THE CRITICAL SUCCESS FACTORS FOR MANUFACTURING EXECUTION SYSTEMS (MES) ADOPTION IN THE DEFENSE INDUSTRY OF TURKEY: AN INDUSTRIAL CASE STUDY

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Approval of the Graduate School of Social Sciences

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

THE CRITICAL SUCCESS FACTORS FOR MANUFACTURING EXECUTION SYSTEMS (MES) ADOPTION IN TURKEY DEFENSE INDUSTRY: AN INDUSTRIAL CASE STUDY

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The main objective of this thesis is to investigate the Critical Success Factors (CSFs) of Manufacturing Execution Systems (MES) adoption using the case of a Turkish defense industry firm with both a quantitative and a qualitative research design. After the critical factors that are used in the adoption and implementation assessment in different countries and sectors are determined in the literature, about one hundred questionnaires and five interviews are conducted at a defense industry firm. The thesis draws upon Information System (IS) success models and Enterprise Resource Planning (ERP) research models to develop and test a model of MES adoption to the extent of individual use effect and the individual work performance effect as dependent variables. The results of the analysis reveal that communication and business process reengineering are positively related to both dependent variables, while complexity of MES has a negative relationship with individual use effect. Top management/supervisor support and compatibility of software and hardware are positively associated with the adoption of MES. Moreover, qualitative analysis shows similar results, and thus increases the validity of the findings. The results indicate that more customization is needed and more attention should be paid during the MES implementation for better adoption.

Keywords: Manufacturing execution system, Critical success factors, Defense industry.

ÖZ

TÜRKİYE SAVUNMA SANAYİİSİNDE ÜRETİM YÖNETİM SİSTEMİNİN YAYILMASINDAKİ KRİTİK BAŞARI FAKTÖRLERİ: BİR ENDÜSTRİ VAKA ÇALIŞMASI

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Bu tezin temel amacı, bir Türk savunma şirketinde hem nicel hem nitel yaklaşımlar kullanarak vaka incelemesi yoluyla üretim yönetim sisteminin (ÜYS) yayılmasındaki kritik başarı faktörlerini araştırmaktır. Yayılma ve uygulama değerlendirmesinde kullanılan kritik faktörler farklı ülke, sektör ve akademik kaynaklardan yapılan araştırmalardan sonra tespit edilmiş ve bunun sonucunda yüz kişilik anket uygulaması ve beş farklı kişiyle de bire bir görüşme yapılmıştır. Tez, ÜYS'nin yayılmasındaki kritik başarı faktörlerini bazı bilgi sistemleri başarı modelleri ile kurumsal kaynak planlaması araştırma modellerindeki bağımsız değişkenleri baz alarak ve bireysel kullanım ile bireysel iş performansın açıklamaya çalışmaktadır. Analiz sonuçlarına göre iletişim ve iş süreçlerinin yeniden yapılanmasının bağımlı değişkenlerle pozitif yönde ilişkili iken, ÜYS'nin karmaşıklığının bireysel kullanımda negatif bir etkisinin olduğunu ortaya çıkmaktadır. Ayrıca, üst yönetim desteği ve yazılım ile donanım uyumluluğu, ÜYS'nin yayılmasındaki etkili faktörler arasındadır. Dahası, nitel analiz, niceliksel analiz ile benzer sonuçları göstermektedir ve bu durum bulguların geçerliliğini artırmaktadır. Son olarak, şirket ihtiyaçlarına göre özel uyarlamaya ihtiyaç duyulmaktadır ve bu yapıldığında ÜYS'nin yayılması hızlanacaktır.

Anahtar Kelimeler: Üretim yönetim sistemleri, Kritik başarı faktörleri, Savunma sanayi.

To My Wife and Mother

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First of all, I would like to thank my supervisor Assoc. Prof. Dr. İ. Semih Akçomak for his help, advice and encouragement.

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LIST OF ABBREVIATIONS

BPR	Business Process Reengineering
BS	Bilgi Sistemleri
CSFs	Critical Success Factors
ERP	Enterprise Resource Planning
HRCAERC	Human Research Committee of Applied Ethics Research Centre
IS	Information Systems
IT	Information Technologies
KKP	Kurumsal Kaynak Planlama
MES	Manufacturing Execution Systems
MRP	Material Requirement Planning
MRP II	Manufacturing Resource Planning
PLM	Product Lifecycle Management
ÜYS	Üretim Yönetim Sistemi

CHAPTER 1

INTRODUCTION

Economic globalization and internationalization of operations are essential factors in the integration of partners, suppliers and customers within and across national borders, and thus, the objective is to achieve integrated supply chains. The global nature of modern marketplace requires active players to internationalize their operations in terms of production, logistics and also research and development (R&D). In the past, companies competed based on one or two competitive performance objectives such as quality and price. However, present markets demand both price and quality in addition to greater flexibility and responsiveness, and hence, today's organizations must compete based on all competitive objectives. Therefore, today's world includes great challenges and needs more coordination and collaboration (Yusuf et al., 2004).

