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,056

Figure 4.95. Kruskal-Wallis Test with respect to Yearly Turnover (Accounting Management Module).

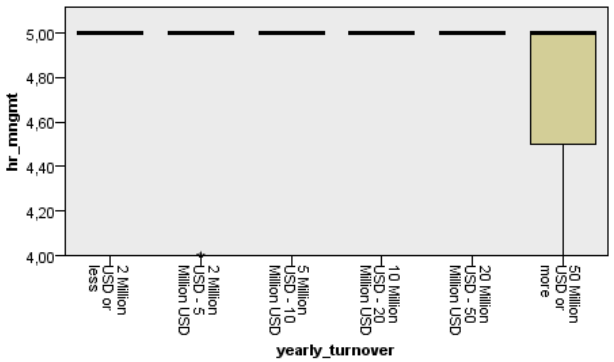
According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	9,208
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,101

Figure 4.96. Kruskal-Wallis Test with respect to Age Groups (Procurement Management Module).

According to the figure below, it can be seen that “Human Resources Management” module user satisfaction scores do not change with respect to “yearly turnover.”

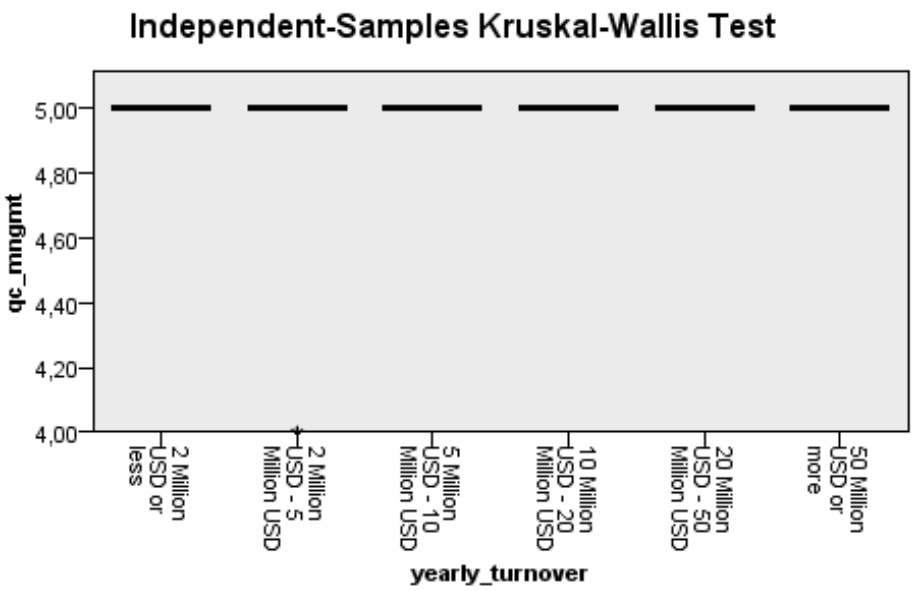


Total N	105
Test Statistic	10,978
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,052

Figure 4.97. Kruskal-Wallis Test with respect to Yearly Turnover (Human Resources Management Module).

According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more” yearly turnover respondents.

16.7% of “2 – 5 Million USD” yearly turnover respondents scored as 4 – High and 83.3% of them scored as 5 – Very High. All of other yearly turnover respondents have scored as 5 – Very High.

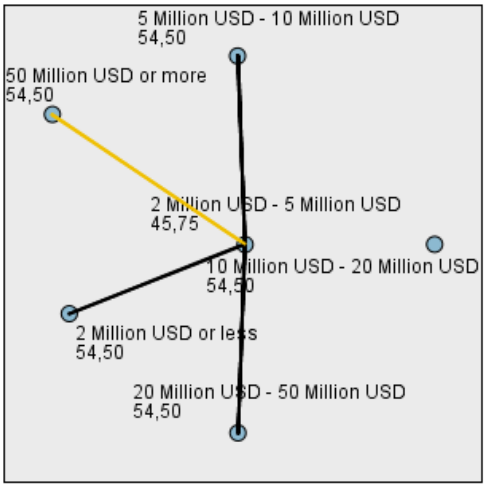


Total N	105
Test Statistic	14,784
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,011

1. The test statistic is adjusted for ties.

Figure 4.98. Kruskal-Wallis Test with respect to Age Groups (Quality Control Management Module).

Pairwise Comparisons of yearly_turnover

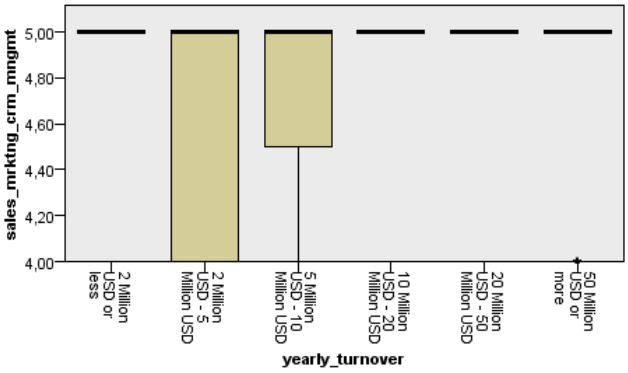


Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2 Million USD - 5 Million USD-2 Million USD or less	8,750	3,275	2,672	,008	,113
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-8,750	3,275	-2,672	,008	,113
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-8,750	5,481	-1,597	,110	1,000
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-8,750	3,275	-2,672	,008	,113
2 Million USD - 5 Million USD-50 Million USD or more	-8,750	2,429	-3,602	,000	,005
2 Million USD or less-5 Million USD - 10 Million USD	,000	3,588	,000	1,000	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
2 Million USD or less-20 Million USD - 50 Million USD	,000	3,588	,000	1,000	1,000
2 Million USD or less-50 Million USD or more	,000	2,836	,000	1,000	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
5 Million USD - 10 Million USD-20 Million USD - 50 Million USD	,000	3,588	,000	1,000	1,000
5 Million USD - 10 Million USD-50 Million USD or more	,000	2,836	,000	1,000	1,000
10 Million USD - 20 Million USD-20 Million USD - 50 Million USD	,000	5,673	,000	1,000	1,000
10 Million USD - 20 Million USD-50 Million USD or more	,000	5,230	,000	1,000	1,000
20 Million USD - 50 Million USD-50 Million USD or more	,000	2,836	,000	1,000	1,000

Figure 4.99. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Quality Control Management Module).

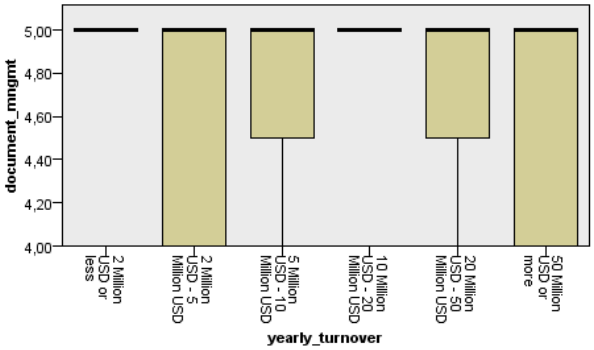
According to the figure below, it can be seen that “Sales & Marketing & CRM Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	10,978
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,052

Figure 4.100. Kruskal-Wallis Test with respect to Yearly Turnover (Sales & Marketing & CRM Management Module).

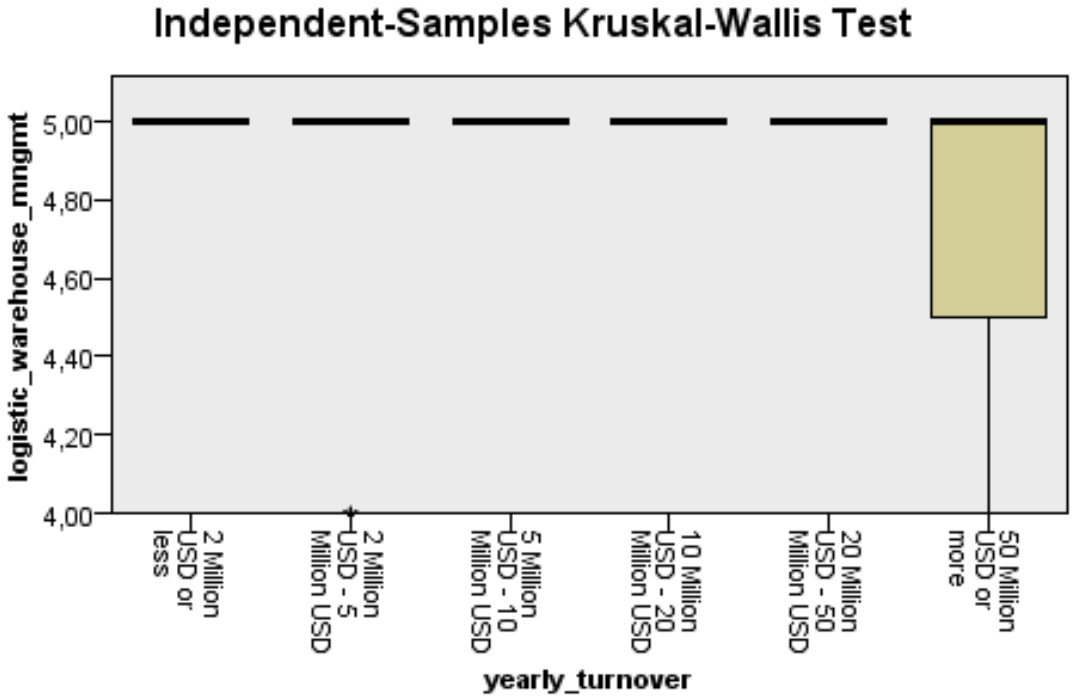
According to the figure below, it can be seen that “Document Management” module user satisfaction scores do not change with respect to “yearly turnover.”



Total N	105
Test Statistic	6,454
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,265

Figure 4.101. Kruskal-Wallis Test with respect to Yearly Turnover (Document Management Module).

According to the figure below, it can be seen that “Logistics & Warehouse Management” module user satisfaction scores do not change with respect to “yearly turnover.”

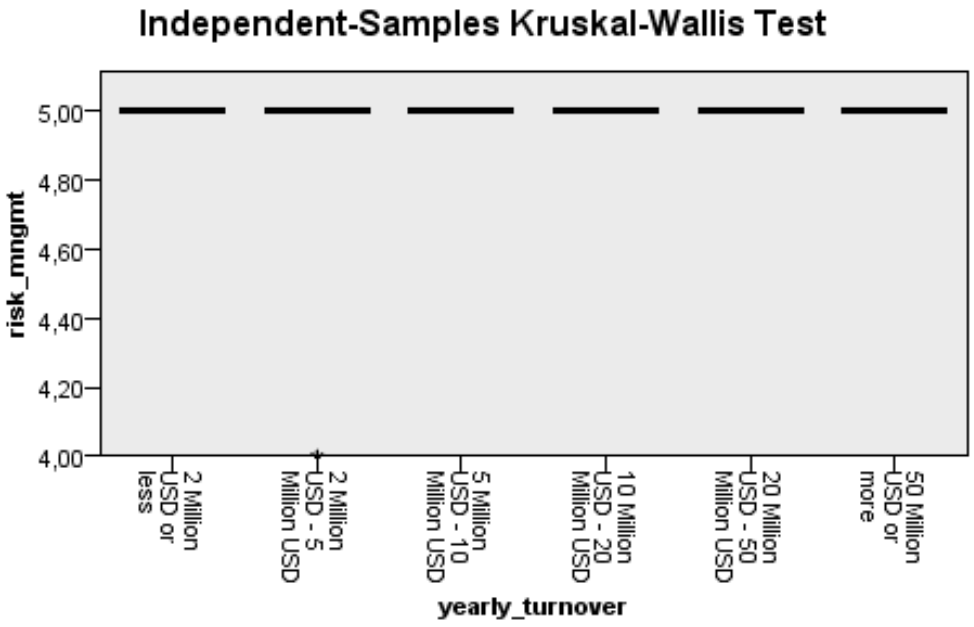


Total N	105
Test Statistic	10,978
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,052

Figure 4.102. Kruskal-Wallis Test with respect to Yearly Turnover (Logistics & Warehouse Management Module).

According to the figure below, it can be seen that “Risk Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more” yearly turnover respondents.

16.7% of “2 – 5 Million USD” yearly turnover respondents scored as 4 – High and 83.3% of them scored as 5 – Very High. All of other yearly turnover respondents have scored as 5 – Very High.

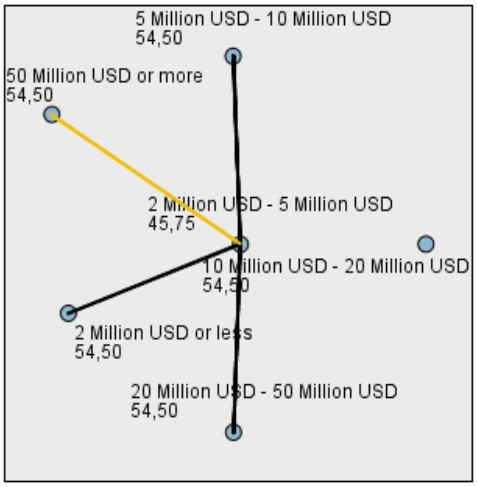


Total N	105
Test Statistic	14,784
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,011

1. The test statistic is adjusted for ties.

Figure 4.103. Kruskal-Wallis Test with respect to Yearly Turnover (Risk Management Module).

Pairwise Comparisons of yearly_turnover



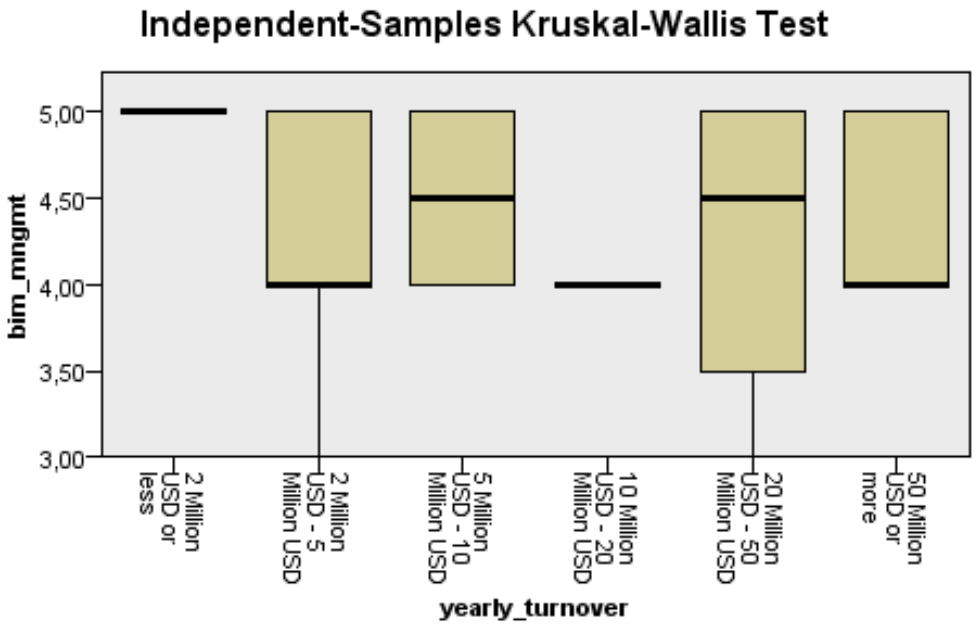
Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2 Million USD - 5 Million USD-2 Million USD or less	8,750	3,275	2,672	,008	,113
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-8,750	3,275	-2,672	,008	,113
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-8,750	5,481	-1,597	,110	1,000
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-8,750	3,275	-2,672	,008	,113
2 Million USD - 5 Million USD-50 Million USD or more	-8,750	2,429	-3,602	,000	,005
2 Million USD or less-5 Million USD - 10 Million USD	,000	3,588	,000	1,000	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
2 Million USD or less-20 Million USD - 50 Million USD	,000	3,588	,000	1,000	1,000
2 Million USD or less-50 Million USD or more	,000	2,836	,000	1,000	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	,000	5,673	,000	1,000	1,000
5 Million USD - 10 Million USD-20 Million USD - 50 Million USD	,000	3,588	,000	1,000	1,000
5 Million USD - 10 Million USD-50 Million USD or more	,000	2,836	,000	1,000	1,000
10 Million USD - 20 Million USD-20 Million USD - 50 Million USD	,000	5,673	,000	1,000	1,000
10 Million USD - 20 Million USD-50 Million USD or more	,000	5,230	,000	1,000	1,000
20 Million USD - 50 Million USD-50 Million USD or more	,000	2,836	,000	1,000	1,000

Figure 4.104. Kruskal-Wallis Test with respect to Yearly Turnover (Risk Management Module).

According to the figure below, it can be seen that “BIM Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “2 Million USD or less” yearly turnover respondents. Also, the answers of “50 Million USD or more” yearly turnover respondents are significantly different than “2 Million USD or less” yearly turnover respondents.

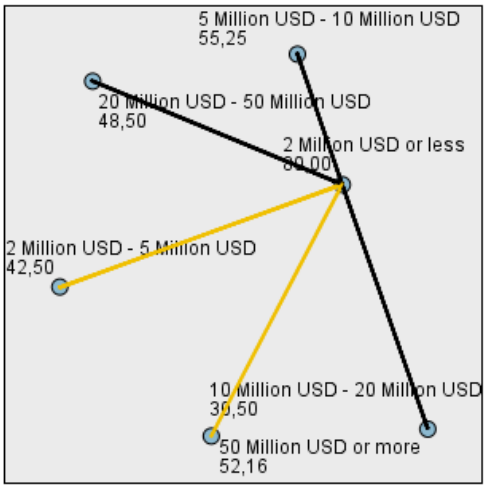
16.7% of “2 – 5 Million USD” yearly turnover respondents scored as 3 – Middle, 50% of them scored as 4 – High and 33.3% of them scored as 5 – Very High but 100% of “2 Million USD or less” of the other yearly turnover respondents have scored as 5 – Very High.



Total N	105
Test Statistic	17,186
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,004

Figure 4.105. Kruskal-Wallis Test with respect to Yearly Turnover (BIM Management Module).

Pairwise Comparisons of yearly_turnover



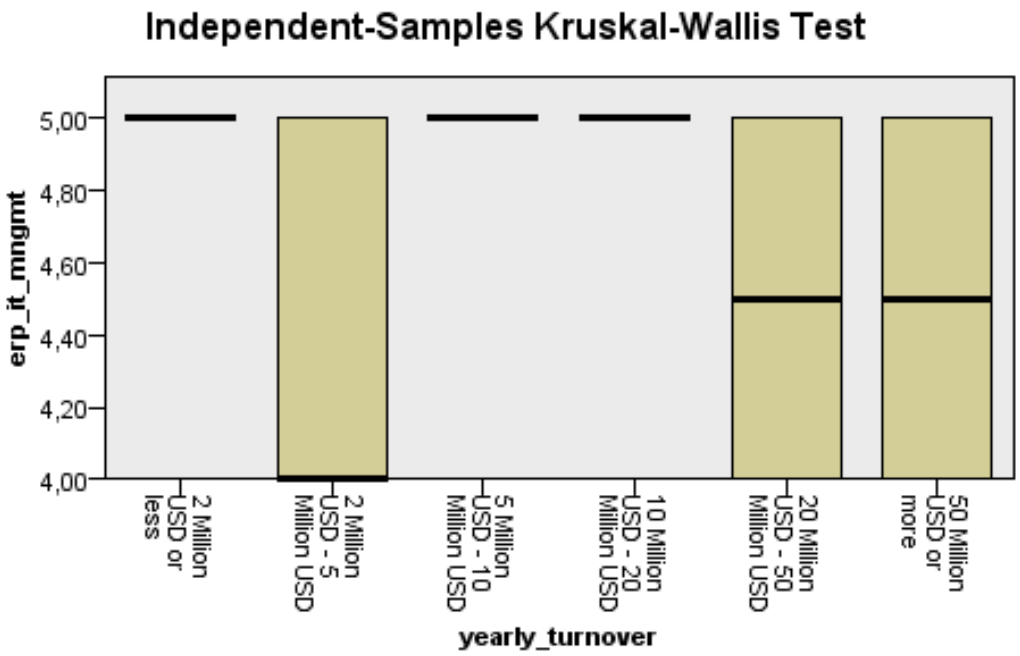
Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
10 Million USD - 20 Million USD-2 Million USD - 5 Million USD	12,000	16,878	,711	,477	1,000
10 Million USD - 20 Million USD-20 Million USD - 50 Million USD	-18,000	17,470	-1,030	,303	1,000
10 Million USD - 20 Million USD-50 Million USD or more	-21,656	16,107	-1,345	,179	1,000
10 Million USD - 20 Million USD-5 Million USD - 10 Million USD	24,750	17,470	1,417	,157	1,000
10 Million USD - 20 Million USD-2 Million USD or less	49,500	17,470	2,833	,005	,069
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-6,000	10,086	-,595	,552	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-9,656	7,480	-1,291	,197	1,000
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-12,750	10,086	-1,264	,206	1,000
2 Million USD - 5 Million USD-2 Million USD or less	37,500	10,086	3,718	,000	,003
20 Million USD - 50 Million USD-50 Million USD or more	-3,656	8,735	-,419	,676	1,000
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	6,750	11,049	,611	,541	1,000
20 Million USD - 50 Million USD-2 Million USD or less	31,500	11,049	2,851	,004	,065
50 Million USD or more-5 Million USD - 10 Million USD	3,094	8,735	,354	,723	1,000
50 Million USD or more-2 Million USD or less	27,844	8,735	3,188	,001	,022
5 Million USD - 10 Million USD-2 Million USD or less	24,750	11,049	2,240	,025	,376

Figure 4.106. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (BIM Management Module).

According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies.

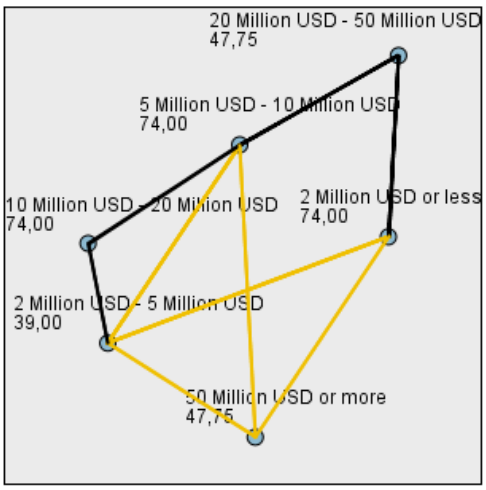
It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “5 -10 Million USD or more” and “2 Million USD or less” yearly turnover respondents. Also, the answers of “50 Million USD or more” yearly turnover respondents are significantly different than “2 Million USD or less” and “5 – 10 Million USD” yearly turnover respondents.



Total N	105
Test Statistic	25,587
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

Figure 4.107. Kruskal-Wallis Test with respect to Yearly Turnover (ERP & IT Management Module).

Pairwise Comparisons of yearly_turnover



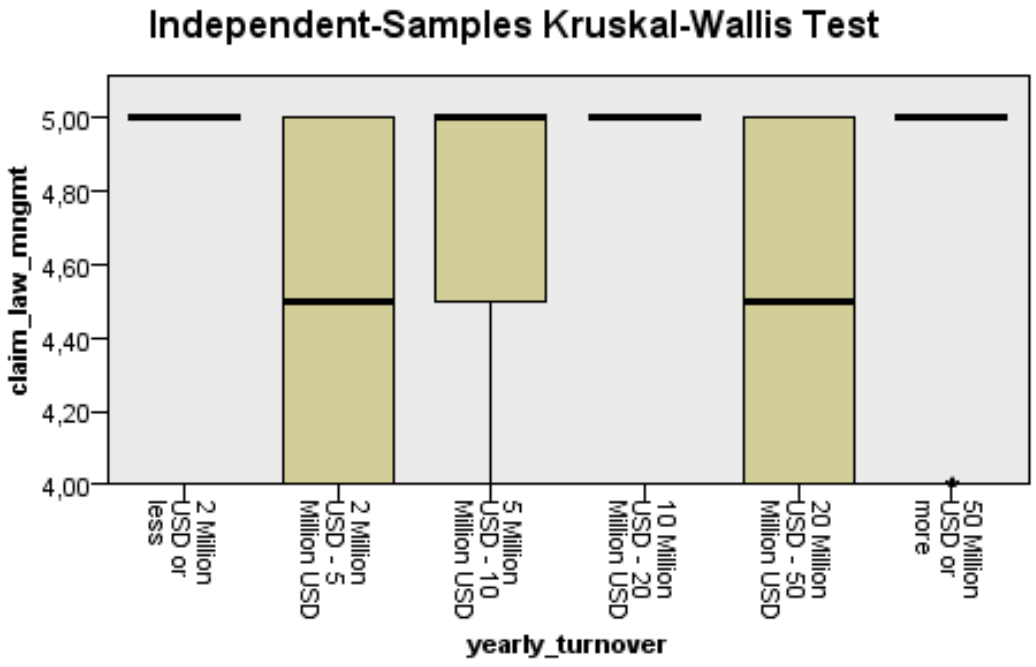
Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-8,750	9,631	-,909	,364	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-8,750	7,143	-1,225	,221	1,000
2 Million USD - 5 Million USD-2 Million USD or less	35,000	9,631	3,634	,000	,004
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-35,000	9,631	-3,634	,000	,004
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-35,000	16,116	-2,172	,030	,448
20 Million USD - 50 Million USD-50 Million USD or more	,000	8,341	,000	1,000	1,000
20 Million USD - 50 Million USD-2 Million USD or less	26,250	10,550	2,488	,013	,193
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	26,250	10,550	2,488	,013	,193
20 Million USD - 50 Million USD-10 Million USD - 20 Million USD	26,250	16,682	1,574	,116	1,000
50 Million USD or more-2 Million USD or less	26,250	8,341	3,147	,002	,025
50 Million USD or more-5 Million USD - 10 Million USD	26,250	8,341	3,147	,002	,025
50 Million USD or more-10 Million USD - 20 Million USD	26,250	15,380	1,707	,088	1,000
2 Million USD or less-5 Million USD - 10 Million USD	,000	10,550	,000	1,000	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	16,682	,000	1,000	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	,000	16,682	,000	1,000	1,000

Figure 4.108. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (ERP & IT Management Module).

According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “2 Million USD or less” yearly turnover respondents.

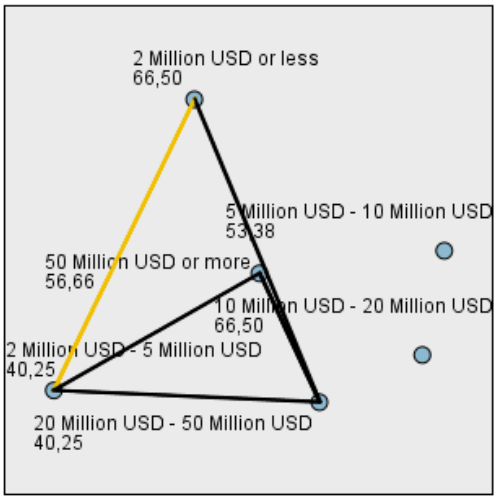
50% of “2 – 5 Million USD” yearly turnover respondents scored as 4 – High and 50% of them scored as 5 – Very High but 100% of “2 Million USD or less” yearly turnover respondents have scored as 5 – Very High.



Total N	105
Test Statistic	15,528
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,008

Figure 4.109. Kruskal-Wallis Test with respect to Yearly Turnover (Claim & Law Management Module).

Pairwise Comparisons of yearly_turnover

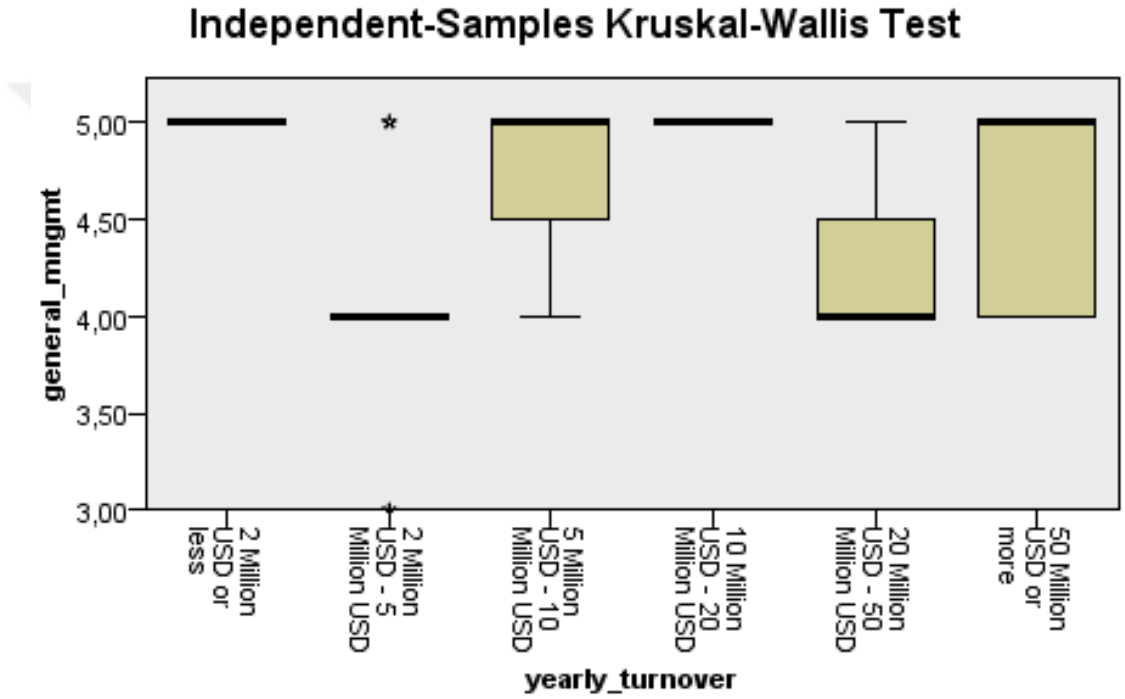


Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	,000	8,592	,000	1,000	1,000
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-13,125	8,592	-1,528	,127	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-16,406	6,372	-2,575	,010	,151
2 Million USD - 5 Million USD-2 Million USD or less	26,250	8,592	3,055	,002	,034
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-26,250	14,378	-1,826	,068	1,000
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	13,125	9,412	1,394	,163	1,000
20 Million USD - 50 Million USD-50 Million USD or more	-16,406	7,441	-2,205	,027	,412
20 Million USD - 50 Million USD-2 Million USD or less	26,250	9,412	2,789	,005	,079
20 Million USD - 50 Million USD-10 Million USD - 20 Million USD	26,250	14,882	1,764	,078	1,000
5 Million USD - 10 Million USD-50 Million USD or more	-3,281	7,441	-,441	,659	1,000
5 Million USD - 10 Million USD-2 Million USD or less	13,125	9,412	1,394	,163	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	-13,125	14,882	-,882	,378	1,000
50 Million USD or more-2 Million USD or less	9,844	7,441	1,323	,186	1,000
50 Million USD or more-10 Million USD - 20 Million USD	9,844	13,721	,717	,473	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	14,882	,000	1,000	1,000

Figure 4.110. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (Claim & Law Management Module).

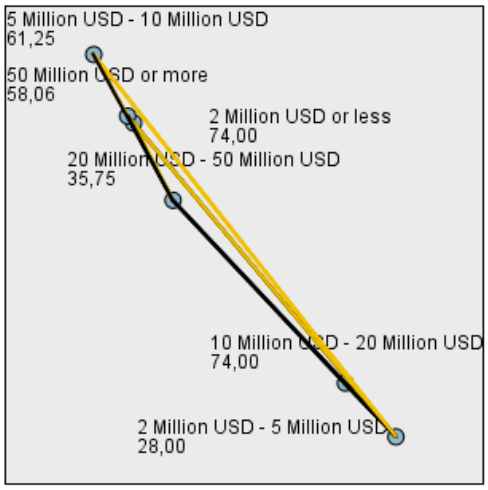
According to the figure below, it can be seen that “General Management” module user satisfaction scores change with respect to “yearly turnover” of the respondent’s companies. It can be seen that the answers of “2 – 5 Million USD” yearly turnover respondents are significantly different than “50 Million USD or more”, “5 – 10 Million USD” and “2 Million USD or less” yearly turnover respondents. Also, the answers of “20 – 50 Million USD” yearly turnover respondents are significantly different than “2 Million USD or less” yearly turnover respondents.



Total N	105
Test Statistic	34,550
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

Figure 4.111. Kruskal-Wallis Test with respect to Yearly Turnover (General Management Module).

Pairwise Comparisons of yearly_turnover



Each node shows the sample average rank of yearly_turnover.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2 Million USD - 5 Million USD-20 Million USD - 50 Million USD	-7,750	9,716	-,798	,425	1,000
2 Million USD - 5 Million USD-50 Million USD or more	-30,062	7,206	-4,172	,000	,000
2 Million USD - 5 Million USD-5 Million USD - 10 Million USD	-33,250	9,716	-3,422	,001	,009
2 Million USD - 5 Million USD-2 Million USD or less	46,000	9,716	4,734	,000	,000
2 Million USD - 5 Million USD-10 Million USD - 20 Million USD	-46,000	16,258	-2,829	,005	,070
20 Million USD - 50 Million USD-50 Million USD or more	-22,312	8,414	-2,652	,008	,120
20 Million USD - 50 Million USD-5 Million USD - 10 Million USD	25,500	10,643	2,396	,017	,249
20 Million USD - 50 Million USD-2 Million USD or less	38,250	10,643	3,594	,000	,005
20 Million USD - 50 Million USD-10 Million USD - 20 Million USD	38,250	16,828	2,273	,023	,345
50 Million USD or more-5 Million USD - 10 Million USD	3,188	8,414	,379	,705	1,000
50 Million USD or more-2 Million USD or less	15,938	8,414	1,894	,058	,873
50 Million USD or more-10 Million USD - 20 Million USD	15,938	15,515	1,027	,304	1,000
5 Million USD - 10 Million USD-2 Million USD or less	12,750	10,643	1,198	,231	1,000
5 Million USD - 10 Million USD-10 Million USD - 20 Million USD	-12,750	16,828	-,758	,449	1,000
2 Million USD or less-10 Million USD - 20 Million USD	,000	16,828	,000	1,000	1,000

Figure 4.112. Kruskal-Wallis Pairwise Comparison Test with respect to Yearly Turnover (General Management Module).

4.5.4.4. Kruskal-Wallis Test with Respect To "Company Age Groups". Here below at Table 4.22 Hypothesis Test Summary (Company Age Group) Table, it can be seen Kruskal-Wallis test results of all modules with respect to "age groups." It can be seen from the table that Business Development, Owner Progress Report Management, Site & Subcontractor Management, Finance Management, Accounting Management, Procurement Management, HR Management, Quality Control Management, Sales & Marketing & CRM Management, Risk Management, ERP & IT Management, Claim & Law Management and General Management modules user satisfaction survey scores changes with respondent "company age groups".

Table 4.22. Hypothesis Test Summary (Company Age Groups).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,290	Retain the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,320	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,320	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,320	Retain the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,320	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,034	Reject the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,002	Reject the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,657	Retain the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,005	Reject the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,003	Reject the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,002	Reject the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,002	Reject the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,032	Reject the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
18	The distribution of document_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,173	Retain the null hypothesis.

Table 4.22. Hypothesis Test Summary (Company Age Groups) (cont.).

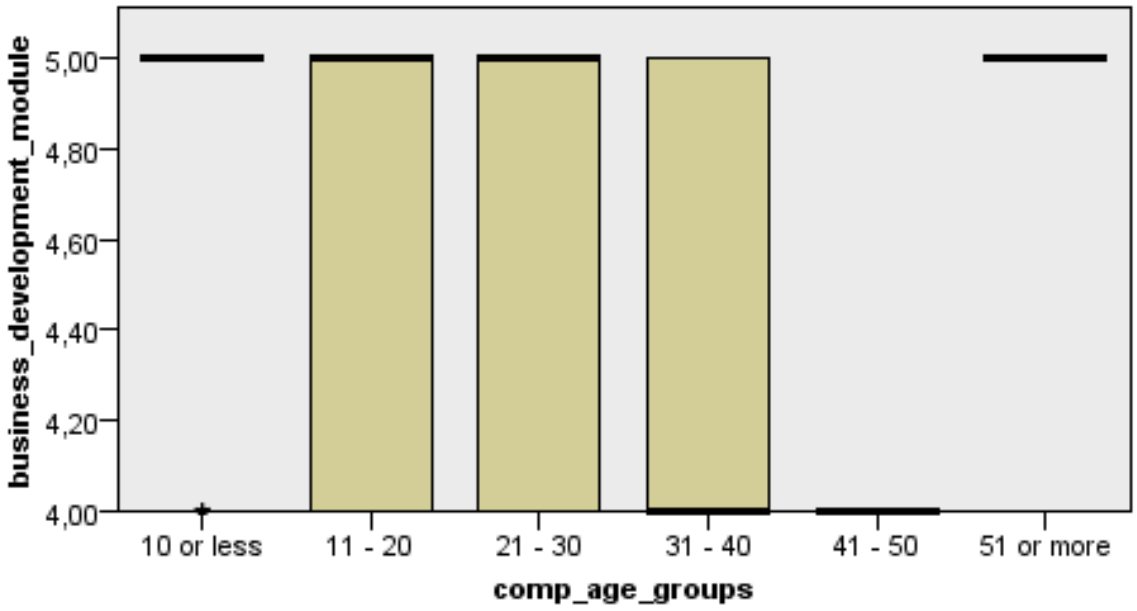
19	The distribution of logistic_warehouse_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,168	Retain the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,032	Reject the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,060	Retain the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,008	Reject the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,001	Reject the null hypothesis.
24	The distribution of general_mngmt is the same across categories of comp_age_groups.	Independent-Samples Kruskal-Wallis Test	0,030	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is ,05.				

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to "company age groups" of the respondents in details.

According to the figure below, it can be seen that "Business Development" module user satisfaction scores do change with respect to "company age groups." It can be seen that the answers of "41 – 50" company age group respondents are significantly different than "51 or more" company age group respondents.

Also, the answers of "31 – 40" company age group respondents are significantly different than "51 or more" company age group respondents.

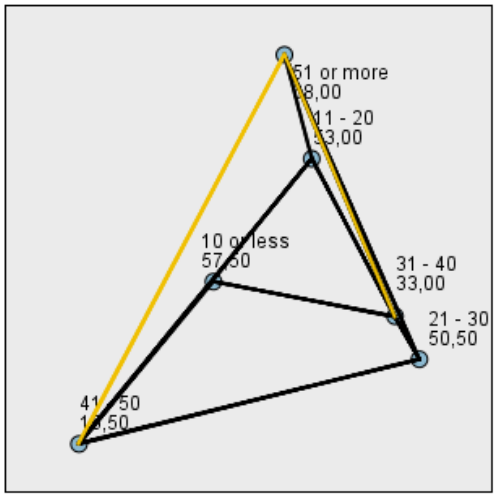
100% of "51 or more" company age group professionals have scored the module proficiencies as 5 – Very High but only 33.3% and 66.7% of "31-40" and "41-50" company age groups have scored the module proficiencies as 5 – Very High.



Total N	105
Test Statistic	23,019
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

Figure 4.113. Kruskal-Wallis Test with respect to Company Age Groups (Business Development Module).

Pairwise Comparisons of comp_age_groups

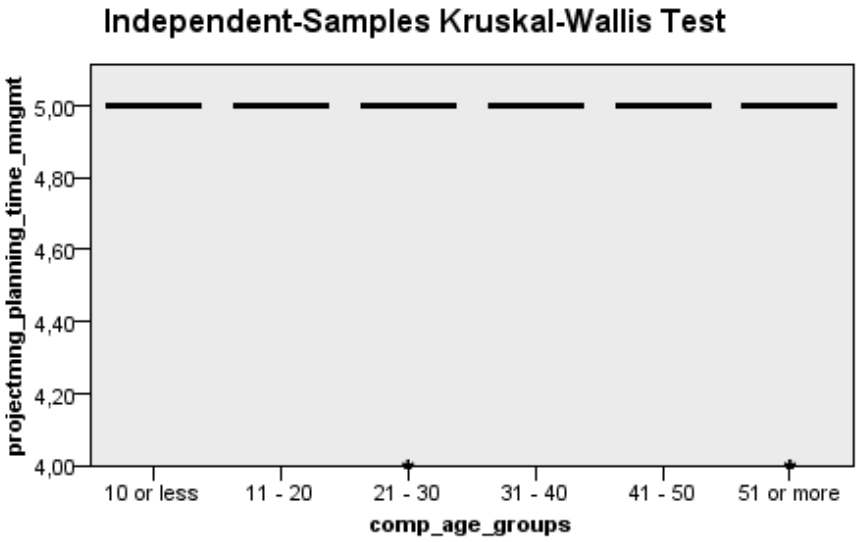


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
41 - 50-31 - 40	17,500	15,887	1,102	,271	1,000
41 - 50-21 - 30	35,000	14,321	2,444	,015	,218
41 - 50-11 - 20	37,500	14,709	2,550	,011	,162
41 - 50-10 or less	42,000	15,072	2,787	,005	,080
41 - 50-51 or more	-52,500	14,709	-3,569	,000	,005
31 - 40-21 - 30	17,500	8,881	1,970	,049	,732
31 - 40-11 - 20	20,000	9,494	2,106	,035	,527
31 - 40-10 or less	24,500	10,048	2,438	,015	,221
31 - 40-51 or more	-35,000	9,494	-3,686	,000	,003
21 - 30-11 - 20	2,500	6,544	,382	,702	1,000
21 - 30-10 or less	7,000	7,324	,956	,339	1,000
21 - 30-51 or more	-17,500	6,544	-2,674	,007	,112
11 - 20-10 or less	4,500	8,056	,559	,576	1,000
11 - 20-51 or more	-15,000	7,354	-2,040	,041	,621
10 or less-51 or more	-10,500	8,056	-1,303	,192	1,000

Figure 4.114. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Business Development Module).

According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do not change with respect to “company age groups.”

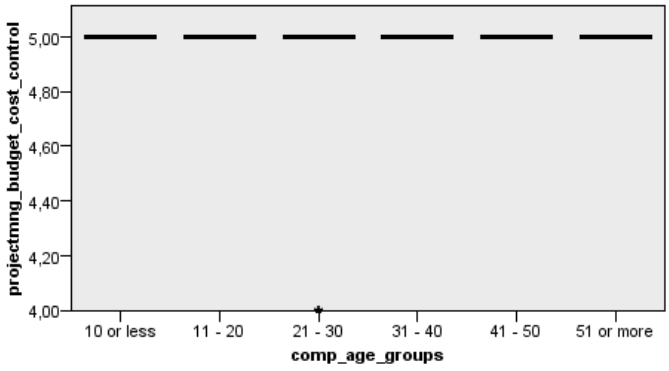


Total N	105
Test Statistic	6,172
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,290

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.115. Kruskal-Wallis Test with respect to Company Age Groups (Planning & Time Management Module).

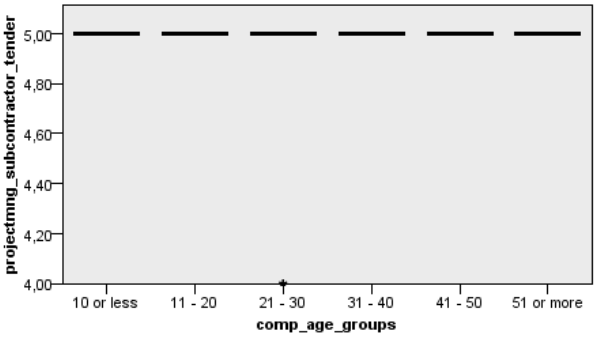
According to the figure below, it can be seen that “Project Management – Budget & Cost Control Management” module user satisfaction scores do not change with respect to “company age groups.”



Total N	105
Test Statistic	5,863
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,320

Figure 4.116. Kruskal-Wallis Test with respect to Company Age Groups (Budget & Cost Control Management Module).

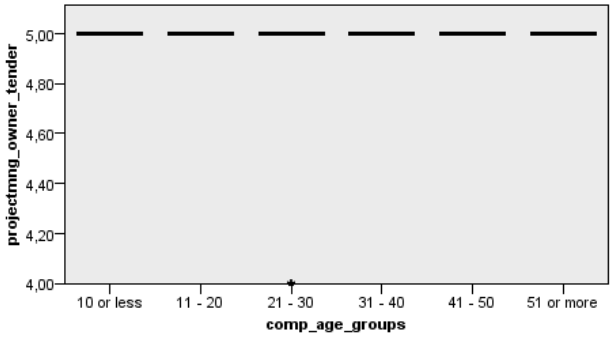
According to the figure below, it can be seen that "Project Management – Subcontractor Tender Management" module user satisfaction scores do not change with respect to "company age groups."



Total N	105
Test Statistic	5,863
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,320

Figure 4.117. Kruskal-Wallis Test with respect to Company Age Groups (Subcontractor Tender Management Module).

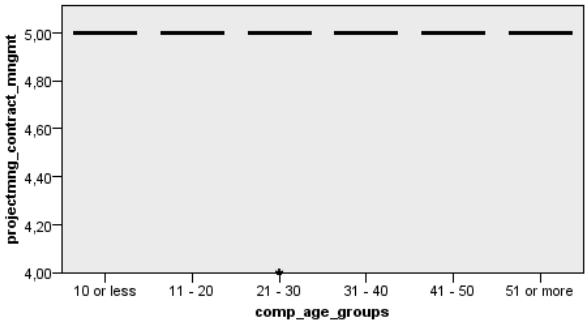
According to the figure below, it can be seen that “Project Management – Owner Tender Management” module user satisfaction scores do not change with respect to “company age groups.”



Total N	105
Test Statistic	5,863
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,320

Figure 4.118. Kruskal-Wallis Test with respect to Company Age Groups (Owner Tender Management Module).

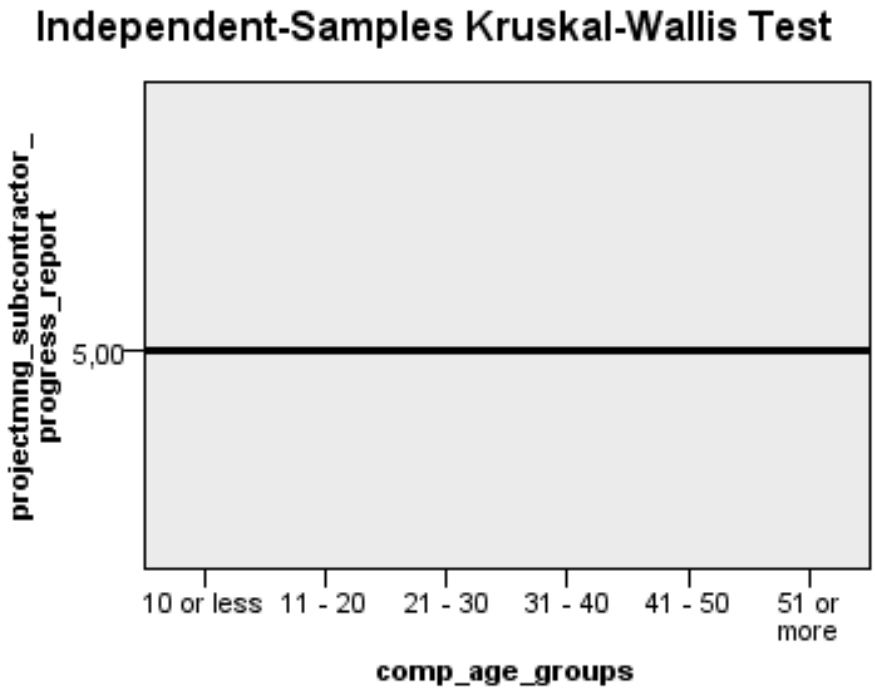
According to the figure below, it can be seen that “Project Management – Contract Management” module user satisfaction scores do not change with respect to “company age groups.”



Total N	105
Test Statistic	5,863
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,320

Figure 4.119. Kruskal-Wallis Test with respect to Age Groups (Contract Management Module).

According to the figure below, it can be seen that “Project Management – Subcontractor Progress Report” module user satisfaction scores do not change with respect to “company age groups.”