Information Systems (IS) such as Enterprise Resource Planning (ERP), Product Lifecycle Management (PLM), Manufacturing Execution Systems (MES) and many others are able to meet the needs of companies in terms of flexibility and responsiveness. These are software packages to manage company resources in an effective manner.

When we examine the ERP systems, which might be business software packages, we see that they impose standardized (predetermined) procedures on the input, and thus use and disseminate data across an organization, and integrate business processes. ERP systems have many modules such as financials, manufacturing, supply chain management, project management, customer relationship management, and MES *(known as a kind of ERP module or layer between shop floor level and management level*).

The ERP system leads to important improvement in efficiency, service quality and also reduction in service costs. It also enables a more effective decision-making process and decreases the time to market. It began in the 1960s as MRP (Material Requirement Planning), and later it evolved into MRP II (Manufacturing Resource Planning). Between the 1980s and 1990s, MRP and MRP II could not meet the globalization and organization requirements. Thus, ERP and MES solutions emerged after the 1990s, and companies gave importance to these kinds of solutions. Some companies such as SAP, Oracle, Baan, PeopleSoft, Siemens etc. have made huge investments in this area. Oracle and SAP companies are the leaders in ERP solutions.

ERP emphasizes resource planning from the perspective of an enterprise. ERP systems implement ERP concepts enterprise wide and cover all the business functions. ERP systems offer many benefits, which include better information sharing within the organization, improved planning and decision quality, smoother coordination between business units resulting in higher efficiency, and quicker response time to customer demands and inquiries. Furthermore, organizations may promote customer relationship management that would strengthen customer loyalty and satisfaction, and achieve larger market share (Chang et al., 2008).

As far as MES is concerned, it could transform information management by *creating a paperless shop floor tracking and managing the paperless-based shop floor environment.* It enables to obtain critical information and collecting data from the shop floor and transacting in real time like other enterprise systems (e.g. another ERP modules: finance, purchase etc.). It also allows shop floor personnel to record and monitor shop floor activities in a highly efficient and effective manner[1]. Having such information about production/materials when they occur allows planning departments to identify and prevent potential problems or bottlenecks.

ERP, MES or other software packages assist the company in terms of time-to-market entry, flexible and cheap design/production, resource utilization, and thus, the

[1] This means doing things rightly and doing right things, respectively.

company can compete with local and global competitors. Nowadays, Industry 4.0, which was coined by the German Government and Siemens in 2011[2], covers cyber-physical world (smart factory), PLM, ERP, MES, machine to machine (M2M), vertical-horizontal integration of systems, robotic-systems, internet of things (IoT), big analytics, cloud computing, virtual reality and so forth. However, some firms are not aware of these systems or some firms are not successful at the implementation of these information systems. The main purpose of Industry 4.0 or digitalization is the connection of each system which is related with industrial production/design, to obtain real time data from anywhere, and to increase value by using these data.

MES is a new management technology that advocates an integrated approach to conduct business. Organizations apply this technology to improve the overall company performance. Also, they must understand what the meaning and advantages of software program are for their employees since the use of ERP or MES might not be voluntary. Therefore, the understanding of system adoption from the user's perspective is useful in helping the organizations prepare their employees to face new challenges and to teach the company using these technologies. In the IS literature, authors emphasize that business units or departments of an organization should work together to achieve its overall IS strategies and objectives, which requires each unit of company not only to work efficiently and effectively but also to understand how IS activities and decisions about IS affect the functions of other units (e.g. Nah et al., 2001; Sarker and Lee, 2003 etc.).

The above mentioned importance of the IS system thus entails the measurement of the success and effectiveness of the information systems, which is critical in understanding the value and efficacy of IS management actions and IS investments (DeLone and McLean, 2003). ERP and MES systems have been qualified as the most important developments in the corporate use of Information Technology (IT) between the 1990s and 2000s (Davenport, 1998). However, the implementation or adoption of enterprise systems is not only costly and complex but also it is a painful process. While

[2] Available siemens.com.tr/dijitalfabrikalar accessed on 16.03.2018.

some companies have achieved significant efficiencies through ERP or MES, others have complained about failed implementations/adoption, budget overruns, and disappointing performance (e.g. Fryer, 1999; Campbell, 2000).

The main objective in this thesis is to focus on the critical success factors of MES adoption, which may be defined as essential aspects of MES adoption processes in order to utilize MES benefits. Thus, we investigate not only the organizational factors but also the technological factors and innovative characteristics of software package for better diffusion since early adopters of a package might better benefit from it both individually and organizationally.

For a comprehensive investigation, this thesis follows a case study approach. The selected case is one of the largest defense companies in Turkey which also uses IS systems such as ERP, PLM and MES. This study investigates how MES was adopted and how MES adoption contributed to employee's outcomes and organizational changes. These issues have recently become a hot debate in the IS literature. Many studies have shown that there is a negative impact of IS or ERP adoption on employees because of organizational politics and power (e.g. Dery et al., 2006; Tatari et al., 2008; Garg, 2010, Ozorhon and Cinar, 2015 and many others). Hence, MES adoption process is worth investigating especially in a country like Turkey, which overly emphasizes adaption to Industry 4.0 or digitalization.

Project implementation success can be measured on time, budget and expected scope meeting dimensions. Using quantitative analysis, only scope meeting requirement is specifically emphasized in terms of individual use and individual performance effect in this thesis. Besides, qualitative analysis is used to validate the findings of the quantitative analysis. In the quantitative analysis, a questionnaire is conducted to about one hundred employees who work in the defense company mentioned earlier and have different roles such as project managers, key users and analyzers who are usually white-color employees and only data entry employees who are generally blue-color workers. In the literature, on ERP adoption, the analysis only focuses on project managers or key users of a company. Yet, we concentrate not only on project

managers and key users but also on blue-color employees who work in shop floor and whose main job is data entry which is a novelty of this thesis. Gathering perspectives of all stakeholders enhances the validity of findings. For qualitative analysis, one-to-one interviews are conducted with five different employees (middle-level managers) who have been working in MES project-related areas to strengthen analysis.

On the other hand, this thesis contributes to critical success factors for IS implementation and adoption in the literature along four dimensions. First, to our knowledge, this is the first study which uses both quantitative and qualitative research approaches. Most of the studies in the literature focus on one type of research approach, particularly quantitative approach. Second, blue-color employee's views are considered and the methodology design of research is thus novel, which enables a more comprehensive analysis. Third, to the best of our knowledge, this is the first study that examines MES adoption (in Turkey) though there are many others that examine the IS implementation in general. Last, this study helps policy makers or company managers to understand critical success factors before for better implementation success. Therefore, this study is an onset for future research on MES implementation. The following research questions are addressed to better understand deployment:

i. *What critical success factors affect MES Success? Why are these factors critical to MES implementation and adoption?*
ii. *Does MES help employees in performing their job (individual effects)?*
iii. *Is MES a beneficial solution for the organization?*

The thesis is composed of six chapters. Chapter 1 and 2 present not only the aim of the study, literature background of IS and ERP adoption but also MES characteristic. In Chapter 3, introduction of thesis subject, research questions, research method and data collection are analyzed. In Chapter 4, descriptive analysis and data validity/reliability are described. In Chapter 5, results of the descriptive and econometric analysis are summarized and further robustness tests, such as the finding

of the qualitative part, are discussed. The last chapter concludes with a brief presentation of the research results and implications for policy and future research.

CHAPTER 2

LITERATURE REVIEW

Defense industry contains high Research and Development (R&D) and cutting-edge technology, but it is a low-efficient industry. ERP and MES have been used to overcome efficiency problems, enhance integration and access data easily in supply chain network. The ERP and MES implementations are challenging as they include a number of technical and organizational barriers (Ozorhon and Cinar, 2015). Furthermore, the industry faces many barriers (such as organizational and technological) in the implementation of IS technologies such as ERP, PLM and MES. Therefore, it is important to elaborate on these barriers and factors to understand the success of the IS.

Critical Success Factors emerges as a vital aspect in IS, ERP and MES success or failure and it is a typical approach, which is used to define, measure and analyze all the aspects of system implementation and adoption success or failure. These aspects include not only technical and financial factors but also organizational and managerial issues. Davenport (1998) states that IS implementation process carries cost and complexity in its nature which may create many problems in the installation of a new system without thinking through its full business implications.

This chapter mainly describes the IS success models, ERP research adoption methods and MES functions and characteristics.

2.1 Information Systems Models

The examination of Information System is generally based on system accuracy, efficiency, value, efficacy and effectiveness of a system. IS influences the users who actively use such systems and it is also affected by them.