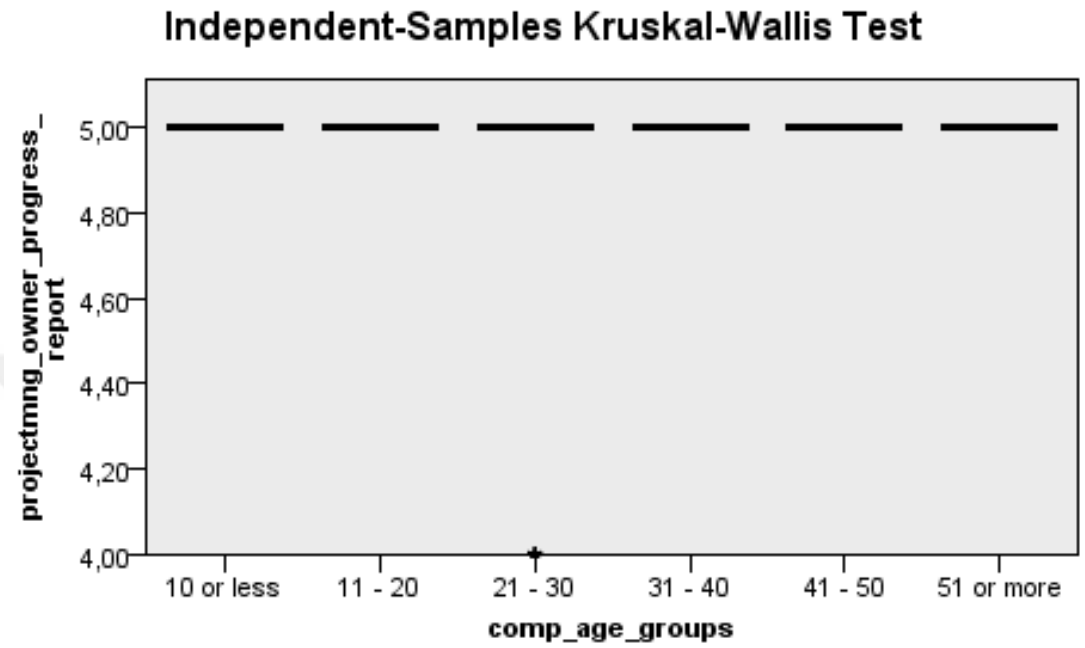


Total N	105
Test Statistic	,000
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	1,000

Figure 4.120. Kruskal-Wallis Test with respect to Company Age Groups (Subcontractor Progress Report Module).

According to the figure below, it can be seen that “Owner Progress Report Management” module user satisfaction scores do change with respect to “company age groups.”

It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “51 or more” and “11 – 20” company age group respondents.

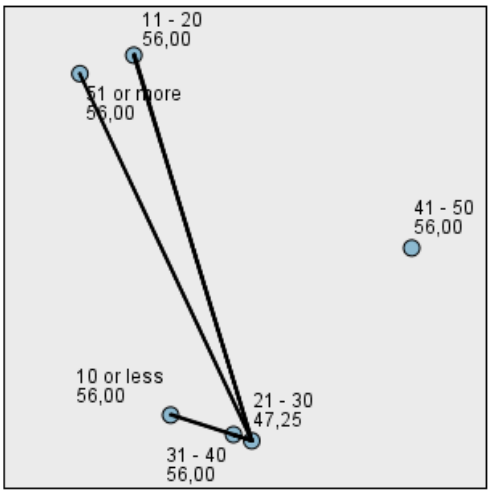


Total N	105
Test Statistic	12,081
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,034

1. The test statistic is adjusted for ties.

Figure 4.121. Kruskal-Wallis Test with respect to Company Age Groups (Owner Progress Report Management Module).

Pairwise Comparisons of comp_age_groups

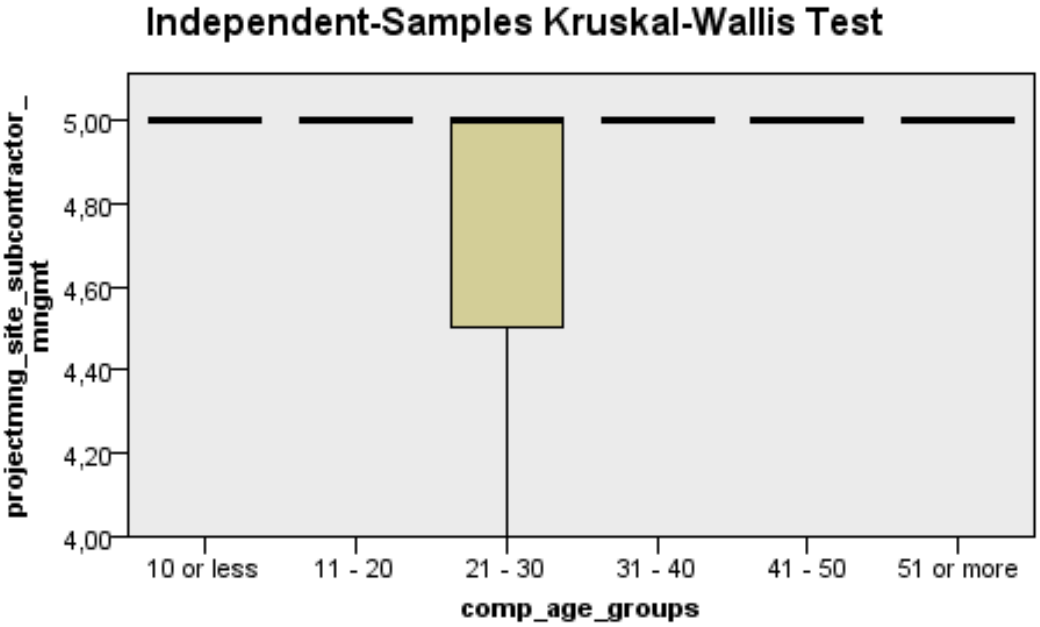


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-10 or less	8,750	3,763	2,325	,020	,301
21 - 30-11 - 20	8,750	3,362	2,602	,009	,139
21 - 30-31 - 40	-8,750	4,563	-1,917	,055	,828
21 - 30-41 - 50	-8,750	7,358	-1,189	,234	1,000
21 - 30-51 or more	-8,750	3,362	-2,602	,009	,139
10 or less-11 - 20	,000	4,139	,000	1,000	1,000
10 or less-31 - 40	,000	5,163	,000	1,000	1,000
10 or less-41 - 50	,000	7,744	,000	1,000	1,000
10 or less-51 or more	,000	4,139	,000	1,000	1,000
11 - 20-31 - 40	,000	4,878	,000	1,000	1,000
11 - 20-41 - 50	,000	7,557	,000	1,000	1,000
11 - 20-51 or more	,000	3,779	,000	1,000	1,000
31 - 40-41 - 50	,000	8,163	,000	1,000	1,000
31 - 40-51 or more	,000	4,878	,000	1,000	1,000
41 - 50-51 or more	,000	7,557	,000	1,000	1,000

Figure 4.122. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Owner Progress Report Management Module).

According to the figure below, it can be seen that “Site & Subcontractor Management” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “51 or more” and “11 – 20” company age group respondents.

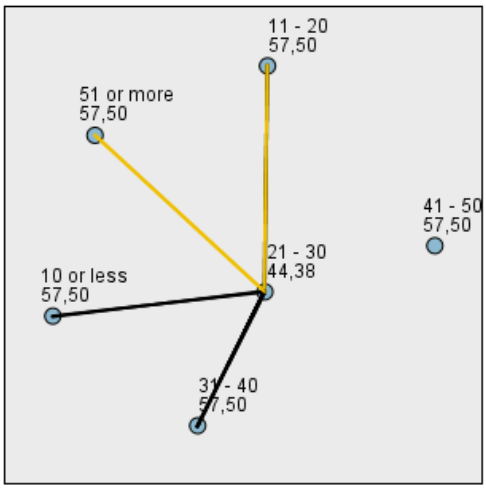


Total N	105
Test Statistic	18,688
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,002

1. The test statistic is adjusted for ties.

Figure 4.123. Kruskal-Wallis Test with respect to Company Age Groups (Site & Subcontractor Management Module).

Pairwise Comparisons of comp_age_groups

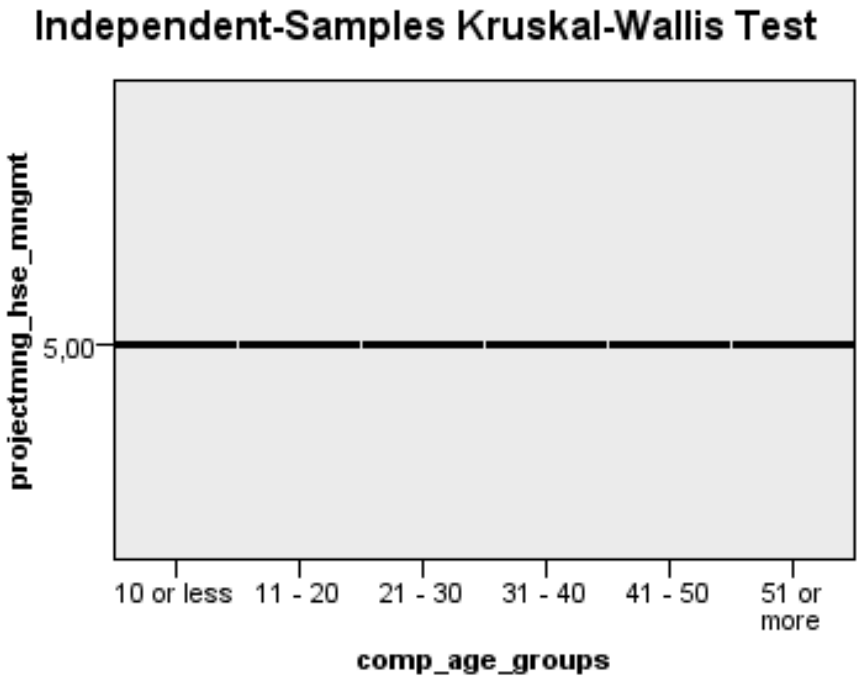


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-10 or less	13,125	4,538	2,892	,004	,057
21 - 30-11 - 20	13,125	4,055	3,237	,001	,018
21 - 30-31 - 40	-13,125	5,503	-2,385	,017	,256
21 - 30-41 - 50	-13,125	8,874	-1,479	,139	1,000
21 - 30-51 or more	-13,125	4,055	-3,237	,001	,018
10 or less-11 - 20	,000	4,992	,000	1,000	1,000
10 or less-31 - 40	,000	6,226	,000	1,000	1,000
10 or less-41 - 50	,000	9,340	,000	1,000	1,000
10 or less-51 or more	,000	4,992	,000	1,000	1,000
11 - 20-31 - 40	,000	5,883	,000	1,000	1,000
11 - 20-41 - 50	,000	9,115	,000	1,000	1,000
11 - 20-51 or more	,000	4,557	,000	1,000	1,000
31 - 40-41 - 50	,000	9,845	,000	1,000	1,000
31 - 40-51 or more	,000	5,883	,000	1,000	1,000
41 - 50-51 or more	,000	9,115	,000	1,000	1,000

Figure 4.124. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Site & Subcontractor Management Module).

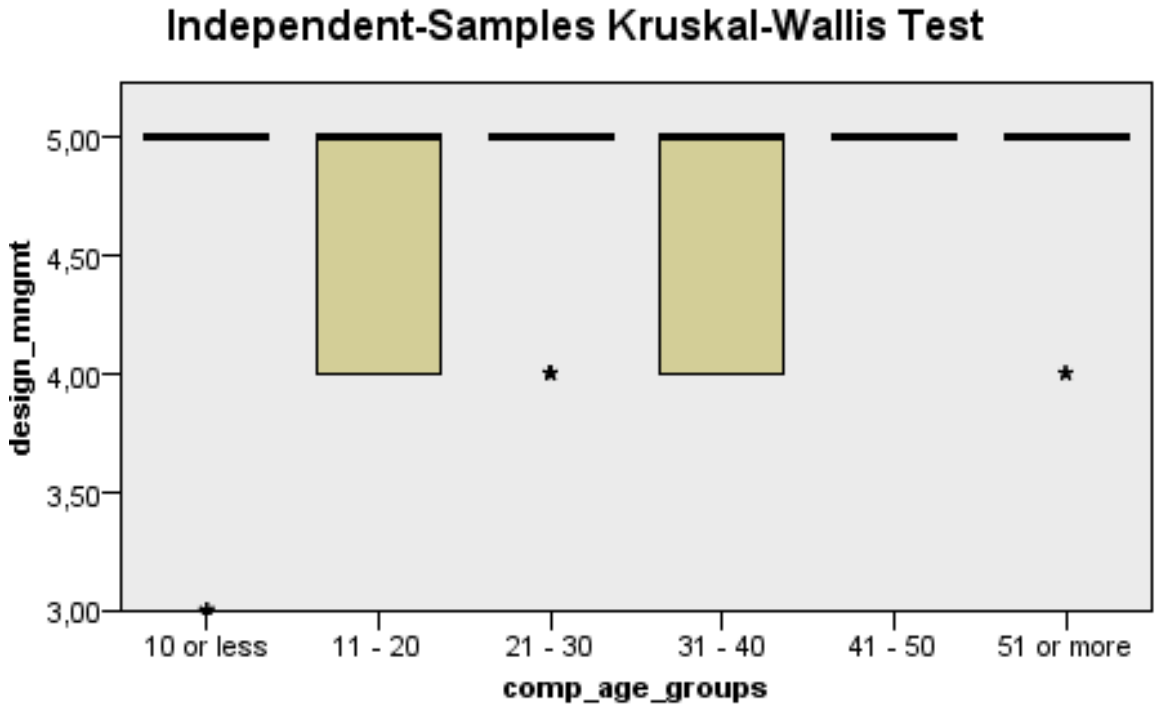
According to the figure below, it can be seen that “Project Management – HSE Management” module user satisfaction scores do not change with respect to “company age groups.”



Total N	105
Test Statistic	,000
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	1,000

Figure 4.125. Kruskal-Wallis Test with respect to Company Age Groups (HSE Management Module).

According to the figure below, it can be seen that “Design Management” module user satisfaction scores do not change with respect to “company age groups.”

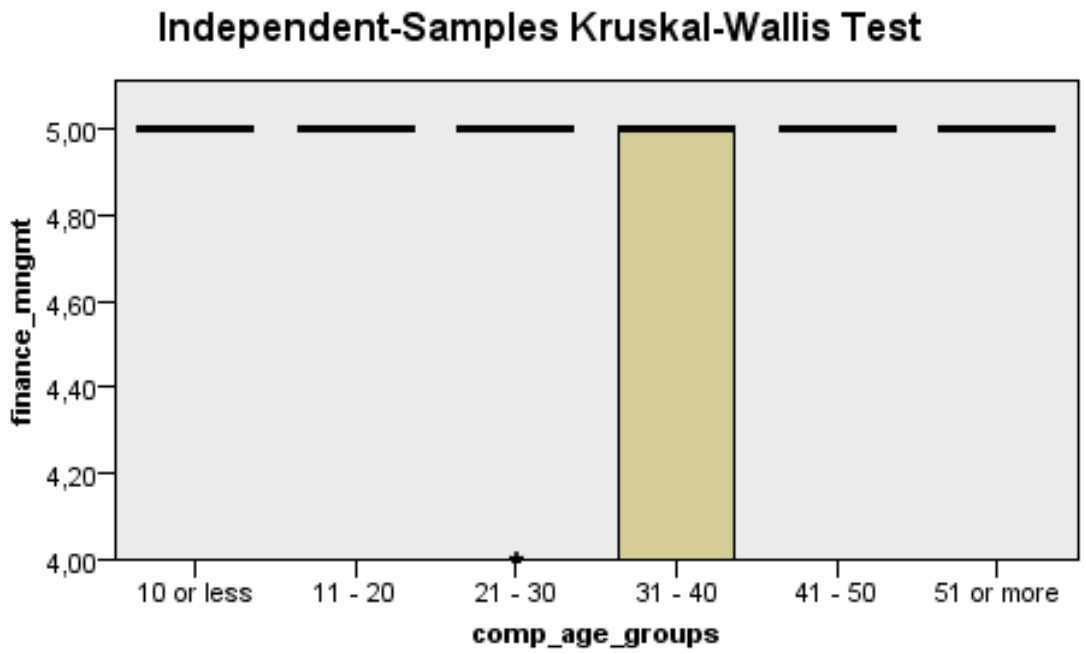


Total N	105
Test Statistic	3,279
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,657

Figure 4.126. Kruskal-Wallis Test with respect to Company Age Groups (Design Management Module).

According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do change with respect to “company age groups.”

It can be seen that the answers of “31 – 40” company age group respondents are significantly different than “51 or more”, “10 or less” and “11 – 20” company age group respondents.

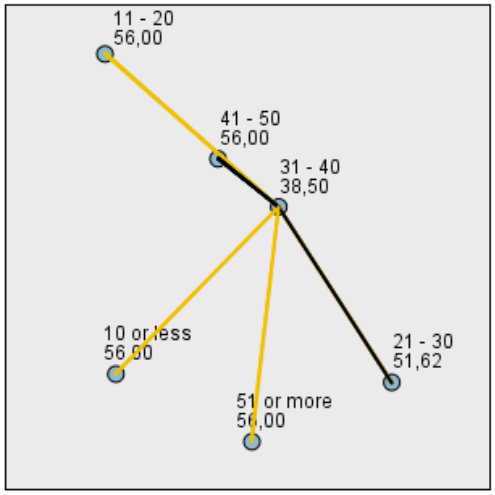


Total N	105
Test Statistic	16,677
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,005

1. The test statistic is adjusted for ties.

Figure 4.127. Kruskal-Wallis Test with respect to Company Age Groups (Finance Management Module).

Pairwise Comparisons of comp_age_groups



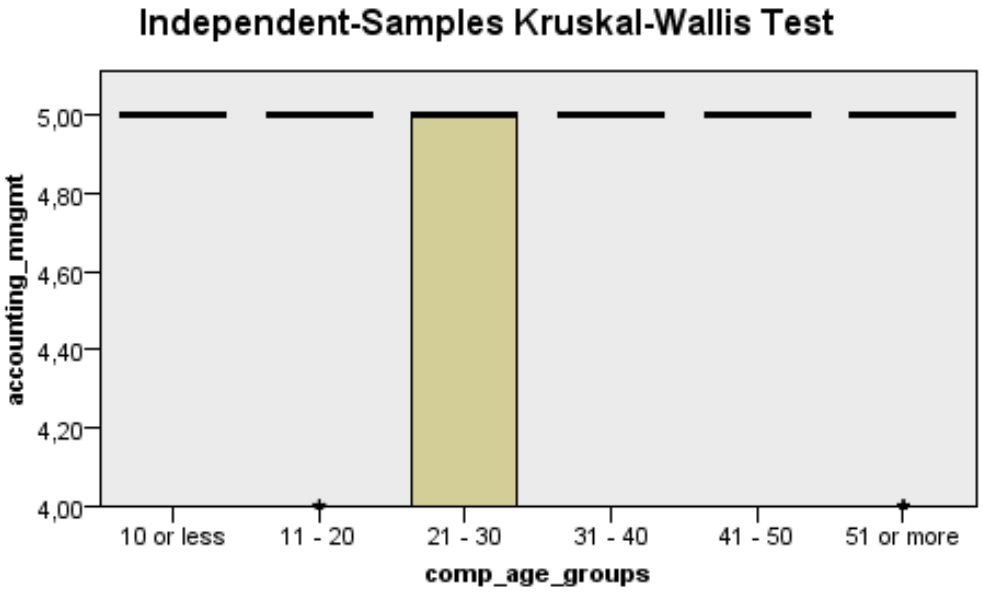
Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
31 - 40-21 - 30	13,125	4,563	2,876	,004	,060
31 - 40-10 or less	17,500	5,163	3,390	,001	,010
31 - 40-11 - 20	17,500	4,878	3,587	,000	,005
31 - 40-41 - 50	-17,500	8,163	-2,144	,032	,481
31 - 40-51 or more	-17,500	4,878	-3,587	,000	,005
21 - 30-10 or less	4,375	3,763	1,163	,245	1,000
21 - 30-11 - 20	4,375	3,362	1,301	,193	1,000
21 - 30-41 - 50	-4,375	7,358	-,595	,552	1,000
21 - 30-51 or more	-4,375	3,362	-1,301	,193	1,000
10 or less-11 - 20	,000	4,139	,000	1,000	1,000
10 or less-41 - 50	,000	7,744	,000	1,000	1,000
10 or less-51 or more	,000	4,139	,000	1,000	1,000
11 - 20-41 - 50	,000	7,557	,000	1,000	1,000
11 - 20-51 or more	,000	3,779	,000	1,000	1,000
41 - 50-51 or more	,000	7,557	,000	1,000	1,000

Figure 4.128. Kruskal-Wallis Pairwise Comparison Test with respect to Age Groups (Finance Management Module).

According to the figure below, it can be seen that “Accounting Development” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “10 or less” company age group respondents.

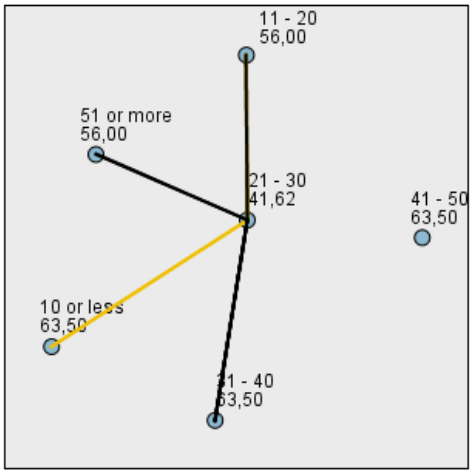
Only 58.3% of “21 – 30” company age group professionals have scored the module proficiencies as 5 – Very High but only 100% of “10 or less” company age groups have scored the module proficiencies as 5 – Very High.



Total N	105
Test Statistic	17,997
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,003

1. The test statistic is adjusted for ties.

Figure 4.129. Kruskal-Wallis Test with respect to Age Groups (Accounting Development Module).



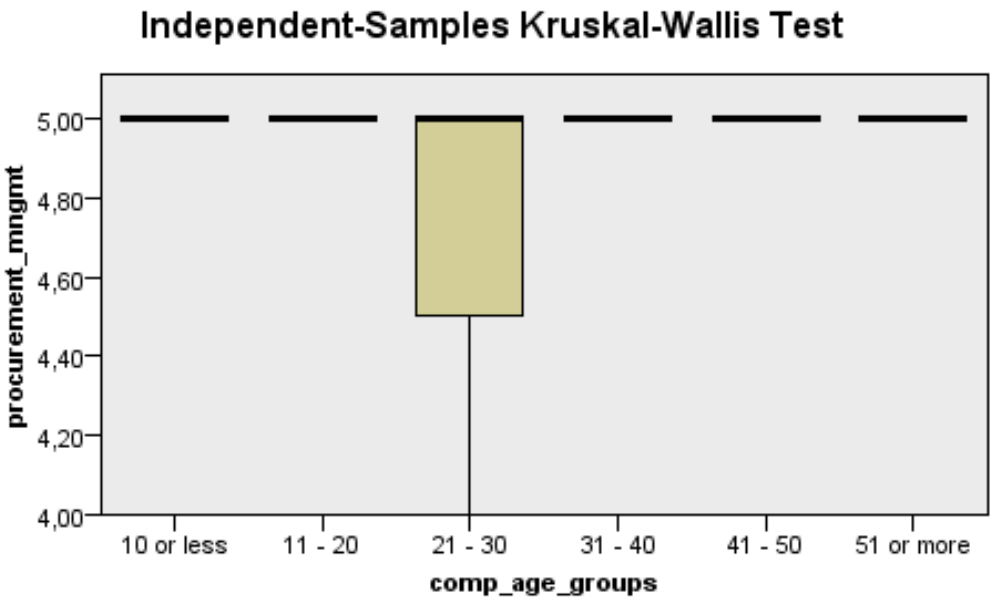
Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-11 - 20	14,375	5,794	2,481	,013	,196
21 - 30-51 or more	-14,375	5,794	-2,481	,013	,196
21 - 30-10 or less	21,875	6,485	3,373	,001	,011
21 - 30-31 - 40	-21,875	7,864	-2,782	,005	,081
21 - 30-41 - 50	-21,875	12,680	-1,725	,084	1,000
11 - 20-51 or more	,000	6,512	,000	1,000	1,000
11 - 20-10 or less	7,500	7,133	1,051	,293	1,000
11 - 20-31 - 40	-7,500	8,407	-,892	,372	1,000
11 - 20-41 - 50	-7,500	13,024	-,576	,565	1,000
51 or more-10 or less	7,500	7,133	1,051	,293	1,000
51 or more-31 - 40	7,500	8,407	,892	,372	1,000
51 or more-41 - 50	7,500	13,024	,576	,565	1,000
10 or less-31 - 40	,000	8,897	,000	1,000	1,000
10 or less-41 - 50	,000	13,345	,000	1,000	1,000
31 - 40-41 - 50	,000	14,067	,000	1,000	1,000

Figure 4.130. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Accounting Development Module).

According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do change with respect to “company age groups.”

It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “51 or more” and “11 – 20” company age group respondents.

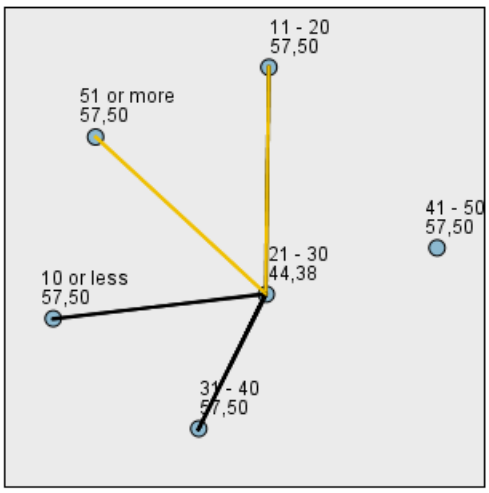


Total N	105
Test Statistic	18,688
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,002

1. The test statistic is adjusted for ties.

Figure 4.131. Kruskal-Wallis Test with respect to Company Age Groups (Procurement Management Module).

Pairwise Comparisons of comp_age_groups

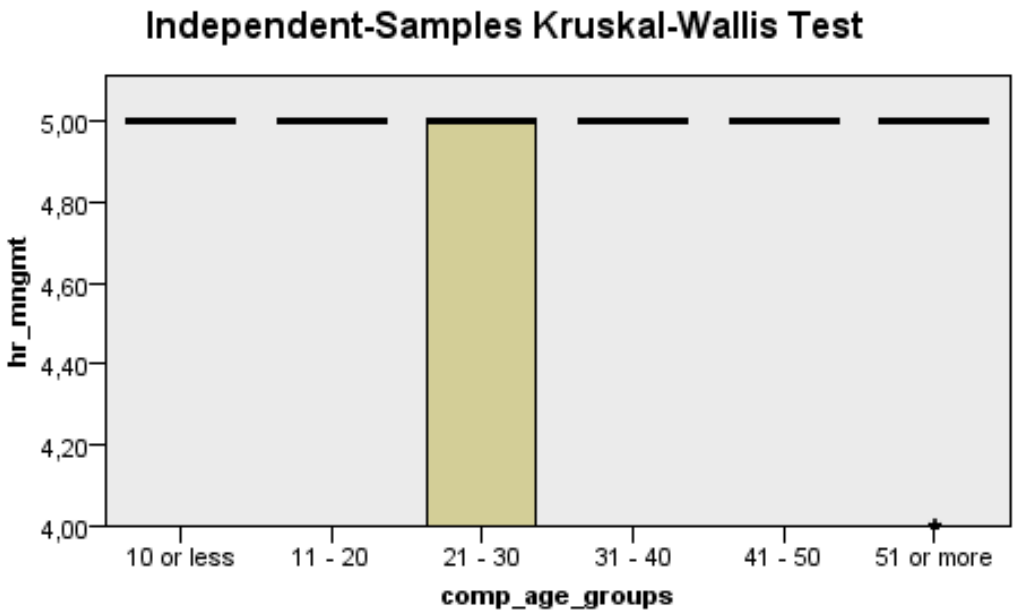


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-10 or less	13,125	4,538	2,892	,004	,057
21 - 30-11 - 20	13,125	4,055	3,237	,001	,018
21 - 30-31 - 40	-13,125	5,503	-2,385	,017	,256
21 - 30-41 - 50	-13,125	8,874	-1,479	,139	1,000
21 - 30-51 or more	-13,125	4,055	-3,237	,001	,018
10 or less-11 - 20	,000	4,992	,000	1,000	1,000
10 or less-31 - 40	,000	6,226	,000	1,000	1,000
10 or less-41 - 50	,000	9,340	,000	1,000	1,000
10 or less-51 or more	,000	4,992	,000	1,000	1,000
11 - 20-31 - 40	,000	5,883	,000	1,000	1,000
11 - 20-41 - 50	,000	9,115	,000	1,000	1,000
11 - 20-51 or more	,000	4,557	,000	1,000	1,000
31 - 40-41 - 50	,000	9,845	,000	1,000	1,000
31 - 40-51 or more	,000	5,883	,000	1,000	1,000
41 - 50-51 or more	,000	9,115	,000	1,000	1,000

Figure 4.132. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Procurement Management Module).

According to the figure below, it can be seen that “HR Management” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “10 or less” and “11 – 20” company age group respondents.

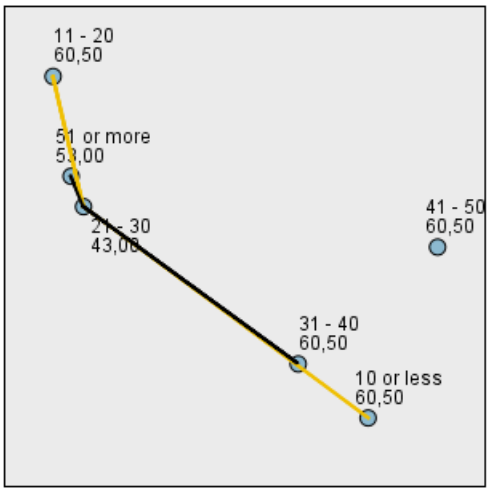


Total N	105
Test Statistic	18,489
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,002

1. The test statistic is adjusted for ties.

Figure 4.133. Kruskal-Wallis Test with respect to Company Age Groups (HR Management Module).

Pairwise Comparisons of comp_age_groups



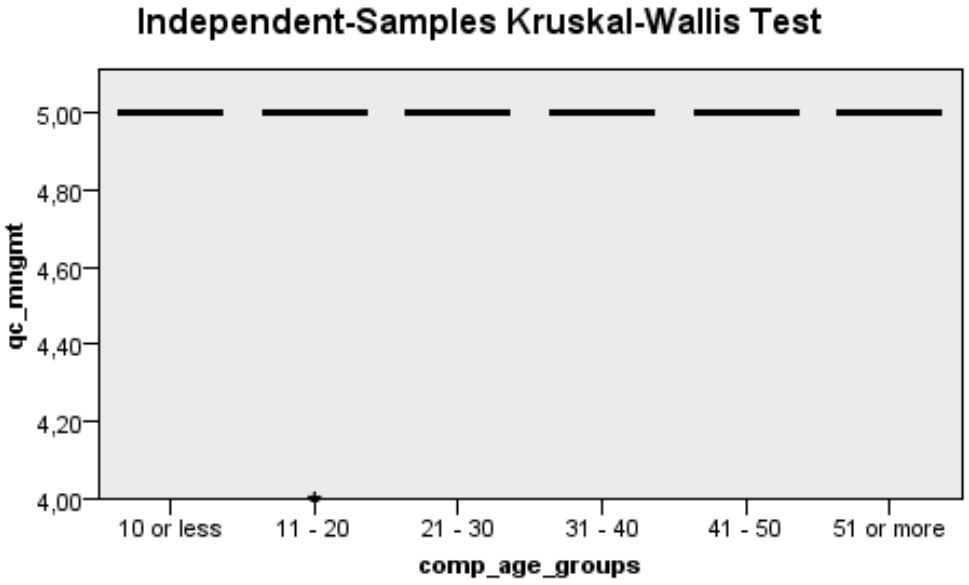
Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-51 or more	-10,000	5,069	-1,973	,049	,728
21 - 30-10 or less	17,500	5,673	3,085	,002	,031
21 - 30-11 - 20	17,500	5,069	3,453	,001	,008
21 - 30-31 - 40	-17,500	6,879	-2,544	,011	,164
21 - 30-41 - 50	-17,500	11,093	-1,578	,115	1,000
51 or more-10 or less	7,500	6,240	1,202	,229	1,000
51 or more-11 - 20	7,500	5,697	1,317	,188	1,000
51 or more-31 - 40	7,500	7,354	1,020	,308	1,000
51 or more-41 - 50	7,500	11,393	,658	,510	1,000
10 or less-11 - 20	,000	6,240	,000	1,000	1,000
10 or less-31 - 40	,000	7,783	,000	1,000	1,000
10 or less-41 - 50	,000	11,675	,000	1,000	1,000
11 - 20-31 - 40	,000	7,354	,000	1,000	1,000
11 - 20-41 - 50	,000	11,393	,000	1,000	1,000
31 - 40-41 - 50	,000	12,306	,000	1,000	1,000

Figure 4.134. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (HR Management Module).

According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “11 – 20” company age group respondents are significantly different than “21 – 30” company age group respondents.

100% of “21 - 30” company age group professionals have scored the module proficiencies as 5 – Very High but only 85.7% of “11-20” company age groups have scored the module proficiencies as 5 – Very High.



Total N	105
Test Statistic	12,235
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,032

1. The test statistic is adjusted for ties.

Figure 4.135. Kruskal-Wallis Test with respect to Company Age Groups (Quality Control Management Module).

Pairwise Comparisons of comp_age_groups

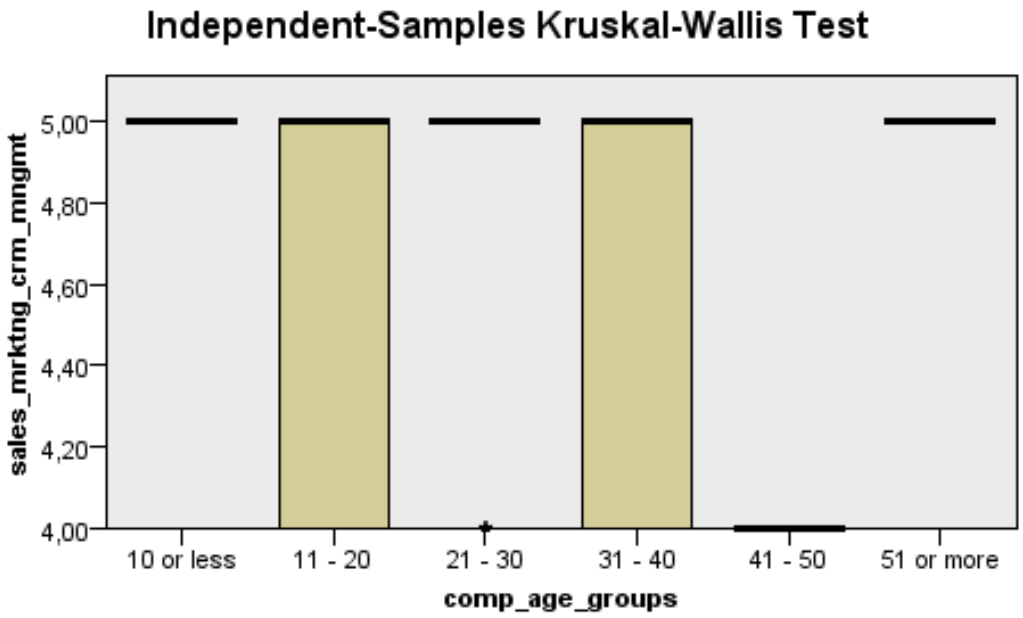


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
11 - 20-10 or less	7,500	2,971	2,524	,012	,174
11 - 20-21 - 30	-7,500	2,413	-3,108	,002	,028
11 - 20-31 - 40	-7,500	3,501	-2,142	,032	,483
11 - 20-41 - 50	-7,500	5,424	-1,383	,167	1,000
11 - 20-51 or more	-7,500	2,712	-2,765	,006	,085
10 or less-21 - 30	,000	2,701	,000	1,000	1,000
10 or less-31 - 40	,000	3,706	,000	1,000	1,000
10 or less-41 - 50	,000	5,558	,000	1,000	1,000
10 or less-51 or more	,000	2,971	,000	1,000	1,000
21 - 30-31 - 40	,000	3,275	,000	1,000	1,000
21 - 30-41 - 50	,000	5,281	,000	1,000	1,000
21 - 30-51 or more	,000	2,413	,000	1,000	1,000
31 - 40-41 - 50	,000	5,859	,000	1,000	1,000
31 - 40-51 or more	,000	3,501	,000	1,000	1,000
41 - 50-51 or more	,000	5,424	,000	1,000	1,000

Figure 4.136. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Quality Control Management Module).

According to the figure below, it can be seen that “Sales & Marketing & CRM Management” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “41 – 50” company age group respondents are significantly different than “51 or more”, “11 – 20”, “21 – 30” and “10 or less” company age group respondents.

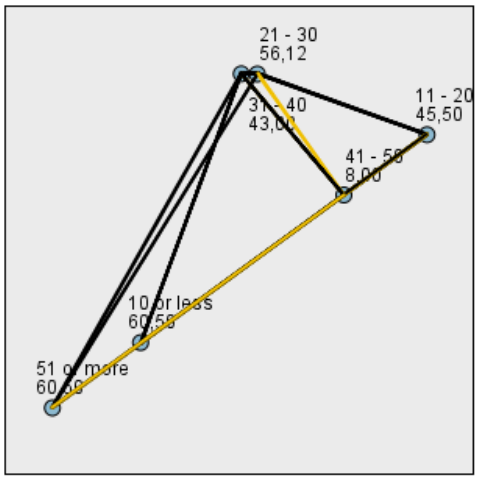


Total N	105
Test Statistic	30,911
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.137. Kruskal-Wallis Test with respect to Company Age Groups (Sales & Marketing & CRM Management Module).

Pairwise Comparisons of comp_age_groups

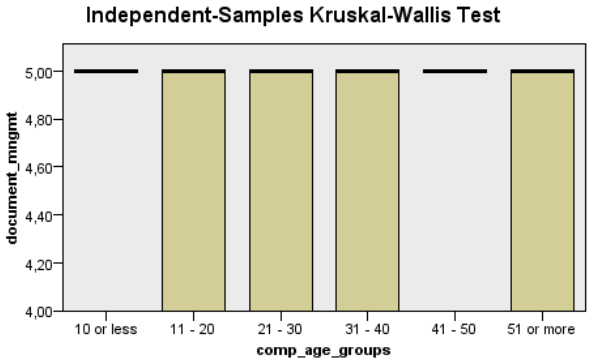


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
41 - 50-31 - 40	35,000	12,306	2,844	,004	,067
41 - 50-11 - 20	37,500	11,393	3,291	,001	,015
41 - 50-21 - 30	48,125	11,093	4,338	,000	,000
41 - 50-10 or less	52,500	11,675	4,497	,000	,000
41 - 50-51 or more	-52,500	11,393	-4,608	,000	,000
31 - 40-11 - 20	2,500	7,354	,340	,734	1,000
31 - 40-21 - 30	13,125	6,879	1,908	,056	,846
31 - 40-10 or less	17,500	7,783	2,248	,025	,368
31 - 40-51 or more	-17,500	7,354	-2,380	,017	,260
11 - 20-21 - 30	-10,625	5,069	-2,096	,036	,541
11 - 20-10 or less	15,000	6,240	2,404	,016	,243
11 - 20-51 or more	-15,000	5,697	-2,633	,008	,127
21 - 30-10 or less	4,375	5,673	,771	,441	1,000
21 - 30-51 or more	-4,375	5,069	-,863	,388	1,000
10 or less-51 or more	,000	6,240	,000	1,000	1,000

Figure 4.138. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Sales & Marketing & CRM Management Module).

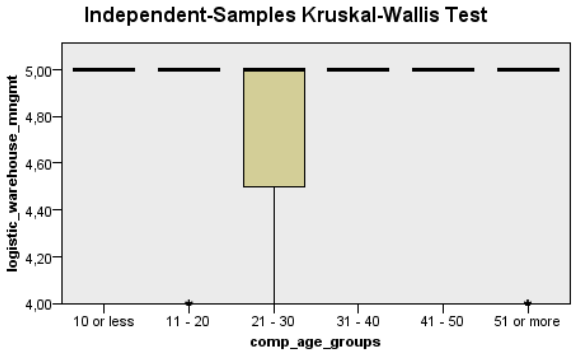
According to the figure below, it can be seen that “Document Management” module user satisfaction scores do not change with respect to “company age groups.”



Total N	105
Test Statistic	7,704
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,173

Figure 4.139. Kruskal-Wallis Test with respect to Company Age Groups (Document Management Module).

According to the figure below, it can be seen that “Logistic & Warehouse Management” module user satisfaction scores do not change with respect to “company age groups.”

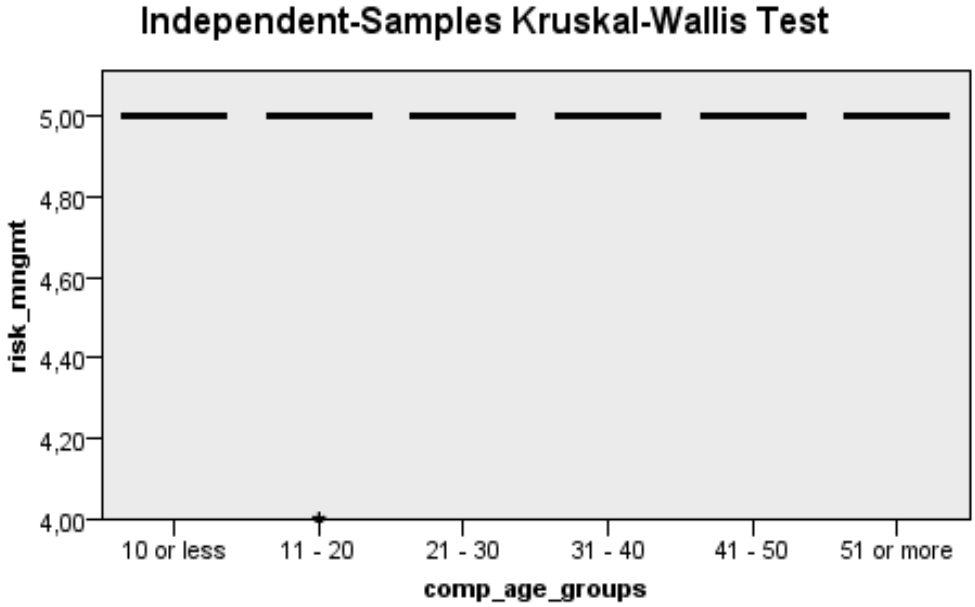


Total N	105
Test Statistic	7,800
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,168

Figure 4.140. Kruskal-Wallis Test with respect to Age Groups (Logistic & Warehouse Management Module).

According to the figure below, it can be seen that “Risk Management” module user satisfaction scores do change with respect to “company age groups.” It can be seen that the answers of “11 – 20” company age group respondents are significantly different than “21 - 30” company age group respondents.

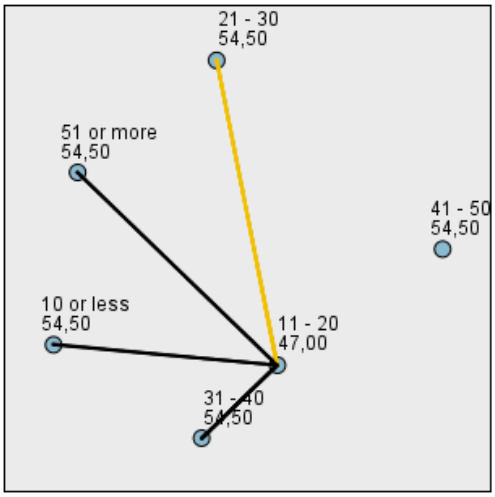
100% of “21-30” company age group professionals have scored the module proficiencies as 5 – Very High but only 85.7% of “11-20” company age groups have scored the module proficiencies as 5 – Very High.



Total N	105
Test Statistic	12,235
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,032

Figure 4.141. Kruskal-Wallis Test with respect to Company Age Groups (Risk Management Module).

Pairwise Comparisons of comp_age_groups

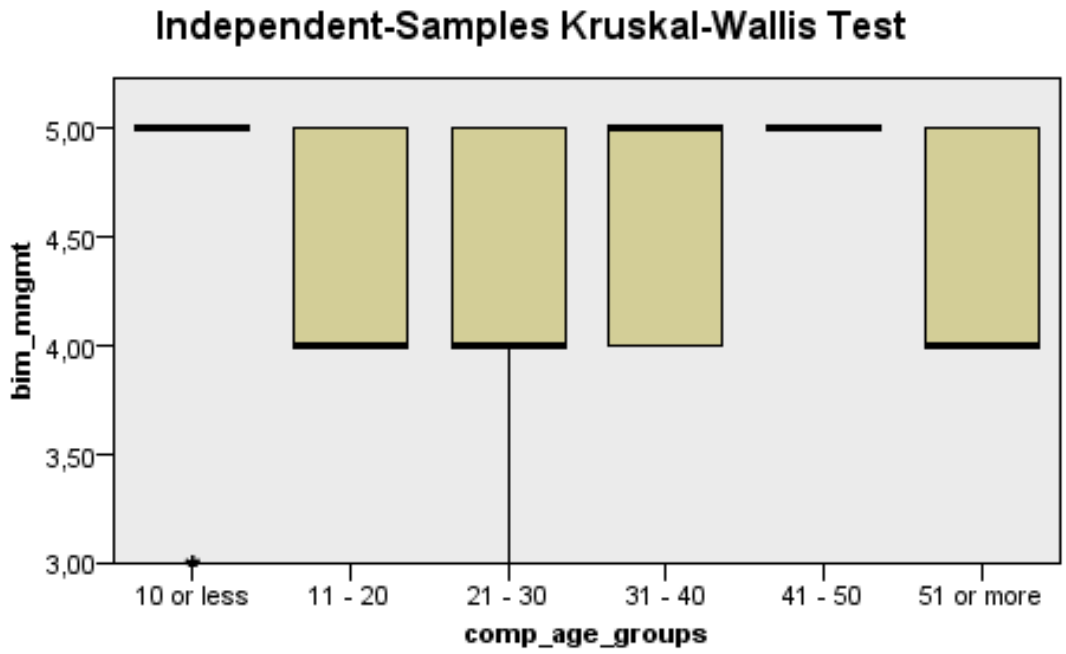


Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
11 - 20-10 or less	7,500	2,971	2,524	,012	,174
11 - 20-21 - 30	-7,500	2,413	-3,108	,002	,028
11 - 20-31 - 40	-7,500	3,501	-2,142	,032	,483
11 - 20-41 - 50	-7,500	5,424	-1,383	,167	1,000
11 - 20-51 or more	-7,500	2,712	-2,765	,006	,085
10 or less-21 - 30	,000	2,701	,000	1,000	1,000
10 or less-31 - 40	,000	3,706	,000	1,000	1,000
10 or less-41 - 50	,000	5,558	,000	1,000	1,000
10 or less-51 or more	,000	2,971	,000	1,000	1,000
21 - 30-31 - 40	,000	3,275	,000	1,000	1,000
21 - 30-41 - 50	,000	5,281	,000	1,000	1,000
21 - 30-51 or more	,000	2,413	,000	1,000	1,000
31 - 40-41 - 50	,000	5,859	,000	1,000	1,000
31 - 40-51 or more	,000	3,501	,000	1,000	1,000
41 - 50-51 or more	,000	5,424	,000	1,000	1,000

Figure 4.142. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Risk Management Module).

According to the figure below, it can be seen that “BIM Management” module user satisfaction scores do not change with respect to “company age groups.”



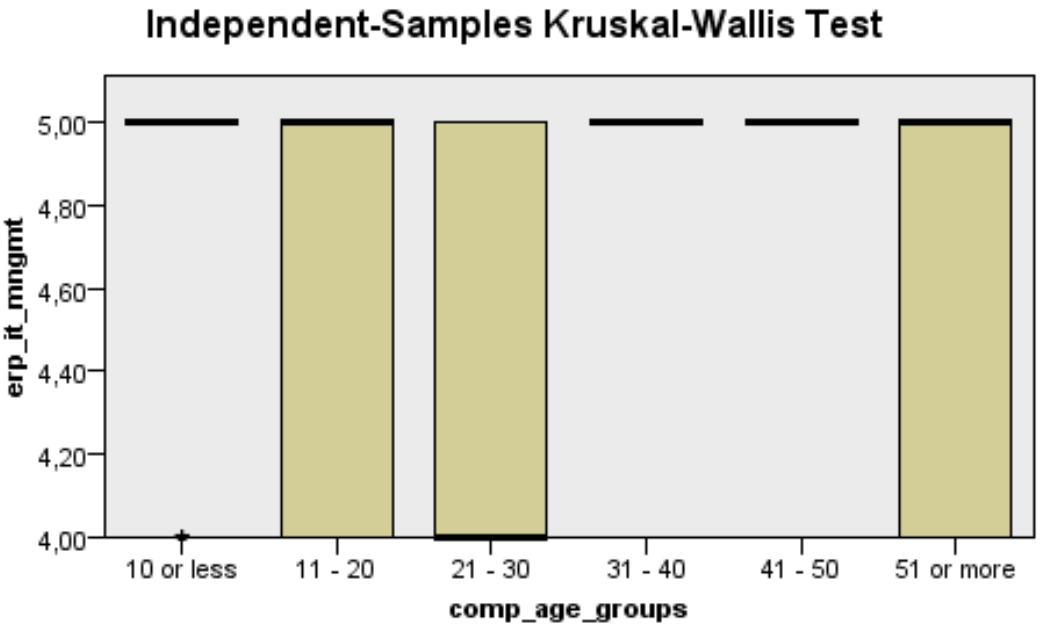
Total N	105
Test Statistic	10,583
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,060

Figure 4.143. Kruskal-Wallis Test with respect to Company Age Groups (BIM Management Module).