Lyytinen and Hırschheim (1987) present a new IS failure concept, and an associated framework for better understanding IS failure. In their research, they suggest two dimensions. The first is related to some aspects of an IS problem and it includes four domains of IS failure assessment which are technical domain, data domain, user domain, and organizational domain. These domains interact with each other in an IS adoption process. They tell that it might be possible to examine how technology affects organizational structure or design. The second dimension is identifying temporal characteristic of problematic aspect in the IS product life-cycle. It is related to how the four domains of an IS change over time, and it also covers IS development and use failures processes. Furthermore, development problems or failures might have an important impact on use failures. On the other hand, they add interference and development process into domain side (in the first dimension). When one looks into IS failure problems, it is seen that technology problems, data problems, complexity of use, complexity of maintenance, communication, job satisfaction, goal and operational problems are the most common ones. Failure types, relevant stakeholders and environment aspects should be identified for IS failure analysis since it is a complex process.

DeLone and McLean (1992) address the question of how to understand IS success. They present the DeLone and McLean Information Systems (IS) Success Model as a framework and model for measuring the complex dependent variable in IS research. They attempt to bring some awareness and structure by defining IS success as the dependent variable and propose a taxonomy and an interactive model as a framework for conceptualizing and operationalizing IS success. Their review of the literature resulted (180 articles including both conceptual and empirical studies cited) in a taxonomy of IS success consisting of six variables: i-) system quality, ii-) information quality, iii-) use, iv-) user satisfaction, v-) individual impact and vi-) organizational impact.

DeLone and McLean's (1992) research yields six categories, which are given in Table 1. As seen in the table, there are many variables to measure the success of IS. Therefore, no single measure is better than another, so the choice of a success variable

is often related to the objective of study and the context of the study. System Quality and Information Quality individually and jointly affect use and user satisfaction. Moreover, the amount of use can affect the degree of user satisfaction positively or negatively. The reverse can also be true. Use and user satisfaction are the direct antecedents of individual impact, and this impact on individual performance should eventually have some organizational impact. The last four variables are related to the effectiveness of the system. Notably, user satisfaction, individual impact and organizational impact show the influence of IS on the recipient or organization. The relationships among the variables are indicated in Figure 1.

DeLone and McLean (1992) discussed many of the important IS success research contributions of the last decade until 2002, focusing especially on research efforts that apply, validate, challenge, and propose enhancements to their original model. Based on their evaluation of those contributions, they proposed minor refinements to the model and proposed an updated DeLone and McLean IS Success Model (DeLone and McLean, 2003). Their preliminary model was cited 285 times during the period of 1993 to mid-2002 and also it has totally had more than ten thousand citations up to now.

In the updated model, they added a new quality dimension into their model, which is service quality. Therefore, there are three dimensions concerning quality aspects: information, systems, and service qualities, which could affect the use and user satisfaction individually or jointly. Service quality is commonly used as a measure of IS effectiveness that focuses on the products rather than the services of the IS function. What is more, for measuring the overall success of the IS department, as opposed to the individual systems, service quality might become the most important variable because it includes the assurance, empathy and responsiveness of the system.

Table 1. IS Success Model Constructs

Constructs	***Description***
System Quality	Measures of information processing system itself. Performance of the IS in terms of reliability, convenience, ease of use, functionality, and other system metrics. e.g. Data accuracy, resource utilization, system efficiency, response time (download time), reliability, adaptability etc.
Information Quality	Desired characteristics including accuracy, meaningfulness, and timeliness. It focuses on the quality of the information system output and measures it. e.g. Readability, content, be personalized, easy to understand, security, completeness etc.
Information Use	Recipient Consumption of the Output of an Information System means that binary measure of use vs. non-use, connect time and frequency of computer access. e.g. Use for getting instructions, use for recording data, use for control, and use for planning, amount of use/duration of use, number of record accessed, numbers of reports generated etc.
User Satisfaction	Recipient response to the use of the output of an Information System. Approval or likeability of an IS and its output. e.g. Overall satisfaction, repeat visits/purchases.
Individual Impact	The effect an IS has on an individual group/recipient. It is often measured in terms of perceived usefulness, and effects on work practices. e.g. Change in user activity, decision maker's perception and usefulness of the IS, information understanding, decision effectiveness, time to make decision, improved individual productivity etc.
Organizational Impact	The effect an IS has on an organization or industry. It is often measured in terms of perceived usefulness, and effect on work practices. e.g. Staff reduction, service effectiveness, operating cost reductions, reduced search costs etc.

Source: Edited on basis of following articles: DeLone and McLean (1992) and Petter and McLean (2009)

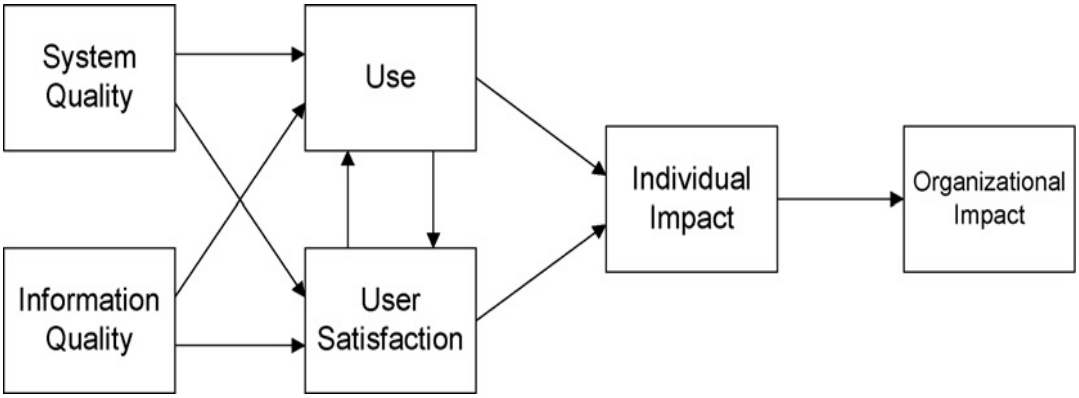

Figure 1. DeLone and McLean Primitive Information Systems (IS) Success Model (Source: Delone and McLean (1992))

Use can be mandatory versus voluntary, informed versus uninformed and so on. Therefore, Delone and McLean suggest that 'intention to use' may be a valuable alternative measure in some contexts. Intention to use is an attitude, whereas use is a behavior.

As a result of the impact of independent variables, both use and user satisfaction lead to certain net benefits such as time and money savings, customer responsiveness, and reduced search costs. Figure 2 displays the relationships between dependent and independent variables of IS success (updated IS Success Model) and Table 2 gives the definition of new indicators.

Table 2. Updated DeLone and McLean IS Success Model

Constructs	***Description***
Service Quality	Support of users by the IS department, often measured by the responsiveness, reliability, and empathy of the support organization. E.g. Assurance, empathy and responsiveness.
Intention to Use	Expected future consumption of an IS or its output.
Net Benefits	The effect an IS has on an individual, group, organization, industry, society, etc., which is often measured in terms of organizational performance, perceived usefulness, and effect on work practices. E.g. Time and money savings, reduced search costs etc.

Source: Edited on basis of following articles: DeLone and McLean (2003) and Petter and McLean (2009)

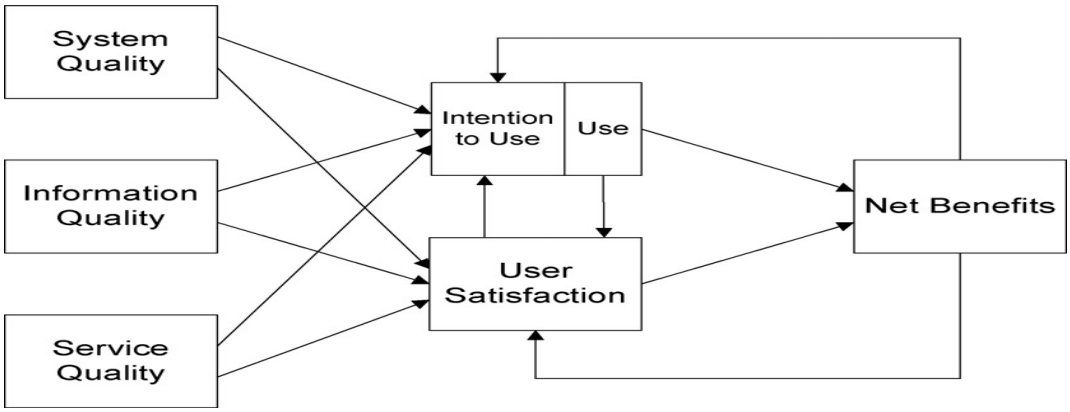

Figure 2. DeLone and McLean Updated Information Systems (IS) Success Model (Source: Delone and McLean (2002))

According to Shannon and Weaver (1949, cited in DeLone and McLean, 1992), the output of information can be measured in different levels including the technical level as the accuracy and efficiency of system, the semantic level as the success of the information in conveying the intended meaning, and the effectiveness level as the effect of the information on the receiver. The information system creates information, which is communicated to the recipient who is then influenced by the information.

This means that using and/or producing IS influence the performance of individual and/or organization. Basically, DeLone and McLean are influenced by Shannon and Weaver (1949) as well as Mason (1978) who came up with a hierarchy of IS Success that includes IS production, product, receipt, influence on recipient and influence on system. Table 3 summarizes IS success relationships between the studies of these three groups of researchers.