According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores do change with respect to “company age groups.”

It can be seen that the answers of “21 – 30” company age group respondents are significantly different than “31 - 40” company age group respondents.

41.7% of “21 – 30” company age group professionals have scored the module proficiencies as 5 – Very High but 100% of “31-40” company age groups have scored the module proficiencies as 5 – Very High.

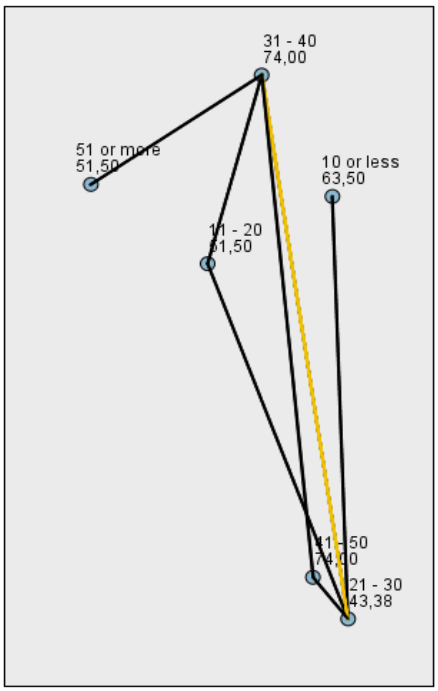


Total N	105
Test Statistic	15,535
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,008

1. The test statistic is adjusted for ties.

Figure 4.144. Kruskal-Wallis Test with respect to Company Age Groups (Business Development Module) (ERP & IT Management Module).

Pairwise Comparisons of comp_age_groups



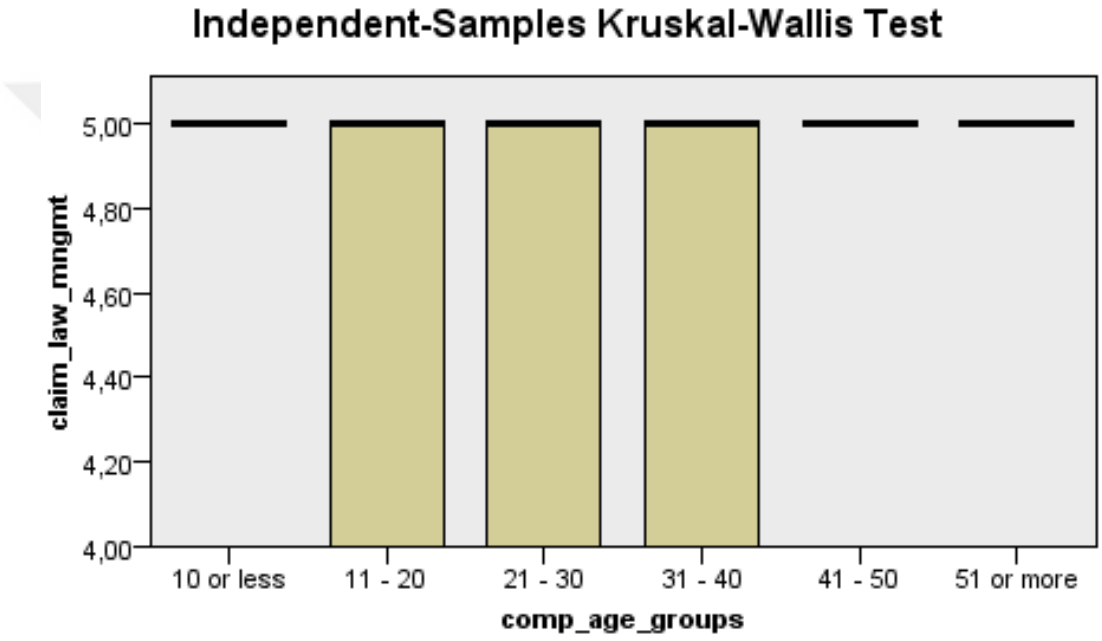
Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 30-11 - 20	8,125	7,096	1,145	,252	1,000
21 - 30-51 or more	-8,125	7,096	-1,145	,252	1,000
21 - 30-10 or less	20,125	7,942	2,534	,011	,169
21 - 30-31 - 40	-30,625	9,631	-3,180	,001	,022
21 - 30-41 - 50	-30,625	15,530	-1,972	,049	,729
11 - 20-51 or more	,000	7,975	,000	1,000	1,000
11 - 20-10 or less	12,000	8,737	1,374	,170	1,000
11 - 20-31 - 40	-22,500	10,296	-2,185	,029	,433
11 - 20-41 - 50	-22,500	15,951	-1,411	,158	1,000
51 or more-10 or less	12,000	8,737	1,374	,170	1,000
51 or more-31 - 40	22,500	10,296	2,185	,029	,433
51 or more-41 - 50	22,500	15,951	1,411	,158	1,000
10 or less-31 - 40	-10,500	10,896	-,964	,335	1,000
10 or less-41 - 50	-10,500	16,345	-,642	,521	1,000
31 - 40-41 - 50	,000	17,229	,000	1,000	1,000

Figure 4.145. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (ERP & IT Management Module).

According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores do change with respect to “company age groups.”

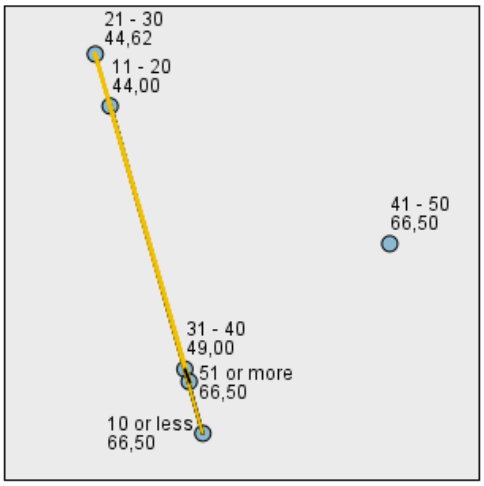
It can be seen that the answers of “11 – 20” company age group respondents are significantly different than “51 or more” company age group respondents. Also, the answers of “21 – 30” company age group respondents are significantly different than “51 or more” and “10 or less” company age group respondents.



Total N	105
Test Statistic	21,593
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,001

Figure 4.146. Kruskal-Wallis Test with respect to Company Age Groups (Claim & Law Management Module).

Pairwise Comparisons of comp_age_groups



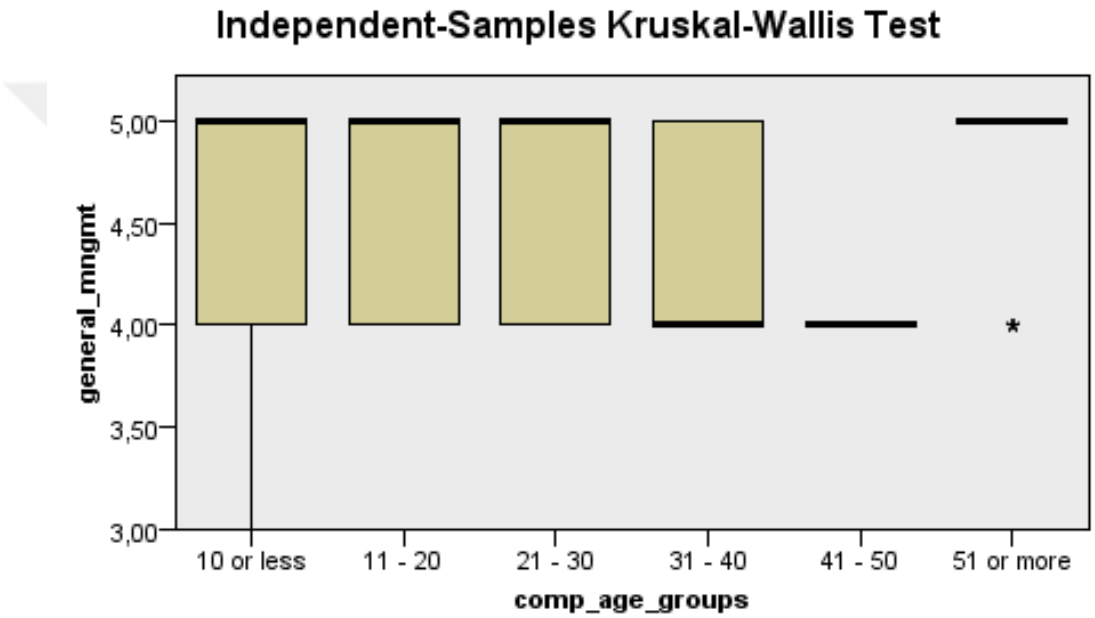
Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
11 - 20-21 - 30	-,625	6,331	-,099	,921	1,000
11 - 20-31 - 40	-5,000	9,186	-,544	,586	1,000
11 - 20-10 or less	22,500	7,794	2,887	,004	,058
11 - 20-41 - 50	-22,500	14,230	-1,581	,114	1,000
11 - 20-51 or more	-22,500	7,115	-3,162	,002	,023
21 - 30-31 - 40	-4,375	8,592	-,509	,611	1,000
21 - 30-10 or less	21,875	7,085	3,087	,002	,030
21 - 30-41 - 50	-21,875	13,855	-1,579	,114	1,000
21 - 30-51 or more	-21,875	6,331	-3,455	,001	,008
31 - 40-10 or less	17,500	9,721	1,800	,072	1,000
31 - 40-41 - 50	-17,500	15,370	-1,139	,255	1,000
31 - 40-51 or more	-17,500	9,186	-1,905	,057	,851
10 or less-41 - 50	,000	14,582	,000	1,000	1,000
10 or less-51 or more	,000	7,794	,000	1,000	1,000
41 - 50-51 or more	,000	14,230	,000	1,000	1,000

Figure 4.147. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (Claim & Law Management Module).

According to the figure below, it can be seen that “General Management” module user satisfaction scores do change with respect to “company age groups.”

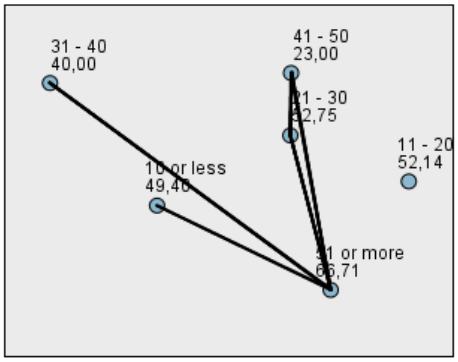
It can be seen that the answers of “41 – 50” company age group respondents are significantly different than “51 or more” company age group respondents. Also, the answers of “31 – 40” company age group respondents are significantly different than “51 or more” company age group respondents.



Total N	105
Test Statistic	12,334
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	,030

1. The test statistic is adjusted for ties.

Figure 4.148. Kruskal-Wallis Test with respect to Company Age Groups (General Management Module).



Each node shows the sample average rank of comp_age_groups.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
41 - 50-31 - 40	17,000	17,380	,978	,328	1,000
41 - 50-10 or less	26,400	16,488	1,601	,109	1,000
41 - 50-11 - 20	29,143	16,091	1,811	,070	1,000
41 - 50-21 - 30	29,750	15,666	1,899	,058	,864
41 - 50-51 or more	-43,714	16,091	-2,717	,007	,099
31 - 40-10 or less	9,400	10,992	,855	,392	1,000
31 - 40-11 - 20	12,143	10,387	1,169	,242	1,000
31 - 40-21 - 30	12,750	9,716	1,312	,189	1,000
31 - 40-51 or more	-26,714	10,387	-2,572	,010	,152
10 or less-11 - 20	-2,743	8,813	-,311	,756	1,000
10 or less-21 - 30	-3,350	8,012	-,418	,676	1,000
10 or less-51 or more	-17,314	8,813	-1,965	,049	,742
11 - 20-21 - 30	-,607	7,159	-,085	,932	1,000
11 - 20-51 or more	-14,571	8,046	-1,811	,070	1,000
21 - 30-51 or more	-13,964	7,159	-1,951	,051	,766

Figure 4.149. Kruskal-Wallis Pairwise Comparison Test with respect to Company Age Groups (General Management Module).

4.5.4.5. Kruskal-Wallis Test with Respect To "Total Employee". Here below at Table 4.23 Hypothesis Test Summary (Total Employee) Table, it can be seen Kruskal-Wallis test results of all modules with respect to "age groups." It can be seen from the table that Business Development, Sub-Contractor Tender Management, Owner Tender Management, Contract

Management, Owner Progress Report, Site Subcontractor Management, Design Management, Finance Management, Accounting Management, Procurement Management, HR Management, Quality Control Management, Logistics & Warehouse Management, Risk Management, BIM Management, ERP & IT Management and Claim & Law Management modules user satisfaction survey scores changes with respondent “total employee groups”.

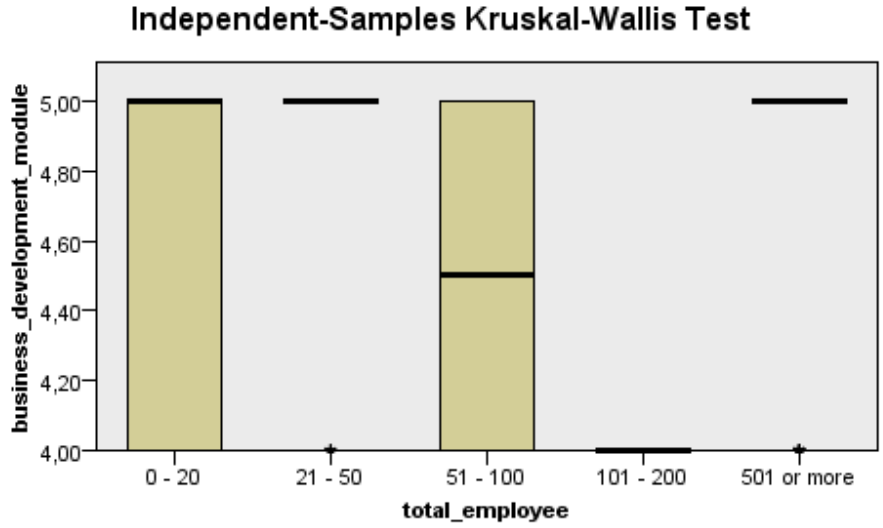
Table 4.23. Hypothesis Test Summary (Total Employee).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,112	Retain the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,458	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,021	Reject the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,018	Reject the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,016	Reject the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,679	Retain the null hypothesis.
18	The distribution of document_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,103	Retain the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,006	Reject the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,016	Reject the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,006	Reject the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,001	Reject the null hypothesis.
24	The distribution of general_mngmt is the same across categories of total_employee.	Independent-Samples Kruskal-Wallis Test	0,067	Retain the null hypothesis.

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to "total employee" of companies of the respondents in details.

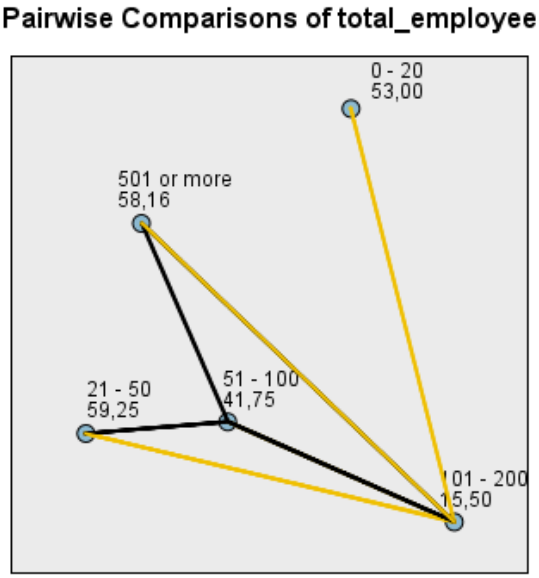
According to the figure below, it can be seen that "Business Development" module user satisfaction scores do change with respect to "total employee." It can be seen that the answers of "101 – 200" total employee of companies of the respondents are significantly different than "0 – 20", "21 – 50" and "501 or more" total employee of companies of the respondents.

%100 percent of the respondents whose companies' total employee are between 101 and 200 has scored the module proficiencies as 4 – High level but the respondents whose companies' total employees are "0-20", "21-50" and "501 or more" has scored as 5 – High Level with 71.4%, 83.3% and 81.3% respectively.



Total N	105
Test Statistic	21,017
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

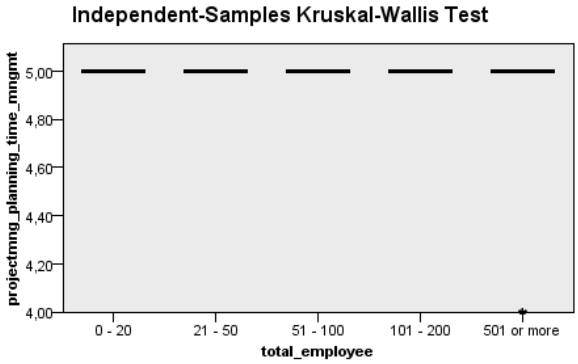
Figure 4.150. Kruskal-Wallis Test with respect to Total Employee (Business Development Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-51 - 100	26,250	11,915	2,203	,028	,276
101 - 200-0 - 20	37,500	11,032	3,399	,001	,007
101 - 200-501 or more	-42,656	10,319	-4,134	,000	,000
101 - 200-21 - 50	43,750	11,234	3,894	,000	,001
51 - 100-0 - 20	11,250	8,624	1,305	,192	1,000
51 - 100-501 or more	-16,406	7,691	-2,133	,033	,329
51 - 100-21 - 50	17,500	8,881	1,970	,049	,488
0 - 20-501 or more	-5,156	6,235	-,827	,408	1,000
0 - 20-21 - 50	-6,250	7,655	-,816	,414	1,000
501 or more-21 - 50	1,094	6,586	,166	,868	1,000

Figure 4.151. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Business Development Module).

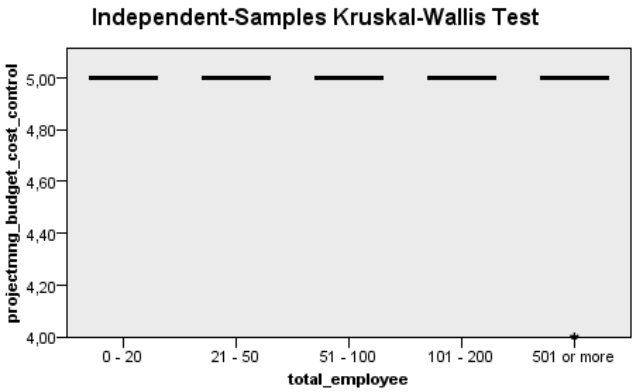
According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



Total N	105
Test Statistic	7,485
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,112

Figure 4.152. Kruskal-Wallis Test with respect to Total Employee (Planning & Time Management Module).

According to the figure below, it can be seen that “Project Management – Budget & Cost Control Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



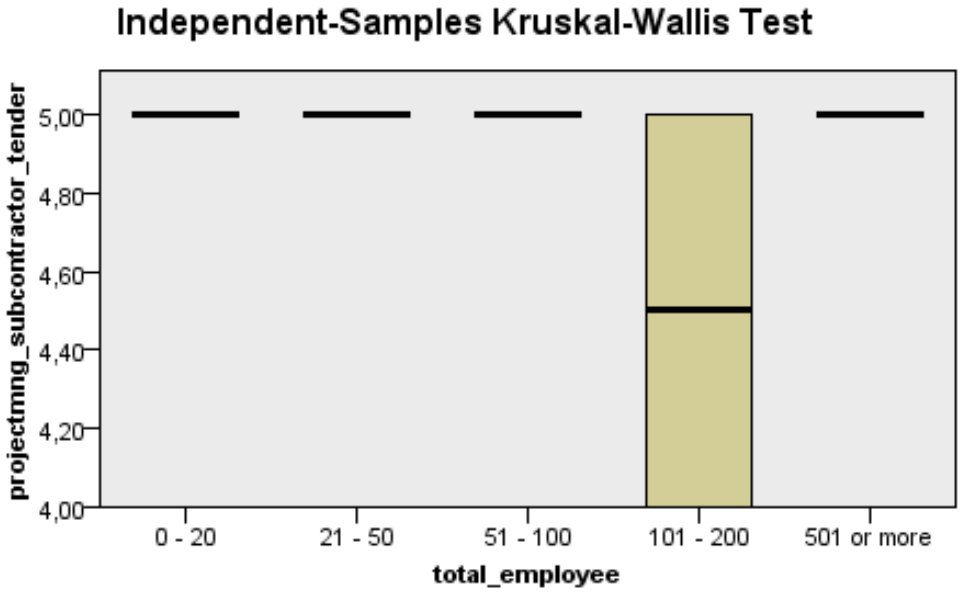
Total N	105
Test Statistic	3,632
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,458

Figure 4.153. Kruskal-Wallis Test with respect to Total Employee (Budget & Cost Control Management Module).

According to the figure below, it can be seen that “Subcontractor Tender Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.

Only %50 percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 5 – Very High level but 100% of the respondents whose companies’ total employees are “0-20”, “21-50”, “51-100” and “501 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	50,471
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

Figure 4.154. Kruskal-Wallis Test with respect to Total Employee (Subcontractor Tender Management Module).

Pairwise Comparisons of total_employee



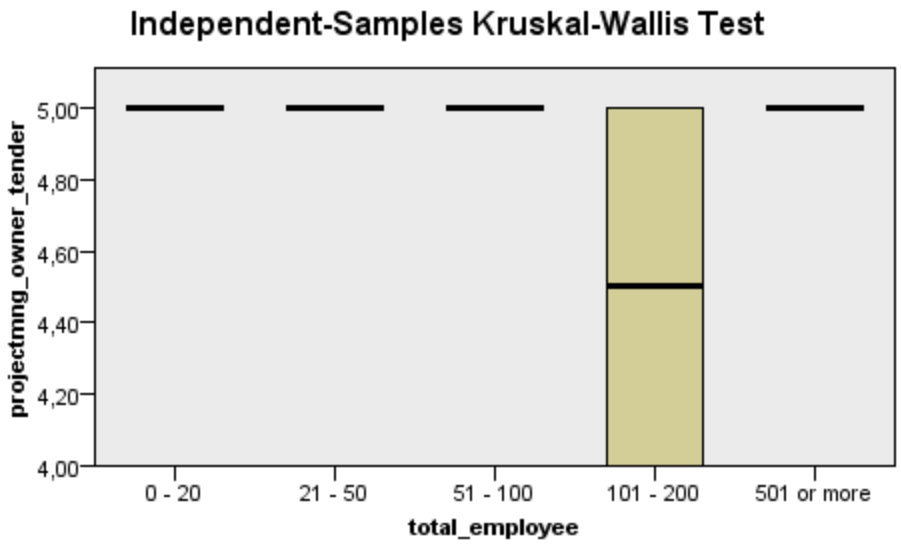
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-0 - 20	26,250	4,068	6,452	,000	,000
101 - 200-21 - 50	26,250	4,143	6,336	,000	,000
101 - 200-51 - 100	26,250	4,394	5,974	,000	,000
101 - 200-501 or more	-26,250	3,805	-6,898	,000	,000
0 - 20-21 - 50	,000	2,823	,000	1,000	1,000
0 - 20-51 - 100	,000	3,180	,000	1,000	1,000
0 - 20-501 or more	,000	2,299	,000	1,000	1,000
21 - 50-51 - 100	,000	3,275	,000	1,000	1,000
21 - 50-501 or more	,000	2,429	,000	1,000	1,000
51 - 100-501 or more	,000	2,836	,000	1,000	1,000

Figure 4.155. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Subcontractor Tender Management Module).

According to the figure below, it can be seen that “Owner Tender Management” module user satisfaction scores do change with respect to “total employee.” It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50” and “51 – 100” total employee of companies of the respondents.

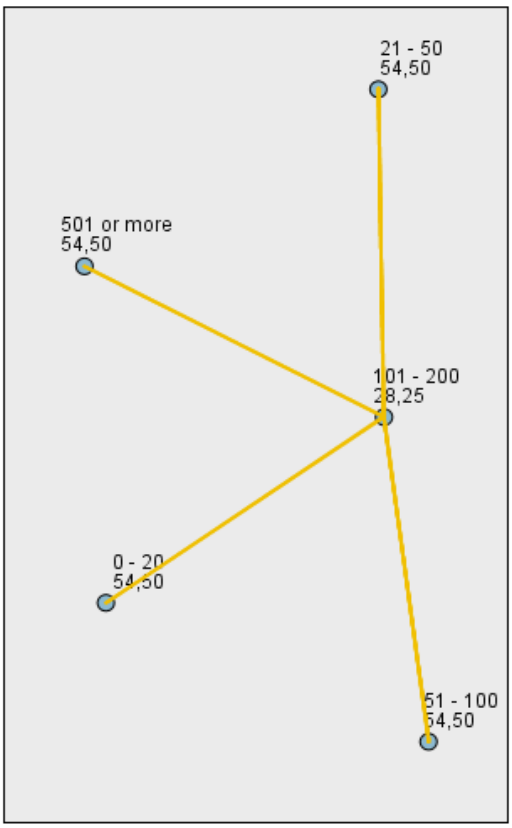
Only %50 percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 5 – Very High level but 100% of the respondents whose companies’ total employees are “0-20”, “21-50”, “51-100” and “501 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	50,471
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.156. Kruskal-Wallis Test with respect to Total Employee (Owner Tender Management Module).



Each node shows the sample average rank of total_employee.

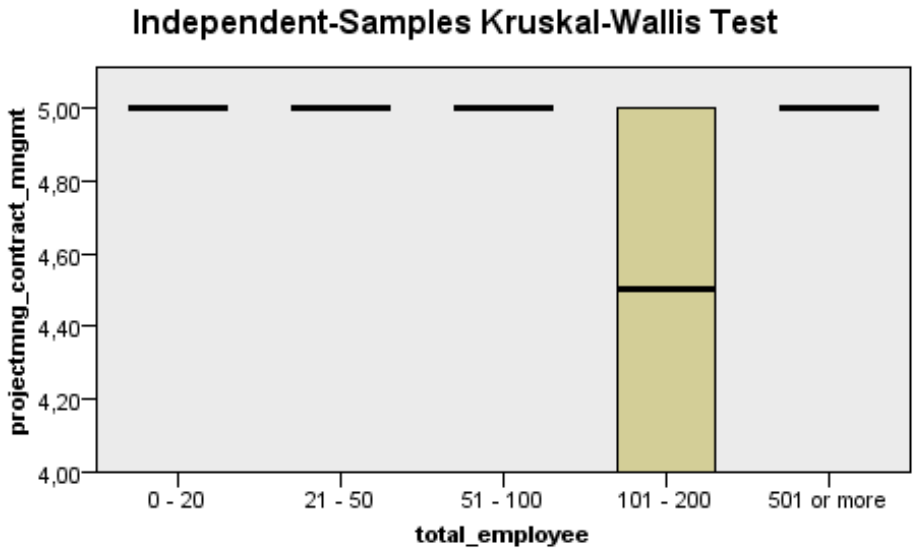
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-0 - 20	26,250	4,068	6,452	,000	,000
101 - 200-21 - 50	26,250	4,143	6,336	,000	,000
101 - 200-51 - 100	26,250	4,394	5,974	,000	,000
101 - 200-501 or more	-26,250	3,805	-6,898	,000	,000
0 - 20-21 - 50	,000	2,823	,000	1,000	1,000
0 - 20-51 - 100	,000	3,180	,000	1,000	1,000
0 - 20-501 or more	,000	2,299	,000	1,000	1,000
21 - 50-51 - 100	,000	3,275	,000	1,000	1,000
21 - 50-501 or more	,000	2,429	,000	1,000	1,000
51 - 100-501 or more	,000	2,836	,000	1,000	1,000

Figure 4.157. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Owner Tender Management Module).

According to the figure below, it can be seen that “Contract Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.

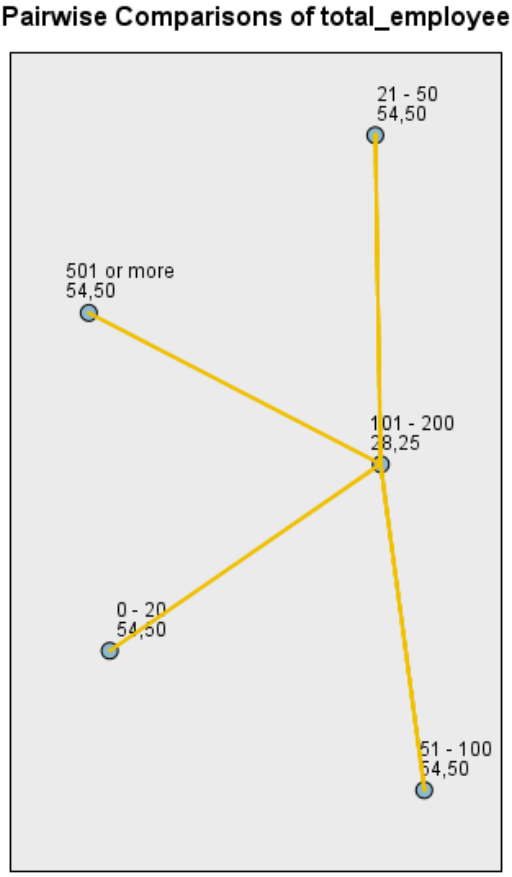
Only %50 percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 5 – Very High level but 100% of the respondents whose companies’ total employees are “0-20”, “21-50”, “51-100” and “501 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	50,471
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.158. Kruskal-Wallis Test with respect to Total Employee (Contract Management Module).

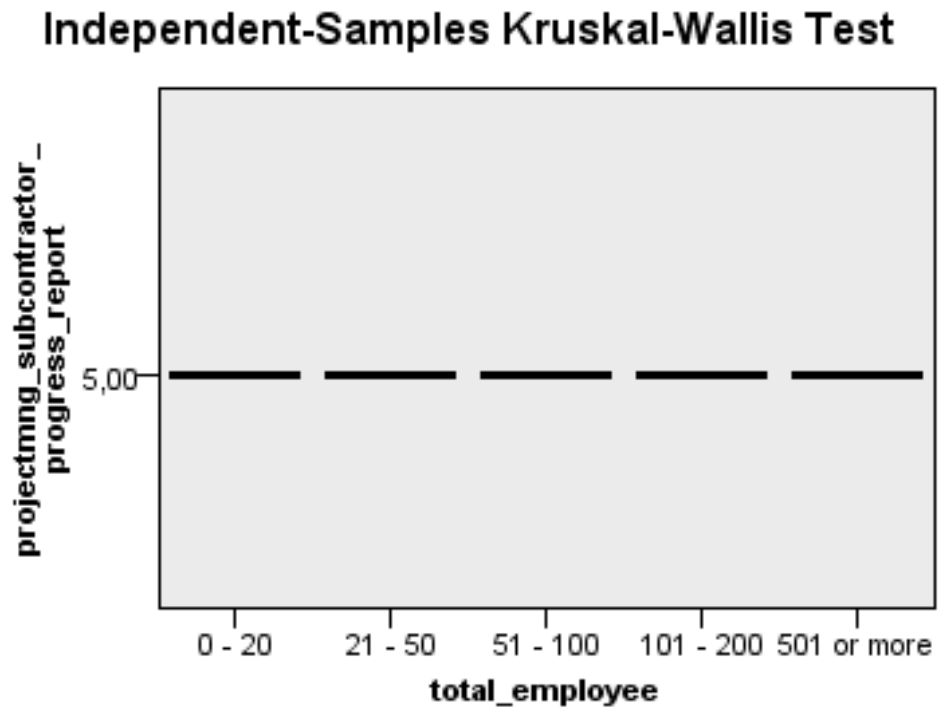


Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-0 - 20	26,250	4,068	6,452	,000	,000
101 - 200-21 - 50	26,250	4,143	6,336	,000	,000
101 - 200-51 - 100	26,250	4,394	5,974	,000	,000
101 - 200-501 or more	-26,250	3,805	-6,898	,000	,000
0 - 20-21 - 50	,000	2,823	,000	1,000	1,000
0 - 20-51 - 100	,000	3,180	,000	1,000	1,000
0 - 20-501 or more	,000	2,299	,000	1,000	1,000
21 - 50-51 - 100	,000	3,275	,000	1,000	1,000
21 - 50-501 or more	,000	2,429	,000	1,000	1,000
51 - 100-501 or more	,000	2,836	,000	1,000	1,000

Figure 4.159. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Contract Management Module).

According to the figure below, it can be seen that “Project Management – Sub-Contractor Progress Report Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



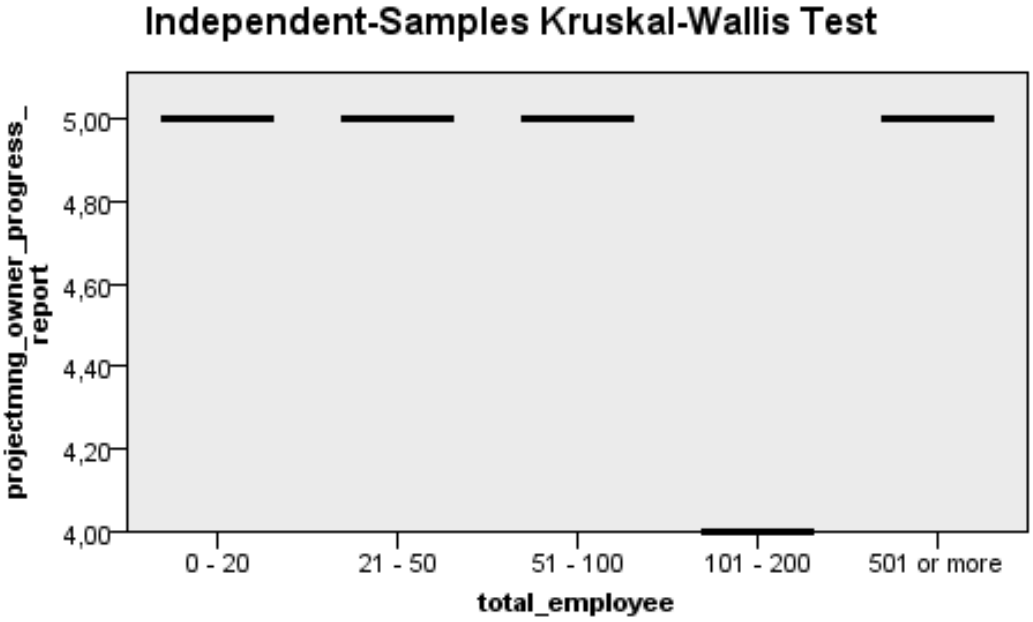
Total N	105
Test Statistic	,000
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	1,000

Figure 4.160. Kruskal-Wallis Test with respect to Total Employee (Sub-Contractor Progress Report Management Module).

According to the figure below, it can be seen that “Owner Progress Report Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.

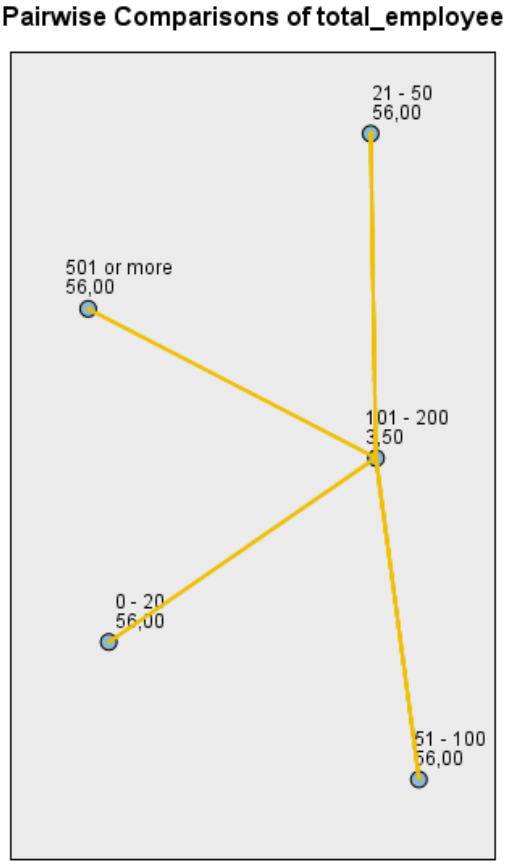
%100 percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “0-20”, “21-50”, “51-100” and “501 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	104,000
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.161. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Owner Progress Report Management Module).



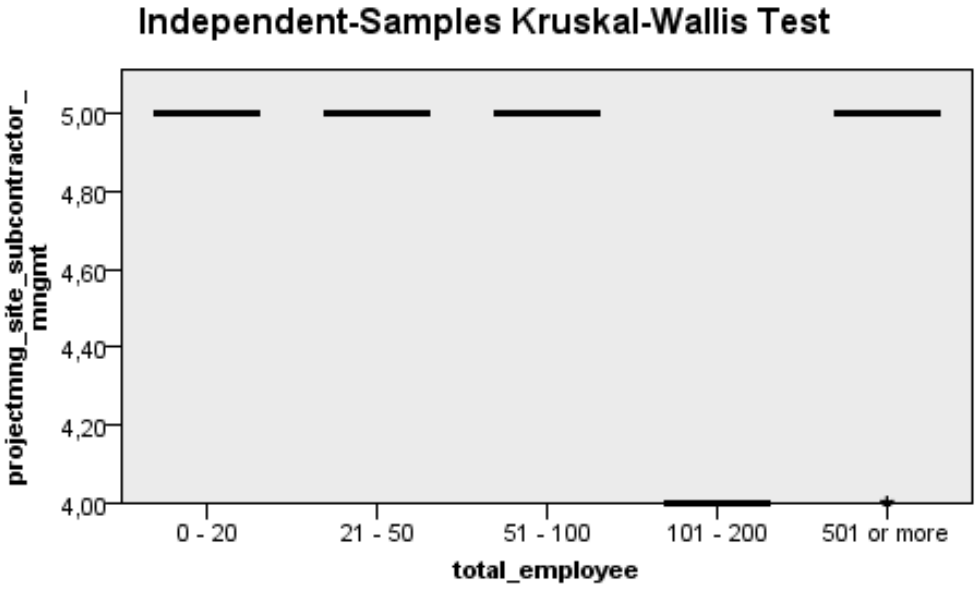
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-0 - 20	52,500	5,668	9,262	,000	,000
101 - 200-21 - 50	52,500	5,772	9,095	,000	,000
101 - 200-51 - 100	52,500	6,122	8,575	,000	,000
101 - 200-501 or more	-52,500	5,302	-9,902	,000	,000
0 - 20-21 - 50	,000	3,933	,000	1,000	1,000
0 - 20-51 - 100	,000	4,431	,000	1,000	1,000
0 - 20-501 or more	,000	3,204	,000	1,000	1,000
21 - 50-51 - 100	,000	4,563	,000	1,000	1,000
21 - 50-501 or more	,000	3,384	,000	1,000	1,000
51 - 100-501 or more	,000	3,952	,000	1,000	1,000

Figure 4.162. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Owner Progress Report Management Module).

According to the figure below, it can be seen that “Site & Subcontractor Management” module user satisfaction scores do change with respect to “total employee.” It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.

100% of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “0-20”, “21-50” and “51-100” have scored as 5 – High Level, and again about 100% of the respondents whose companies’ total employees are “51 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	68,453
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

Figure 4.163. Kruskal-Wallis Test with respect to Total Employee (Site & Subcontractor Management Module).

Pairwise Comparisons of total_employee

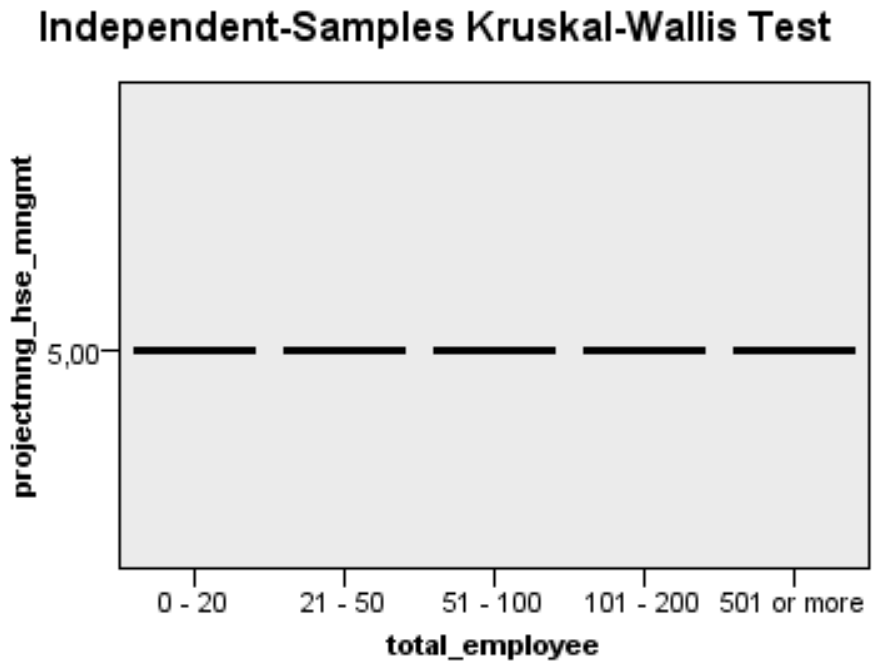


Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-501 or more	-49,219	6,394	-7,697	,000	,000
101 - 200-0 - 20	52,500	6,836	7,680	,000	,000
101 - 200-21 - 50	52,500	6,961	7,542	,000	,000
101 - 200-51 - 100	52,500	7,384	7,110	,000	,000
501 or more-0 - 20	3,281	3,864	,849	,396	1,000
501 or more-21 - 50	3,281	4,082	,804	,421	1,000
501 or more-51 - 100	3,281	4,766	,688	,491	1,000
0 - 20-21 - 50	,000	4,743	,000	1,000	1,000
0 - 20-51 - 100	,000	5,344	,000	1,000	1,000
21 - 50-51 - 100	,000	5,503	,000	1,000	1,000

Figure 4.164. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Site & Subcontractor Management Module).

According to the figure below, it can be seen that “Project Management – HSE Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



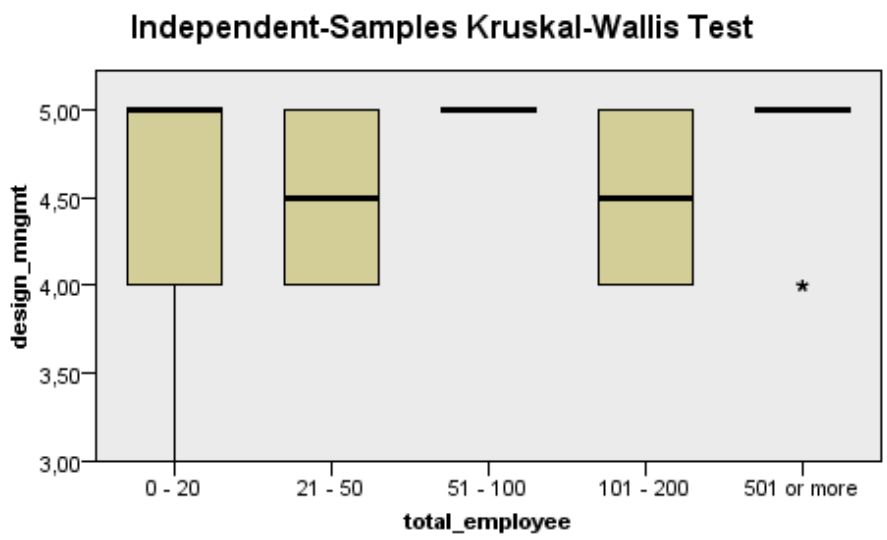
Total N	105
Test Statistic	,000
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	1,000

Figure 4.165. Kruskal-Wallis Test with respect to Total Employee (HSE Management Module).

According to the figure below, it can be seen that “Design Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “21 – 50” total employee of companies of the respondents are significantly different than “51 – 100” and “501 or more” total employee of companies of the respondents.

50% percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “51-100” have scored as 5 – High Level, and again about 100% of the respondents whose companies’ total employees are “51 or more” have scored as 5 – High Level.

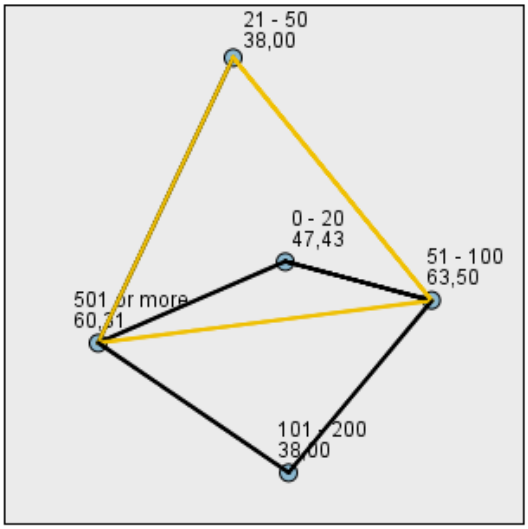


Total N	105
Test Statistic	22,193
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.166. Kruskal-Wallis Test with respect to Total Employee (Design Management Module).

Pairwise Comparisons of total_employee



Each node shows the sample average rank of total_employee.

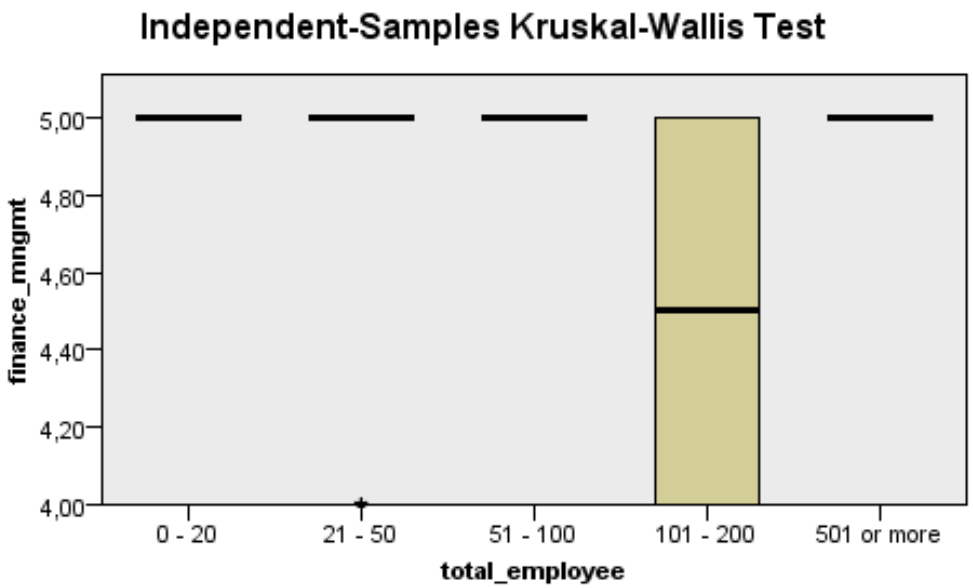
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
21 - 50-101 - 200	,000	9,977	,000	1,000	1,000
21 - 50-0 - 20	9,429	6,798	1,387	,165	1,000
21 - 50-501 or more	-22,312	5,850	-3,814	,000	,001
21 - 50-51 - 100	-25,500	7,888	-3,233	,001	,012
101 - 200-0 - 20	9,429	9,798	,962	,336	1,000
101 - 200-501 or more	-22,312	9,165	-2,435	,015	,149
101 - 200-51 - 100	25,500	10,583	2,410	,016	,160
0 - 20-501 or more	-12,884	5,538	-2,327	,020	,200
0 - 20-51 - 100	-16,071	7,659	-2,098	,036	,359
501 or more-51 - 100	3,188	6,831	,467	,641	1,000

Figure 4.167. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Design Management Module).

According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50” and “51 – 100” total employee of companies of the respondents.

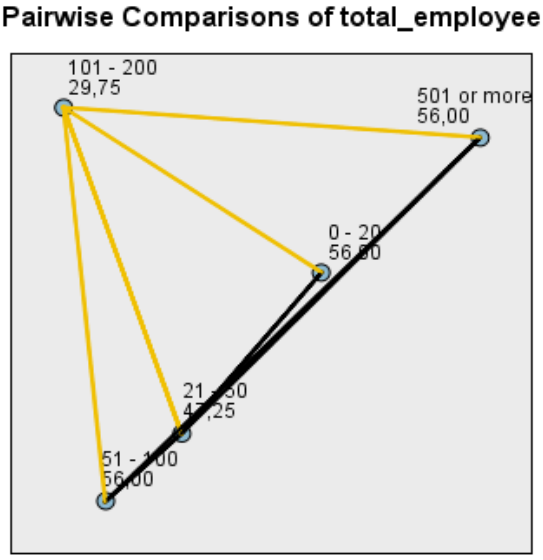
50% percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “0-20” and “51-100” have scored as 5 – High Level, and again 83.3% of the respondents whose companies’ total employees are “51 or more” have scored as 5 – High Level.



Total N	105
Test Statistic	30,465
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.168. Kruskal-Wallis Test with respect to Total Employee (Finance Management Module).