Table 3. Categories of IS Success

Researchers	***Independent Variable-1***	***Independent Variable-2***	***Dependent Variables***
Shannon and Weaver (1949)	Technical Level	Semantic Level	Effectiveness/Influence Level
Mason (1978)	Production	Product	Receipt, Influence on Receipt, Influence on System
DeLone and McLean (1992)	System Quality	Information Quality	Use, User Satisfaction, Individual Impact, Organizational Impact

Grover et al. (1996) used an alternative way, which is theoretically based perspective to build a theoretically-based construct space for IS effectiveness that complements and extends the preliminary DeLone and McLean IS Success Model. Based on unit-of-analysis and evaluation-type context dimensions, they created six IS effectiveness categories. The six effectiveness classes are infusion measures that are variations of organizational impact, market measures, economic measures (i.e., organizational impacts), usage measures (i.e., system use), perceptual measures (i.e., user satisfaction), and productivity measures (i.e., individual impact).

Wang and Liao (2008) used DeLone and McLean IS Success Model for assessing e-Government system success, and data was collected through a questionnaire applied to 119 e-Government users in Taiwan. They found the relationship between information/service quality and use. Their research shows that user satisfaction is

influenced by information quality, system quality and service quality in a statistically significant way.

Petter and McLean (2009) performed a meta-analysis to determine whether DeLone and McLean Updated Information Systems Success Model is validated by research in the literature by combining the results of 52 empirical studies and examined these at the individual level of analysis. They have thirteen hypotheses and eleven of them are statistically supported such as the positive relationship between system quality and use, intention to use, user satisfaction and so on.

As mentioned above, IS success depends on various variables and choosing the appropriate factor depends on the firm and industry needs as well as technological change.

2.2 Enterprise Resource Planning Research Model

ERP system is a generic term for a broad set of activities supported by multi-module application software that helps organizations to manage their resources. Managers should decide whether the organization is willing to change its business flow to fit the software, or whether it prefers to change the software to fit the business flow. Among the most important attributes of ERP are its abilities to (Nah et al., 2001):

- automate and integrate an organization's business processes;
- share common data and practices across the entire enterprise; and
- produce and access information in a real-time environment.

ERP implementation is regarded as a technological, business, and organizational project. ERP projects typically require a balanced combination of implementation teams where technical and business competence is available. In addition, the decision maker in the project team should be empowered to make quick and effective decisions (Teltumbde, 2000).

There are some critical success factors (CSFs), which are widely cited in the literature about ERP implementation. Nah et al. (2001) developed 11 CSFs for ERP implementation which are ERP teamwork and composition; top management support; change management program and culture; business plan and vision; business process reengineering with minimum customization; project management; monitoring and evaluation of performance; effective communication; software development, testing and troubleshooting; project champion; appropriate business and IS legacy systems. They consider CSFs as a project life cycle assessment model that consists of three main steps: i-) preparation, analysis, design, ii-) implementation and iii-) maintenance. Among these CSFs, teamwork composition and good communication between partners are critical and essential. These factors help to understand the relationship between ERP implementation cost and improved process savings, information sharing and business process re-engineering.

In the literature, articles generally focus on the organizational and technological dimensions. For instance, Sousa and Collado (2000) analyze the CSFs in the ERP literature with a grounded theory and propose a unified model of the critical success factors in ERP implementations and adoption which have four perspectives: organizational, technological, strategic and tactical. These include sustained management support, effective organizational change management, good project scope management, comprehensive business process reengineering, strong communication inwards and outwards, empowered decision makers, avoiding customization, adequate software configuration etc. Their research shows that organizational aspects are considered to be more significant than technological ones. Because of the cross-functional nature and the large cost of an ERP implementation, the extent of risk taking of the top management might be the most important factor. Another example is Ozorhon and Cinar's (2015) study where they identified 14 critical success factors of ERP implementation in Turkey for the construction industry that has three dimensions: human factors, organization and technology. These success factors are effectiveness of project leader, training and support for users, organizational change management, use of consultants, end-user involvement, startup

and testing the system, top management support and commitment, project team competence, clear goals and objectives, team composition, cooperation between team members, vendor support, choice of ERP software package, and choice of ERP modules. They collected data from 90 construction firms in Turkey and found that top management support and commitment, clear goals and objectives, project team competence, effectiveness of the project leader and cooperation between team members are the most important drivers of success.

Lastly, according to Zhang et al. (2005) top management support, company-wide support, business process reengineering, effective project management, organizational culture are related to organizational environment; education and training, user involvement, user characteristics are related to user environment; ERP software suitability, information quality, system quality are associated with system environment; and lastly, System ERP vendor quality is related to ERP Vendor Environment are factors that affect the ERP implementation and adoption. They use a case study method for measuring ERP success. Effective project management, ERP software suitability, information quality and system quality are found to have a strong positive impact on the ERP implementation success.

Table 4 gives brief information about some critical success factors, which are investigated in this thesis under two perspectives: organizational and technological factors. The following paragraphs give details about each paper cited in Table 4.

Sarker and Lee (2003) focused on three social enablers which are strong and committed leadership, open and honest communication, and empowered implementation team in ERP implementation. They found that all three enablers might contribute to ERP implementation, but leadership is the necessary condition for success.

Ehie and Madsen (2005) used qualitative analysis to identify the critical factors of ERP implementation and applied their questionnaire to forty companies. There are eight critical factors in their study that are project management principles, feasibility/evaluation of ERP project, human resource development, process re-

engineering, top management support, cost/budget, IT infrastructure and consulting services. Apart from IT infrastructure and human resource development, other critical factors were found to be significant for ERP implementation.

Wu and Wang (2006) proposed a model to evaluate knowledge management systems empirically. They used five variables that are system quality, knowledge or information quality, perceived system benefit, user satisfaction, and system use which were used as dependent or independent variables for assessing system success. By using questionnaires from fifty firms, seven hypotheses were tested and information quality and user perceived knowledge management systems are found to be significant.

According to Ngai et al. (2008), top management support and training and education are the most frequently cited critical factors of successful adoption/implementation of ERP. Their study was performed across 10 different countries/regions. They revealed that appropriate business and IT legacy systems, business plan/vision/goals/justification, business process reengineering, top management support, data management, change management culture and programme, communication, ERP teamwork and composition, monitoring and evaluation of performance, project champion, project management, software/system development, testing and troubleshooting, ERP strategy and implementation methodology, ERP vendor, organizational characteristics, fit between ERP and business/process, national culture and country-related functional requirement are the critical factors for ERP adoption.

Bernroider's (2008) study examines the role of information technology governance in driving the success of ERP projects. He has six hypotheses which are related to IS strategy, strategic alignment, top management commitment, and team domination by business management. He found that top management commitment is observed and supported only in large enterprises. He used data from two hundred and nine questionnaires applied to Austrian companies.

Garg (2010) used top management, product selection, project management, team composition and training/education as critical success factors for ERP implementation in India by collecting data from 110 respondents in the retail sector. They found that all the factors are statistically significant for ERP adoption.

Tatari et al. (2008) examined top management support, interdepartmental cooperation, communication, vendor support, clear goals and objectives, project team competence, careful package selection, business process reengineering, minimum customization, and user training in the construction industry. They performed their study by making a qualitative analysis and found that BPR, clear goals and objectives and user training are significant factors.

Jones et al. (2011) investigated the impact of adopting an ERP system in a retail chain and found interesting parallels between firm and employee outcomes. They have three categories for the adoption process which are the use of ERP, the problems with ERP, and the impact of ERP on organization that covers teamwork, job difficulty, job discretion, responsibility, amount of work, multi-tasking and employee motivation. The increase in responsibility and decrease in not only job discretion but also employee motivation is found to have statistically significant effects.

ERP systems have revolutionized organizational computing by facilitating integrated and real-time planning, production, and customer response. These systems involve diffusion of innovation. Innovation and organizational and environmental characteristics in the diffusion process might influence ERP implementation success both at user satisfaction and firm performance levels. Bradford and Florin (2003) reached some conclusions after their research:

- Top management support and training are positively related to user satisfaction,
- The perceived complexity of ERP and competitive pressure show a negative relationship,
- Consensus in organizational objectives and competitive pressure are positively associated with perceived organizational performance.

Figure 3 shows their research model. In *innovative characteristics*, they include technical compatibility (integrate new IT with retained systems easily) and perceived complexity that is the opposite of ease of use. Besides, they contribute to this research by including the level of business process reengineering (BPR) as an important additional dimension of innovation that could influence successful ERP implementations. The second characteristic, which is organizational views, encapsulates top management support, organizational objectives consensus and training. These are important to see the cultural dimensions influencing the success of IS implementation.

Table 4. Comparison Matrix of the Literature

Dimensions	***Variables***	Bradford, Florin (2003)	Sarker, Lee (2003)	Ehie, Madsen (2005)	Zhang et al. (2005)	Wu,. Wang (2006)	Bernroider (2008)	Chang et al. (2008)	Wang, Liao (2008)	Tatari et al. (2008)	Petter, McLean (2009)	Garg, 2010	Ozorhon, Cinar (2015)
Organizational Factors	*Understanding of Business Plan & Vision*	O			X		X			X			X
	Communication		O				X			O			X
	Change Management Culture				O			X					O
	Top Management&Supervisor S.	X	X	X	X		X			O		X	X
	Training	X			X					X		X	O
Technological Factors	*Compatibility*	O		O	X			X					
	Complexity	X			X	X		O	X		X		
	Business Process Reengineering	O		X	X					X			

Notes. “X” means that this factor (row) is statistically significant in this article (column). "0" means that this variable used in this article but not statistically significant.