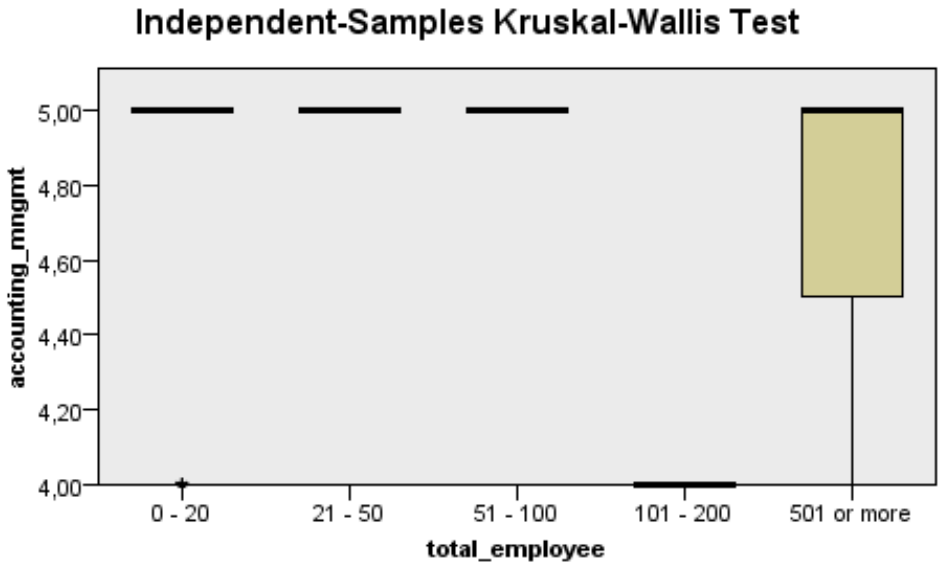
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-21 - 50	17,500	5,772	3,032	,002	,024
101 - 200-0 - 20	26,250	5,668	4,631	,000	,000
101 - 200-51 - 100	26,250	6,122	4,288	,000	,000
101 - 200-501 or more	-26,250	5,302	-4,951	,000	,000
21 - 50-0 - 20	8,750	3,933	2,225	,026	,261
21 - 50-51 - 100	-8,750	4,563	-1,917	,055	,552
21 - 50-501 or more	-8,750	3,384	-2,586	,010	,097
0 - 20-51 - 100	,000	4,431	,000	1,000	1,000
0 - 20-501 or more	,000	3,204	,000	1,000	1,000
51 - 100-501 or more	,000	3,952	,000	1,000	1,000

Figure 4.169. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Finance Management Module).

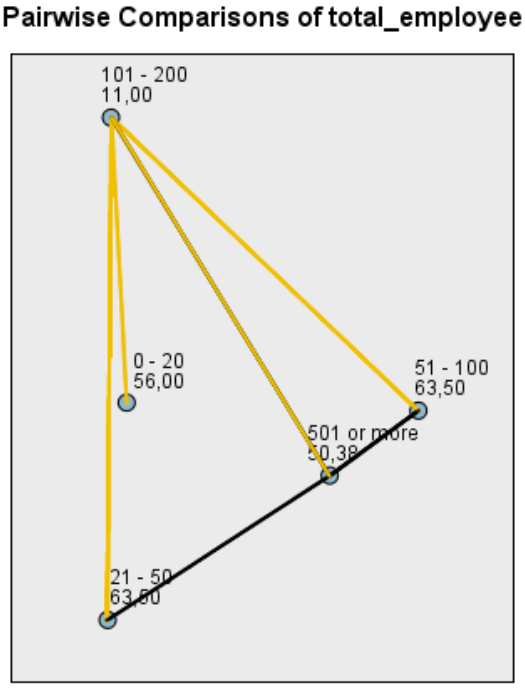
According to the figure below, it can be seen that “Accounting Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.



Total N	105
Test Statistic	32,367
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

Figure 4.170. Kruskal-Wallis Test with respect to Total Employee (Accounting Management Module)



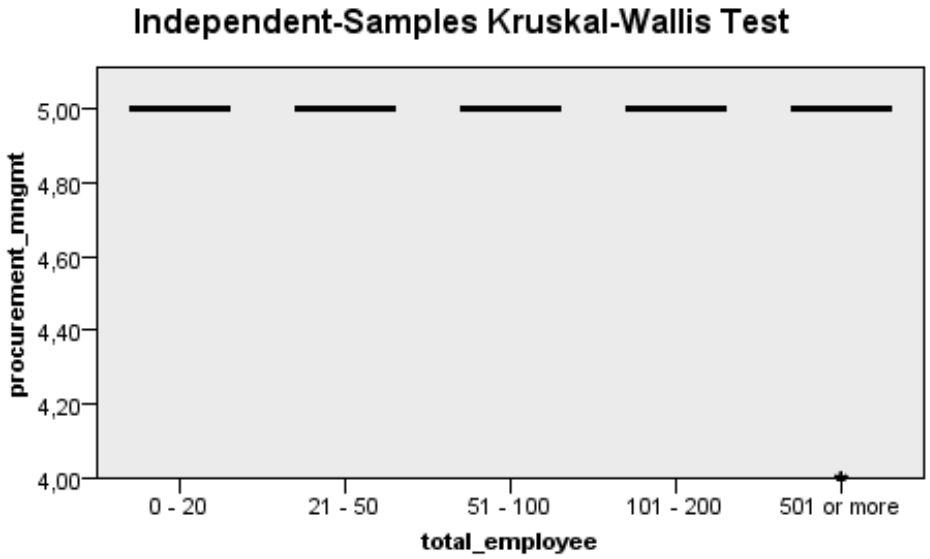
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-501 or more	-39,375	9,137	-4,309	,000	,000
101 - 200-0 - 20	45,000	9,768	4,607	,000	,000
101 - 200-21 - 50	52,500	9,947	5,278	,000	,000
101 - 200-51 - 100	52,500	10,550	4,976	,000	,000
501 or more-0 - 20	5,625	5,521	1,019	,308	1,000
501 or more-21 - 50	13,125	5,832	2,251	,024	,244
501 or more-51 - 100	13,125	6,810	1,927	,054	,539
0 - 20-21 - 50	-7,500	6,778	-1,107	,268	1,000
0 - 20-51 - 100	-7,500	7,636	-,982	,326	1,000
21 - 50-51 - 100	,000	7,864	,000	1,000	1,000

Figure 4.171. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Accounting Management Module)

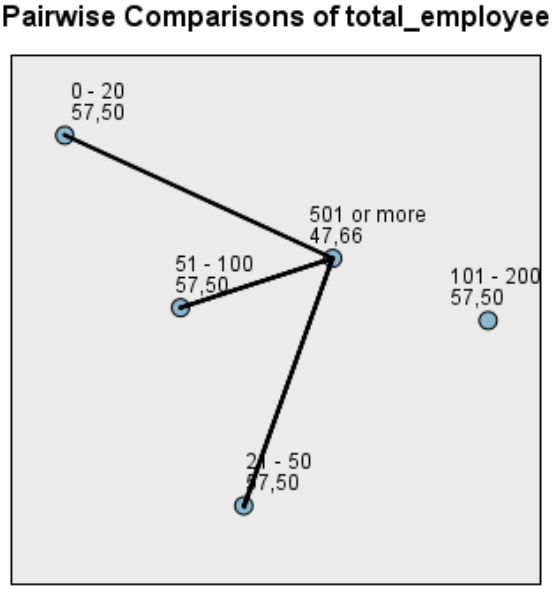
According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “501 or more” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50” and “51 – 100” total employee of companies of the respondents.



Total N	105
Test Statistic	11,578
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,021

Figure 4.172. Kruskal-Wallis Test with respect to Total Employee (Procurement Management Module).



Each node shows the sample average rank of total_employee.

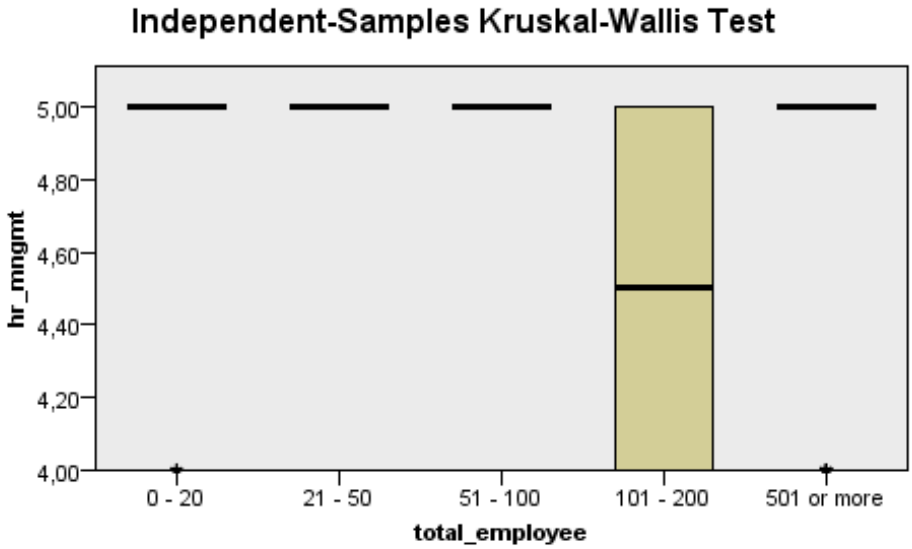
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
501 or more-0 - 20	9,844	3,864	2,548	,011	,108
501 or more-21 - 50	9,844	4,082	2,412	,016	,159
501 or more-51 - 100	9,844	4,766	2,065	,039	,389
501 or more-101 - 200	9,844	6,394	1,539	,124	1,000
0 - 20-21 - 50	,000	4,743	,000	1,000	1,000
0 - 20-51 - 100	,000	5,344	,000	1,000	1,000
0 - 20-101 - 200	,000	6,836	,000	1,000	1,000
21 - 50-51 - 100	,000	5,503	,000	1,000	1,000
21 - 50-101 - 200	,000	6,961	,000	1,000	1,000
51 - 100-101 - 200	,000	7,384	,000	1,000	1,000

Figure 4.173. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Procurement Management Module).

According to the figure below, it can be seen that “HR Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “21 – 50” and “51 – 100” total employee of companies of the respondents.

50% percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “21-50” and “51-100” have scored as 5 – High Level.



Total N	105
Test Statistic	11,917
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,018

1. The test statistic is adjusted for ties.

Figure 4.174. Kruskal-Wallis Test with respect to Total Employee (HR Management Module).

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-501 or more	-16,406	7,993	-2,053	,040	,401
101 - 200-0 - 20	18,750	8,545	2,194	,028	,282
101 - 200-21 - 50	26,250	8,702	3,017	,003	,026
101 - 200-51 - 100	26,250	9,230	2,844	,004	,045
501 or more-0 - 20	2,344	4,830	,485	,627	1,000
501 or more-21 - 50	9,844	5,102	1,929	,054	,537
501 or more-51 - 100	9,844	5,958	1,652	,098	,985
0 - 20-21 - 50	-7,500	5,929	-1,265	,206	1,000
0 - 20-51 - 100	-7,500	6,680	-1,123	,262	1,000
21 - 50-51 - 100	,000	6,879	,000	1,000	1,000

Figure 4.175. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (HR Management Module).

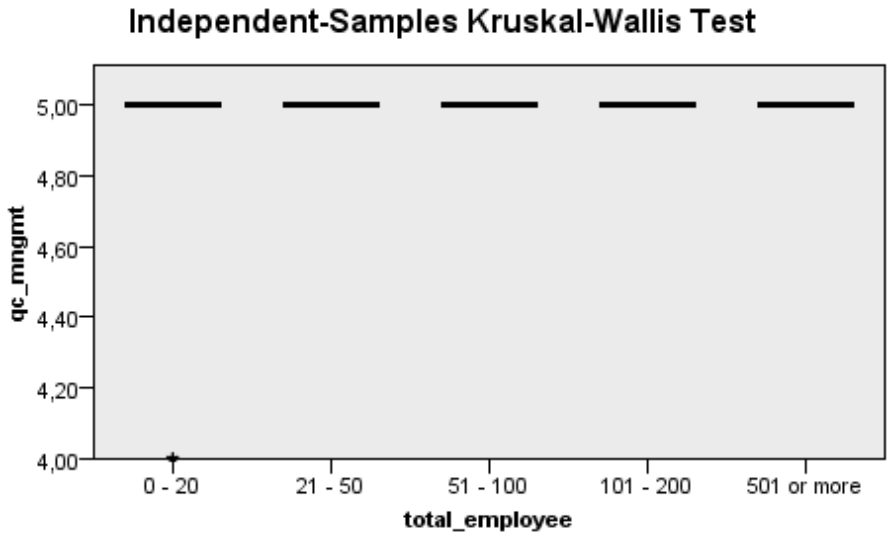
According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “0 – 20” total employee of companies of the respondents are significantly different than “501 or more” total employee of companies of the respondents.

85.7% percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 5 – Very High level but 100% of the respondents whose companies’ total employees are “501 or more” have scored as 5 – High

Level. Other total employee groups interviewees have scored the module proficiency as 5 – Very High level, also.

It can be said the more total employee increases at the construction companies, the proficiency level of the module for user satisfaction has been increased.

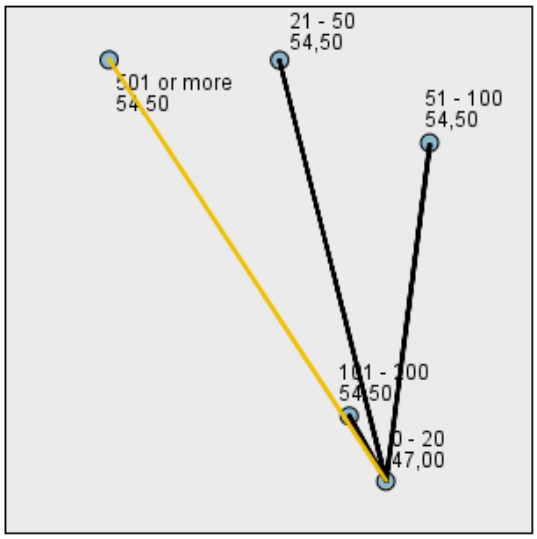


Total N	105
Test Statistic	12,235
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,016

1. The test statistic is adjusted for ties.

Figure 4.176. Kruskal-Wallis Test with respect to Total Employee (Quality Control Management Module).

Pairwise Comparisons of total_employee

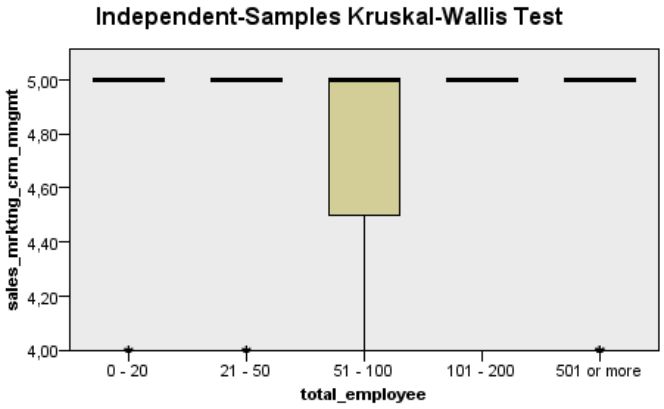


Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0 - 20-21 - 50	-7,500	2,823	-2,657	,008	,079
0 - 20-51 - 100	-7,500	3,180	-2,358	,018	,184
0 - 20-101 - 200	-7,500	4,068	-1,844	,065	,652
0 - 20-501 or more	-7,500	2,299	-3,262	,001	,011
21 - 50-51 - 100	,000	3,275	,000	1,000	1,000
21 - 50-101 - 200	,000	4,143	,000	1,000	1,000
21 - 50-501 or more	,000	2,429	,000	1,000	1,000
51 - 100-101 - 200	,000	4,394	,000	1,000	1,000
51 - 100-501 or more	,000	2,836	,000	1,000	1,000
101 - 200-501 or more	,000	3,805	,000	1,000	1,000

Figure 4.177. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Quality Control Management Module).

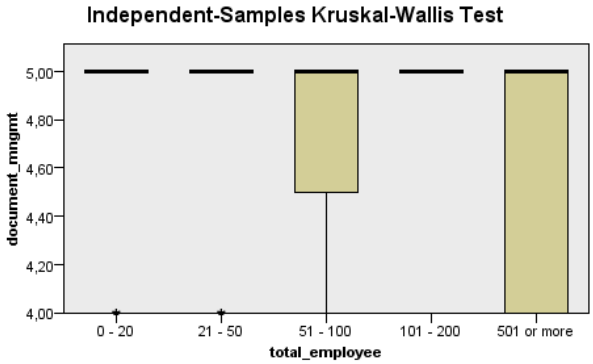
According to the figure below, it can be seen that “Sales & Marketing & CRM Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



Total N	105
Test Statistic	2,311
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,679

Figure 4.178. Kruskal-Wallis Test with respect to Total Employee (Sales & Marketing & CRM Management Module).

According to the figure below, it can be seen that “Document Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



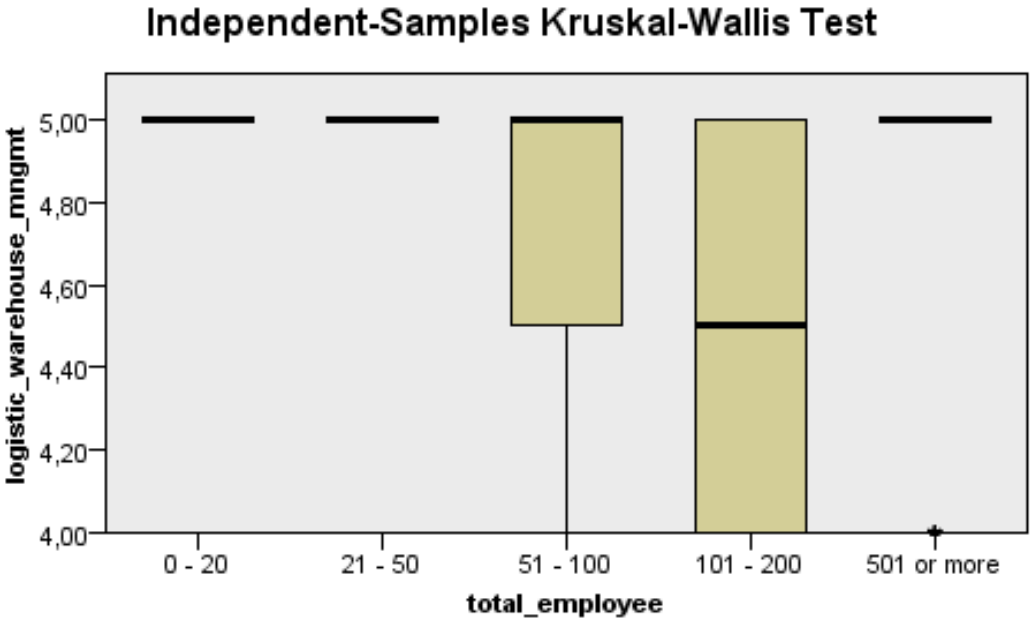
Total N	105
Test Statistic	7,704
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,103

Figure 4.179. Kruskal-Wallis Test with respect to Age Groups (Document Management Module).

According to the figure below, it can be seen that “Logistics & Warehouse Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20” and “21 – 50” total employee of companies of the respondents.

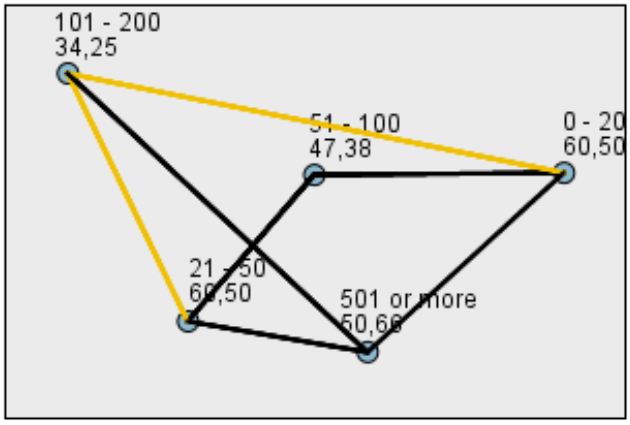
50% percent of the respondents whose companies’ total employee are between 101 and 200 have scored the module proficiencies as 4 – High level but 100% of the respondents whose companies’ total employees are “0-20” and “21-50” have scored as 5 – High Level.



Total N	105
Test Statistic	14,517
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,006

Figure 4.180. Kruskal-Wallis Test with respect to Total Employee (Logistics & Warehouse Management Module).

Pairwise Comparisons of total_employee



Each node shows the sample average rank of total_employee.

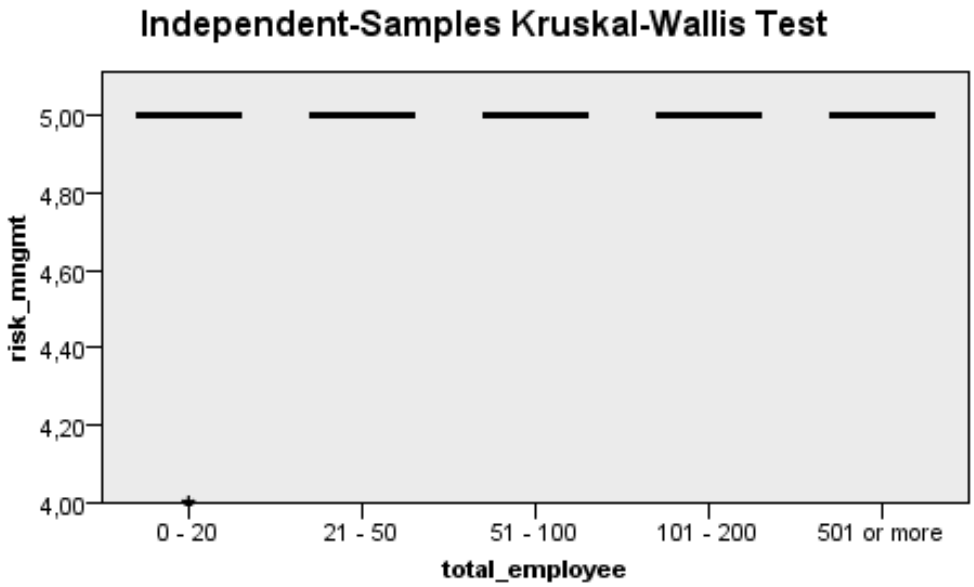
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-51 - 100	13,125	9,230	1,422	,155	1,000
101 - 200-501 or more	-16,406	7,993	-2,053	,040	,401
101 - 200-0 - 20	26,250	8,545	3,072	,002	,021
101 - 200-21 - 50	26,250	8,702	3,017	,003	,026
51 - 100-501 or more	-3,281	5,958	-,551	,582	1,000
51 - 100-0 - 20	13,125	6,680	1,965	,049	,494
51 - 100-21 - 50	13,125	6,879	1,908	,056	,564
501 or more-0 - 20	9,844	4,830	2,038	,042	,415
501 or more-21 - 50	9,844	5,102	1,929	,054	,537
0 - 20-21 - 50	,000	5,929	,000	1,000	1,000

Figure 4.181. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Logistics & Warehouse Management Module).

According to the figure below, it can be seen that “Risk Management” module user satisfaction scores do change with respect to “total employee.”

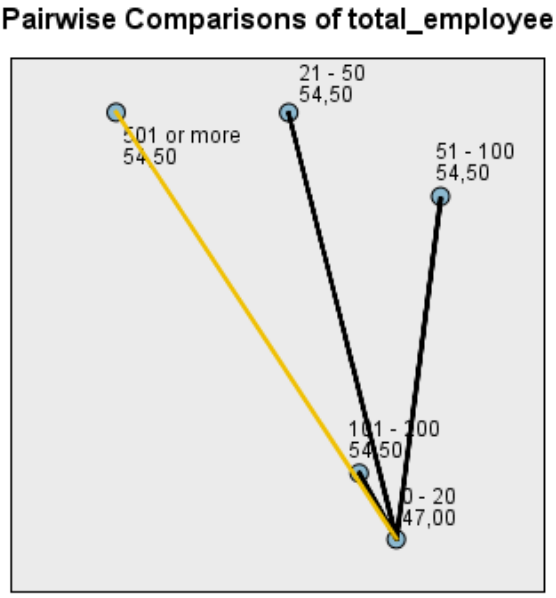
It can be seen that the answers of “0 – 20” total employee of companies of the respondents are significantly different than “501 or more” total employee of companies of the respondents.

85.7% percent of the respondents whose companies’ total employee are between 0 and 20 have scored the module proficiencies as 5 – Very High level but 100% of the respondents whose companies’ total employees are “501 or more” have scored as 5 – High Level. Other total employee groups interviewees have scored the module proficiency as 5 – Very High level, also. It can be said the more total employee increases at the construction companies, the proficiency level of the module for user satisfaction has been increased.



Total N	105
Test Statistic	12,235
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,016

Figure 4.182. Kruskal-Wallis Test with respect to Total Employee (Risk Management Module).



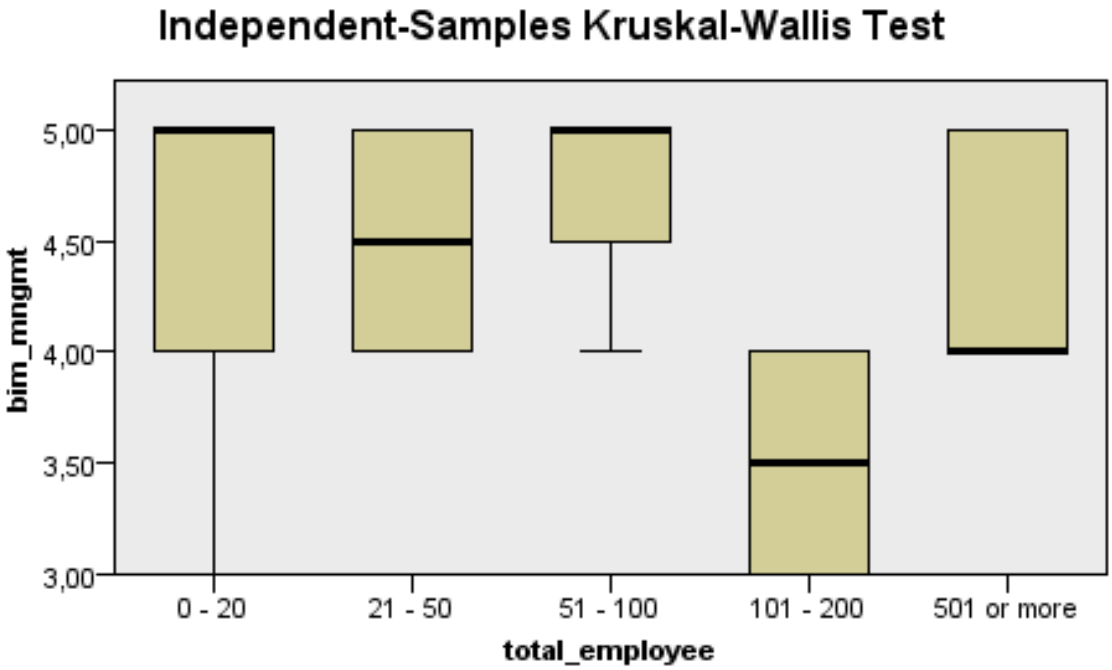
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0 - 20-21 - 50	-7,500	2,823	-2,657	,008	,079
0 - 20-51 - 100	-7,500	3,180	-2,358	,018	,184
0 - 20-101 - 200	-7,500	4,068	-1,844	,065	,652
0 - 20-501 or more	-7,500	2,299	-3,262	,001	,011
21 - 50-51 - 100	,000	3,275	,000	1,000	1,000
21 - 50-101 - 200	,000	4,143	,000	1,000	1,000
21 - 50-501 or more	,000	2,429	,000	1,000	1,000
51 - 100-101 - 200	,000	4,394	,000	1,000	1,000
51 - 100-501 or more	,000	2,836	,000	1,000	1,000
101 - 200-501 or more	,000	3,805	,000	1,000	1,000

Figure 4.183. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Risk Management Module).

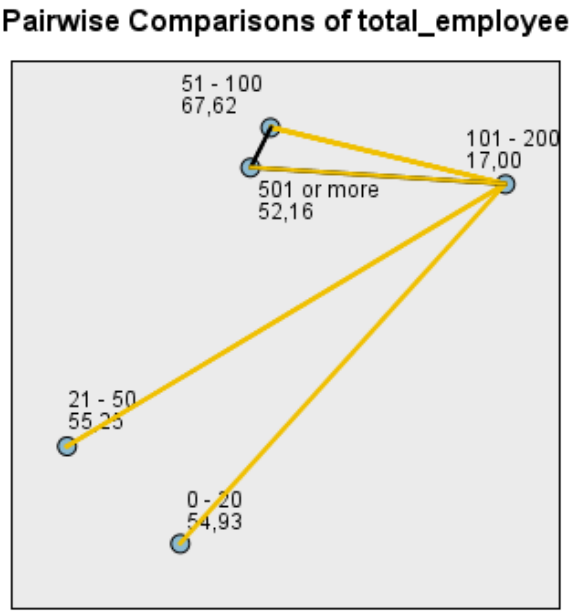
According to the figure below, it can be seen that “BIM Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.



Total N	105
Test Statistic	14,397
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,006

Figure 4.184. Kruskal-Wallis Test with respect to Total Employee (BIM Management Module).



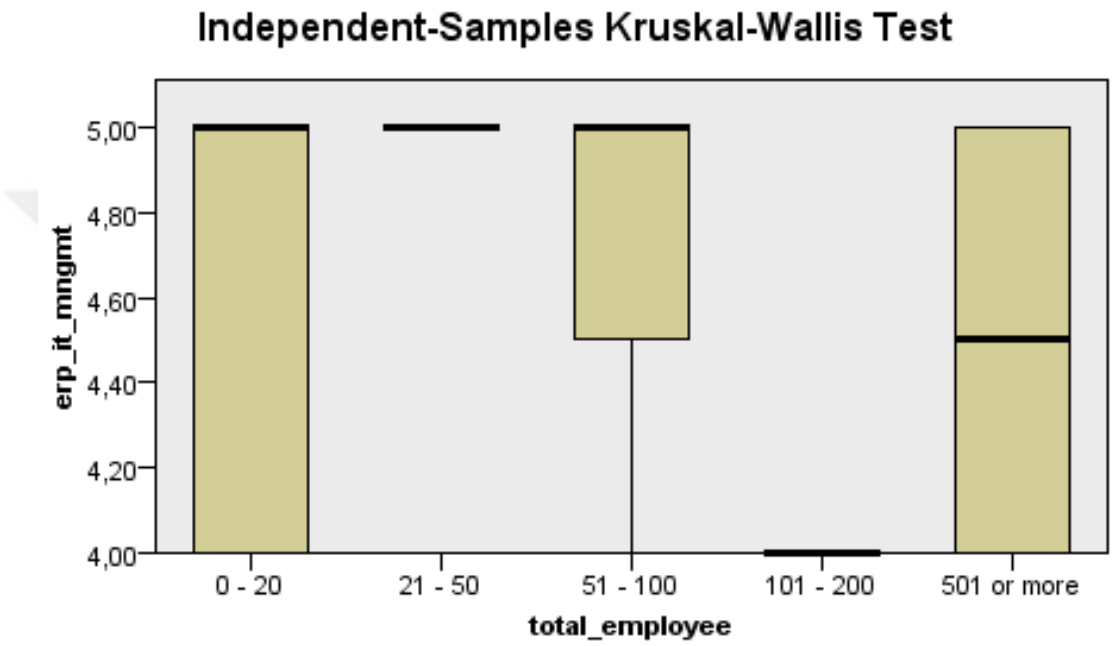
Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-501 or more	-35,156	11,719	-3,000	,003	,027
101 - 200-0 - 20	37,929	12,529	3,027	,002	,025
101 - 200-21 - 50	38,250	12,758	2,998	,003	,027
101 - 200-51 - 100	50,625	13,532	3,741	,000	,002
501 or more-0 - 20	2,772	7,081	,392	,695	1,000
501 or more-21 - 50	3,094	7,480	,414	,679	1,000
501 or more-51 - 100	15,469	8,735	1,771	,077	,766
0 - 20-21 - 50	-,321	8,693	-,037	,971	1,000
0 - 20-51 - 100	-12,696	9,794	-1,296	,195	1,000
21 - 50-51 - 100	-12,375	10,086	-1,227	,220	1,000

Figure 4.185. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (BIM Management Module).

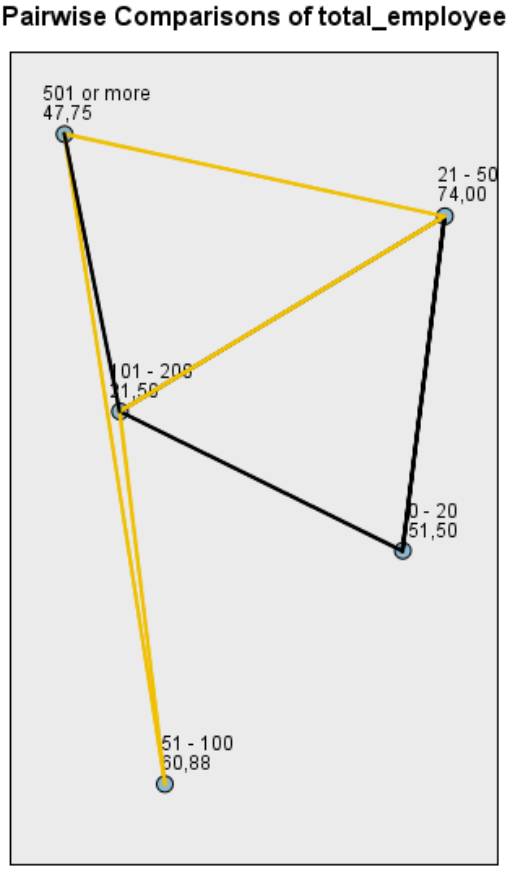
According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores do change with respect to “total employee.”

It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “51 – 100” and “21 – 50” total employee of companies of the respondents. Also, that the answers of “501 or more” total employee of companies of the respondents are significantly different than “21 – 50” total employee of companies of the respondents.



Total N	105
Test Statistic	23,966
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,000

Figure 4.186. Kruskal-Wallis Test with respect to Age Groups (ERP & IT Management Module).

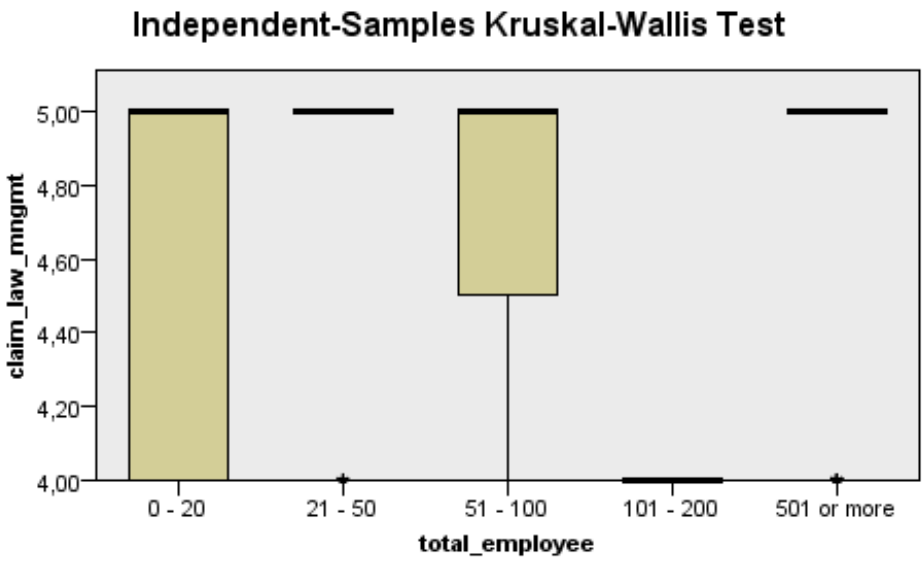


Each node shows the sample average rank of total_employee.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-501 or more	-26,250	11,190	-2,346	,019	,190
101 - 200-0 - 20	30,000	11,963	2,508	,012	,122
101 - 200-51 - 100	39,375	12,921	3,047	,002	,023
101 - 200-21 - 50	52,500	12,183	4,309	,000	,000
501 or more-0 - 20	3,750	6,761	,555	,579	1,000
501 or more-51 - 100	13,125	8,341	1,574	,116	1,000
501 or more-21 - 50	26,250	7,143	3,675	,000	,002
0 - 20-51 - 100	-9,375	9,352	-1,002	,316	1,000
0 - 20-21 - 50	-22,500	8,301	-2,711	,007	,067
51 - 100-21 - 50	13,125	9,631	1,363	,173	1,000

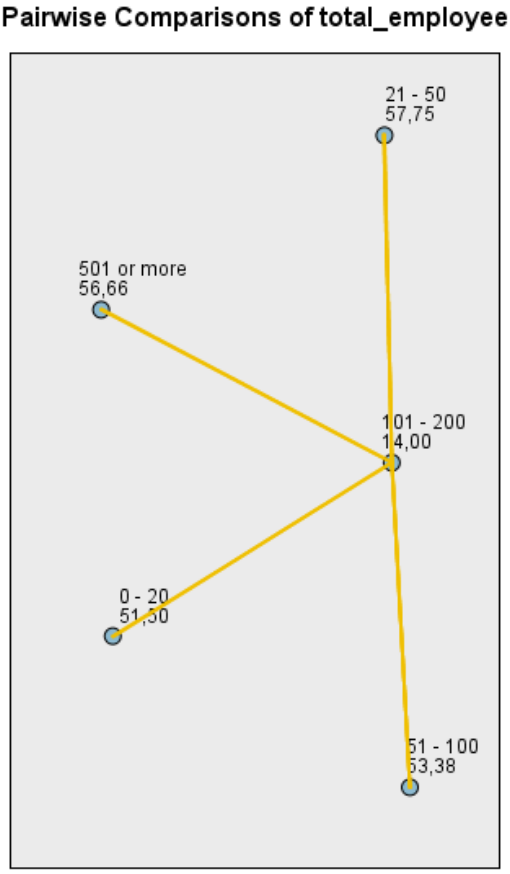
Figure 4.187. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (ERP & IT Management Module).

According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores do change with respect to “total employee.” It can be seen that the answers of “101 – 200” total employee of companies of the respondents are significantly different than “0 – 20”, “21 – 50”, “51 – 100” and “501 or more” total employee of companies of the respondents.



Total N	105
Test Statistic	19,231
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,001

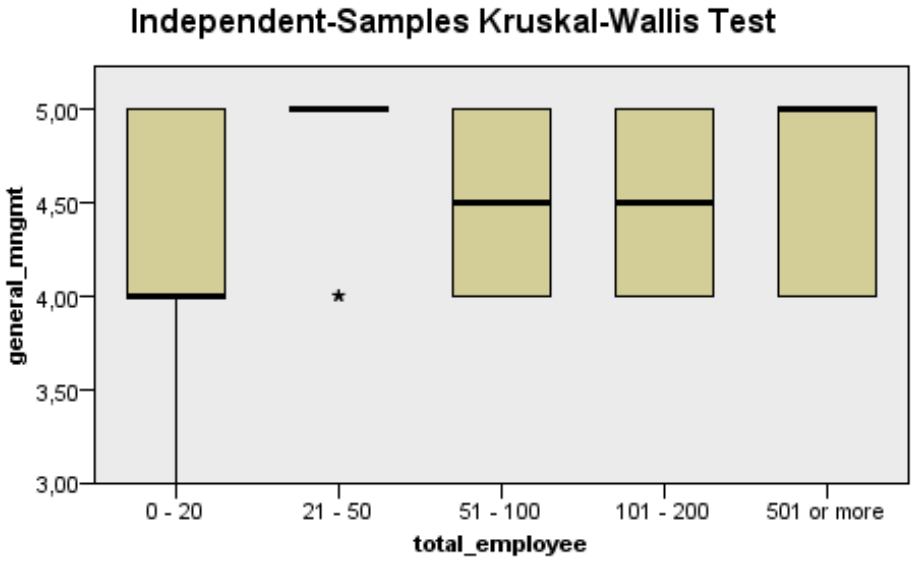
Figure 4.188. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Claim & Law Management Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
101 - 200-0 - 20	37,500	10,673	3,514	,000	,004
101 - 200-51 - 100	39,375	11,528	3,416	,001	,006
101 - 200-501 or more	-42,656	9,983	-4,273	,000	,000
101 - 200-21 - 50	43,750	10,869	4,025	,000	,001
0 - 20-51 - 100	-1,875	8,343	-,225	,822	1,000
0 - 20-501 or more	-5,156	6,032	-,855	,393	1,000
0 - 20-21 - 50	-6,250	7,406	-,844	,399	1,000
51 - 100-501 or more	-3,281	7,441	-,441	,659	1,000
51 - 100-21 - 50	4,375	8,592	,509	,611	1,000
501 or more-21 - 50	1,094	6,372	,172	,864	1,000

Figure 4.189. Kruskal-Wallis Pairwise Comparison Test with respect to Total Employee (Claim & Law Management Module).

According to the figure below, it can be seen that “General Management” module user satisfaction scores do not change with respect to “total employee” of the companies of the respondents.



Total N	105
Test Statistic	8,759
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	,067

Figure 4.190. Kruskal-Wallis Test with respect to Total Employee (General Management Module).

4.5.4.6. Kruskal-Wallis Test with Respect To “Department”. Here below at Table 4.24 Hypothesis Test Summary (Department) Table, it can be seen Kruskal-Wallis test results of all modules with respect to “departments.” It can be seen from the table that Business Development, Owner Tender Management, Design Management, Accounting Management, Procurement Management, HR Management, Logistics & Warehouse Management, Document Management, BIM Management, ERP & IT Management, Claim & Law Management and General Management modules user satisfaction survey scores changes with respondent “departments.”

Table 4.24. Hypothesis Test Summary (Departments).

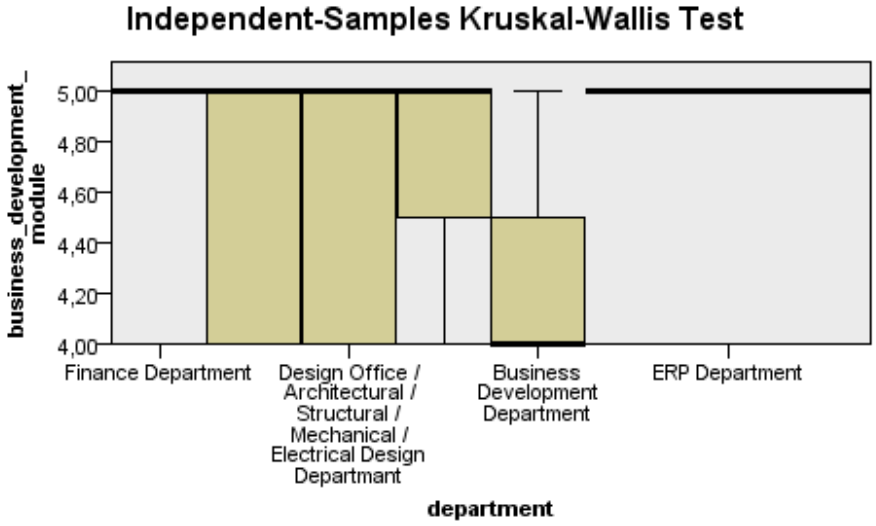
Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,001	Reject the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,298	Retain the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,771	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,771	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,001	Reject the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,771	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,132	Retain the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,198	Retain the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,132	Retain the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,047	Reject the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,004	Reject the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,771	Retain the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,228	Retain the null hypothesis.
18	The distribution of document_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,009	Reject the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,771	Retain the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,004	Reject the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,004	Reject the null hypothesis.
24	The distribution of general_mngmt is the same across categories of department.	Independent-Samples Kruskal-Wallis Test	0,003	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Here below, it can be seen *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to "departments" of the respondents in details.

According to the figure below, it can be seen that "Business Development" module user satisfaction scores do change with respect to "departments" of the respondents. It can be seen that the answers of respondents at "business development" department are significantly different than the respondents at "finance" and "ERP" departments.

Only 25% of the interviewees from business development department have scored the module proficiency as 5 – Very High and the rest of the department have scored the module proficiency as 4 – High but 100% of finance and ERP department interviewees have scored the proficiency level of the module as 5 – Very High. Business development department professionals them have scored the module proficiency as 4 – High or higher.



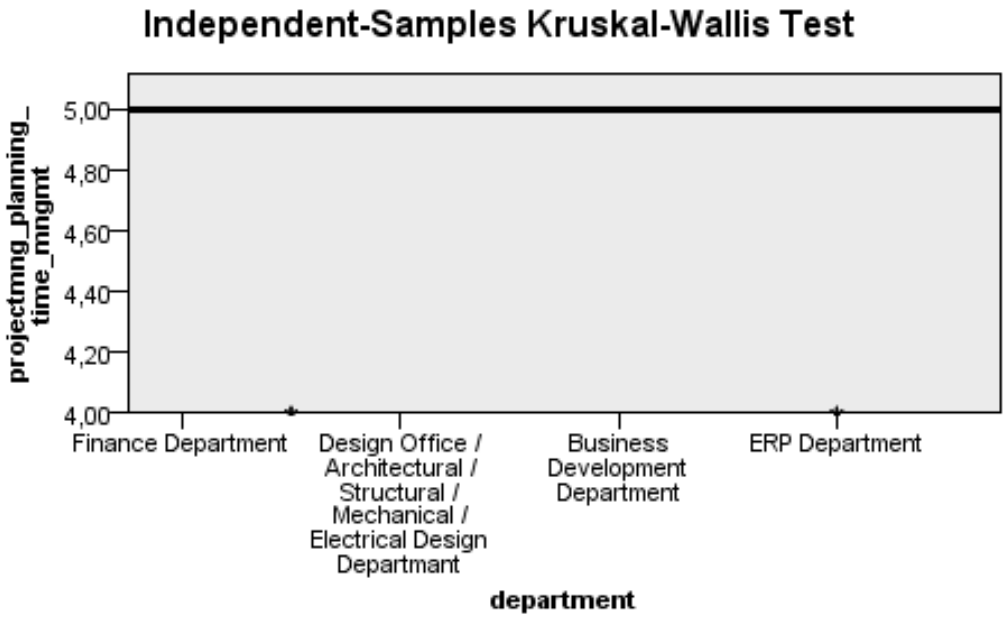
Total N	105
Test Statistic	23,920
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,001

Figure 4.191. Kruskal-Wallis Test with respect to Departments (Business Development Module).

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Business Development Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	21,875	7,742	2,825	,005	,132
Business Development Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	21,875	10,508	2,082	,037	1,000
Business Development Department-Construction (Site)	26,250	9,729	2,698	,007	,195
Business Development Department-Finance Department	39,375	11,915	3,305	,001	,027
Business Development Department-Purchasing / Procurement Department	-39,375	15,383	-2,560	,010	,293
Business Development Department-ERP Department	-39,375	9,230	-4,266	,000	,001
Business Development Department-IT Department	-39,375	15,383	-2,560	,010	,293
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	,000	8,702	,000	1,000	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	-4,375	7,742	-,565	,572	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	17,500	10,357	1,690	,091	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-17,500	14,210	-1,232	,218	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-17,500	7,105	-2,463	,014	,386
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-IT Department	-17,500	14,210	-1,232	,218	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Construction (Site)	-4,375	10,508	-,416	,677	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Finance Department	17,500	12,560	1,393	,164	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Purchasing / Procurement Department	-17,500	15,887	-1,102	,271	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-ERP Department	-17,500	10,048	-1,742	,082	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-IT Department	-17,500	15,887	-1,102	,271	1,000
Construction (Site)-Finance Department	13,125	11,915	1,102	,271	1,000
Construction (Site)-Purchasing / Procurement Department	-13,125	15,383	-,853	,394	1,000
Construction (Site)-ERP Department	-13,125	9,230	-1,422	,155	1,000
Construction (Site)-IT Department	-13,125	15,383	-,853	,394	1,000
Finance Department-Purchasing / Procurement Department	,000	16,851	,000	1,000	1,000
Finance Department-ERP Department	,000	11,511	,000	1,000	1,000
Finance Department-IT Department	,000	16,851	,000	1,000	1,000
Purchasing / Procurement Department-ERP Department	,000	15,072	,000	1,000	1,000
Purchasing / Procurement Department-IT Department	,000	19,458	,000	1,000	1,000
ERP Department-IT Department	,000	15,072	,000	1,000	1,000

Figure 4.192. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Business Development Module).

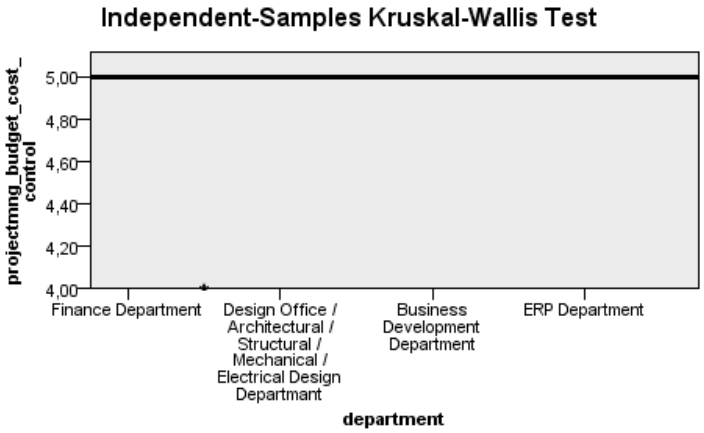
According to the figure below, it can be seen that “Project Management – Planning & Time Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	8,404
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,298

Figure 4.193. Kruskal-Wallis Test with respect to Departments (Planning & Time Management Module).

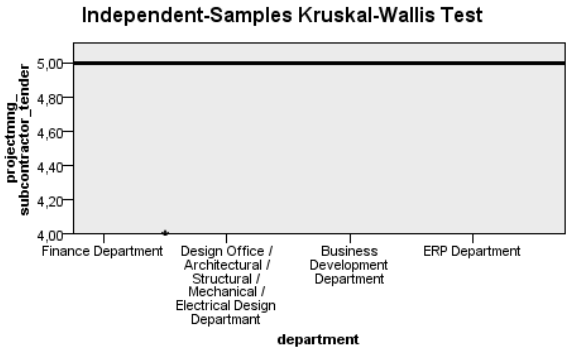
According to the figure below, it can be seen that “Project Management – Budget & Cost Control Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	4,078
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,771

Figure 4.194. Kruskal-Wallis Test with respect to Departments (Budget & Cost Control Management Module).

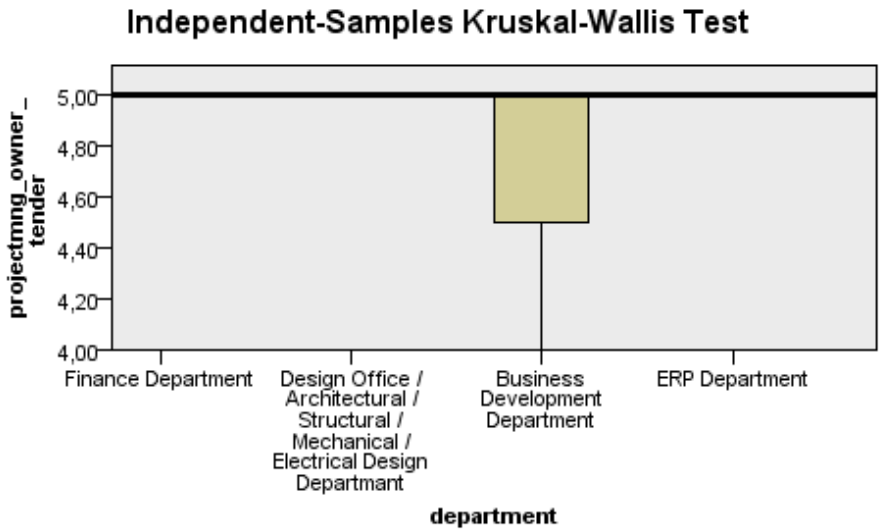
According to the figure below, it can be seen that "Project Management – Subcontractor Tender Management" module user satisfaction scores do not change with respect to "department" of the respondents.



Total N	105
Test Statistic	4,078
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,771

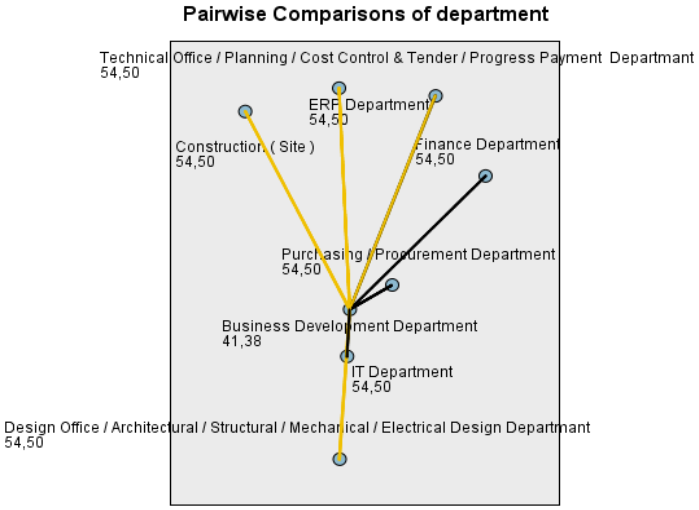
Figure 4.195. Kruskal-Wallis Test with respect to Departments (Subcontractor Tender Management Module).

According to the figure below, it can be seen that “Owner Tender Management” module user satisfaction scores do change with respect to “departments” of the respondents. It can be seen that the answers of respondents at “business development” department are significantly different than the respondents at “technical office”, “design office”, “construction (site)” and “ERP” departments.



Total N	105
Test Statistic	23,706
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,001

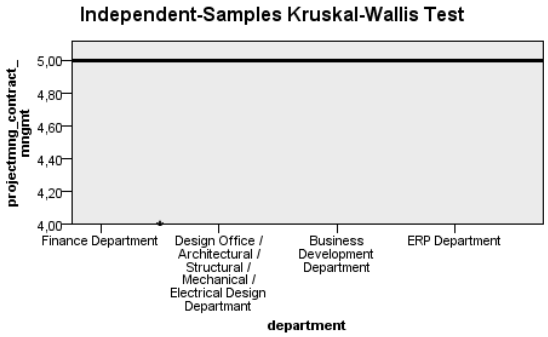
Figure 4.196. Kruskal-Wallis Test with respect to Departments (Owner Tender Management Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Business Development Department-Finance Department	13,125	4,394	2,987	,003	,079
Business Development Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	13,125	2,855	4,597	,000	,000
Business Development Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	13,125	3,875	3,387	,001	,020
Business Development Department-Construction (Site)	13,125	3,588	3,658	,000	,007
Business Development Department-Purchasing / Procurement Department	-13,125	5,673	-2,314	,021	,579
Business Development Department-ERP Department	-13,125	3,404	-3,856	,000	,003
Business Development Department-IT Department	-13,125	5,673	-2,314	,021	,579
Finance Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	,000	3,820	,000	1,000	1,000
Finance Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	,000	4,632	,000	1,000	1,000
Finance Department-Construction (Site)	,000	4,394	,000	1,000	1,000
Finance Department-Purchasing / Procurement Department	,000	6,214	,000	1,000	1,000
Finance Department-ERP Department	,000	4,245	,000	1,000	1,000
Finance Department-IT Department	,000	6,214	,000	1,000	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	,000	3,209	,000	1,000	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	,000	2,855	,000	1,000	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	,000	5,240	,000	1,000	1,000

Figure 4.197. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Owner Tender Management Module).

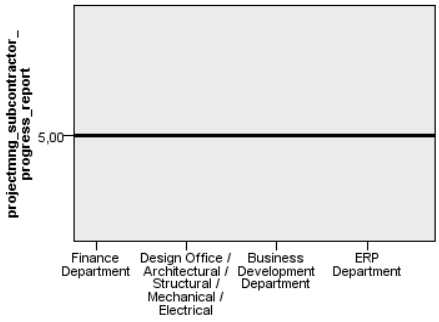
According to the figure below, it can be seen that “Project Management – Contract Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	4,078
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,771

Figure 4.198. Kruskal-Wallis Test with respect to Departments (Contract Management Module).

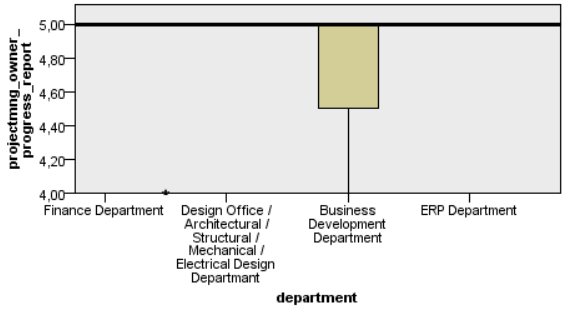
According to the figure below, it can be seen that “Project Management – Subcontractor Progress Report Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	,000
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	1,000

Figure 4.199. Kruskal-Wallis Test with respect to Departments (Subcontractor Progress Report Management Module).

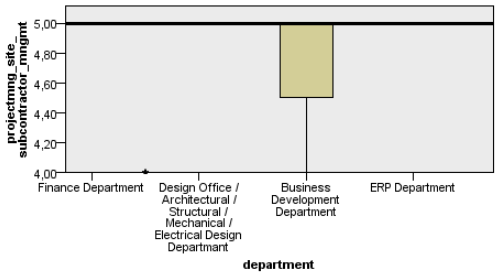
According to the figure below, it can be seen that “Project Management – Owner Progress Report Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	11,162
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,132

Figure 4.200. Kruskal-Wallis Test with respect to Departments (Owner Progress Report Management Module).

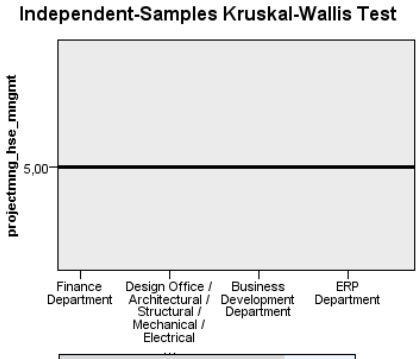
According to the figure below, it can be seen that “Project Management – Site & Subcontractor Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	9,840
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,198

Figure 4.201. Kruskal-Wallis Test with respect to Departments (Site & Subcontractor Management Module).

According to the figure below, it can be seen that “Project Management – HSE Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	,000
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	1,000

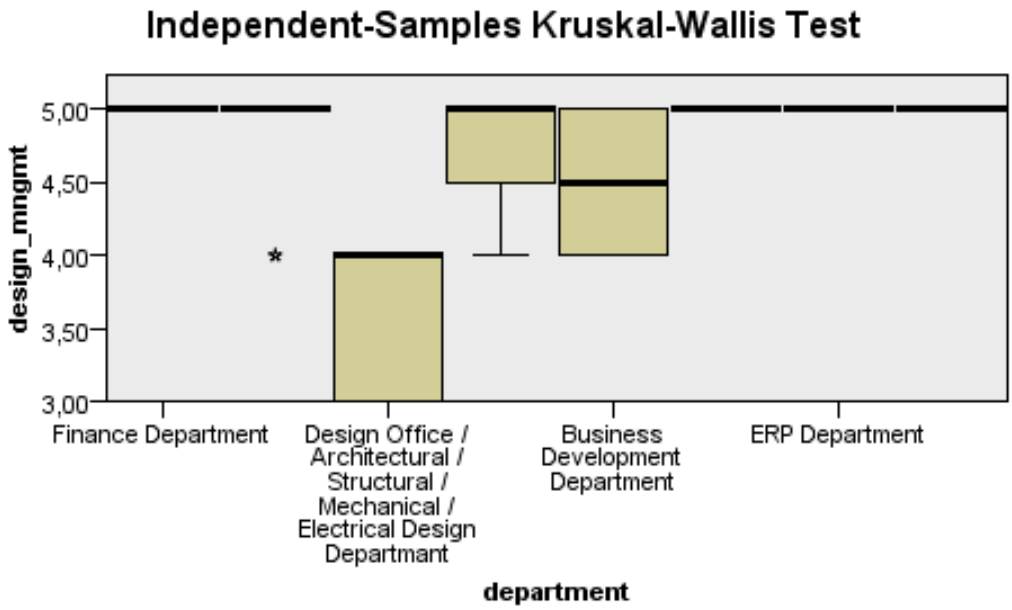
Figure 4.202. Kruskal-Wallis Test with respect to Departments (HSE Management Module).

According to the figure below, it can be seen that “Design Management” module user satisfaction scores do change with respect to “departments” of the respondents.

It can be seen that the answers of respondents at “design office” department are significantly different than the respondents at “construction (site)”, “technical office”, “finance”, “procurement”, “ERP” and “IT” departments. Also, the answers of respondents at “business development” department are significantly different than the respondents at “technical office” departments.

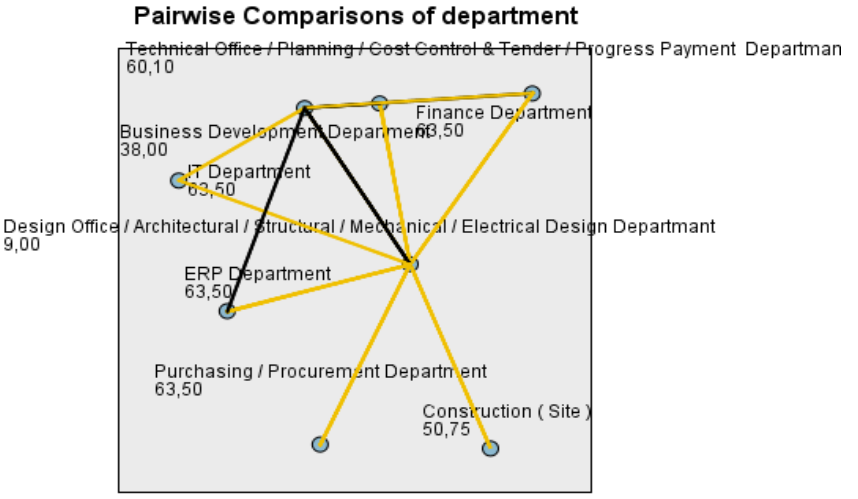
66.7% of the interviewees from design department have scored the module proficiency as 4 – High and the rest of the department have scored the module proficiency as 3 – Middle but construction (site), technical office, finance, procurement, ERP and IT departments interviewees have scored the module proficiency as 5 – Very High with 75%, 93.3%, 100%, 100%, 100% and 100% respectively.

It can be said that design department professionals will use this module much more actively than other department professionals and they have scored the module proficiency a bit lower than other departments, so the module proficiency should be increased. Yet it should be noted that 66.7% of the design department interviewees have scored the module proficiency as 4 – High.



Total N	105
Test Statistic	56,768
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,000

Figure 4.203. Kruskal-Wallis Test with respect to Departments (Design Management Module).

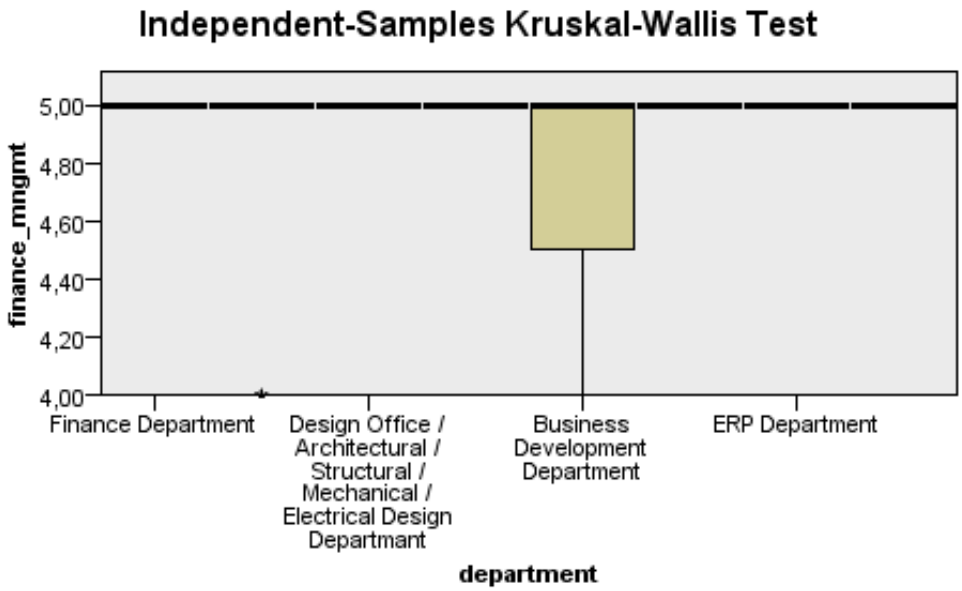


Each node shows the sample average rank of department.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Business Development Department	-29,000	9,333	-3,107	,002	,053
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Construction (Site)	-41,750	9,333	-4,473	,000	,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	51,100	7,728	6,612	,000	,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Finance Department	54,500	11,155	4,886	,000	,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Purchasing / Procurement Department	-54,500	14,110	-3,862	,000	,003
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-ERP Department	-54,500	8,924	-6,107	,000	,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-IT Department	-54,500	14,110	-3,862	,000	,003
Business Development Department-Construction (Site)	12,750	8,641	1,476	,140	1,000
Business Development Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	22,100	6,876	3,214	,001	,037
Business Development Department-Finance Department	25,500	10,583	2,410	,016	,447
Business Development Department-Purchasing / Procurement Department	-25,500	13,662	-1,866	,062	1,000
Business Development Department-ERP Department	-25,500	8,197	-3,111	,002	,052

Figure 4.204. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Design Management Module).

According to the figure below, it can be seen that “Finance Management” module user satisfaction scores do not change with respect to “department” of the respondents.

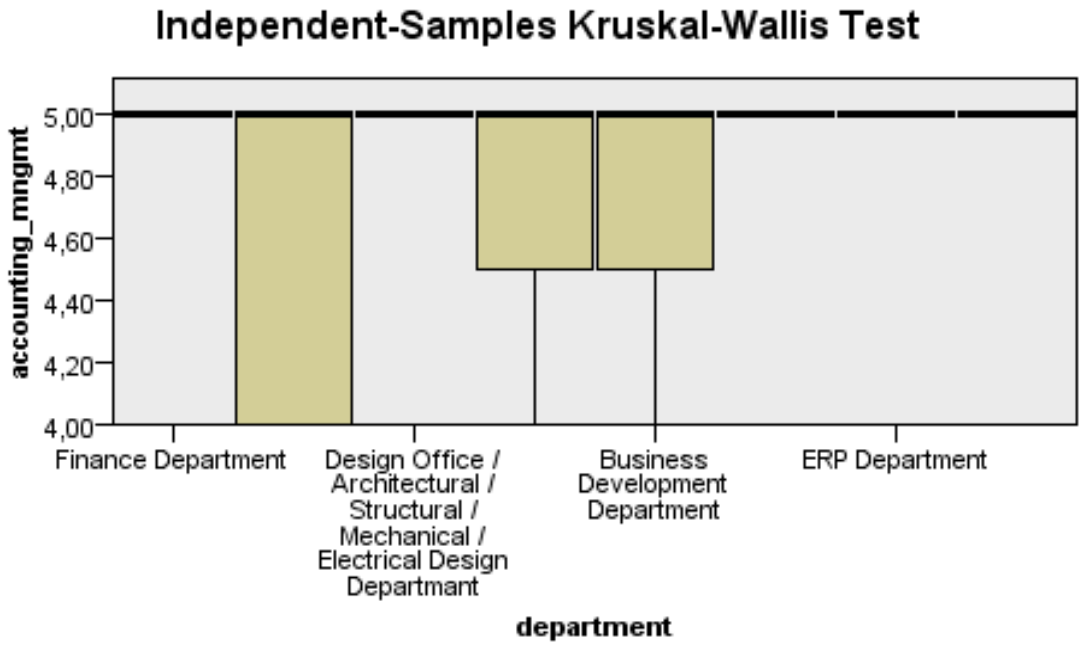


Total N	105
Test Statistic	11,162
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,132

Figure 4.205. Kruskal-Wallis Test with respect to Age Groups (Finance Management Module).

According to the figure below, it can be seen that “Accounting Management” module user satisfaction scores do change with respect to “departments” of the respondents.

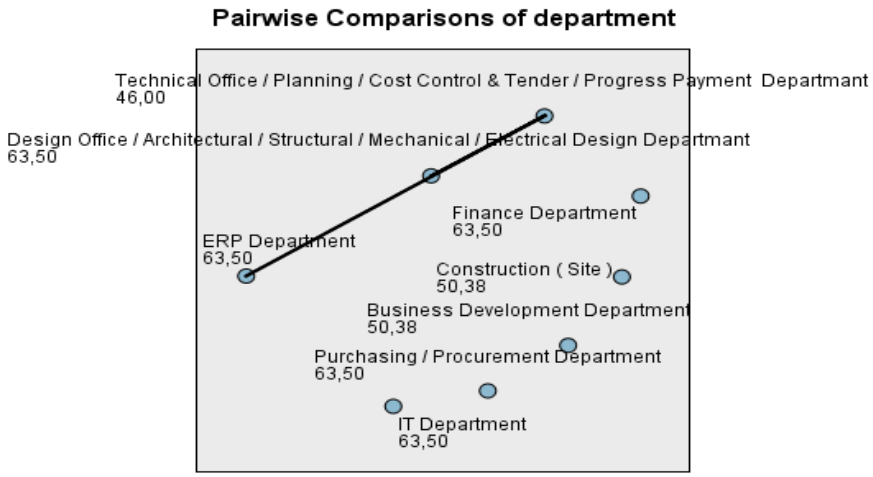
It can be seen that the answers of respondents at “technical office” department are significantly different than the respondents at “design” and “ERP” departments.



Total N	105
Test Statistic	14,238
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,047

1. The test statistic is adjusted for ties.

Figure 4.206. Kruskal-Wallis Test with respect to Departments (Accounting Management Module).

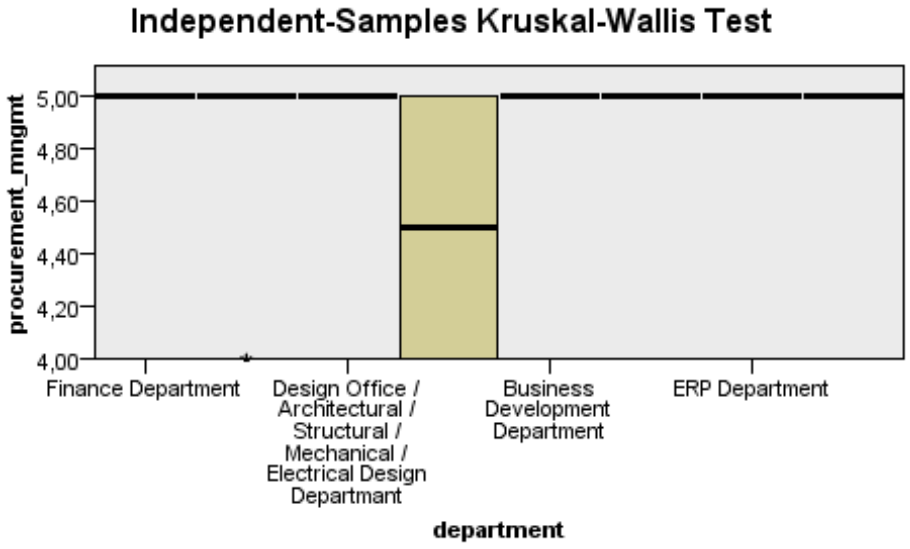


Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	-4,375	6,855	-,638	,523	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Business Development Department	-4,375	6,855	-,638	,523	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	17,500	9,171	1,908	,056	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-17,500	7,705	-2,271	,023	,648
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-17,500	12,582	-1,391	,164	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-17,500	6,291	-2,782	,005	,151
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-IT Department	-17,500	12,582	-1,391	,164	1,000
Construction (Site)-Business Development Department	,000	8,614	,000	1,000	1,000
Construction (Site)-Finance Department	13,125	10,550	1,244	,213	1,000
Construction (Site)-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	13,125	9,305	1,411	,158	1,000
Construction (Site)-Purchasing / Procurement Department	-13,125	13,620	-,964	,335	1,000
Construction (Site)-ERP Department	-13,125	8,172	-1,606	,108	1,000
Construction (Site)-IT Department	-13,125	13,620	-,964	,335	1,000
Business Development Department-Finance Department	13,125	10,550	1,244	,213	1,000

Figure 4.207. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Accounting Management Module).

According to the figure below, it can be seen that “Procurement Management” module user satisfaction scores do change with respect to “departments” of the respondents. It can be seen that the answers of respondents at “construction (site)” department are significantly different than the respondents at “technical”, “finance”, “design”, “business development” and “ERP” departments.

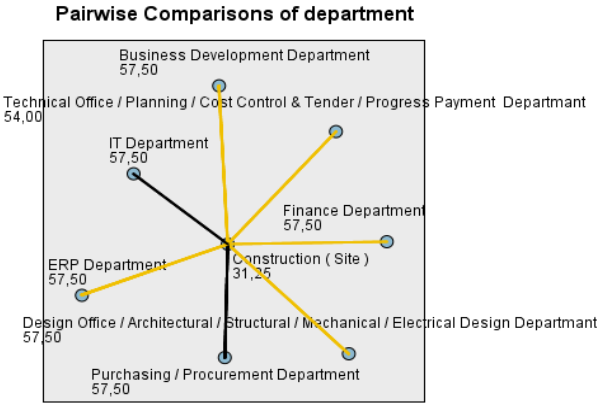
50% of the interviewees from construction (site) department have scored the module proficiency as 4 – High and the rest of the department have scored the module proficiency as 5 – Very High but finance, design, business development and ERP departments interviewees have scored the module proficiency as 5 – Very High with 100%. Also, 93.3% of technical department professionals have scored the module proficiency as 5 – Very High.



Total N	105
Test Statistic	30,694
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.208. Kruskal-Wallis Test with respect to Departments (Procurement Management Module).

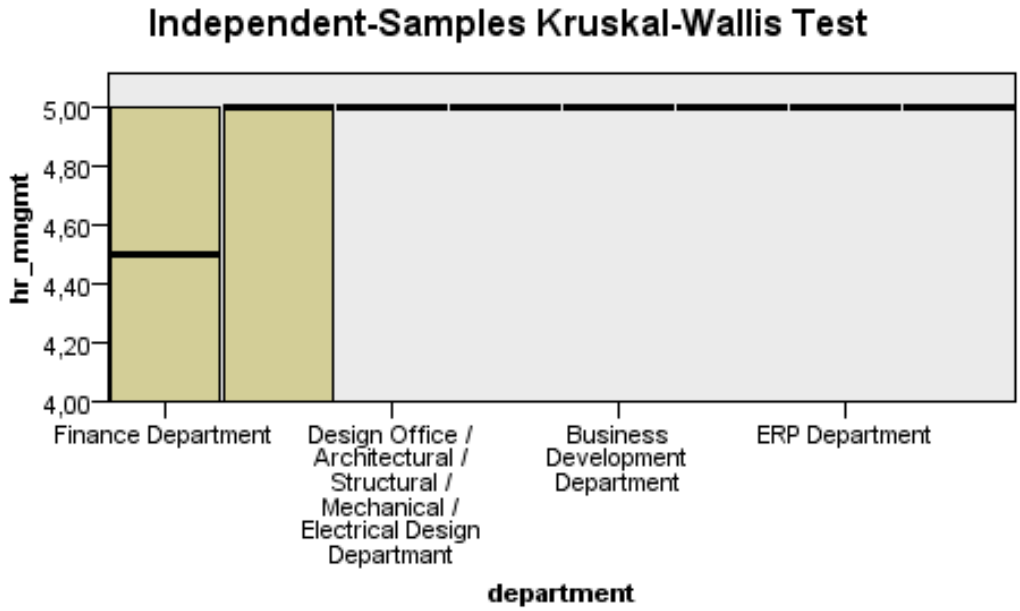


Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Construction (Site)-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	22,750	4,798	4,742	,000	,000
Construction (Site)-Finance Department	26,250	7,384	3,555	,000	,011
Construction (Site)-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	26,250	6,512	4,031	,000	,002
Construction (Site)-Business Development Department	-26,250	6,029	-4,354	,000	,000
Construction (Site)-Purchasing / Procurement Department	-26,250	9,532	-2,754	,006	,165
Construction (Site)-ERP Department	-26,250	5,719	-4,590	,000	,000
Construction (Site)-IT Department	-26,250	9,532	-2,754	,006	,165
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	3,500	6,418	,545	,586	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-3,500	5,392	-,649	,516	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Business Development Department	-3,500	4,798	-,729	,466	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-3,500	8,806	-,397	,691	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-3,500	4,403	-,795	,427	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-IT Department	-3,500	8,806	-,397	,691	1,000
Finance Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	,000	7,783	,000	1,000	1,000
Finance Department-Business Development Department	,000	7,384	,000	1,000	1,000
Finance Department-Purchasing / Procurement Department	,000	10,442	,000	1,000	1,000
Finance Department-ERP Department	,000	7,133	,000	1,000	1,000
Finance Department-IT Department	,000	10,442	,000	1,000	1,000

Figure 4.209. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Procurement Management Module).

According to the figure below, it can be seen that “HR Management” module user satisfaction scores do change with respect to “departments” of the respondents.

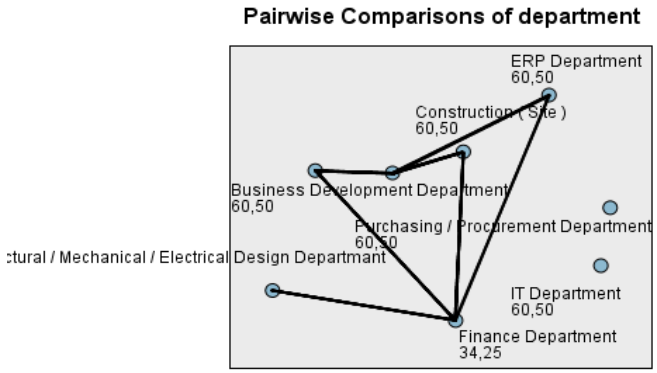
It can be seen that the answers of respondents at “finance” department are significantly different than the respondents at “design”, “construction (site)”, “business development”, “ERP”, “IT” and “Procurement” departments. Also, the answers of respondents at “technical office” department are significantly different than the respondents at “design”, “construction (site)”, “business development”, “procurement”, and “ERP” departments.



Total N	105
Test Statistic	20,684
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,004

1. The test statistic is adjusted for ties.

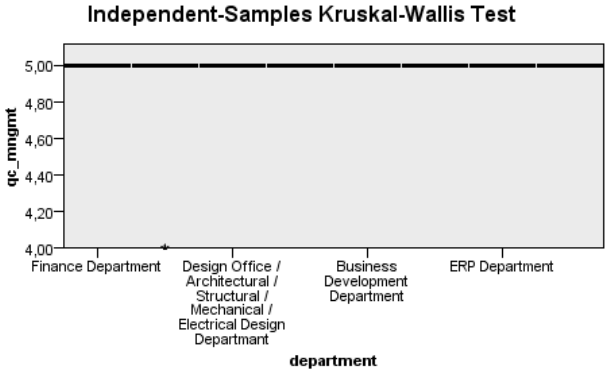
Figure 4.210. Kruskal-Wallis Test with respect to Departments (HR Management Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Finance Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	-12,250	8,023	-1,527	,127	1,000
Finance Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-26,250	9,729	-2,698	,007	,195
Finance Department-Construction (Site)	-26,250	9,230	-2,844	,004	,125
Finance Department-Business Development Department	-26,250	9,230	-2,844	,004	,125
Finance Department-Purchasing / Procurement Department	-26,250	13,053	-2,011	,044	1,000
Finance Department-ERP Department	-26,250	8,917	-2,944	,003	,091
Finance Department-IT Department	-26,250	13,053	-2,011	,044	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-14,000	6,740	-2,077	,038	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	-14,000	5,997	-2,334	,020	,548
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Business Development Department	-14,000	5,997	-2,334	,020	,548
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-14,000	11,007	-1,272	,203	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-14,000	5,503	-2,544	,011	,307
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-IT Department	-14,000	11,007	-1,272	,203	1,000

Figure 4.211. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (HR Management Module).

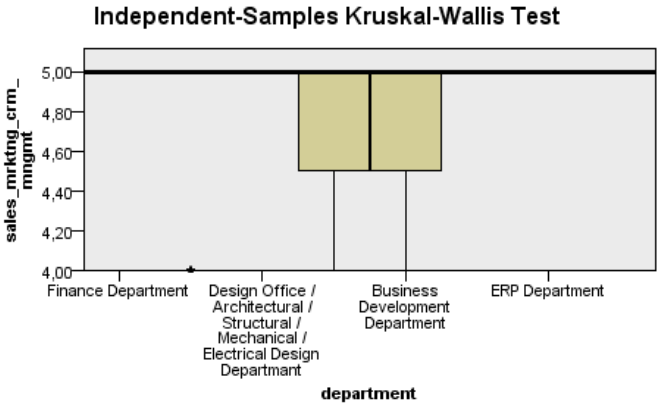
According to the figure below, it can be seen that “Quality Control Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	4,078
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,771

Figure 4.212. Kruskal-Wallis Test with respect to Departments (Quality Control Management Module).

According to the figure below, it can be seen that “Sales & Marketing & CRM Management” module user satisfaction scores do not change with respect to “department” of the respondents.

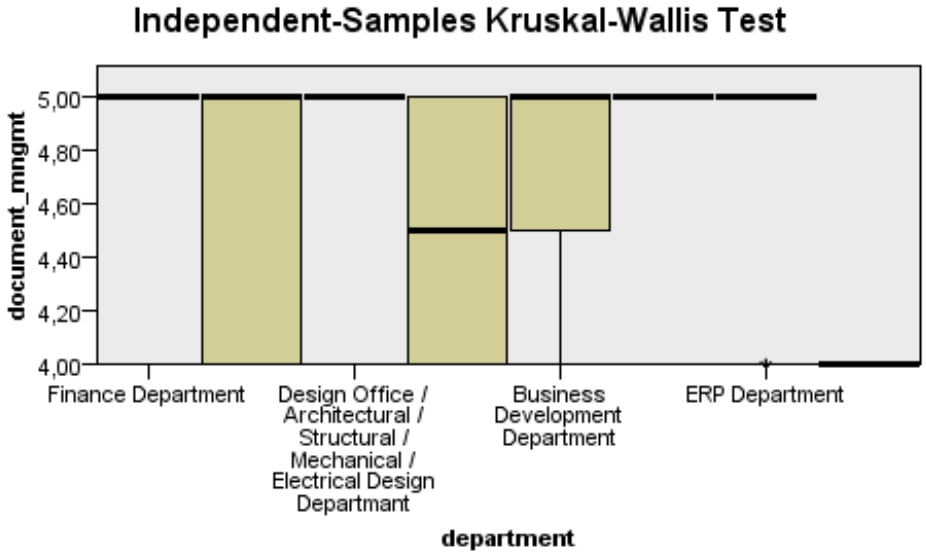


Total N	105
Test Statistic	9,360
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,228

Figure 4.213. Kruskal-Wallis Test with respect to Departments (Sales & Marketing & CRM Management Module).

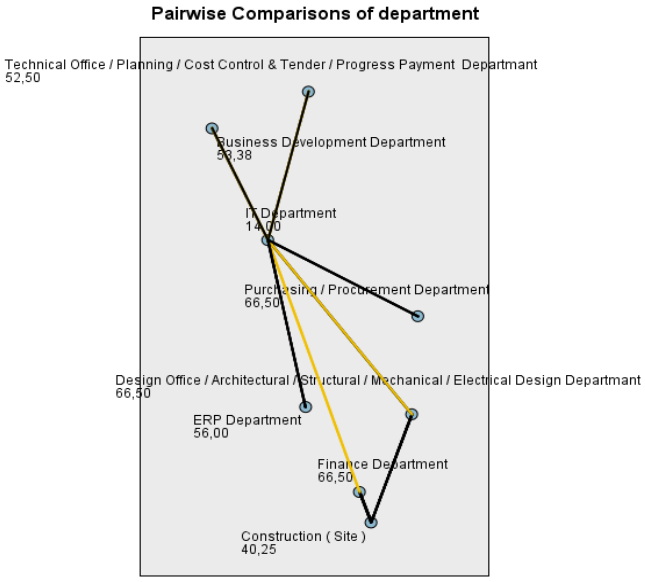
According to the figure below, it can be seen that “Document Management” module user satisfaction scores do change with respect to “departments” of the respondents. It can be seen that the answers of respondents at “IT” department are significantly different than the respondents at “finance” and “design” departments.

100% of the interviewees from IT department have scored the module proficiency as 4 – High but finance and design departments interviewees have scored the module proficiency as 5 – Very High with 100%.



Total N	105
Test Statistic	18,704
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,009

Figure 4.214. Kruskal-Wallis Test with respect to Departments (Document Management Module).



Each node shows the sample average rank of department.

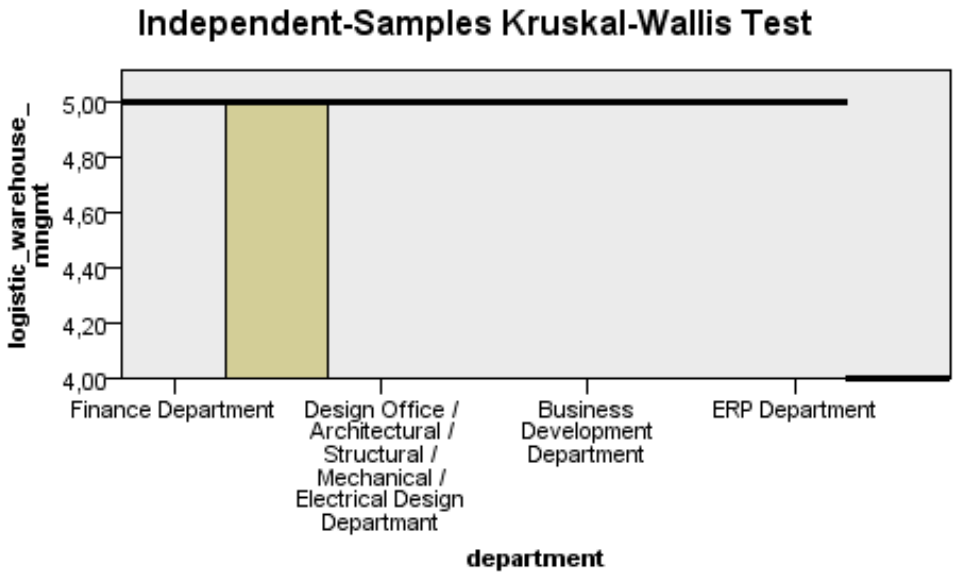
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
IT Department-Construction (Site)	26,250	14,882	1,764	,078	1,000
IT Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	38,500	13,748	2,800	,005	,143
IT Department-Business Development Department	39,375	14,882	2,646	,008	,228
IT Department-ERP Department	42,000	14,582	2,880	,004	,111
IT Department-Finance Department	52,500	16,303	3,220	,001	,036
IT Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	52,500	15,370	3,416	,001	,018
IT Department-Purchasing / Procurement Department	52,500	18,825	2,789	,005	,148
Construction (Site)-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	12,250	7,491	1,635	,102	1,000
Construction (Site)-Business Development Department	-13,125	9,412	-1,394	,163	1,000
Construction (Site)-ERP Department	-15,750	8,929	-1,764	,078	1,000
Construction (Site)-Finance Department	26,250	11,528	2,277	,023	,638
Construction (Site)-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	26,250	10,167	2,582	,010	,275
Construction (Site)-Purchasing / Procurement Department	-26,250	14,882	-1,764	,078	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Business Development Department	-,875	7,491	-,117	,907	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-3,500	6,874	-,509	,611	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	14,000	10,020	1,397	,162	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-14,000	8,419	-1,663	,096	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-14,000	13,748	-1,018	,309	1,000

Figure 4.215. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Document Management Module).

According to the figure below, it can be seen that “Logistics & Warehouse Management” module user satisfaction scores do change with respect to “departments” of the respondents.

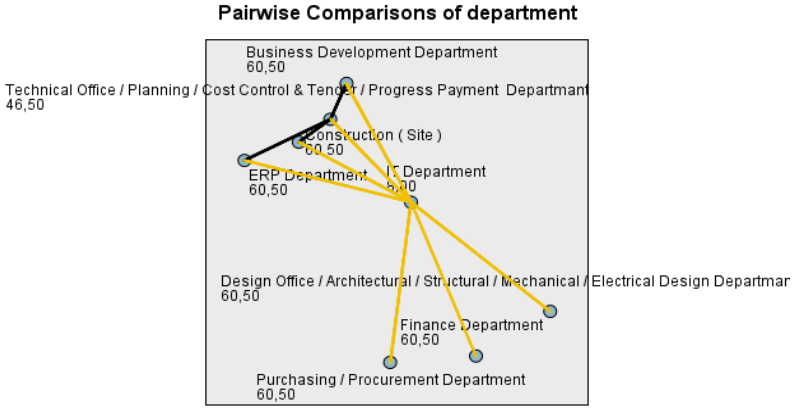
It can be seen that the answers of respondents at “IT” department are significantly different than the respondents at “technical office”, “finance”, “design” “construction(site)”, “procurement” and “ERP” departments.

100% of the interviewees from IT department have scored the module proficiency as 4 – High but finance, design, construction (site), procurement and ERP departments interviewees have scored the module proficiency as 5 – Very High with 100%. Also, 73.3% of technical department professionals have scored the module proficiency as 5 – Very High.



Total N	105
Test Statistic	32,818
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,000

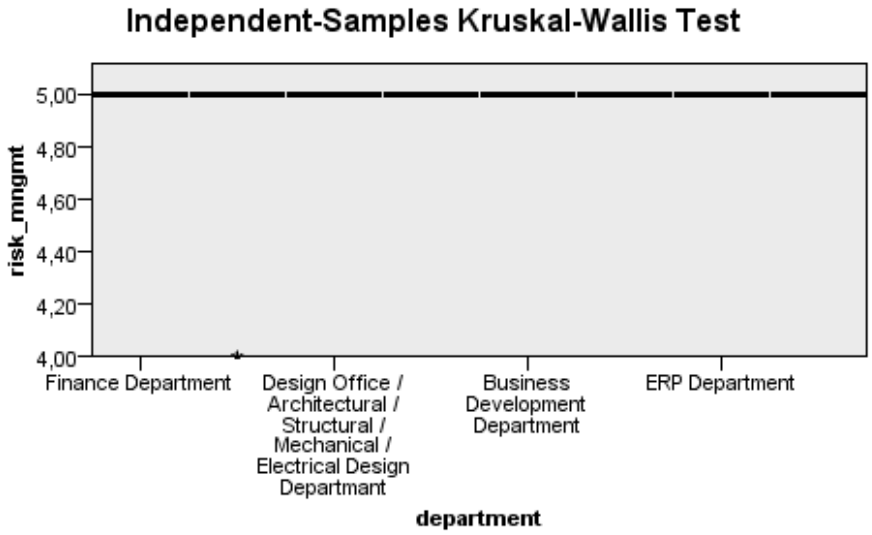
Figure 4.216. Kruskal-Wallis Test with respect to Departments (Logistics & Warehouse Management Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
IT Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	38,500	11,007	3,498	,000	,013
IT Department-Finance Department	52,500	13,053	4,022	,000	,002
IT Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	52,500	12,306	4,266	,000	,001
IT Department-Construction (Site)	52,500	11,915	4,406	,000	,000
IT Department-Business Development Department	52,500	11,915	4,406	,000	,000
IT Department-Purchasing / Procurement Department	52,500	15,072	3,483	,000	,014
IT Department-ERP Department	52,500	11,675	4,497	,000	,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	14,000	8,023	1,745	,081	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-14,000	6,740	-2,077	,038	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	-14,000	5,997	-2,334	,020	,548
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Business Development Department	-14,000	5,997	-2,334	,020	,548
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-14,000	11,007	-1,272	,203	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-14,000	5,503	-2,544	,011	,307
Finance Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	,000	9,729	,000	1,000	1,000
Finance Department-Construction (Site)	,000	9,230	,000	1,000	1,000
Finance Department-Business Development Department	,000	9,230	,000	1,000	1,000
Finance Department-Purchasing / Procurement Department	,000	13,053	,000	1,000	1,000
Finance Department-ERP Department	,000	8,917	,000	1,000	1,000

Figure 4.217. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Logistics & Warehouse Management Module).

According to the figure below, it can be seen that “Risk Management” module user satisfaction scores do not change with respect to “department” of the respondents.



Total N	105
Test Statistic	4,078
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,771

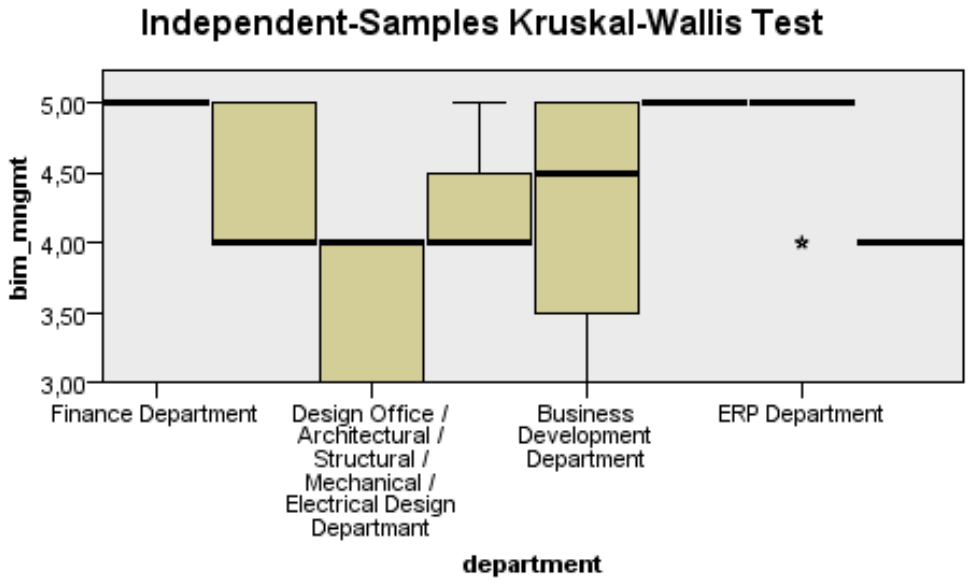
1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 4.218. Kruskal-Wallis Test with respect to Departments (Risk Management Module).

According to the figure below, it can be seen that “BIM Management” module user satisfaction scores do change with respect to “departments” of the respondents.

It can be seen that the answers of respondents at “design office” department are significantly different than the respondents at “finance”, “technical office”, “procurement” and “ERP” departments.

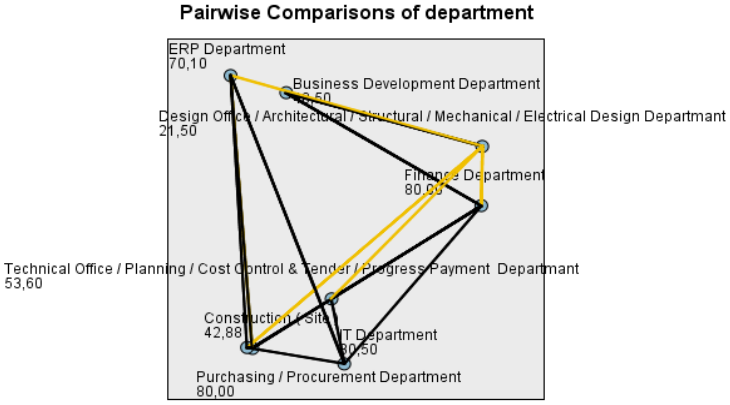
33.3% of the interviewees from design department have scored the module proficiency as 3 – Middle and 66.7% of them have scored the module proficiency as 4 – High but finance and procurement departments interviewees have scored the module proficiency as 5 – Very High with 100%. Also, 80% of ERP department and 46.7% of technical office professionals have scored the module proficiency as 5 – Very High. BIM Management module mostly used by design department and technical office departments and due to respectively low score of design department professionals evaluation, it can be said that BIM Management module can be advanced.



Total N	105
Test Statistic	31,243
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,000

1. The test statistic is adjusted for ties.

Figure 4.219. Kruskal-Wallis Test with respect to Departments (BIM Management Module).

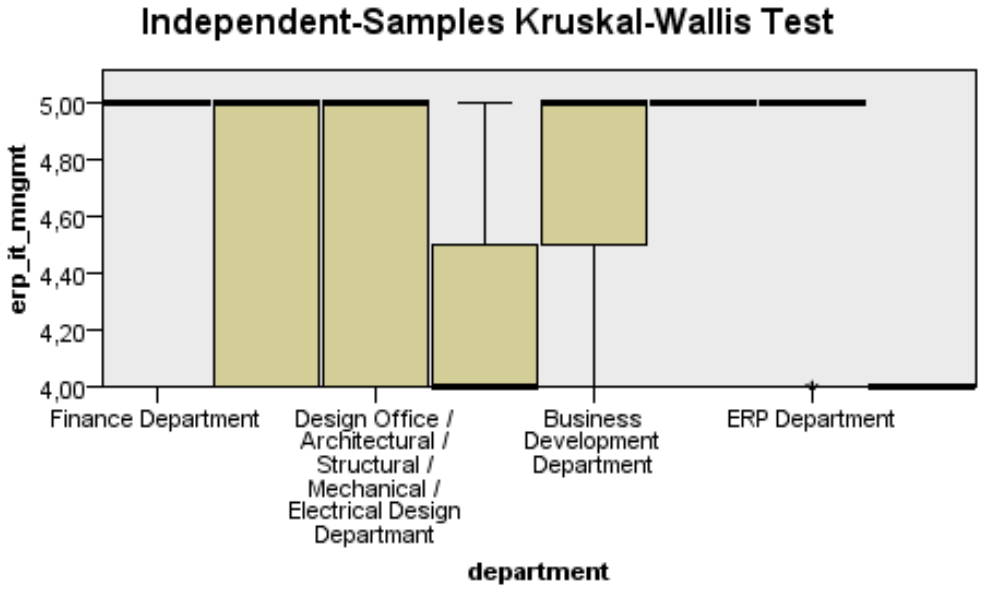


Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-IT Department	-9,000	18,043	-,499	,618	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Construction (Site)	-21,375	11,934	-1,791	,073	1,000
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Business Development Department	-27,000	11,934	-2,262	,024	,663
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	32,100	9,883	3,248	,001	,033
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-ERP Department	-48,600	11,412	-4,259	,000	,001
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Finance Department	58,500	14,264	4,101	,000	,001
Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant-Purchasing / Procurement Department	-58,500	18,043	-3,242	,001	,033
IT Department-Construction (Site)	12,375	17,470	,708	,479	1,000
IT Department-Business Development Department	18,000	17,470	1,030	,303	1,000
IT Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	23,100	16,138	1,431	,152	1,000
IT Department-ERP Department	39,600	17,117	2,313	,021	,580
IT Department-Finance Department	49,500	19,138	2,587	,010	,271
IT Department-Purchasing / Procurement Department	49,500	22,098	2,240	,025	,703
Construction (Site)-Business Development Department	-5,625	11,049	-,509	,611	1,000
Construction (Site)-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	10,725	8,793	1,220	,223	1,000
Construction (Site)-ERP Department	-27,225	10,482	-2,597	,009	,263
Construction (Site)-Finance Department	37,125	13,532	2,743	,006	,170
Construction (Site)-Purchasing / Procurement Department	-37,125	17,470	-2,125	,034	,940

Figure 4.220. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (BIM Management Module).

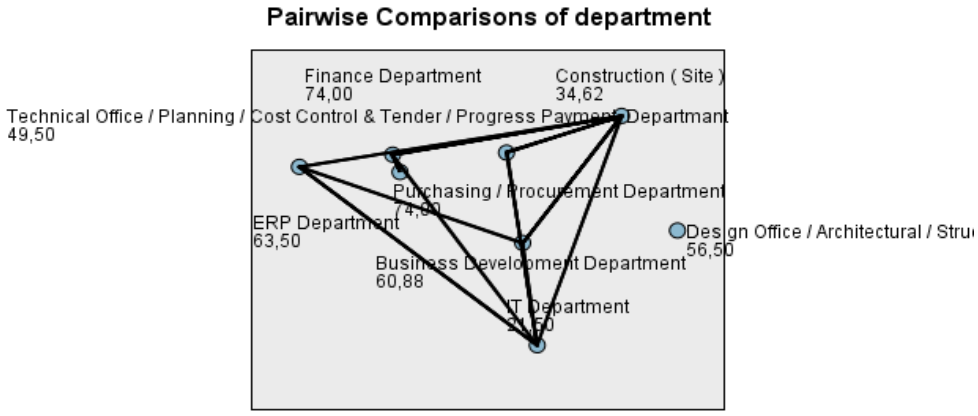
According to the figure below, it can be seen that “ERP & IT Management” module user satisfaction scores do change with respect to “departments” of the respondents.

It can be seen that the answers of respondents at “IT” department are significantly different than the respondents at “finance”, “design office”, “procurement”, “business development” and “ERP” departments. Also, the answers of respondents at “construction” department are significantly different than the respondents at “finance”, “procurement”, “business development” and “ERP” departments.



Total N	105
Test Statistic	21,048
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,004

Figure 4.221. Kruskal-Wallis Test with respect to Departments (ERP & IT Management Module).

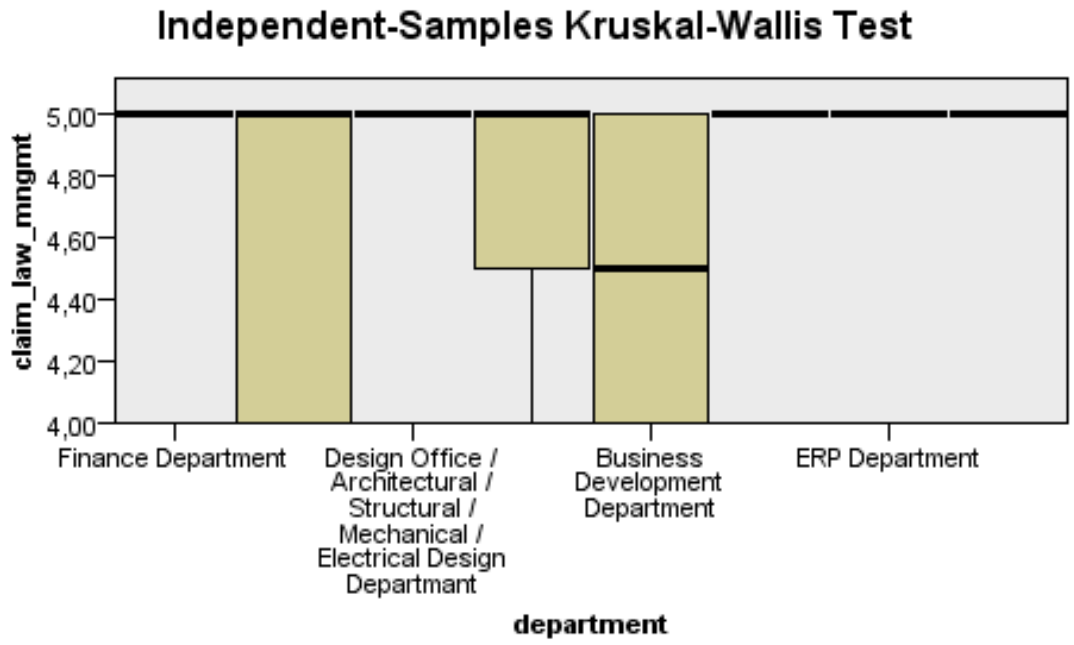


Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
IT Department-Construction (Site)	13,125	16,682	,787	,431	1,000
IT Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	28,000	15,410	1,817	,069	1,000
IT Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	35,000	17,229	2,031	,042	1,000
IT Department-Business Development Department	39,375	16,682	2,360	,018	,511
IT Department-ERP Department	42,000	16,345	2,570	,010	,285
IT Department-Finance Department	52,500	18,274	2,873	,004	,114
IT Department-Purchasing / Procurement Department	52,500	21,101	2,488	,013	,360
Construction (Site)-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	14,875	8,396	1,772	,076	1,000
Construction (Site)-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	21,875	11,396	1,920	,055	1,000
Construction (Site)-Business Development Department	-26,250	10,550	-2,488	,013	,360
Construction (Site)-ERP Department	-28,875	10,009	-2,885	,004	,110
Construction (Site)-Finance Department	39,375	12,921	3,047	,002	,065
Construction (Site)-Purchasing / Procurement Department	-39,375	16,682	-2,360	,018	,511

Figure 4.222. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (ERP & IT Management Module).

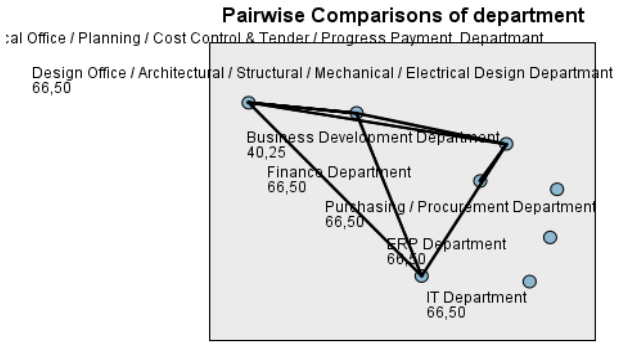
According to the figure below, it can be seen that “Claim & Law Management” module user satisfaction scores do change with respect to “departments” of the respondents.

It can be seen that the answers of respondents at “business development” department are significantly different than the respondents at “finance”, “design” and “ERP” departments. Also, the answers of respondents at “technical office” department are significantly different than the respondents at “design” and “ERP” departments.



Total N	105
Test Statistic	20,778
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,004

Figure 4.223. Kruskal-Wallis Test with respect to Departments (Claim & Law Management Module).



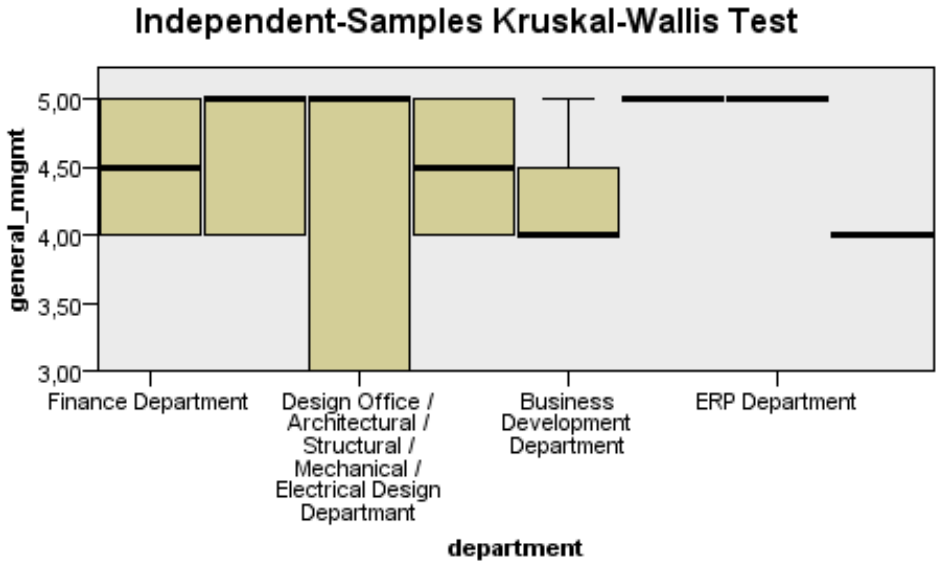
Each node shows the sample average rank of department.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Business Development Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	5,250	7,491	,701	,483	1,000
Business Development Department-Construction (Site)	13,125	9,412	1,394	,163	1,000
Business Development Department-Finance Department	26,250	11,528	2,277	,023	,638
Business Development Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	26,250	10,167	2,582	,010	,275
Business Development Department-Purchasing / Procurement Department	-26,250	14,882	-1,764	,078	1,000
Business Development Department-ERP Department	-26,250	8,929	-2,940	,003	,092
Business Development Department-IT Department	-26,250	14,882	-1,764	,078	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Construction (Site)	-7,875	7,491	-1,051	,293	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Finance Department	21,000	10,020	2,096	,036	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-21,000	8,419	-2,494	,013	,353
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-Purchasing / Procurement Department	-21,000	13,748	-1,528	,127	1,000
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-ERP Department	-21,000	6,874	-3,055	,002	,063
Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant-IT Department	-21,000	13,748	-1,528	,127	1,000
Construction (Site)-Finance Department	13,125	11,528	1,139	,255	1,000
Construction (Site)-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	13,125	10,167	1,291	,197	1,000
Construction (Site)-Purchasing / Procurement Department	-13,125	14,882	-,882	,378	1,000
Construction (Site)-ERP Department	-13,125	8,929	-1,470	,142	1,000
Construction (Site)-IT Department	-13,125	14,882	-,882	,378	1,000

Figure 4.224. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (Claim & Law Management Module).

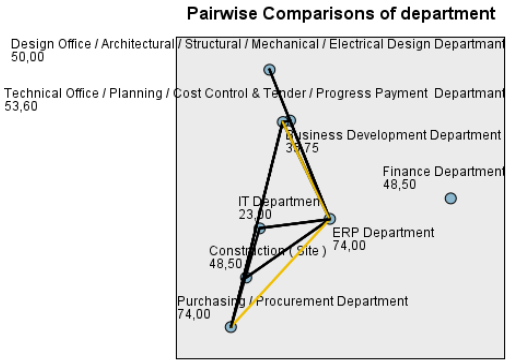
According to the figure below, it can be seen that “General Management” module user satisfaction scores do change with respect to “departments” of the respondents. It can be seen that the answers of respondents at “business development” department are significantly different than the respondents at “ERP” departments.

25% of business development professionals have scored the module proficiency as 5 – Very High and 75% of them have scored as 4 – High but 100% of ERP department professionals have scored the module proficiency as 5 – Very High. It can be said that business development professionals expect much more advanced and functional module but all of them have scored 4 – High or higher.



Total N	105
Test Statistic	21,585
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,003

Figure 4.225. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (General Management Module).



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
IT Department-Business Development Department	12,750	16,828	,758	,449	1,000
IT Department-Finance Department	25,500	18,435	1,383	,167	1,000
IT Department-Construction (Site)	25,500	16,828	1,515	,130	1,000
IT Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	27,000	17,380	1,553	,120	1,000
IT Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	30,600	15,545	1,968	,049	1,000
IT Department-Purchasing / Procurement Department	51,000	21,287	2,396	,017	,464
IT Department-ERP Department	51,000	16,488	3,093	,002	,055
Business Development Department-Finance Department	12,750	13,035	,978	,328	1,000
Business Development Department-Construction (Site)	12,750	10,643	1,198	,231	1,000
Business Development Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	14,250	11,496	1,240	,215	1,000
Business Development Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	17,850	8,470	2,107	,035	,982
Business Development Department-Purchasing / Procurement Department	-38,250	16,828	-2,273	,023	,645
Business Development Department-ERP Department	-38,250	10,097	-3,788	,000	,004
Finance Department-Construction (Site)	,000	13,035	,000	1,000	1,000
Finance Department-Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	-1,500	13,740	-,109	,913	1,000
Finance Department-Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	-5,100	11,331	-,450	,653	1,000
Finance Department-Purchasing / Procurement Department	-25,500	18,435	-1,383	,167	1,000
Finance Department-ERP Department	-25,500	12,593	-2,025	,043	1,000

Figure 4.226. Kruskal-Wallis Pairwise Comparison Test with respect to Departments (General Management Module).

4.5.4.7. Kruskal-Wallis Test with Respect To "ERP Usage". Here below at Table 4.25 Hypothesis Test Summary (ERP Usage in Company) Table, it can be seen Kruskal-Wallis test results of all modules with respect to "departments." It can be seen from the table that Business Development, Planning & Time Management, Owner Progress Report

Management, Design Management, Finance Management, BIM Management and Claim & Law Management modules user satisfaction survey scores changes with respect to ERP Usage of the respondents in their company.

Table 4.25. Hypothesis Test Summary (ERP Usage in Company).

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of business_development_module is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
2	The distribution of projectmng_planning_time_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,015	Reject the null hypothesis.
3	The distribution of projectmng_budget_cost_control is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,089	Retain the null hypothesis.
4	The distribution of projectmng_subcontractor_tender is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,072	Retain the null hypothesis.
5	The distribution of projectmng_owner_tender is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,072	Retain the null hypothesis.
6	The distribution of projectmng_contract_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,072	Retain the null hypothesis.
7	The distribution of projectmng_subcontractor_progress_report is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
8	The distribution of projectmng_owner_progress_report is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,010	Reject the null hypothesis.
9	The distribution of projectmng_site_subcontractor_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,258	Retain the null hypothesis.
10	The distribution of projectmng_hse_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.
11	The distribution of design_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
12	The distribution of finance_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,010	Reject the null hypothesis.
13	The distribution of accounting_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,382	Retain the null hypothesis.
14	The distribution of procurement_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,341	Retain the null hypothesis.
15	The distribution of hr_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,475	Retain the null hypothesis.
16	The distribution of qc_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,072	Retain the null hypothesis.
17	The distribution of sales_mrktng_crm_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,341	Retain the null hypothesis.
18	The distribution of document_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,620	Retain the null hypothesis.
19	The distribution of logistic_warehouse_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,475	Retain the null hypothesis.
20	The distribution of risk_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,072	Retain the null hypothesis.
21	The distribution of bim_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,003	Reject the null hypothesis.
22	The distribution of erp_it_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,153	Retain the null hypothesis.
23	The distribution of claim_law_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,000	Reject the null hypothesis.
24	The distribution of general_mngmt is the same across categories of erp_usage_yes_no.	Independent-Samples Kruskal-Wallis Test	0,106	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is ,05.				

Because the degree of freedom at Kruskal-Wallis Test is 1 (yes or no question), further *Kruskal-Wallis with post-hoc* test of Module Satisfaction survey analysis with respect to "ERP Usage" of the respondents has not been performed.

Here below the pivot table of variables and modules that comes from Kruskal-Wallis test that "1" means that variable is significant for that module.

It can be seen from the table that "total employee", "company age group" and "department" are variables that their within groups are mostly significantly different between within groups variables of same variable.

Table 4.26. Module vs. Respondent Variable - Significance Pivot Table

MODULES	Age Groups	Business Type	Company Age Groups	Departments	ERP Usage	Total Employee	Yearly Turnover	Grand Total
Accounting Management	1	1	1	1	0	1	0	**5**
Bim Management	0	1	0	1	1	1	1	**5**
Business Development Module	0	0	1	1	1	1	1	**5**
Claim & Law Management	0	0	1	1	1	1	1	**5**
Design Management	0	1	0	1	1	1	1	**5**
Document Management	0	0	0	1	0	0	0	**1**
Erp & It Management	0	1	1	1	0	1	1	**5**
Finance Management	0	0	1	0	1	1	0	**3**
General	0	1	1	1	0	0	1	**4**
Human Resources Management	1	1	1	1	0	1	0	**5**
Logistics & Warehouse Management	1	1	0	1	0	1	0	**4**
Procurement Management	0	0	1	1	0	1	0	**3**
Project Management - Budgeting & Cost Control Management	1	0	0	0	0	0	0	**1**
Project Management - Contract Management	0	0	0	0	0	1	0	**1**
Project Management - Health & Security & Environment Management	0	0	0	0	0	0	0	**0**
Project Management - Owner Tenders Management (quotation Module)	0	0	0	1	0	1	1	**3**
Project Management - Planning and Time Management Module	1	0	0	0	1	0	0	**2**
Project Management - Progress Report (owners) Management	0	0	1	0	1	1	0	**3**
Project Management - Progress Report (sub-contractors) Management	0	0	0	0	0	0	0	**0**
Project Management - Site & Sub-contractor Management	0	0	1	0	0	1	0	**2**
Project Management - Sub-contractor Tender Management	0	0	0	0	0	1	0	**1**
Quality Control Management	0	1	1	0	0	1	1	**4**
Risk Management	0	1	1	0	0	1	1	**4**
Sales & Marketing & Crm Managements	0	1	1	0	0	0	0	**2**
Grand Total	**5**	**10**	**13**	**12**	**7**	**17**	**9**	**73**

5. GRAPHICAL USER INTERFACE (GUI) DESIGN OF NEW PROJECT-BASED C-ERP SYSTEM

5.1. Methodology

The graphical user interface (GUI) is the name of general tools that allows users to send direct comments to an electronic system by using some icons, graphical buttons, graphical indicators by pointing visual elements instead of typing user commands.

In the context of this thesis, it is also aimed to show a sample GUI for defined new ERP system by using function, control, organization and data lists of ARIS methodology elements.

In order to simulate Graphical User Interface (GUI), first of all, it is researched for the most suitable GUI mockup software to design new GUI. After investigating Mockup Screens, Balsamiq Mockups, Justinmind, Mockplus, Axure RP, Mockingbird and Mockup Builder, it is decided to use Balsamiq Mockups.

After installing Balsamiq Mockups, it is begun with login page to design until finishing last user GUI page. At the next section, it can be seen the screenshots of the GUI's. This GUI design is only sample for the elements comes from ARIS structures and this sample views can be changed with respect to designer and developer.

5.2. Screenshots

It can be seen some of the GUI screenshots of new C-ERP design sample. All of the GUI screenshots can be seen at the Appendix K - GUI Sample.

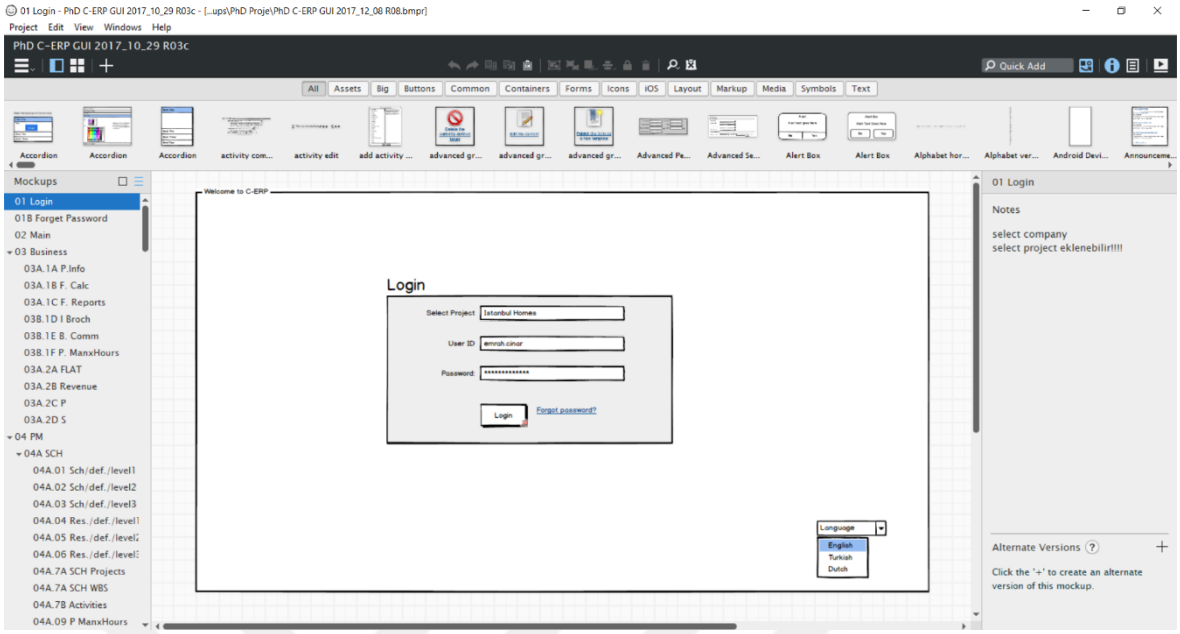


Figure 5.1. GUI Works Desktop Screenshots (Login Page).

At Figure 5.1, it can be seen general Balsamiq GUI screenshots login page and work platform. A general login page is created to login to the system.

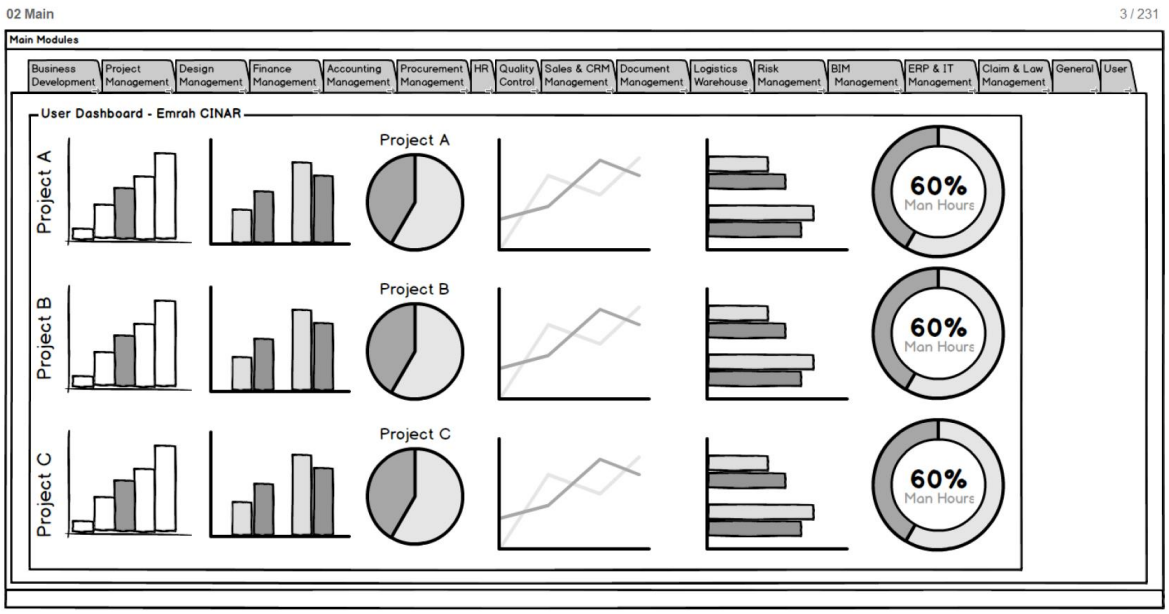


Figure 5.2. GUI Screenshots (User Dashboard).

At Figure 5.2, it can be seen a general user dashboard that users can configure their dashboard whatever they want to see at the opening screen of the system. The executives can see the progress of the projects at their user dashboards.

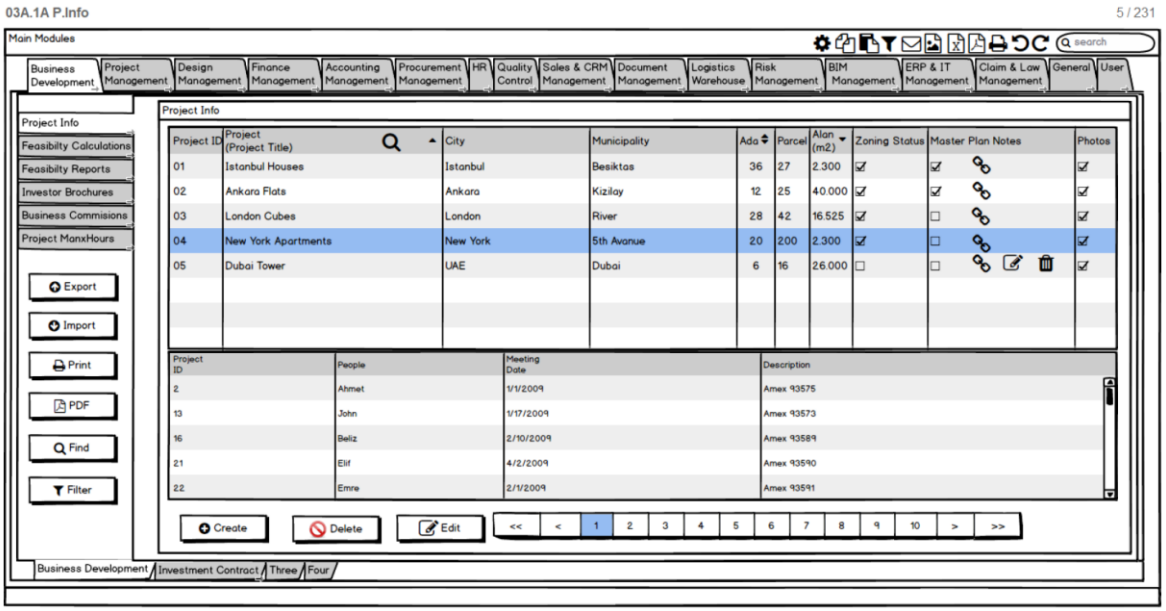


Figure 5.3. GUI Screenshots (Business Development Project Info).

At Figure 5.3, it can be seen business development module general project info parts. By using ARIS House function view and control process view data, it is tried to make a GUI that can illustrate what functions users want to use and what kind of data the users want to process and organize at this module.

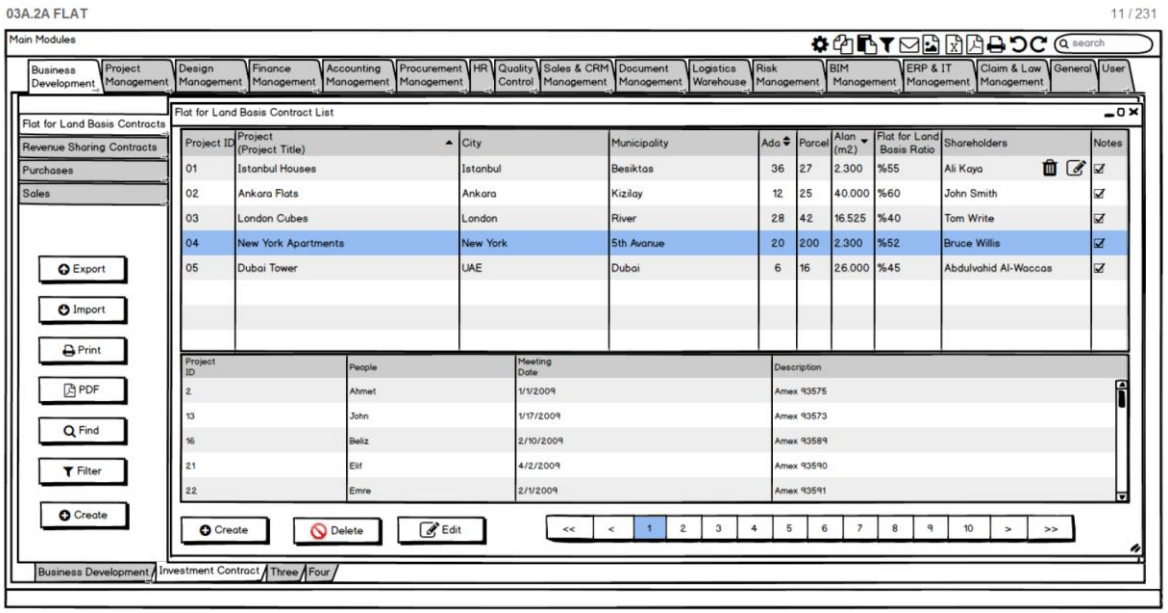


Figure 5.4. GUI Screenshots (Business Development – Investment Contracts – Flat for Land Basis Contracts).

At Figure 5.4, it can be seen business development contract sub-module parts. By using ARIS House function view data, it is tried to show investment contracts parts. There are four types of investment contracts according to ARIS House function list and they are; flat for land basis contracts, revenue sharing contracts, purchases and sales contracts. At the figure of GUI, flat for land basis contracts menu and information can be seen.

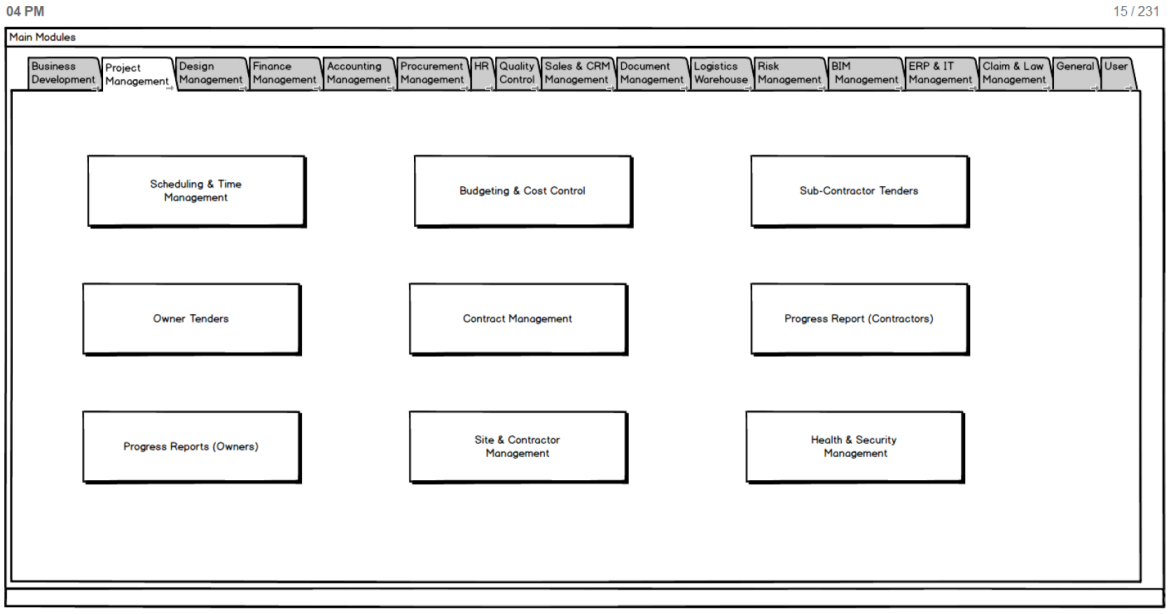


Figure 5.5. GUI Screenshots (Project Management Main Module).

At Figure 5.5, it can be seen 9 Project Management module main screen of the GUI screen. By using ARIS House function view and control process view data, it is tried to make all 9 module GUI's that illustrate all needed functions, processes and related data of these modules. At the following figure, it can be seen Scheduling & Time Management Module screens in detail. At the figure 5.6 and 5.7 activity and resource codes can be seen and changed according to the companies' active codes. These codes can be used at not only budget planning and cost control operations but also other operations such as; realization calculations, cash flows, unit price analysis etc.

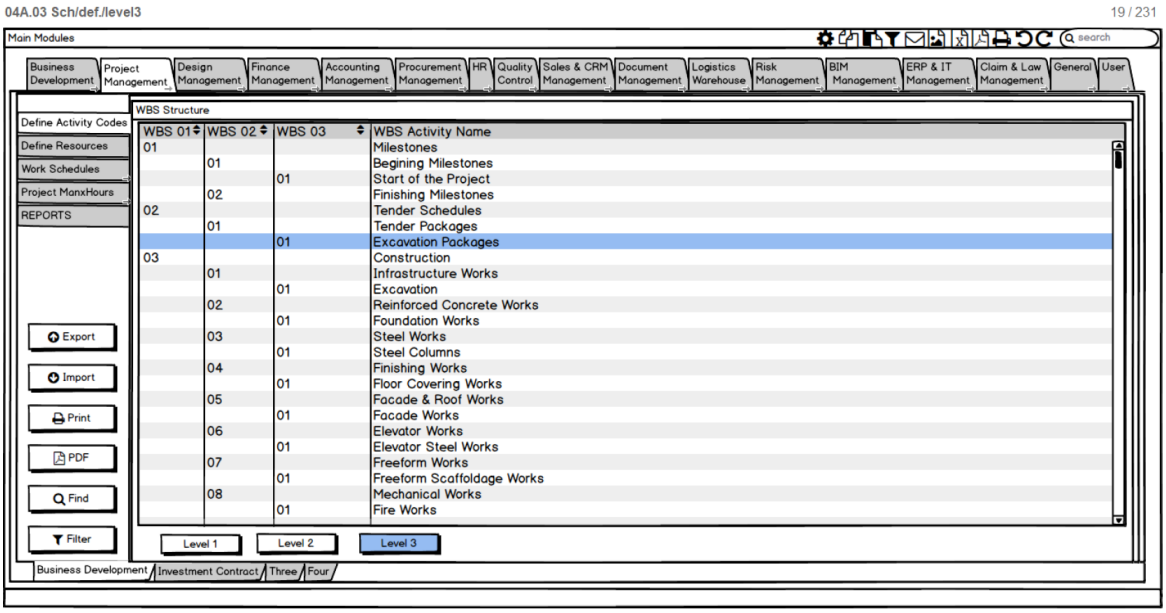


Figure 5.6. GUI Screenshots (Scheduling & Time Management Module – Define Activity Codes).

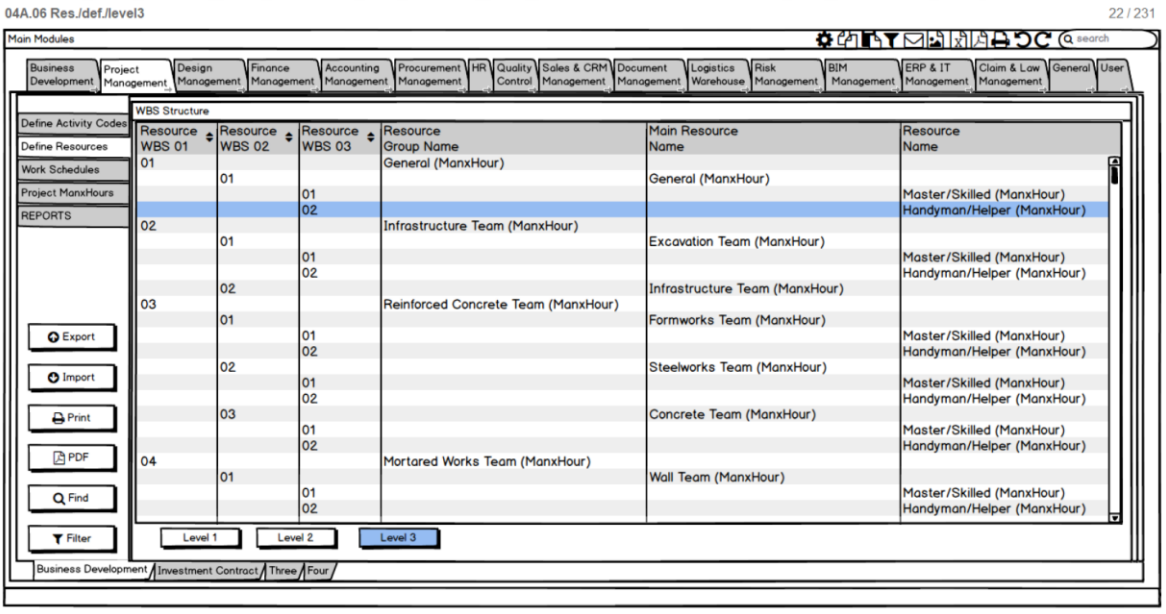


Figure 5.7. GUI Screenshots (Scheduling & Time Management Module – Define Resource Codes).

6. SUMMARY AND DISCUSSION

6.1. Summary

This thesis has two research methods in its research methodology that try to determine and explain the needs and expectations of construction industry and architecture components for a well-defined and prepared C-ERP system by using quantitative and qualitative research methodologies. The first one is the case study as qualitative research methodology and second one is questionnaire survey as quantitative research methodologies. The discussion chapter is based on these two analyses.

The questionnaire survey analysis is based on non-parametric ANOVA analysis with Kruskal-Wallis Test and is made by using SPSS analysis software. The case study is made face to face conversation in the guidance of case study question table.

6.2. Discussion on Case Study Analysis and User Satisfaction Survey Results

During the interviews of the case studies, it is asked to the companies what modules implemented in your current ERP system, which functions your ERP system perform, what kind of organizational departments your company have and use ERP modules, what kind of data your ERP systems produce or use and what kind of control mechanisms and control processes your ERP systems manage. Then, it is determined correlation of these function, data, control and organization information by asking extra questions and investigating ERP modules alive. Some modules and functions are not available at some ERP systems, some modules and functions partially available and some of them are available at all three ERP systems. All of data is recorded at the case study research tables.

According to six case study research, it is determined 18 organizations, 40 kinds of data, 41 control processes and 653 functions within 24 possible C-ERP modules.

In order to use all of these 24 C-ERP modules, the case study interviewees have indicated that at least 653 functions should be performed on the system. The whole function

list and correlation with other ARIS House components can be found at Appendix D, Appendix E, Appendix F and Appendix G.

Also, in order to use these 653 functions within 24 modules, the case study interviewees have indicated that at least 18 organizational departments should be found in a construction company. The whole organization and function correlation list can be found at Appendix E.

Also, in order to use these 653 functions and 18 organizational units within 24 modules, the case study interviewees have indicated that at least 40 kinds of data should be created and used in a construction company. The whole data and function correlation list can be found at Appendix F.

Also, in order to use these 653 functions, 40 kinds of data and 18 organizational units within 24 modules, the case study interviewees have indicated that at least 41 control processes should be performed within C-ERP system. The whole control and function correlation list can be found at Appendix G.

After finishing case studies, the module and function lists are checked by using user satisfaction survey. In the simplest term, the following mean table of module proficiency comes from user satisfaction survey indicates highly satisfaction level of respondents. The minimum mean value of respondents is 4.43 for BIM Management that is still between High and Very High level. Thus, it can easily be indicated that all of the module proficiency level is highly satisfied according to survey results.

Table 6.1. Mean Table of Module Proficiency at User Satisfaction Survey.

No	MODULE VARIABLE NAME	MODULE NAME	Mean	Proficiency Level FROM	Proficiency Level TO
1	*business_development_module*	Business Development Module	4,71	High	Very High
2	*projectmng_planning_time_mngmt*	Project Management - Planning and Time Management Module	4,94	High	Very High
3	*projectmng_budget_cost_control*	Project Management - Budgeting & Cost Control Management	4,97	High	Very High
4	*projectmng_subcontractor_tender*	Project Management - Sub-contractor Tender Management	4,97	High	Very High
5	*projectmng_owner_tender*	Project Management - Owner Tenders Management (quotation Module)	4,97	High	Very High
6	*projectmng_contract_mngmt*	Project Management - Contract Management	4,97	High	Very High
7	*projectmng_subcontractor_progress_report*	Project Management - Progress Report (sub-contractors) Management	5,00	Very High	Very High
8	*projectmng_owner_progress_report*	Project Management - Progress Report (owners) Management	4,94	High	Very High
9	*projectmng_site_subcontractor_mngmt*	Project Management - Site & Sub-contractor Management	4,91	High	Very High
10	*projectmng_hse_mngmt*	Project Management - Health & Security & Environment Management	5,00	Very High	Very High
11	*design_mngmt*	Design Management	4,77	High	Very High
12	*finance_mngmt*	Finance Management	4,94	High	Very High
13	*accounting_mngmt*	Accounting Management	4,80	High	Very High
14	*procurement_mngmt*	Procurement Management	4,91	High	Very High
15	*hr_mngmt*	Human Resources Management	4,86	High	Very High
16	*qc_mngmt*	Quality Control Management	4,97	High	Very High
17	*sales_mrktng_crm_mngmt*	Sales & Marketing & Crm Managements	4,86	High	Very High
18	*document_mngmt*	Document Management	4,74	High	Very High
19	*logistic_warehouse_mngmt*	Logistics & Warehouse Management	4,86	High	Very High
20	*risk_mngmt*	Risk Management	4,97	High	Very High
21	*bim_mngmt*	Bim Management	4,43	High	Very High
22	*erp_it_mngmt*	Erp & It Management	4,60	High	Very High
23	*claim_law_mngmt*	Claim & Law Management	4,74	High	Very High
24	*general_mngmt*	General	4,57	High	Very High

At the analysis of questionnaire survey section, first of all, it is given cross tables between the details of respondents and the proficiency level of the modules. The module cross tables inform us on the scores of respondents with respect to their age groups, business types, departments, company age groups, previous ERP usage experiences, company turnovers, the number of employees at companies.

After cross table, it is investigated survey results in much more detail by using non-parametric ANOVA analysis with Kruskal-Wallis test with pairwise comparison because the data comes from survey analysis is not normally distributed.

If we examine Kruskal-Wallis test results with respect to age groups of the respondents, it can be seen that “age groups” factor is significantly important at the proficiency level of “Planning and Time Management, Budget and Cost Control Management, Accounting Management, HR Management and Logistic & Warehouse Management” modules at the user satisfaction survey. According to the different age groups of the respondents, these modules have different proficiency levels but it must be known that the average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, not at all module proficiency levels but at the most of them, it can be indicated that the more the age of the respondents getting higher, the proficiency level of the modules are getting higher score. The more experienced professionals have scored much higher for the module proficiencies.

If we examine Kruskal-Wallis test results with respect to business types of the respondents, it can be seen that “business type” factor is significantly important at the proficiency level of Design Management, Accounting Management, HR Management and Quality Control Management, Sales & Marketing & CRM Managements, Logistic & Warehouse Management, Risk Management, BIM Management, ERP & IT Management and General Management modules at the user satisfaction survey. According to the different business types of the respondents, these modules have different proficiency levels but it must be known that the average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, it can be indicated that if a module is actively used by a business type, that business type survey respondents have scored slightly lower than other business type respondents.

If we examine Kruskal-Wallis test results with respect to yearly turnover of the companies of the respondents, it can be seen that “yearly turnover” factor is significantly important at the proficiency level of Business Development, Owner Tender, Design Management, Quality Control Management, Risk Management, BIM Management, ERP & IT Management, Claim & Law Management and General Management modules at the user satisfaction survey. According to the different yearly turnover levels of the companies of the respondents, these modules have different proficiency levels but it must be known that the

average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, not at all module proficiency levels but at the some of them, it can be indicated that the higher yearly turnover of a construction company become, the higher proficiency level of the module is shown in the survey results.

If we examine Kruskal-Wallis test results with respect to company age groups of the respondents, it can be seen that “company age groups” factor is significantly important at the proficiency level of Business Development, Owner Progress Report Management, Site & Subcontractor Management, Finance Management, Accounting Management, Procurement Management, HR Management, Quality Control Management, Sales & Marketing & CRM Management, Risk Management, ERP & IT Management, Claim & Law Management and General Management modules at the user satisfaction survey. According to the different company age groups of the respondents, these modules have different proficiency levels but it must be known that the average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, not at all module proficiency levels but at the some of them, it can be indicated that the higher company age of a construction company become, the higher proficiency level of the module is shown in the survey results.

If we examine Kruskal-Wallis test results with respect to total number of the employees of the companies of the respondents, it can be seen that “total employee” factor is significantly important at the proficiency level of Business Development, Sub-Contractor Tender Management, Owner Tender Management, Contract Management, Owner Progress Report, Site Subcontractor Management, Design Management, Finance Management, Accounting Management, Procurement Management, HR Management, Quality Control Management, Logistics & Warehouse Management, Risk Management, BIM Management, ERP & IT Management and Claim & Law Management modules at the user satisfaction survey. According to the different total number of employee groups of the respondents, these modules have different proficiency levels at different number of total employee groups of the companies but it must be known that the average score of all respondents is still between

high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high.

If we examine Kruskal-Wallis test results with respect to departments of the respondents, it can be seen that “departments” factor is significantly important at the proficiency level of Business Development, Owner Tender Management, Design Management, Accounting Management, Procurement Management, HR Management, Logistics & Warehouse Management, Document Management, BIM Management, ERP & IT Management, Claim & Law Management and General Management modules at the user satisfaction survey. According to the different departments of the respondents, these modules have different proficiency levels but it must be known that the average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, it can be seen from the survey results, different department professionals have scored different modules at different proficiency level but it can also be indicated that all modules have been scored as highly proficient.

If we examine Kruskal-Wallis test results with respect to ERP usage experience before (yes or no) of the respondents, it can be seen that “ERP Usage” factor is significantly important at the proficiency level of Business Development, Planning & Time Management, Owner Progress Report Management, Design Management, Finance Management, BIM Management and Claim & Law Management modules at the user satisfaction survey. According to the ERP Usage experiences of the respondents, these modules have different proficiency levels but it must be known that the average score of all respondents is still between high and very high proficiency level at all modules but Sub-Contractor Progress Report and HSE Management modules. At these two modules, the score of all respondents is very high. Also, not at all module proficiency levels but at the most of them, it can be indicated that the if a construction company uses any ERP system currently, the respondent of that construction company have scored much higher for the proficiency levels of the modules according to the survey results. That means that the more ERP experienced in the construction companies and the respondents, the higher proficiency level at the module evaluations.

As mentioned at related studies part of the thesis, there are some studies that focus on system architecture of ERP and MEP systems [21, 23, 52, 83, 92, 106, 137, 140] but there is not a specific study on system architecture of a complete project-based ERP systems and this thesis explains architecture components of related project-based ERP systems for construction industry by indicating ARIS House methodology views.

Also, as mentioned at related studies part, there is limited number of studies on different aspects of ERP systems in construction industry [25, 137, 138, 153]. Tserng *et al.* [149] have investigated the transformation of current IT systems to the implementation of new ERP system at a general contractor organization for only project management module. However, complete system architecture components of a project-based C-ERP systems have never been proposed.

In this context, this study addresses all expected project-based C-ERP modules, all of their functions and related components in detail by investigating current availably ERP systems in Turkish construction industry. This study indicates all of system components of project-based C-ERP systems with respect to ARIS House methodology elements. Moreover, there is not any study about Graphical User Interface (GUI) sample for project-based C-ERP systems in literature. Along with this study, it is shown GUI sample by using ARIS House system architecture components.

7. CONCLUSIONS AND FURTHER WORK

7.1. Major Findings and Contributions of the Study to the Literature on C-ERP

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 well-defined project-based C-ERP systems.

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 being a project-based industry, it is important to learn from the professionals on how large construction organizations works and what requirements they need at the headquarters and construction sites.

One of the main concerns of this thesis was to find out needs and expectations of construction industry for a well-defined and prepared C-ERP system by defining correct dimensions and elements of it. This thesis explains the requirements and system architecture components of a well-defined and prepared C-ERP system by indicating 24 modules, 653 functions, 40 kinds of data and 41 control processes. Also, this thesis tests the validity of these function and module units by a user satisfaction questionnaire survey.

Furthermore, this thesis explains the theoretical background of the development of a new C-ERP system architecture by using one of integrated information system modelling theories, ARIS House methodology. This thesis shows us core elements of ARIS House Diagram to develop a new C-ERP system.

Moreover, this thesis presents us a sample GUI for newly defined C-ERP system and illustrates all the information comes from case studies.

In conclusion, this thesis builds and documents core structures for a well-defined C-ERP system and demonstrates us the result of all theoretical studies with a GUI sample.

7.2. Limitations of the Study

One of the limitations of this study is about the questionnaire survey studies. The respondents of the face-to-face questionnaire survey are generally focuses on a few modules at their companies because of their departments or the restrictions of users to reach other modules. Therefore, some of the respondents answers the module proficiencies as only their future and potential expectations from module functionality. Also, there are 105 respondents from different kind of construction companies. The interviews with more construction related people could have enriched the data collected.

7.3. Recommendations for Further Works

By using ARIS House function, data, organization and control information, ARIS House process chains can be made and real C-ERP software can be developed by using GUI sample and the support of a software company.

Moreover, by using the same parameters and research methods in this study, data from companies and construction executives at other countries can also be collected in order to examine the results of same sector at 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.

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APPENDIX A: SAP MODULES LIST

The following table denotes SAP modules and their work units.

Table A.1. SAP Module List

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO (MBS 04)	MODULE NO	NO	WORK NO	MAIN MODULES (MBS 01)	MODULES (MBS 02)	SUB MODULES 01 (MBS 03)	SUB MODULES 02 (MBS 04)	WORK UNIT
01	00	00	00	01.00.00.00	1	01.00.00.00.1	Financial Services Network Connector				Connector Monitor
01	00	00	00	01.00.00.00	2	01.00.00.00.2	Financial Services Network Connector				Pull Messages
01	00	00	00	01.00.00.00	3	01.00.00.00.3	Financial Services Network Connector				Send Messages
01	00	00	00	01.00.00.00	4	01.00.00.00.4	Financial Services Network Connector				Pick-up Files
01	00	00	00	01.00.00.00	5	01.00.00.00.5	Financial Services Network Connector				Create FSN Message
01	01	00	00	01.01.00.00	6	01.01.00.00.6	Financial Services Network Connector	Message Archiving			Select Messages to Archive
01	01	00	00	01.01.00.00	7	01.01.00.00.7	Financial Services Network Connector	Message Archiving			Archive Selected Messages
01	01	00	00	01.01.00.00	8	01.01.00.00.8	Financial Services Network Connector	Message Archiving			Delete Archived Messages
01	01	00	00	01.01.00.00	9	01.01.00.00.9	Financial Services Network Connector	Message Archiving			Reload Archived Messages
02	00	00	00	02.00.00.00	10	02.00.00.00.10	Office				Workplace
02	01	00	00	02.01.00.00	11	02.01.00.00.11	Office	Telephone Integration			Own Telephone Number
02	01	00	00	02.01.00.00	12	02.01.00.00.12	Office	Telephone Integration			Extended Settings
02	02	00	00	02.02.00.00	13	02.02.00.00.13	Office	Appointment Calendar			Owner
02	02	00	00	02.02.00.00	14	02.02.00.00.14	Office	Appointment Calendar			Employee
02	03	00	00	02.03.00.00	15	02.03.00.00.15	Office	Room Reservations			Reservation
02	03	00	00	02.03.00.00	16	02.03.00.00.16	Office	Room Reservations			Services
02	00	00	00	02.00.00.00	17	02.00.00.00.17	Office				Start Workflow
02	04	00	00	02.04.00.00	18	02.04.00.00.18	Office	Business Documents			Find Lists
02	04	01	00	02.04.01.00	19	02.04.01.00.19	Office	Business Documents	Documents		Check In
02	04	01	00	02.04.01.00	20	02.04.01.00.20	Office	Business Documents	Documents		Find
02	04	01	00	02.04.01.00	21	02.04.01.00.21	Office	Business Documents	Documents		
02	05	01	00	02.05.01.00	22	02.05.01.00.22	Office	Notification	Create		Simplified View
02	05	01	00	02.05.01.00	23	02.05.01.00.23	Office	Notification	Create		Extended View
02	05	02	00	02.05.02.00	24	02.05.02.00.24	Office	Notification	Change		Simplified View
02	05	02	00	02.05.02.00	25	02.05.02.00.25	Office	Notification	Change		Extended View
02	05	03	00	02.05.03.00	26	02.05.03.00.26	Office	Notification	Display		Simplified View
02	05	03	00	02.05.03.00	27	02.05.03.00.27	Office	Notification	Display		Extended View
02	05	04	00	02.05.04.00	28	02.05.04.00.28	Office	Notification	Task		Process
02	05	04	00	02.05.04.00	29	02.05.04.00.29	Office	Notification	Task		Display
02	05	05	00	02.05.05.00	30	02.05.05.00.30	Office	Notification	Worklist		Notifications
02	05	05	00	02.05.05.00	31	02.05.05.00.31	Office	Notification	Worklist		Tasks
03	01	01	00	03.01.01.00	32	03.01.01.00.32	Cross-Application Components	Processes and Tools for Enterprise Applications	Analytics Infrastructure		BIA for Classic InfoSets
03	01	02	00	03.01.02.00	33	03.01.02.00.33	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework		Log Display
03	01	02	01	03.01.02.01	34	03.01.02.01.34	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Administration	Version Display
03	01	02	01	03.01.02.01	35	03.01.02.01.35	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Administration	Display Active Sessions
03	01	02	02	03.01.02.02	36	03.01.02.02.36	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Settings	Edit Destinations
03	01	02	02	03.01.02.02	37	03.01.02.02.37	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Settings	Make Settings for Experts
03	01	03	03	03.01.03.03	38	03.01.03.03.38	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Define Filter Criteria
03	01	03	03	03.01.03.03	39	03.01.03.03.39	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Execute Data Replication
03	01	03	03	03.01.03.03	40	03.01.03.03.40	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Analyze Replication Log
03	01	03	03	03.01.03.03	41	03.01.03.03.41	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Delete Replication Log
03	01	03	03	03.01.03.03	42	03.01.03.03.42	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Display Object Replication Status
03	01	03	03	03.01.03.03	43	03.01.03.03.43	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Delete Object Replication Status
03	01	03	03	03.01.03.03	44	03.01.03.03.44	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Subscribe Objects for Replication
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Table A.1. SAP Module List (cont.)

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO (MBS 04)	MODULE NO	NO	WORK NO	MAIN MODULES (MBS 01)	MODULES (MBS 02)	SUB MODULES 01 (MBS 03)	SUB MODULES 02 (MBS 04)	WORK UNIT
01	00	00	00	01.00.00.00	1	01.00.00.00.1	Financial Services Network Connector				Connector Monitor
01	00	00	00	01.00.00.00	2	01.00.00.00.2	Financial Services Network Connector				Pull Messages
01	00	00	00	01.00.00.00	3	01.00.00.00.3	Financial Services Network Connector				Send Messages
01	00	00	00	01.00.00.00	4	01.00.00.00.4	Financial Services Network Connector				Pick-up Files
01	00	00	00	01.00.00.00	5	01.00.00.00.5	Financial Services Network Connector				Create FSN Message
01	01	00	00	01.01.00.00	6	01.01.00.00.6	Financial Services Network Connector	Message Archiving			Select Messages to Archive
01	01	00	00	01.01.00.00	7	01.01.00.00.7	Financial Services Network Connector	Message Archiving			Archive Selected Messages
01	01	00	00	01.01.00.00	8	01.01.00.00.8	Financial Services Network Connector	Message Archiving			Delete Archived Messages
01	01	00	00	01.01.00.00	9	01.01.00.00.9	Financial Services Network Connector	Message Archiving			Reload Archived Messages
02	00	00	00	02.00.00.00	10	02.00.00.00.10	Office				Workplace
02	01	00	00	02.01.00.00	11	02.01.00.00.11	Office	Telephone Integration			Own Telephone Number
02	01	00	00	02.01.00.00	12	02.01.00.00.12	Office	Telephone Integration			Extended Settings
02	02	00	00	02.02.00.00	13	02.02.00.00.13	Office	Appointment Calendar			Owner
02	02	00	00	02.02.00.00	14	02.02.00.00.14	Office	Appointment Calendar			Employee
02	03	00	00	02.03.00.00	15	02.03.00.00.15	Office	Room Reservations			Reservation
02	03	00	00	02.03.00.00	16	02.03.00.00.16	Office	Room Reservations			Services
02	00	00	00	02.00.00.00	17	02.00.00.00.17	Office				Start Workflow
02	04	00	00	02.04.00.00	18	02.04.00.00.18	Office	Business Documents			Find Lists
02	04	01	00	02.04.01.00	19	02.04.01.00.19	Office	Business Documents	Documents		Check In
02	04	01	00	02.04.01.00	20	02.04.01.00.20	Office	Business Documents	Documents		Find
02	04	01	00	02.04.01.00	21	02.04.01.00.21	Office	Business Documents	Documents		
02	05	01	00	02.05.01.00	22	02.05.01.00.22	Office	Notification	Create		Simplified View
02	05	01	00	02.05.01.00	23	02.05.01.00.23	Office	Notification	Create		Extended View
02	05	02	00	02.05.02.00	24	02.05.02.00.24	Office	Notification	Change		Simplified View
02	05	02	00	02.05.02.00	25	02.05.02.00.25	Office	Notification	Change		Extended View
02	05	03	00	02.05.03.00	26	02.05.03.00.26	Office	Notification	Display		Simplified View
02	05	03	00	02.05.03.00	27	02.05.03.00.27	Office	Notification	Display		Extended View
02	05	04	00	02.05.04.00	28	02.05.04.00.28	Office	Notification	Task		Process
02	05	04	00	02.05.04.00	29	02.05.04.00.29	Office	Notification	Task		Display
02	05	05	00	02.05.05.00	30	02.05.05.00.30	Office	Notification	Worklist		Notifications
02	05	05	00	02.05.05.00	31	02.05.05.00.31	Office	Notification	Worklist		Tasks
03	01	01	00	03.01.01.00	32	03.01.01.00.32	Cross-Application Components	Processes and Tools for Enterprise Applications	Analytics Infrastructure		BIA for Classic InfoSets
03	01	02	00	03.01.02.00	33	03.01.02.00.33	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework		Log Display
03	01	02	01	03.01.02.01	34	03.01.02.01.34	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Administration	Version Display
03	01	02	01	03.01.02.01	35	03.01.02.01.35	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Administration	Display Active Sessions
03	01	02	02	03.01.02.02	36	03.01.02.02.36	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Settings	Edit Destinations
03	01	02	02	03.01.02.02	37	03.01.02.02.37	Cross-Application Components	Processes and Tools for Enterprise Applications	Remote Control and Communication Framework	Settings	Make Settings for Experts
03	01	03	03	03.01.03.03	38	03.01.03.03.38	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Define Filter Criteria
03	01	03	03	03.01.03.03	39	03.01.03.03.39	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Execute Data Replication
03	01	03	03	03.01.03.03	40	03.01.03.03.40	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Analyze Replication Log
03	01	03	03	03.01.03.03	41	03.01.03.03.41	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Delete Replication Log
03	01	03	03	03.01.03.03	42	03.01.03.03.42	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Display Object Replication Status
03	01	03	03	03.01.03.03	43	03.01.03.03.43	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Delete Object Replication Status
03	01	03	03	03.01.03.03	44	03.01.03.03.44	Cross-Application Components	Processes and Tools for Enterprise Applications	Master Data Governance	Data Replication	Subscribe Objects for Replication
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APPENDIX B: MS DYNAMICS NAVISION MODULES LIST

The following table denotes MS Dynamics modules and their work units.

Table B.1. MS Dynamics Navision Modules List

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	NO	WORK NO	MAIN MODULES	MODULES	SUB MODULES	SUB MODULES 02	WORK UNITS
01	**01**	**00**	**01.01.00**	**1**	**01.01.00.1**	**Project Management**	Quote Preparation		Lists	Unit Price Analysis
01	**01**	**00**	**01.01.00**	**2**	**01.01.00.2**	**Project Management**	Quote Preparation		Lists	Project Locations
01	**01**	**00**	**01.01.00**	**3**	**01.01.00.3**	**Project Management**	Quote Preparation		Lists	Survey BOQ Lists
01	**01**	**00**	**01.01.00**	**4**	**01.01.00.4**	**Project Management**	Quote Preparation		Lists	Survey/BOQ Change Lists
01	**01**	**00**	**01.01.00**	**5**	**01.01.00.5**	**Project Management**	Quote Preparation		Lists	Project Bids
01	**01**	**00**	**01.01.00**	**6**	**01.01.00.6**	**Project Management**	Quote Preparation		Reports and Analysis - Lists	List by project location
01	**01**	**00**	**01.01.00**	**7**	**01.01.00.7**	**Project Management**	Quote Preparation		Reports and Analysis - Lists	List by budget codes
01	**01**	**00**	**01.01.00**	**8**	**01.01.00.8**	**Project Management**	Quote Preparation		Reports and Analysis - Lists	
01	**01**	**00**	**01.01.00**	**9**	**01.01.00.9**	**Project Management**	Quote Preparation		Reports	Project Locations
01	**01**	**00**	**01.01.00**	**10**	**01.01.00.10**	**Project Management**	Quote Preparation		Reports	Project Survey BOQ Lists
01	**01**	**00**	**01.01.00**	**11**	**01.01.00.11**	**Project Management**	Quote Preparation		Reports	Project Survey BOQ Lists (Illustrated)
01	**01**	**00**	**01.01.00**	**12**	**01.01.00.12**	**Project Management**	Quote Preparation		Reports	Project Survey BOQ Lists
01	**01**	**00**	**01.01.00**	**13**	**01.01.00.13**	**Project Management**	Quote Preparation		Reports	Project Survey BOQ Comparison Lists
01	**01**	**00**	**01.01.00**	**14**	**01.01.00.14**	**Project Management**	Quote Preparation		Reports	Survey BOQ Lists by project locations
01	**01**	**00**	**01.01.00**	**15**	**01.01.00.15**	**Project Management**	Quote Preparation		Reports	Unit Price List by Survey/BOQ List
01	**01**	**00**	**01.01.00**	**16**	**01.01.00.16**	**Project Management**	Quote Preparation		Reports	Unit Price Analysis in Survey/BOQ List
01	**01**	**00**	**01.01.00**	**17**	**01.01.00.17**	**Project Management**	Quote Preparation		Reports	Unit Price Analysis in Survey/BOQ List (by budget code)
01	**01**	**00**	**01.01.00**	**18**	**01.01.00.18**	**Project Management**	Quote Preparation		Reports	Unit Price Analysis
01	**01**	**00**	**01.01.00**	**19**	**01.01.00.19**	**Project Management**	Quote Preparation		Reports	Offers for Survey/BOQ budget codes
01	**01**	**00**	**01.01.00**	**20**	**01.01.00.20**	**Project Management**	Quote Preparation		Reports	Sub-contractors offer comperisons for Survey/BOQ budget codes
01	**01**	**00**	**01.01.00**	**21**	**01.01.00.21**	**Project Management**	Quote Preparation		Reports	Project Tender Offer (Illustrated)
01	**01**	**00**	**01.01.00**	**22**	**01.01.00.22**	**Project Management**	Quote Preparation		Reports	Project Tender Offer Statistics
01	**01**	**00**	**01.01.00**	**23**	**01.01.00.23**	**Project Management**	Quote Preparation		Reports	Project Tender Offer Lists
01	**01**	**00**	**01.01.00**	**24**	**01.01.00.24**	**Project Management**	Quote Preparation		Reports	Project Tender Offer Lists
01	**01**	**00**	**01.01.00**	**25**	**01.01.00.25**	**Project Management**	Quote Preparation		Reports	Project Tender Offer Price Lists
01	**01**	**00**	**01.01.00**	**26**	**01.01.00.26**	**Project Management**	Quote Preparation		Reports	Project tender offers comparison tables
01	**01**	**00**	**01.01.00**	**27**	**01.01.00.27**	**Project Management**	Quote Preparation		Reports	Project Costs Budget Codes Analysis
01	**01**	**00**	**01.01.00**	**28**	**01.01.00.28**	**Project Management**	Quote Preparation		Reports	Project Exchange Rate Risks
01	**01**	**00**	**01.01.00**	**29**	**01.01.00.29**	**Project Management**	Quote Preparation		Administration - Installation - Formulas	Mathematical Constants
01	**01**	**00**	**01.01.00**	**30**	**01.01.00.30**	**Project Management**	Quote Preparation		Administration - Installation - Formulas	Formulas
01	**01**	**00**	**01.01.00**	**31**	**01.01.00.31**	**Project Management**	Quote Preparation		Administration - Installation	Profit Calculation Groups
01	**01**	**00**	**01.01.00**	**32**	**01.01.00.32**	**Project Management**	Quote Preparation		Administration - Installation	Overhead Cost Types
01	**01**	**00**	**01.01.00**	**33**	**01.01.00.33**	**Project Management**	Quote Preparation		Administration - Installation	Project List Groups
01	**01**	**00**	**01.01.00**	**34**	**01.01.00.34**	**Project Management**	Quote Preparation		Administration - Installation	Unit Price Analysis Groups
01	**01**	**00**	**01.01.00**	**35**	**01.01.00.35**	**Project Management**	Quote Preparation		Administration - Installation	Item Multipliers
01	**02**	**00**	**01.02.00**	**36**	**01.02.00.36**	**Project Management**	Planning		Lists	Projects
01	**02**	**00**	**01.02.00**	**37**	**01.02.00.37**	**Project Management**	Planning		Lists	Work Orders
01	**02**	**00**	**01.02.00**	**38**	**01.02.00.38**	**Project Management**	Planning		Task	Aktivities
01	**02**	**00**	**01.02.00**	**39**	**01.02.00.39**	**Project Management**	Planning		Report and Analysis - Reports	Project Activitiy Lists
01	**02**	**00**	**01.02.00**	**40**	**01.02.00.40**	**Project Management**	Planning		Report and Analysis - Reports	Project Information Form
01	**02**	**00**	**01.02.00**	**41**	**01.02.00.41**	**Project Management**	Planning		Report and Analysis - Reports	Project Team
01	**02**	**00**	**01.02.00**	**42**	**01.02.00.42**	**Project Management**	Planning		Report and Analysis - Reports	Aktivity Progresses
01	**02**	**00**	**01.02.00**	**43**	**01.02.00.43**	**Project Management**	Planning		Report and Analysis - Reports	Aktivity Progress Info
01	**02**	**00**	**01.02.00**	**44**	**01.02.00.44**	**Project Management**	Planning		Report and Analysis - Reports	Comparison of Approved Schedule vs. Baseline Schedule
01	**03**	**00**	**01.03.00**	**45**	**01.03.00.45**	**Project Management**	Budget		Lists	Survey/BOQ Budget Analysis
01	**03**	**00**	**01.03.00**	**46**	**01.03.00.46**	**Project Management**	Budget		Lists	Aktivity Budget
01	**03**	**00**	**01.03.00**	**47**	**01.03.00.47**	**Project Management**	Budget		Lists	Project Budget
01	**03**	**00**	**01.03.00**	**48**	**01.03.00.48**	**Project Management**	Budget		Lists	Realization Budget
01	**03**	**00**	**01.03.00**	**49**	**01.03.00.49**	**Project Management**	Budget		Lists	Project Budget Cash Flow
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Table B.1. MS Dynamics Navision Modules List (cont.)

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	NO	WORK NO	MAIN MODULES	MODULES	SUB MODULES	SUB MODULES 02	WORK UNITS
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APPENDIX C: YAPITAŞI ERP MODULES LIST

The following table denotes Yapıtaşı modules and their work units.

Table C.1. Yapıtaşı ERP Module List

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	SIRA NO	WORK NO	MAIN MODULES	MODULES	SUB MODULES	SUB MODULES 02	WORKS
01	01	01	01.01.01	1	01.01.01.1	PLANNING	PROJECT & CODES	ACTIVITY CODES		Activity Groups
01	01	01	01.01.01	2	01.01.01.2	PLANNING	PROJECT & CODES	ACTIVITY CODES		Activity Sub-Groups
01	01	01	01.01.01	3	01.01.01.3	PLANNING	PROJECT & CODES	ACTIVITY CODES		Activity Codes
01	01	02	01.01.02	4	01.01.02.4	PLANNING	PROJECT & CODES	ACTIVITY CODES		resource groups
01	01	02	01.01.02	5	01.01.02.5	PLANNING	PROJECT & CODES	ACTIVITY CODES		resource sub-groups
01	01	02	01.01.02	6	01.01.02.6	PLANNING	PROJECT & CODES	ACTIVITY CODES		resource codes (main codes)
01	01	02	01.01.02	7	01.01.02.7	PLANNING	PROJECT & CODES	ACTIVITY CODES		resource codes (detailed codes)
01	01	03	01.01.03	8	01.01.03.8	PLANNING	PROJECT & CODES	SITES & PROJECTS		
01	01	04	01.01.04	9	01.01.04.9	PLANNING	PROJECT & CODES	COMPANIES		
01	02	01	01.02.01	10	01.02.01.10	PLANNING	BUSINESS DEVELOPMENT	DEED OF REAL ESTATE		general list
01	02	02	01.02.02	11	01.02.02.11	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS		general list
01	02	02	01.02.02	12	01.02.02.12	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS		By Municipality
01	02	02	01.02.02	13	01.02.02.13	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS		By Year
01	02	02	01.02.02	14	01.02.02.14	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS		By Intermediary
01	02	02	01.02.02	15	01.02.02.15	PLANNING	BUSINESS DEVELOPMENT	FEASIBILITY REPORTS		By Condition
01	02	03	01.02.03	16	01.02.03.16	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS		By Date
01	02	03	01.02.03	17	01.02.03.17	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS		By Order Name
01	02	03	01.02.03	18	01.02.03.18	PLANNING	BUSINESS DEVELOPMENT	NEGOTIATIONS		by negotiator
01	02	04	01.02.04	19	01.02.04.19	PLANNING	BUSINESS DEVELOPMENT	UNIT INFO		types and costs
01	03	01	01.03.01	20	01.03.01.20	PLANNING	MASTER PLAN & BUDGETING	BUDGET		By Activities
01	03	01	01.03.01	21	01.03.01.21	PLANNING	MASTER PLAN & BUDGETING	BUDGET		By Resources
01	03	01	01.03.01	22	01.03.01.22	PLANNING	MASTER PLAN & BUDGETING	BUDGET		By Location
01	03	01	01.03.01	23	01.03.01.23	PLANNING	MASTER PLAN & BUDGETING	BUDGET		Revision Comparison
01	03	01	01.03.01	24	01.03.01.24	PLANNING	MASTER PLAN & BUDGETING	BUDGET		All Revisions
01	03	01	01.03.01	25	01.03.01.25	PLANNING	MASTER PLAN & BUDGETING	BUDGET		procurement plan
01	03	01	01.03.01	26	01.03.01.26	PLANNING	MASTER PLAN & BUDGETING	BUDGET		By Resource Condition (Procurement)
01	03	01	01.03.01	27	01.03.01.27	PLANNING	MASTER PLAN & BUDGETING	BUDGET		By Resource Condition (Contractor)
01	04	02	01.04.02	28	01.04.02.28	PLANNING	ANALYSIS & UNIT RATES	UNIT RATES		unit prices
01	04	03	01.04.03	29	01.04.03.29	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)		favorites
01	04	03	01.04.03	30	01.04.03.30	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)		To Be Approved
01	04	03	01.04.03	31	01.04.03.31	PLANNING	ANALYSIS & UNIT RATES	ANALYSIS (UNIT PRICE)		all analysis
01	05	01	01.05.01	32	01.05.01.32	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		All Contracts
01	05	01	01.05.01	33	01.05.01.33	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		USD Contracts
01	05	01	01.05.01	34	01.05.01.34	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		EUR Contracts
01	05	01	01.05.01	35	01.05.01.35	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		TL Contracts
01	05	01	01.05.01	36	01.05.01.36	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		By Region
01	05	01	01.05.01	37	01.05.01.37	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		By Owner
01	05	01	01.05.01	38	01.05.01.38	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	CONTRACTS		By Project
01	05	02	01.05.02	39	01.05.02.39	PLANNING	OWNER CONTRACTS (CONTRACT SYSTEM)	PROGRESS REPORTS		All Progress Reports
01	06	01	01.06.01	40	01.06.01.40	PLANNING	SITE PROGRESS	CURRENT SITUATION		WBS / Activity
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Table C.1. Yapıtaşı ERP Module List (cont.)

MAIN MODULE NO (MBS 01)	MODULE NO (MBS 02)	MODULE NO (MBS 03)	MODULE NO	SIRA NO	WORK NO	MAIN MODULES	MODULES	SUB MODULES	SUB MODULES 02	WORKS
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APPENDIX D: AVAILABILITY OF FUNCTIONS TABLE

The following table denotes the availability of functions at ERP systems.

Table D.1. Availability of Functions Table

						AVAILABILITY OF THE FUNCTONS						PROFICIENCY OF THE MODULES					
MAIN MODULE	**MAIN MODULE NO**	**MODULE NO**	**MODULE**	**FUNCTION NO**	**FUNCTION**	**A**	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
BUSINESS DEVELOPMENT	01											**5**	**5**	**5**	**5**	**5**	**5**
	01	01	**BUSINESS DEVELOPMENT**	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	2	2	1	1	0	1						
				F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibilty calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV (Net Present Value) and IRR (Internal Rate of Return) values can be calculated on system by running feasibility calculations for different scenarios.	0	0	0	0	0	0						
				F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	1	1	1	1	0	1						
				F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	0	0	0	0	0	0						
				F05	This module has document management functions on business development documents.	2	2	2	2	0	2						
				F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	2	2	1	1	0	1						
				F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	1	1	0	0	0	1						
				F08	This module has business development excel work calculation ability by using past project completion m2 costs.	0	0	0	0	0	0						
				F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilties more accurately.	0	0	0	0	0	0						
				F10	This module has Investment Brochures schemes and already maden invesment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.	0	0	0	0	0	0						
				F11	This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module	1	1	0	0	0	0						
				F12	This module has Commission Calculation functions that manage how much commision should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the project business development.	0	0	0	0	0	0						
				F13	This module also calculates and shows credit payments for that business development. Also shows credit payment flows and give details at business development calculations.	0	0	0	0	0	0						
				F14	This module saves the information about how many engineer/architect/city planner man x hours spent for that project	0	0	0	0	0	0						
BUSINESS DEVELOPMENT																	
	01	02	**INVESTMENT CONTRACTS**	F15	Business development department employees enters the signed "flat for land" method contracts. Signed contracts can be reached from related departments	2	2	2	2	1	2						
				F16	Business development department employees enters the signed "revenue sharing" method contracts. Signed contracts can be reached from related departments	2	2	2	2	1	2						
				F17	Business development department employees enters the signed "real estate sales" contracts. Signed contracts can be reached from related departments	2	2	2	2	2	2						
				F18	Business development department employees enters the signed "real estate investments share sales" contracts. Signed contracts can be reached from related departments	0	0	0	0	0	0						
PROJECT MANAGEMENT	02	01	**PLANNING & TIME MANAGEMENT**									5	5	5	5	5	5

Table D.1. Availability of Functions Table (cont.)

						AVAILABILITY OF THE FUNCTONS						PROFICIENCY OF THE MODULES					
MAIN MODULE	MAIN MODULE NO	MODULE NO	MODULE	FUNCTION NO	FUNCTION	A	B	C	D	E	F	A	B	C	D	E	F
				F19	this module has functionality on preparing working schedules and revising imported schedules on system	0	0	0	0	0	0						
				F20	this module has functionality on importing primavera p6 level 4 schedules	1	1	1	1	0	2						
				F21	this module has functionality on exporting primavera p6 level 4 schedules	1	1	1	1	0	2						
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				F650	This module has functionality on creating, monitoring, filtering, alerting and managing trust deeds, their expiration dates	2	2	0	0	0	0						
				F651	This module has functionality on creating, monitoring, filtering and managing trust deeds with respect to subject, proxy giver, proxy holder, date and alerting about expiration dates.	2	2	0	0	0	0						
								0	0	0	0						
			INTERNAL CONTRACT APPROVAL & PROCESS MANA	F652	This module has functionality on monitoring, filtering, approving and managing contracts of projects by approval of law departments	0	0	0	0	1	1						
				F653	This module has functionality on calculating and reporting approval durations and periods by law department attorneys and other department employees	0	0	0	0	1	1						

APPENDIX E: FUNCTIONS VS. ORGANIZATIONS TABLE

The following table denotes the correlations between organization units and their related and used functions.

Table E.1. Functions vs. Organizations Table

						ORGANIZATION																
						01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
MAIN MODULE	MAIN MODULE NO	MODULE NO	MODULE	FUNCTION NO	FUNCTION	O 01 - Business Development Department	O 02 - Technical Office (Project Management) Department	O 03 - Design Office Department	O 04 - Site/Construction Department	O 05 - Quality Control Department	O 06 - HSE Department	O 07 - Finance Department	O 08 - Accounting Department	O 09 - Procurement Department	O 10 - HR Department	O 11 - Administration Department	O 12 - Logistic & Warehouse Management Department	O 13 - Sale & Marketing & CRM Department	O14 - BIM Management Department	O15 - Risk Management Department	O16 - IT Department	O17 - ERP Department	O18 - Claim ve Law Department
BUSINESS DEVELOPMENT	01																					
	01	01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X																	
				F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibility calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV (Net Present Value) and IRR (Internal Rate of Return) values can be calculated on system by running feasibility calculations for different scenarios.	X																
				F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X																
				F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	X																
				F05	This module has document management functions on business development documents.	X																
				F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X																
				F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	X																
				F08	This module has business development excel work calculation ability by using past project completion m2 costs.	X																
				F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilities more accurately.	X																
				F10	This module has Investment Brochures schemes and already maden invesment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.	X																
				F11	This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module	X																
				F12	This module has Commission Calculation functions that manage how much commision should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the project business development	X																
				F13	This module also calculates and shows credit payments for that business development. Also shows credit payment flows and give details at business development calculations..	X																
				F14	This module saves the information about how many engineer/architect/city planner man x hours spent for that project	X																
BUSINESS DEVELOPMENT																						
	01	02	INVESTMENT CONTRACTS	F15	Business development department employees enters the signed "flat for land" method contracts. Signed contracts can be reached from related departments	X																
				F16	Business development department employees enters the signed "revenue sharing" method contracts. Signed contracts can be reached from related departments	X																
				F17	Business development department employees enters the signed "real estate sales" contracts. Signed contracts can be reached from related departments	X																
				F18	Business development department employees enters the signed "real estate investments share sales" contracts. Signed contracts can be reached from related departments	X																
PROJECT MANAGEMENT	02	01	PLANNING & TIME MANAGEMENT																			
				F19	this module has functionality on preparing working schedules and revising imported schedules on system		X															
				F20	this module has functionality on importing primavera p6 level 4 schedules		X															
				F21	this module has functionality on exporting primavera p6 level 4 schedules		X															
				F22	this module has functionality on importing ms project level 4 schedules		X															
				F23	this module has functionality on exporting ms project level 4 schedules		X															
				F24	this module has functionality on importing primavera p6 level 2 schedules		X															
				F25	this module has functionality on exporting primavera p6 level 2 schedules		X															
				F26	this module has functionality on importing ms project level 2 schedules		X															
				F27	this module has functionality on exporting ms project level 2 schedules		X															
				F28	this module has functionality on importing ms excel level 2 schedules		X															
				F29	this module has functionality on exporting ms excel level 2 schedules		X															
				F30	this module has functionality on managing activity codes (adding, deleting, defining and changing etc.)		X															
				F31	this module has functionality on managing cost codes (adding, deleting, defining and changing etc.)		X															
				F32	this module has functionality on creating wbs structure and importing/exporting from ms excel		X															
				F33	this module has functionality on showing activities by their locations as location/activity matrix		X															
				F34	this module has functionality on filtering activities by their unstarted, continued and finished conditions		X															
				F35	this module has functionality on tracing BOQ physical progress		X															

Table E.1. Functions vs. Organizations Table (cont.).

					ORGANIZATION															
					01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	O 01 - Business Development Department	O 02 - Technical Office (Projet Management) Department	O 03 - Design Office Department	O 04 - Site/Construction Department	O 05 - Quality Control Department	O 06 - HSE Department	O 07 - Finance Department	O 08 - Accounting Department	O 09 - Procurement Department	O 10 - HR Department	O 11 - Administration Department	O 12 - Logistic & Warehouse Management Department	O 13 - Sale & Marketing & CRM Department	O14 - BIM Management Department	O15 - Risk Management Department	O16 - IT Department	O17 - ERP Department	O18 - Claim +ve Law Department

APPENDIX F: FUNCTIONS VS. DATA TABLE

The following table denotes the correlations between functions and the data used by these functions.

Table F.1. Functions vs. Data Table

MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	DATA 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
					D 01 - Data on the deeds of real estates, zone notes, planning notes, land notes and project development documents	D 02 - Data on work schedules, activities, resources and connection information	D 03 - Data on man x hours and BOQ values belong to work schedules	D 04 - Data on Unit Price, Unit Price Analysis, BOQ list with respect to Budget Codes	D 05 - Data on all sub-contractors and suppliers	D 06 - Data on all sub-contractor, contracts, unit prices and unit price analysis about past tenders	D 07 - Data on BOQ, Unit Price, Unit Price Analysis, Current Prices, Schedules, Cash flow and Realization Tables about Tender Bids	D 08 - Data on all contractual information about sub-contractor contracts	D 09 - Data on all contractual information about Owner contracts	D 10 - Data on sub-contractor progress report information such as physical amount dates, contractual risks, warrantee and security deposits, deduction etc.	D 11 - Data on owner progress report information such as physical amount dates, contractual risks, warrantee and security deposits, deductions etc.	D 12 - Data on site photos and daily construction works done with their season, location, floor information etc.	D 13 - Data on near-miss, accident, work permit, control, periodical inspection records and other report information about healt, security and environment management	D 14 - Data on design documents and detailed sheet and zone lists about contractor, owner and feasibility design projects	D 15 - Data on exchange rate, invoice, receipt, cheque, promissory notes, barter and other financial management documents	D 16 - Data on customer lists, all receivable accounts, payable accounts, invoices and return invoices, sales journals, balance sheets and return payment information	D 17 - Data on supplier and sub-contractor lists, accounts payables, sales invoices, return invoices and receipts	D 18 - Data on accounts, banks, tax declarations, cost accounting, long term and short term financial reports and financial ratios	D 19 - Data on credit cards, finance cards, credit bank information and transaction	D 20 - Data on cost codes/centres and budget informations	D 21 - Data on all owner and sub-contractor progress reports informations and information from accounts payables and account receivables	D 22 - Data on fixed assets, general accounting journals, insurance journals, fixed asset journals, amortization accounts etc. information	D 23 - Data on warehouse information, warehouse budget codes and other warehouse material informations	D 24 - Data on payment returns/collection informations on account payables, notes/bills, cheques, promissory notes	D 25 - Data on all tax rates, subscription payments, rent increase rates, price inflation rates etc.	D 26 - Data on chart of accounts, e-invoice system, invoice and receipt informations	D 27 - Data on Procurement Request Forms, Order Evaluation Forms, approval durations, OEF budget codes, supplier lists, procurement employee informations including invoices	D 28 - Data on employee lists, employee official records, salary net and gross calculations, team informations, assignment score cards, passport and visa informations, personnel records, personnel evaluation and education informations, training records, internal performance evaluations	D 29 - Data on company procedures, regulatory aim preventive activities (QFA), non-conformity reports, open and closed NCR records, method statements, control lists, calibration documents, TSE EN standards, internal audits, control forms, calibration documents, TSE EN standards, internal	D 30 - Data on all customer representatives daily, weekly and monthly schedules, meeting minutes and notes	D 31 - Data on customer informations, candidate customers tracking records, news letter records, sales/stock reports, sales dates, customer problems and feedback records, customer satisfaction records	D 32 - Data on stock sheets, site availability or each unit, customer payment records and cash flow of each customer, technical specifications of sale contracts, sales price lists, campaigns, planned vs. realised sale price and quantities, sales contracts, sales invoices, sales returns	D 33 - Data on marketing and advertisment information and date, media, project information of advertisements	D 34 - Data on received and sent all documents and their document number, date informations. Also, daily, weekly reports, site photos, executive reports, meeting minutes	D 35 - Data on delivery conditions of all orders, all PRF information, warehouse material conditions, sub-contractor material delivery conditions, material test results, material certificates, material test reports, inspection reports, warehouse journals, machinary/equipment fuel, oil consumption, maintenance records and costs, and performance records	D 36 - Data on risk registrations, risk matrix, assessment of risk categories, risk tracking, risk reports, monte carlo simulation records, risk meeting minutes and other risk know-how documents	D 37 - Data on design, time and cost management informations of BIM software, softwares and BIM documents, sheet lists and BIM model obey controls	D 38 - Data on IT inventories and their properties. Also, data on debit entries, IT team help records and statistics.	D 39 - Data on general address book, to-do list information, all meeting minutes with action lists	D 40 - Data on claims, trials and their documents
BUSINESS DEVELOPMENT	01																																										
	01 01	BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X																																						
			F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibility calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	X																																						
			F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X																																						
			F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	X																																						
			F05	This module has document management functions on business development documents.	X																																						
			F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X																																						
			F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	X																																						
			F08	This module has business development excel work calculation ability by using past project completion m2 costs.	X																																						
			F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilities more accurately.	X																																						
			F10	This module has Investment Brochures schemes and already maden invesment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.	X																																						
			F11	This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module	X																																						
			F12	This module has Commission Calculation functions that manage how much commision should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the project business development	X																																						
			F13	This module also calculates and shows credit payments for that business development. Also shows credit payment flows and give details at business development calculations.	X																																						
			F14	This module saves the information about how many engineer/architect/city planner man x hours spent for that project	X																																						
					X																																						
BUSINESS DEVELOPMENT					X																																						
	01 02	INVESTMENT CONTRACTS	F15	Business development department employees enters the signed "flat for land" method contracts. Signed contracts can be reached from related departments	X																																						
			F16	Business development department employees enters the signed "revenue sharing" method contracts. Signed contracts can be reached from related	X																																						
			F17	Business development department employees enters the signed "real estate sales" contracts. Signed contracts can be reached from related departments	X																																						
			F18	Business development department employees enters the signed "real estate investments share sales" contracts. Signed contracts can be reached from related departments	X																																						
PROJECT MANAGEMENT	02 01	PLANNING & TIME MANAGEMENT																																									
			F19	this module has functionality on preparing working schedules and revising imported schedules on system		X																																					
			F20	this module has functionality on importing primavera p6 level 4 schedules		X																																					
			F21	this module has functionality on exporting primavera p6 level 4 schedules		X																																					

Table F.1. Functions vs. Data Table (cont.)

MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	DATA 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
				D 01 - Data on the deeds of real estates, zone notes, planning notes, land notes and project development documents																																							
				D 02 - Data on work schedules, activities, resources and connection information																																							
				D 03 - Data on man x hours and BOQ values belong to work schedules																																							
				D 04 - Data on Unit Price, Unit Price Analysis, BOQ list with respect to Budget Codes																																							
				D 05 - Data on all sub-contractors and suppliers																																							
				D 06 - Data on all sub-contractor, contracts, unit prices and unit price analysis about past tenders																																							
				D 07 - Data on BOQ, Unit Price, Unit Price Analysis, Current Prices, Schedules, Cash flow and Realisation Tables about Tender Bids																																							
				D 08 - Data on all contractual information about sub-contractor contracts																																							
				D 09 - Data on all contractual information about Owner contracts																																							
				D 10 - Data on sub-contractor progress report information such as physical amount dates, contractual risks, warrantee and security deposits, deduction etc.																																							
				D 11 - Data on owner progress report information such as physical amount dates, contractual risks, warrantee and security deposits, deductions etc.																																							
				D 12 - Data on site photos and daily construction works done with their mounts, location, floor informations etc.																																							
				D 13 - Data on near-miss, accident, work permit, control, environmental issues and risks report information about healt, security and environment management																																							
				D 14 - Data on design documents and detailed sheet and zone lists about contractor, owner and feasibility design projects																																							
				D 15 - Data on exchange rate, invoice, receipt, cheque, promissory notes, barter and other financial management documents																																							
				D 16 - Data on customer lists, all receivable accounts, payable accounts, invoices and return invoices, sales journals, balance sheets and return payment information																																							
				D 17 - Data on supplier and sub-contractor lists, accounts payables, sales invoices, return invoices and receipts																																							
				D 18 - Data on accounts, banks, tax declarations, cost accounting, long term and short term financial reports and statements																																							
				D 19 - Data on credit cards, finance cards, credit bank information and transaction																																							
				D 20 - Data on cost codes/centres and budget informations																																							
				D 21 - Data on all owner and sub-contractor progress reports informations and information from accounts payables and accounts receivables																																							
				D 22 - Data on fixed assets, general accounting journals, insurance journals, fixed asset journals, amortisation accounts etc. information																																							
				D 23 - Data on warehouse informations, warehouse budget codes and other warehouse material informations																																							
				D 24 - Data on payment returns/collection informations on account payables, accounts receivables, cheques, promissory notes																																							
				D 25 - Data on company guarantees, subscription payments, rent increase payments, price indexation informations etc.																																							
				D 26 - Data on chart of accounts, e-invoice system, invoice and receipt informations																																							
				D 27 - Data on Procurement Request Forms, Order Evaluation Forms, approval durations, OFF budget codes, supplier lists, procurement employee informations including invoices																																							
				D 28 - Data on employee lists, employee official records, salary net and gross calculations, team informations, assignment score cards, passport and visa informations, personnel health and safety, accident information, training records, internal performance evaluations																																							
				D 29 - Data on company guarantees, regulatory aim preventive activities (QPA), non-conformity reports, open and closed NCR records, method statements, control forms, calibration documents, HSE public control forms, calibration documents, TSE EN standards, internal																																							
				D 30 - Data on all customer representatives daily, weekly and monthly schedules, meeting minutes and notes																																							
				D 31 - Data on customer informations, candidate customers tracking records, news letter records, sales/stock reports, sales dates, customer problems and complaints, customer satisfaction records																																							
				D 32 - Data on event, stores, raw materials, or each unit, customer payment records and cash flow of each customer, technical specifications of sale contracts, sales price lists, campaigns, planned vs. realised sale price and quantities, sales and marketing annual reports, customer satisfaction																																							
				D 33 - Data on marketing and advertisment information and date, media, project information of advertisements																																							
				D 34 - Data on received and sent all documents and their document number, date informations. Also, daily, weekly reports, site photos, executive reports, meeting minutes																																							
				D 35 - Data on delivery conditions of all orders, all PRF information, warehouse material conditions, sub-contractor material delivery conditions, purchase order records, product and material specifications, technical reports, warehouse journals, machinary/equipment fuel, oil consumption, maintenance records and costs, and performance records																																							
				D 36 - Data on risk registrations, risk matrix, assessment of risk categories, risk tracking, risk reports, monte carlo simulation records, risk meeting minutes and other risk know-how documents																																							
				D 37 - Data on design, time and cost management information of BIM platform softwares and BIM documents, sheet list and BIM model delay reports																																							
				D 38 - Data on IT inventories and their properties. Also, data on debit / entries, IT team help records and statistics.																																							
				D 39 - Data on general address book, to-do list information, all meeting minutes with action lists																																							
				D 40 - Data on claims, trials and their documents																																							
			F650	This module has functionality on creating, monitoring, filtering, alerting and managing trust deeds, their expiration dates																																							X
			F651	This module has functionality on creating, monitoring, filtering and managing trust deeds with respect to subject, proxy giver, proxy holder, date and alerting about expiration dates.																																							X
																																											X
		INTERNAL CONTRACT APPROVAL & PROCESS MANAGEMENT	F652	This module has functionality on monitoring, filtering, approving and managing contracts of projects by approval of law departments																																							X
			F653	This module has functionality on calculating and reporting approval durations and periods by law department attorneys and other department employees																																							X

APPENDIX G: FUNCTIONS VS. CONTROL TABLE

The following table denotes the correlations between control processes and the functions used by these control processes.

Table G.1. Functions vs. Control Table.

MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	CONTROL 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
				1 - Controlling of feasibility report URR, NPV, Rental/Cost/Sale/Ratio limits.		2 - Controlling of schedule/dates , activity by baseline and actual date																																							
BUSINESS DEVELOPMENT	01																																											
	01	01 BUSINESS DEVELOPMENT	F01	This module has list of deed of real estates. All lands and units should be managed from the list.	X																																							
			F02	This module should has feasibility reports as both excel and scanned pdf documents. System has feasibility calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.	X																																						
			F03	This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.	X																																						
			F04	This module has different invesment scenarios for different invesment options as excel on board system investment calculations.	X																																						
			F05	This module has document management functions on business development documents.	X																																						
			F06	Feasibility reports can be managed according to their city, municipality, year, intermediary etc.	X																																						
			F07	This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.	X																																						
			F08	This module has business development excel work calculation ability by using past project completion m2 costs.	X																																						
			F09	This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilities more accurately.	X																																						
			F10	This module has Investment Brochures schemes and already maden investment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.	X																																						
			F11	This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module	X																																						
			F12	This module has Commission Calculation functions that manage how much commission should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the succes business development	X																																						
			F13	This module also calculates and shows credit payments for that business development. Also shows credit payment flows and give details at business development calculations.	X																																						
			F14	This module saves the information about how many engineer/architect/city planner man x hours spent for that project	X																																						
					X																																							
BUSINESS DEVELOPMENT					X																																							
	01	02 INVESTMENT CONTRACTS	F15	Business development department employees enters the signed "flat for land" method contracts. Signed contracts can be reached from related departments	X																																						
			F16	Business development department employees enters the signed "revenue sharing" method contracts. Signed contracts can be reached from related departments	X																																						
			F17	Business development department employees enters the signed "real estate sales" contracts. Signed contracts can be reached from related departments	X																																						
			F18	Business development department employees enters the signed "real estate investments share sales" contracts. Signed contracts can be reached from related departments	X																																						
PROJECT MANAGEMENT	02	01 PLANNING & TIME MANAGEMENT																																										
			F19	this module has functionality on preparing working schedules and revising imported schedules on system		X				X																																		
			F20	this module has functionality on importing primavera p6 level 4 schedules		X				X																																		
			F21	this module has functionality on exporting primavera p6 level 4 schedules		X				X																																		
			F22	this module has functionality on importing ms project level 4 schedules		X				X																																		
			F23	this module has functionality on exporting ms project level 4 schedules		X				X																																		
			F24	this module has functionality on importing primavera p6 level 2 schedules		X				X																																		
			F25	this module has functionality on exporting primavera p6 level 2 schedules		X				X																																		
			F26	this module has functionality on importing ms project level 2 schedules		X				X																																		
			F27	this module has functionality on exporting ms project level 2 schedules		X				X																																		
			F28	this module has functionality on importing ms excel level 2 schedules		X				X																																		
			F29	this module has functionality on exporting ms excel level 2 schedules		X				X																																		
			F30	this module has functionality on managing activity codes (adding, deleting, defining and changing etc.)		X				X																																		
			F31	this module has functionality on managing cost codes (adding, deleting, defining and changing etc.)		X				X																																		
			F32	this module has functionality on creating wbs structure and importing/exporting from ms excel		X				X																																		
			F33	this module has functionality on showing activities by their locations as location/activity matrix		X				X																																		
			F34	this module has functionality on filtering activities by their unstarted, continued and finished conditions		X				X																																		
			F35	this module has functionality on tracing BOQ physical progress		X				X																																		
			F36	this module has functionality on tracing manhour situation and productivity of activities and team by entering BOQ amounts completed and manhours consumed		X				X																																		

1 - Controlling of feasibility report URR, NPV, Rental/Cost/Sale/Ratio limits.
2 - Controlling of schedule/dates , activity by baseline and actual date
3 - Controlling of baseline and actual man x hours planned and spent, physical progress, cost and schedule comparisons
4 - Controlling of budgeted BOQ amounts with prior approved cx resulted comparisons, earned budget revision comparisons
5 - Controlling of planned and realized cash flow and resultation tables and charts based on cash flow and cost control
6 - Controlling of EVA analysis by using schedule, physical progress and budget data
7 - Controlling and cross check of past and current tenders' bids based on their BOQ values, unit prices, unit price analysis, current prices, schedule, cash flows and realization tables
8 - Controlling and cross check of past sub-contractor and current sub-contractor contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractors' deductions and warrantees
9 - Controlling and cross check of past owner and current owner contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractors' deductions and warrantees
10 - Controlling of past and current tender bids based on their BOQ values, unit prices, unit price analysis, current prices, schedule, cash flows and realization tables and charts
11 - Controlling of sub contractor progress reports with respect to their BOQ amounts, completed physical amount vs, budgeted amounts sanity check, contractual clauses sanity check, progress report, deductions, warrantees and other contractual clauses sanity checks.
12 - Controlling of owner progress reports with respective their BOQ amounts completed phy mod amount vs, budgeted amounts sanity check, contractual clauses sanity checks, warrantees and other contractual clauses sanity checks.
13 - Controlling of site construction daily physical progress records with BOQ amounts
14 - Controlling of project HSE (green job, emergency procedures) HSE violations books and alerting HSE executives about project risk, accidents.
15 - Controlling of planned and realized design management schedules for each project, and alerting executive about design delays by comparing design deliverables dates in comparison with design schedules.
16 - Controlling of user defined financial ratios/kpis and standard financial ratios/kpis using financial data including exchange rates, receipts, invoices, cheques, promissory notes, accounts pay ables and recevables, banks' statements of emaulte payments
17 - Control and comparisons of cashs receipts, collection budget , sales journals and account receivables, and alerting the executives to send payment letters to customers and requesting approval for credit/refund/cheques issues/alerts
18 - Controlling of net present values of net cash flows based on all kind of income and expenses, or this thereafter can alert executives to both negative and positive cash flows
19 - Controlling of user defined financial ratios/kpis and standard financial data/systems of periodic activities by using periodic activities financial data including long term and short term payments accounts payable and receivables data.
20 - Controlling of credit card finance card limits and if spending is getting down to user defined specific value, the module can alert finance department
21 - Controlling of budget cost codes and budgets according to matching defined expenses by invoices and controlling cost accounting reports with budgeted cost codes and budgets
22 - Controlling of cash flow data by using progress reports, account receivables and payable, and other financial records compare to cash flow prepared by validated advisement project site.
23 - Controlling of amortization calculations and prices by using fixed assets, executives limit amortization cost/hr and warehouse amortization cost, direct set using materials by comparing leasing rent cost of inventories.
24 - Controlling of amortization cost distributions and stock valuations by use avaliance inventory and time data and price information
25 - Controlling of cash and petty cash and promissory note risk
26 - Controlling of real estate rent and exercise calculations with respect to rent contract clauses, consumer price indexes and comparing with rent invoices.
27 - Controlling of contracts from beginning of cx to contract to payment services with approval of executives and requesting managers to executives
28 - Controlling of employees and Procurement Request Forms and Offer Evaluation Forms to compare with past OEF until prices based on same budget index and alerting if any requested items at OEF is to much higher than past OE items
29 - Controlling of keep man x hours records of the company with PDKS (social security data keeping) system for each contractor and company employee and controlling of each contractor and company employee's overtime and alerting if internal revisions to make sure employees have rational enough about HSE and other procedures.
30 - Controlling of project quality control works by using all quality control documents (WCR, IMR, QR etc.) and reports compared to planned quality control works and alerting if a quality problem is encountered during QC inspections.
31 - Controlling of sale representatives' performances by checking feedbacks from customers, sales volumes and sales representatives' salaries and bonuses along with sales volumes of sales representatives. Also, the module can control user defined algorithms and alert the executives.
32 - Controlling of "after sale customer requests filing directions" and the customer requests are resulted and reported to the executives. Also, the module can control user defined algorithms and alert the executives.
33 - Controlling of planned at the beginning of the project vs. realized sale volumes and alerting executives and sales representatives if delayed and promissory note maturities
34 - Controlling of marketing expenses with respect to budgeted marketing expenses and low result survey lists were sent to which the customer vs. sales profits.
35 - Controlling and reporting of daily, weekly and monthly reports of the projects by checking the daily reports that are uploaded to the project site manager's mobile phones.
36 - Controlling of performances of especially machinery and equipments based on their total working hours, set of downtime, and site financial penalties so as to alert executives to send them to maintenance, maintenance stats compared to leasing costs.
37 - Controlling of project risk scores by using all risk management documents and risk tracking scores and alerting risk management executive.
38 - Controlling of planned and realized HSE design management schedules for each project, and alerting executive about HSE design delays by comparing planned design model delivery and statutory dates compared to design schedules and alerting executive about HSE design management and corrective performances based on the number of clashes and their dates.
39 - Controlling of IT team performances and reporting to the executives based on help request resolving and fixing directions, the number of opened requests and resolved requests.
40 - Controlling of employee performances based on action list completion durations answering minutes and todo lists.
41 - Controlling of trial and claim exercidates along with important site dates and alerting them to the assigned department employees.

Table G.1. Functions vs. Control Table (cont.).

MAIN MODULE	MAIN MODULE NO / MODULE NO	MODULE	FUNCTION NO	FUNCTION	CONTROL 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
				1 - Controlling of feasibility report IRR, NPV, Benefit/Cost Ratio limits																																								
				2 - Controlling of schedule delays, actuals by baseline and actual date																																								
				3 - Controlling of baseline and actual man hours planned and spent, physical work done and delays																																							
				4 - Controlling of budgeted BOQ amounts, unit price approved vs resolved comparisons, and budget revision comparisons																																							
				5 - Controlling of planned and realized cash flow and resolution tables and charts and alerting executive about HSE design delays																																							
				6 - Controlling of EVA analysis by using schedule, physical progress and budget data																																							
				7 - Controlling and cross check of past and current tender bids based on their BOQ values, unit prices, unit price analysis, current prices, schedule, cash flows and resolution tables and sub-contractor																																							
				8 - Controlling of past and current tender bids based on their BOQ values, unit prices, unit price analysis, current prices, schedule, cash flows and resolution tables and sub-contractor																																							
				9 - Controlling and cross check of past sub-contractor and current sub-contractor contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractors, deductions and warranties																																							
				10 - Controlling and cross check of past owner and current owner contracts based on their contractual clauses and unit price comparisons with respect to unit price analysis, sub-contractors, deductions and warranties																																							
				11 - Controlling of sub-contractor progress reports with respect to their BOQ amounts, completed physical amount vs, budgeted amounts sanity check, contractual clauses sanity check, progress report, deductions, warrantees and other contractual clauses sanity checks.																																							
				12 - Controlling of owner progress reports with respective their BOQ amounts completed phy sical amount vs, budgeted amounts sanity check, contractual clauses progress report, deductions, warrantees and other contractual clauses sanity checks.																																							
				13 - Controlling of site construction daily physical progress records with BOQ amounts																																							
				14 - Controlling of project HSE issues with emergency procedures HSE violation limits and alerting HSE executives about project risk conditions.																																							
				15 - Controlling of planned and realized design management schedules for each project, and alerting executive about design delays by comparing design deliverables schedule comparisons with design schedules.																																							
				16 - Controlling of user defined financial algorithms and standard financial algorithms for each project, and alerting executive about budget violations by using financial data including, exchange rates, receipts, invoices, cheques, promissory notes, accounts payables and receivables, banks' statements etc.																																							
				17 - Control and comparison of cash, receipts, collection ledger, sales journals and account receivables, and alerting the executives to send payment letters to customers, and requesting approval to send reminder letters about payments																																							
				18 - Controlling of net present values of net cash flows based on all kind of income and expenses, or this thresholds can alert the executive both negative and positive cash flows.																																							
				19 - Controlling of user defined financial algorithms and standard financial algorithms of periodic activities by using periodic activities financial data including, long term and short term payments, accounts payable and receivables data.																																							
				20 - Controlling of credit and finance card limits and if spending is getting do to user defined specific value, the module can alert finance department																																							
				21 - Controlling of budget cost codes and budgets according to matching realized expenses by invoices and controlling cost accounting reports with budgeted cost codes and budgets.																																							
				22 - Controlling of cash flow, data by using progress reports, account receivables, and payables, and other financial records compare to cash flow prepared by validated advisement project adv.																																							
				23 - Controlling of amortization calculations and prices by using fixed assets, accounts receivables, and payables, and other financial records, and executives limit amortization residual and warehouse amortization cost, direct or not using materials by comparing leasing rent cost of inventories.																																							
				24 - Controlling of amortization cost distributions and stock valuations by using warehouse inventory and time data and price information																																							
				25 - Controlling of cash and promissory note risk calculations by using probability																																							
				26 - Controlling of real estate rent and exercise calculations with respect to rent contract clauses, consumer price indexes and comparing with rent invoices.																																							
				27 - Controlling of executive from beginning of recruitment to payment of executives with approval of executive and requesting payment to executives																																							
				28 - Controlling of employee all Procurement Request Forms and Offer Evaluation Forms to compare with past OEF until prices based on same budget codes and alerting if any requested items at OEF is to much higher than past OE items.																																							
				29 - Controlling of inspection e forms, records of the company with PDMS social security data keeping) system for each contractor and company employee and comparing with past records and alerting executive about HSE and internal training to make sure employees have retained enough about HSE and other procedures.																																							
				30 - Controlling of project quality control records by using all quality control documents (WCR, NCR, QF etc.) and reports compared to equipment quality assurance data and alerting executive if problems and missing QC documents.																																							
				31 - Controlling of cash representatives' performances by checking feedbacks from customers about cash representatives, and comparing with sales volumes along with sales volumes of sales representatives. Also, the module can control user defined algorithms and alert the executives.																																							
				32 - Controlling of "after sale customer requests fixing durations" and the number of requests and comparing with past records and alerting executive if not resolved and reported to the executives. Also, the module can control user defined algorithms and alert the executives.																																							
				33 - Controlling of planned at the beginning of the project vs. realized sub-contractor and supplier selection and alerting executive about delayed and promissory note maturities																																							
				34 - Controlling of marketing expenses with respect to budgeted marketing expenses and low result survey, hit rates sent to which the customer to whole profits.																																							
				35 - Controlling and reporting of daily, weekly and monthly reports of the projects by checking the dimensions, missing properties, and if not replicated in the project and alerting executive about missing properties.																																							
				36 - Controlling of performances of especially machinery and equipments based on their total working hours, set of downtime, and also financial parameters, such as, depreciation, and alerting executive about HSE and consumptions, maintenance rates compared to leasing costs.																																							
				37 - Controlling of project risk scores by using all risk management documents and risk tracking scores and alerting risk management executive.																																							
				38 - Controlling of planned and realized HSE design management schedules for each project, and alerting executive about HSE design delays by comparing planned design model delivery and statutory dates compared to design schedules and HSE violations and HSE violation limits and corrective performance based on the number of clashes and their dates.																																							
				39 - Controlling of IT team performances and reporting to the executives based on help request resolving and fixing durations, the number of opened requests and resolved requests.																																							
			F638	This module has functionality on monitoring and creating new meeting minutes on the module itself or importing new meeting minutes by using ms excel template.																																						X	
			F639	This module has functionality on managing open action lists from meeting minutes and filtering action lists according to condition, attendee, task discipline																																						X	
			F640	This module has functionality on managing closed action lists from meeting minutes and filtering action lists according to condition, responsible, task discipline																																						X	
			F641	This module has functionality on managing action lists from meeting minutes and filtering action lists according to average open time, responsible and discipline																																						X	
			F642	This module has functionality on managing employee request module so that if an employee need anything to request, he or she can use the module make any request and can track the approval of requests.																																						X	
CLAIM & LAW MANAGEMENT	16																																										
		CLAIM MANAGEMENT	F643	This module has functionality on creating, monitoring, filtering and managing claim files and documents including registering notice of claims and sent emails, mails, faxes and other records.																																							X
			F644	This module has functionality on creating, monitoring, filtering and managing claim lists with respect to their condition; open/closed/cancelled etc.																																							X
			F645	This module has functionality on monitoring, archiving and managing all claim document management including schedules, approved tender, contracts, addendums, registering notice of claims and sent emails, mails, faxes, invoices, receipts, any signed documets, meeting minutes etc.																																							X
			F646	This module has functionality on monitoring, archiving and managing all "all risk" and other insurance documents, tracking of insurance contracts and policies																																							X
			F647	This module has functionality on creating claim pivot tables with respect to claim date, claim price, claim type (EOT, financial claim etc.), parties, etc.																																							X
																																										X
		LITIGATION / TRIAL MANAGEMENT	F648	This module has functionality on creating, monitoring, filtering and managing trial files with respect to their project, subject, date, defendant, complainant, type																																							X
			F649	This module has functionality on creating, monitoring, filtering and managing all trial file documents with respect to their project, subject, date, defendant, complainant, type, received or sent document condition, receiver, sender etc. and alerting law department about trial dates and important dates about trials.																																							X
			F650	This module has functionality on creating, monitoring, filtering, alerting and managing trust deeds. their exsistation dates																																							X
			F651	This module has functionality on creating, monitoring, filtering and managing trust deeds with respect to subject, proxy giver, proxy holder, date and alerting about expiration dates.																																							X
																																										X
		INTERNAL CONTRACT APPROVAL & PROCESS MANAGEMENT	F652	This module has functionality on monitoring, filtering, approving and managing contracts of projects by approval of law departments																																							X
			F653	This module has functionality on calculating and reporting approval durations and periods by law department attorneys and other department employees																																							X

APPENDIX H: MODULE AVAILABILITY TABLE

The following table denotes the module availability of ERP systems in detail.

Table H.1. Module Availability Table

							CASE STUDY					
							A	B	C	D	E	F
MAIN MODULES	**MBS 01**	**MBS 02**	**MODULES**	**MBS 03**	**SUB MODULES**	**MODULE NO**						
FINANCE MANAGEMENT	04	00		00		04.00.00						
	04	01	EXCHANGE RATES MANAGEMENT	00		04.01.00	2	2	2	2	2	2
	04	02	E-INVOICE MANAGEMENT	00		04.02.00	2	2	2	2	2	2
	04	03	FINANCE MANAGEMENT	00		04.03.00	2	2	2	2	2	2
	04	04	BILL OF EXCHANGE (COMMERCIAL BILLS)	00		04.04.00	2	2	2	2	2	2
	04	05	RENT MANAGEMENT	00		04.05.00	2	2	2	2	2	2
	04	06	FINANCIAL REPORTS	00		04.06.00	2	2	2	2	2	2
ACCOUNTING MANAGEMENT	05	00		00		05.00.00						
	05	01	ACCOUNTING MANAGEMENT	00		05.01.00	2	2	2	2	2	2
	05	02	E-BALANCING MANAGEMENT	00		05.02.00	2	2	2	2	1	2
	05	03	E-ARCHIVE MANAGEMENT	00		05.03.00	2	2	2	2	1	2
	05	04	JOINT VENTURE MANAGEMENT	00		05.04.00	2	2	2	2	1	2
PROCUREMENT MANAGEMENT	06	00		00		06.00.00						
	06	01	PROCUREMENT MANAGEMENT	00		06.01.00	2	2	2	2	2	2
	06	02	PURCHASING / PROCUREMENT	00		06.02.00	2	2	2	2	2	2
HUMAN RESOURCES MANAGEMENT	07	00		00		07.00.00						
	07	01	EMPLOYEE LISTS & EMPLOYEE MANAGEMENT	00		07.01.00	2	2	2	2	2	2
	07	02	ABSENCE/LEAVE MANAGEMENT	00		07.02.00	2	2	2	2	2	2
	07	03	TIME KEEPING MANAGEMENT	00		07.03.00	1	1	1	1	1	1
	07	04	HR REPORTS	00		07.04.00	2	2	2	2	2	2
	07	05	INTERNAL PERFORMANCE REPORTS	00		07.05.00	1	1	1	1	2	2
	07	06	EVALUATION REPORTS	00		07.06.00	1	1	1	1	2	2
	07	07	INTERNAL ERP TRAINING MODULE (VIDEOS)	00		07.07.00	0	0	0	0	1	1
	07	08	INTERNAL TRAINING MODULE (VIDEOS)	00		07.08.00	0	0	0	0	1	1
QUALITY CONTROL MANAGEMENT	08	00		00		08.00.00						
	08	01	QUALITY CONTROL DOCUMENTS MANAGEMENT MODULE	00		08.01.00	2	2	2	2	2	2
	08	02	PROJECT QUALITY MANAGEMENT	00		08.02.00	2	2	2	2	2	2
SALES & MARKETING & CRM MANAGEMENTS	09	00		00		09.00.00						
	09	01	TASK MANAGEMENT	00		09.01.00	2	2	0	0	2	2
	09	02	CRM MODULE	00		09.02.00	2	2	2	2	0	1

APPENDIX I: CROSS TABLES (SURVEY CRITERIA VS. MODULES)

The following table denotes the cross tables between survey criteria and modules in detail.

Table I.1. Cross Tables (Age Groups vs. Business Development Module)

age_groups * business_development_module Crosstabulation

			business_development_module		
			4	5	Total
age_groups	30 or less	Count	3	9	12
		% within age_groups	25,0%	75,0%	100,0%
		% within business_development_module	10,0%	12,0%	11,4%
		% of Total	2,9%	8,6%	11,4%
	31 - 40	Count	18	45	63
		% within age_groups	28,6%	71,4%	100,0%
		% within business_development_module	60,0%	60,0%	60,0%
		% of Total	17,1%	42,9%	60,0%
	41 - 50	Count	7	21	28
		% within age_groups	25,0%	75,0%	100,0%
		% within business_development_module	23,3%	28,0%	26,7%
		% of Total	6,7%	20,0%	26,7%
	51 or more	Count	2	0	2
		% within age_groups	100,0%	0,0%	100,0%
		% within business_development_module	6,7%	0,0%	1,9%
		% of Total	1,9%	0,0%	1,9%
Total		Count	30	75	105
		% within age_groups	28,6%	71,4%	100,0%
		% within business_development_module	100,0%	100,0%	100,0%
		% of Total	28,6%	71,4%	100,0%

Table I.2. Cross Tables (ERP Implementation Phase vs. General Management Module)

erp_implmnt_phase * general_mngmt Crosstabulation

			general_mngmt		
			4	5	Total
erp_implmnt_phase	At the primary stage of ERP system implementation	Count	3	0	3
		% within erp_implmnt_phase	100,0%	0,0%	100,0%
		% within general_mngmt	16,7%	0,0%	5,6%
		% of Total	5,6%	0,0%	5,6%
	ERP system has being used about 3 years	Count	0	6	6
		% within erp_implmnt_phase	0,0%	100,0%	100,0%
		% within general_mngmt	0,0%	16,7%	11,1%
		% of Total	0,0%	11,1%	11,1%
	ERP system has being used more than 5 years	Count	15	30	45
		% within erp_implmnt_phase	33,3%	66,7%	100,0%
		% within general_mngmt	83,3%	83,3%	83,3%
		% of Total	27,8%	55,6%	83,3%
Total		Count	18	36	54
		% within erp_implmnt_phase	33,3%	66,7%	100,0%
		% within general_mngmt	100,0%	100,0%	100,0%
		% of Total	33,3%	66,7%	100,0%

APPENDIX J: QUESTIONNAIRE SURVEY

The following figure denotes questionnaire survey template mentioned in the part of 4.5 Analysis of Questionnaire Survey.

User Satisfaction Survey of C-ERP Modules

ERP; "Enterprise Resource Planning" systems are integrated IT systems that comprise all departments of companies and their functions in themselves.

C-ERP (Construction Enterprise Resource Planning) systems are project-based ERP systems prepared for construction companies.

In the following questions, you are asked to evaluate the functions (general operations that C-ERP system can perform for its users) belong to the C-ERP system.

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

* Required

1. **Your Age?** *

2. **What is the main business area of your company?** *
   Mark only one oval.
   - ◯ Project & Construction Management
   - ◯ Contractor (Construction)
   - ◯ Consulting Firms
   - ◯ Project Design (Architectural / Structural / MEP) Firms
   - ◯ Other: _____

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

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

5. **Please select yearly turnover of your company.**
   Mark only one oval.
   - ◯ 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

Figure J.1. Questionnaire Survey Template

6. **What is the number of total employees in your company?** *

Mark only one oval.

- ◯ 0 - 20
- ◯ 21 - 50
- ◯ 51 - 100
- ◯ 101 - 200
- ◯ 201 - 500
- ◯ 501 or more

7. **What is your position in your company?** *

Mark only one oval.

- ◯ 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 / HR / Procurement / Business Dev. / Marketing / Finance etc.)
- ◯ Chief Level (Construction Site / Planning / Mechanical / Electrical / Design / Business Dev. / HR / Procurement / Finance etc.)
- ◯ Engineer & Architect etc.
- ◯ Technician etc.
- ◯ Other: _____

Figure J.2. Questionnaire Survey Template (cont.)

8. **What is your department?** *

Mark only one oval.

- ◯ Accounting Department
- ◯ Finance Department
- ◯ Technical Office (Planning / Cost Control / Tender / Progress Payment) Department
- ◯ Administrative Affairs Department
- ◯ Design (Architectural / Structural / Mechanical / Electrical) Department
- ◯ Construction (Site)
- ◯ Sales Department
- ◯ Human Resources & Public Relations Departments
- ◯ Business Development Department
- ◯ Marketing Department
- ◯ Purchasing / Procurement Department
- ◯ HSE (Health & Security & Environment) Department
- ◯ Quality Control Department
- ◯ Logistic Department
- ◯ Warehouse Department
- ◯ BIM Department
- ◯ Risk Management Department
- ◯ Law & Claim Management Department
- ◯ ERP Department
- ◯ IT Department
- ◯ Other: _____

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

Mark only one oval.

- ◯ Yes *Skip to question 10.*
- ◯ No *Skip to "User Satisfaction Survey of C-ERP Modules (Determining Module Proficiency)."*

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

Figure J.3. Questionnaire Survey Template (cont.)

10. **What is the name of ERP Software Implemented in your company or which system has your company been implementing?** *
Mark only one oval.

- ◯ SAP
- ◯ Oracle
- ◯ Microsoft Dynamics
- ◯ Yapitasi ERP
- ◯ IFS
- ◯ Sage
- ◯ NetSuite
- ◯ OpenERP / Odoo
- ◯ My Company has developed/is developing its own ERP system!
- ◯ Other: _____

11. **What is the level of implementation of ERP system in your company?** *
Mark only one oval.

- ◯ 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 about 2 years
- ◯ ERP system has being used about 3 years
- ◯ ERP system has being used about 4 years
- ◯ ERP system has being used about 5 years
- ◯ ERP system has being used more than 5 years
- ◯ Other: _____

User Satisfaction Survey of C-ERP Modules (Determining Module Proficiency)

On the following pages, you are asked to grade from 1 to 5 scoring for 15 main C-ERP Modules and 9 Project Management C-ERP Modules.

In your opinion, to what extent a C-ERP module, whose functions and abilities are defined at below, satisfies your needs and meets the requirements of your C-ERP necessities?

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

BUSINESS DEVELOPMENT MODULE

In your opinion, to what extent "C-ERP Business Development" module, whose functions and abilities are defined as below, satisfies your "Business Development" needs and meets the requirements of "Business Development" Department?

Please score 1 to 5...

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

BUSINESS DEVELOPMENT SUB-MODULE

1. This module has list of deed of real estates. All lands and units should be managed from the list.

Figure J.4. Questionnaire Survey Template (cont.)

2. This module should has feasibility reports as both excel and scanned pdf documents. System has feasibilty calculation itself and also export and import from excel feasibility reports. All sales and rent values should already be inside the system. All NPV and IRR values can be calculated on system by running feasibility calculations for different scenarios.

3. This module has feasibility reports as document management. Also system holds planning notes, zone notes, land notes and other project development documents in itself.

4. This module has different invesment scenarios for different invesment options as excel on board system investment calculations.

5. This module has document management functions on business development documents.

6. Feasibility reports can be managed according to their city, municipality, year, intermediary etc.

7. This module can manage meetings and negotiations with respect to their intermediary man, offer type, the person who offers land or work, etc.

8. This module has business development excel work calculation ability by using past project completion m2 costs.

9. This module has previously recorded costs for project type and standarts. Also, sale prices should be entered for each different project and location. Therefore, system can calculate feasibilties more accurately.

10. This module has Investment Brochures schemes and already maden invesment brochures for past projects in order to sent investors. This investment brochures can be saved as pdf and also excel worksheets. Investment brochures signed by executives should also saved in the system.

11. This module should has list of real estates and their real estate appraisal documents. Real estate value of the company can be seen from this module

12. This module has Commission Calculation functions that manage how much commision should be paid for each real estate agent. Each real estate history holds details on real estate agent information and in what detail he or she contributed to the project business development.

13. This module also calculates and shows credit payments for that business development. Also shows credit payment flows and give details at business development calculations.

14. This module saves the information about how many engineer/architect/city planner man x hours spent for that project

INVESTMENT CONTRACTS SUB MODULE

15. Business development department employees enters the signed "flat for land" method contracts. Signed contracts can be reached from related departments

16. Business development department employees enters the signed "revenue sharing" method contracts. Signed contracts can be reached from related departments

17. Business development department employees enters the signed "real estate sales" contracts. Signed contracts can be reached from related departments

18. Business development department employees enters the signed "real estate investments share sales" contracts. Signed contracts can be reached from related departments.

12. **BUSINESS DEVELOPMENT MODULE** *

Mark only one oval.

- ◯ 1 - Very Low *Skip to question 13.*
- ◯ 2 - Low *Skip to question 13.*
- ◯ 3 - Medium *Skip to question 13.*
- ◯ 4 - High *Skip to question 14.*
- ◯ 5 - Very High *Skip to question 14.*

Figure J.5. Questionnaire Survey Template (cont.)

BUSINESS DEVELOPMENT MODULE (Extra Requests / Expectations)

In order to satisfy Business Development module, what additional functions and abilities did you expected to be added?

13. *

PROJECT MANAGEMENT (PLANNING & TIME MANAGEMENT)

In your opinion, to what extent "C-ERP Planning and Time Management" module, whose functions and abilities are defined as below, satisfies your "Planning and Time Management" needs and meets the requirements of "Planning and Time Management" Department?

Please score 1 to 5...

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

PLANNING & TIME MANAGEMENT

1. this module has functionality on preparing working schedules and revising imported schedules on system

2. this module has functionality on importing primavera p6 level 4 schedules

3. this module has functionality on exporting primavera p6 level 4 schedules

4. this module has functionality on importing ms project level 4 schedules

5. this module has functionality on exporting ms project level 4 schedules

6. this module has functionality on importing primavera p6 level 2 schedules

7. this module has functionality on exporting primavera p6 level 2 schedules

8. this module has functionality on importing ms project level 2 schedules

9. this module has functionality on exporting ms project level 2 schedules

10. this module has functionality on importing ms excel level 2 schedules

11. this module has functionality on exporting ms excel level 2 schedules

12. this module has functionality on managing activity codes (adding, deleting, defining and changing etc.)

13. this module has functionality on managing cost codes (adding, deleting, defining and changing etc.)

14. this module has functionality on creating wbs structure and importing/exporting from ms excel

15. this module has functionality on showing activities by their locations as location/activity matrix

16. this module has functionality on filtering activities by their unstarted, continued and finished conditions

Figure J.6. Questionnaire Survey Template (cont.)

book.

TASK MANAGEMENT

2. This module has functionality on having task management sub-module that all company employees manage their tasks and their executives can reach them through system and can see on what work his or her employee working and can delegate some of the works to someone. This module can communicate with meeting minute records and can understand action lists at the meeting minutes, so that employees can import their action lists from meeting minutes to task magement module and update their task lists. (A labeling employee system works at meeting minutes)

3. This module has functionality on monitoring and managing future meeting arrangements from this module

4. This module has functionality on monitoring and creating new meeting minutes on the module itself or importing new meeting minutes by using ms excel template.

5. This module has functionality on managing open action lists from meeting minutes and filtering action lists according to condition, attendee, task disipline

6. This module has functionality on managing closed action lists from meeting minutes and filtering action lists according to condition, responsible, task disipline

7. This module has functionality on managing action lists from meeting minutes and filtering action lists according to average open time, responsible and disipline

8. This module has functionality on managing employee request module so that if an employee need anything to request, he or she can use the module make any request and can track the approval of requests.

58. **GENERAL (USER GENERAL SYSTEM MANAGEMENT)** *

Mark only one oval.

- ◯ 1 - Very Low *Skip to question 59.*
- ◯ 2 - Low *Skip to question 59.*
- ◯ 3 - Medium *Skip to question 59.*
- ◯ 4 - High *Stop filling out this form.*
- ◯ 5 - Very High *Stop filling out this form.*

USER GENERAL SYSTEM MANAGEMENT MODULE (Extra Requests / Expectations)

In order to satisfy "User General System Management Module" module, what additional functions and abilities did you expected to be added?

59. _____

Powered by Google Forms

Figure J.7. Questionnaire Survey Template (cont.)

APPENDIX K: GUI SAMPLE SCREENSHOTS

The following figures denote some of GUI sample screenshots mentioned in the thesis.

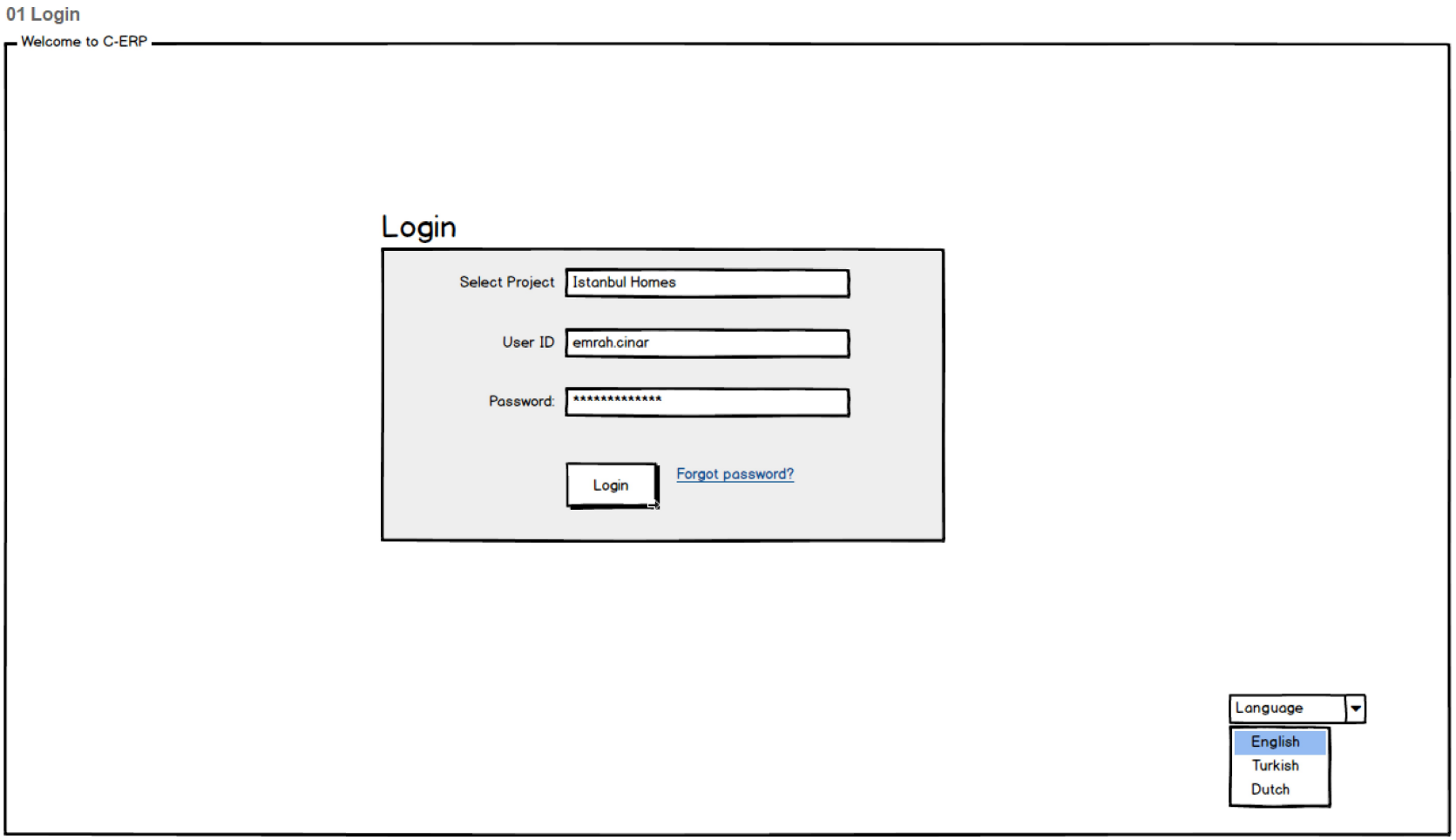

Figure K.1. GUI Login Page

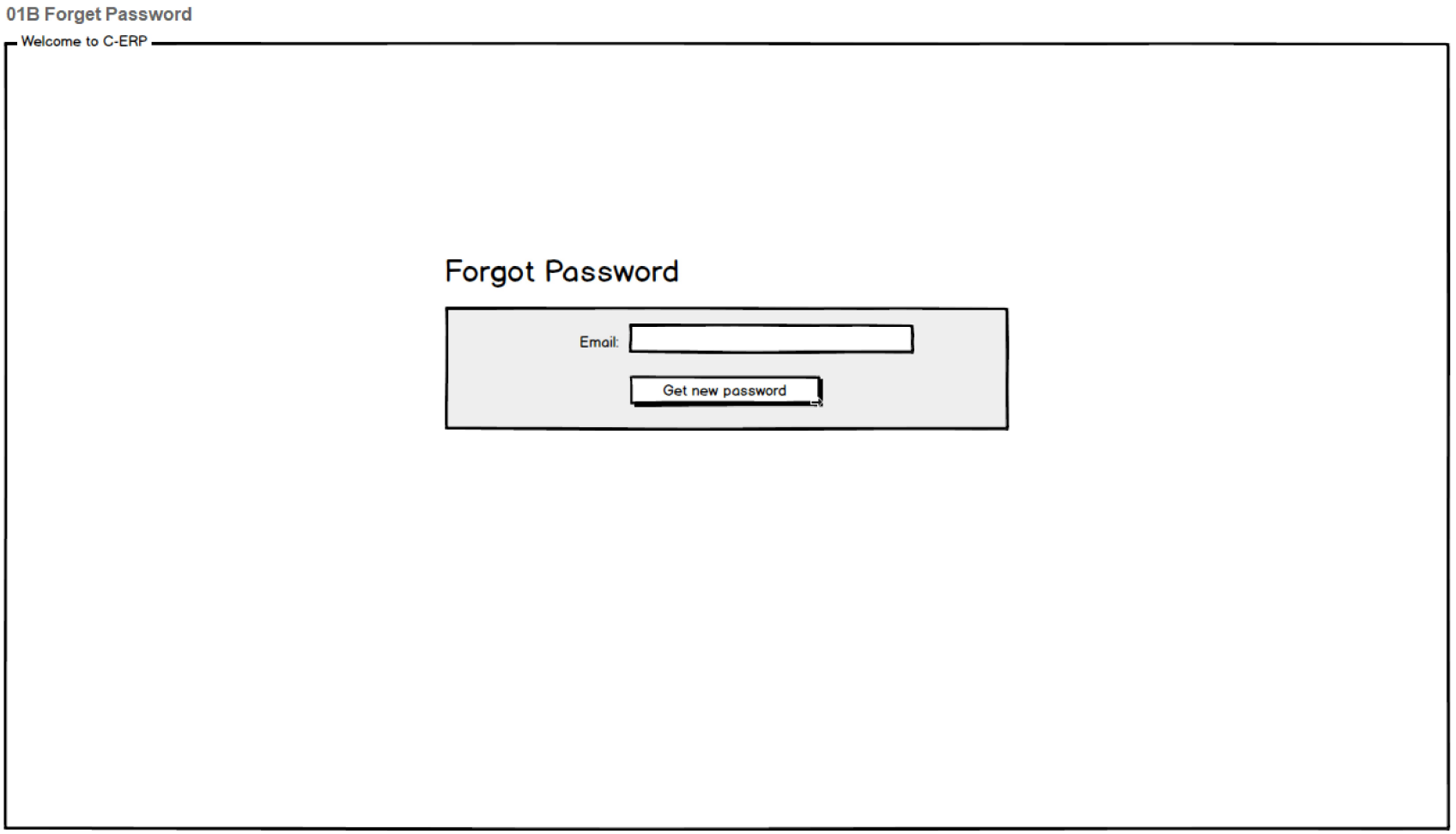

Figure K.2. Forgot Password Page

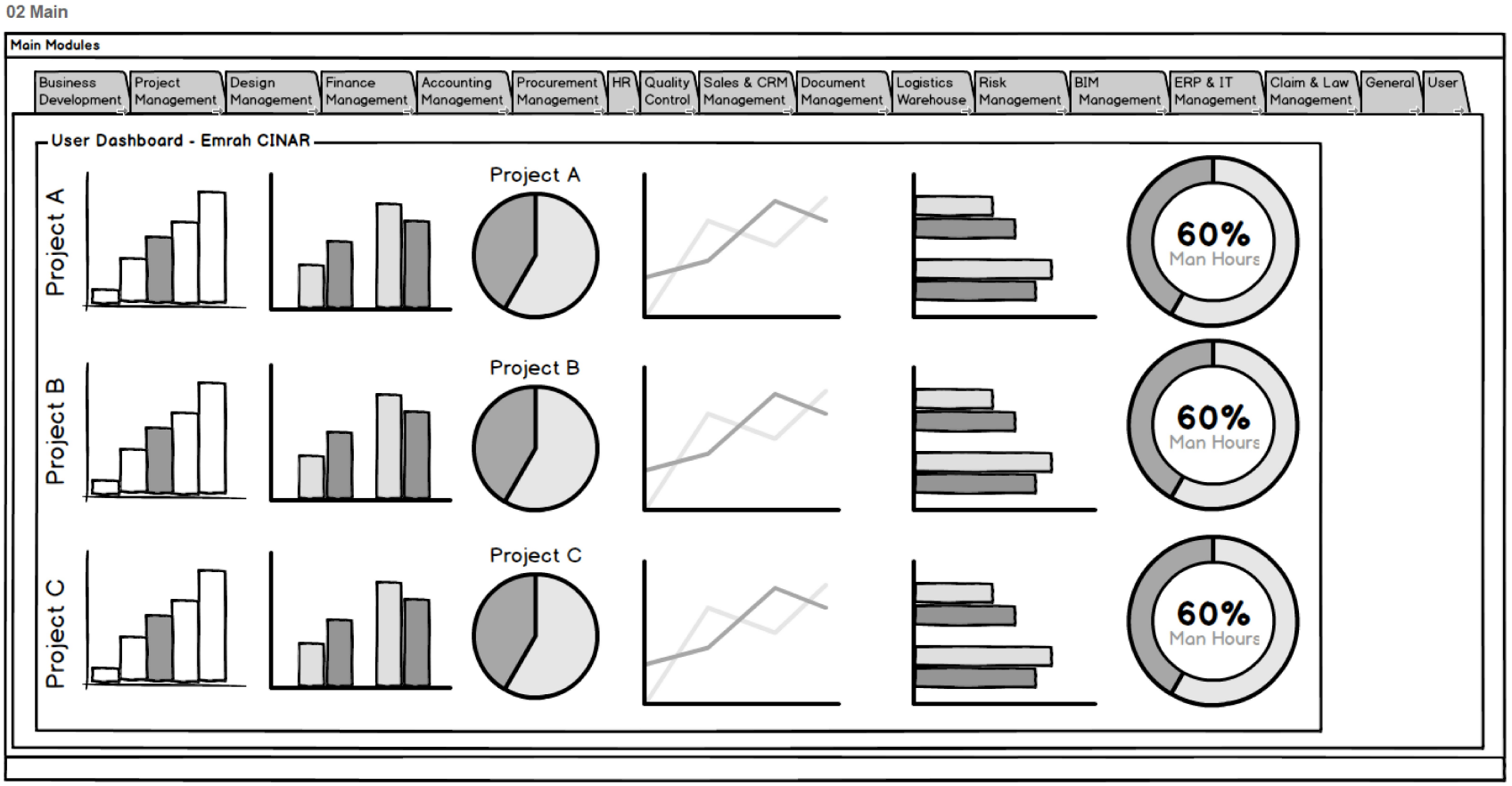

Figure K.3. User Dashboard Page

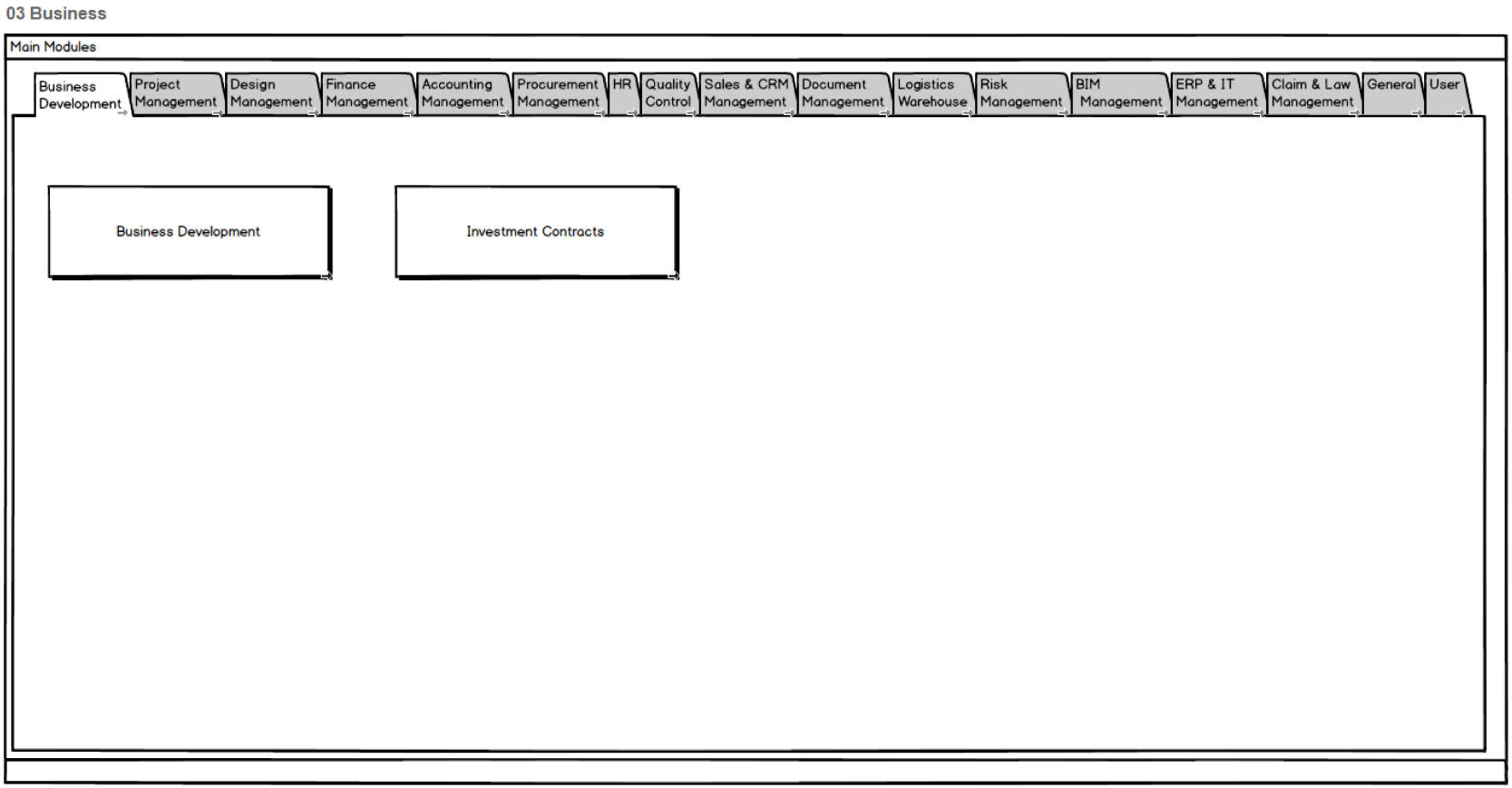

Figure K.4. Business Development Module

03A.1A P.Info

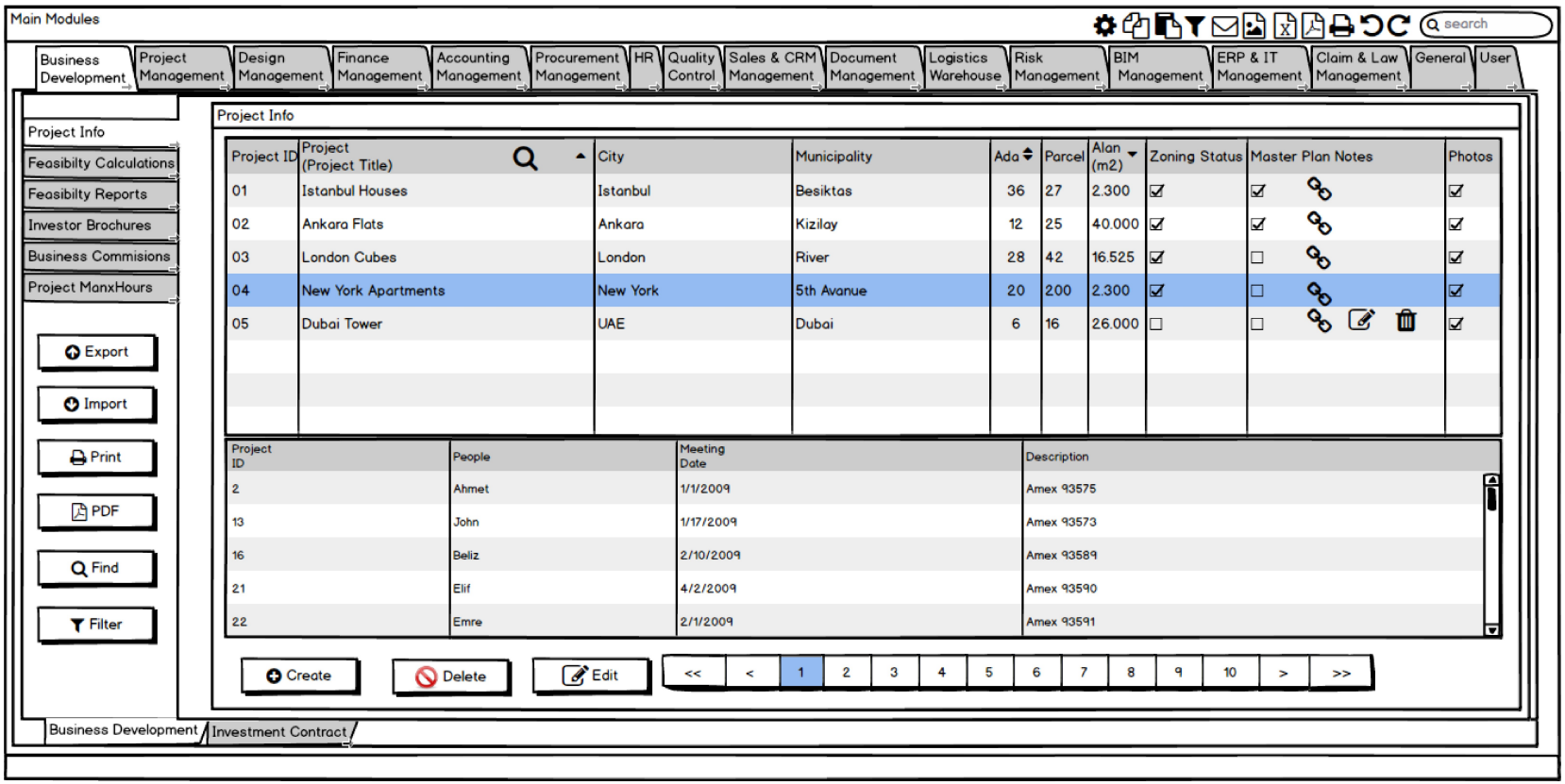

Figure K.5. Business Development Page

APPENDIX L: CROSS TABLES BETWEEN FACTORS

The following table denotes the cross tables between survey factors.

Table L.1. Cross Table Between Age Groups vs. Business Type

age_groups * business_type Crosstabulation							
			business_type				
			Project & Construction Management	Contractor (Construction)	Consulting Firms	Project Design (Architectural / Structural / MEP) Firms	Total
age_groups	30 or less	Count	0	12	0	0	12
		% within age_groups	0,0%	100,0%	0,0%	0,0%	100,0%
		% within business_type	0,0%	18,2%	0,0%	0,0%	11,4%
		% of Total	0,0%	11,4%	0,0%	0,0%	11,4%
	31 - 40	Count	6	36	12	9	63
		% within age_groups	9,5%	57,1%	19,0%	14,3%	100,0%
		% within business_type	100,0%	54,5%	57,1%	75,0%	60,0%
		% of Total	5,7%	34,3%	11,4%	8,6%	60,0%
	41 - 50	Count	0	18	7	3	28
		% within age_groups	0,0%	64,3%	25,0%	10,7%	100,0%
		% within business_type	0,0%	27,3%	33,3%	25,0%	26,7%
		% of Total	0,0%	17,1%	6,7%	2,9%	26,7%
	51 or more	Count	0	0	2	0	2
		% within age_groups	0,0%	0,0%	100,0%	0,0%	100,0%
		% within business_type	0,0%	0,0%	9,5%	0,0%	1,9%
		% of Total	0,0%	0,0%	1,9%	0,0%	1,9%
Total		Count	6	66	21	12	105
		% within age_groups	5,7%	62,9%	20,0%	11,4%	100,0%
		% within business_type	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	5,7%	62,9%	20,0%	11,4%	100,0%

Table L.2. Crosstable Between ERP Usage vs. Department Factors

erp_usage_yes_no * department Crosstabulation

			department								
			Finance Department	Technical Office / Planning / Cost Control & Tender / Progress Payment Departmant	Design Office / Architectural / Structural / Mechanical / Electrical Design Departmant	Construction (Site)	Business Development Department	Purchasing / Procurement Department	ERP Department	IT Department	Total
erp_usage_yes_no	No	Count	3	21	9	3	12	3	0	0	51
		% within erp_usage_yes_no	5,9%	41,2%	17,6%	5,9%	23,5%	5,9%	0,0%	0,0%	100,0%
		% within department	50,0%	46,7%	100,0%	25,0%	100,0%	100,0%	0,0%	0,0%	48,6%
		% of Total	2,9%	20,0%	8,6%	2,9%	11,4%	2,9%	0,0%	0,0%	48,6%
	Yes	Count	3	24	0	9	0	0	15	3	54
		% within erp_usage_yes_no	5,6%	44,4%	0,0%	16,7%	0,0%	0,0%	27,8%	5,6%	100,0%
		% within department	50,0%	53,3%	0,0%	75,0%	0,0%	0,0%	100,0%	100,0%	51,4%
		% of Total	2,9%	22,9%	0,0%	8,6%	0,0%	0,0%	14,3%	2,9%	51,4%
Total		Count	6	45	9	12	12	3	15	3	105
		% within erp_usage_yes_no	5,7%	42,9%	8,6%	11,4%	11,4%	2,9%	14,3%	2,9%	100,0%
		% within department	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	5,7%	42,9%	8,6%	11,4%	11,4%	2,9%	14,3%	2,9%	100,0%