When one examines the ERP implementation success, there are two dimensions, namely perceived organizational performance and user satisfaction, which are inspired by the DeLone and McLean IS Success Model (2002).

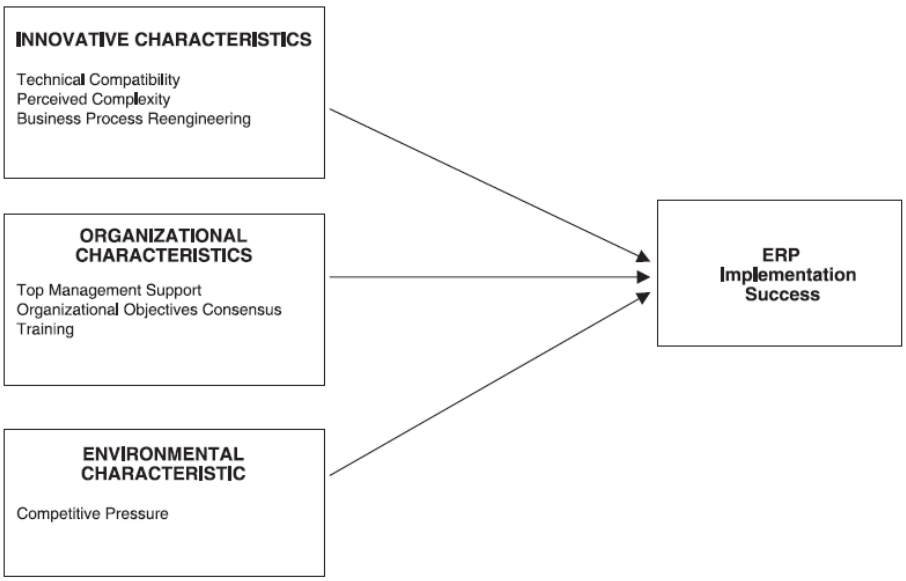

Figure 3. ERP Research Model (Source: Bradford and Florin (2003))

Similar to Bradford and Florin (2003), Chang et al. (2008) developed the ERP adoption model and they argue that ERP systems may not be voluntary; therefore, the understanding of system adoption from the user's perspective is useful in helping the organizations to prepare their employees to face new challenges and learn how to make good use of technology. In their study, they used Triandis framework, which is based on social factors related to adoption and the usage of technology to analyze the factors that affect user's perspective. They found from their empirical study (quantitative analysis including two hundred and forty questions) that social factors, compatibility and near-term consequences are statistically significant for the adoption of ERP. To improve their research model (ERP usage) stated in Figure 4, Chang et al. (2008) used the social psychological model. The model includes the following factors: i-) perceived consequences, which include near-term consequences and long-term

consequences, ii-) affect, iii-) complexity, iv-) compatibility, v-) facilitating conditions and vi-) social factors. These factors fall into three categories: individual, technological and organizational characteristics. Some are similar to *"DeLone and McLean IS Success Model"* and *"Bradford and Florin's ERP Research Model"*. Affect and social factors are the new factors for ERP adoption or usage.

The failure rate of ERP implementation is very high (Yeh et al., 2007) since technical problems and individual related (people) obstacles are found to be major barriers (e.g. Botta-Genoulaz and Millet, 2006; Krasner, 2000, cited in Chang et al., 2008). In professional life, the success of ERP implementation requires a close cross-functional teamwork. The data entered by a division will be used by other divisions in real time. Therefore, employees are expected to use the ERP in order to make the ERP more useful. Thus, ERP is a major investment of a firm and the implementation may involve substantial organizational changes. Top management support has been found to be a key factor as far as success is concerned, but more importantly, top management needs to develop a shared vision and to communicate it to the employees so that the expectation is clear. Moreover, Chang et al. (2008) found that social pressure plays an important role in explaining the use of the internet. Thus, they believe that a user's attitude toward using ERP systems will be strongly influenced by his/her perception of the expectations of the superiors and colleagues. What's more, facilitating conditions (i.e., the availability of the necessary resources and supports to the ERP system usage) are the factors that may affect the adoption of ERP. Affect, an individual characteristic, is the direct emotional response to the thought of the behavior and is referred to as the feelings of joy, elation, pleasure, depression, and so on. Social factors related to culture consist of ways of categorizing experiences, beliefs, ideals, roles, norms and values etc.

According to Sousa and Collado (2000), organizational perspective is described as related concerns like organizational structure and culture and business processes, while the technological perspective focuses on aspects related to the particular ERP product in consideration and on other related technical items, such as hardware and base software requirements.

Since all the factors mentioned above have significant effects on the success of IS implementation, they need to be analyzed in this thesis which focuses on MES adoption.

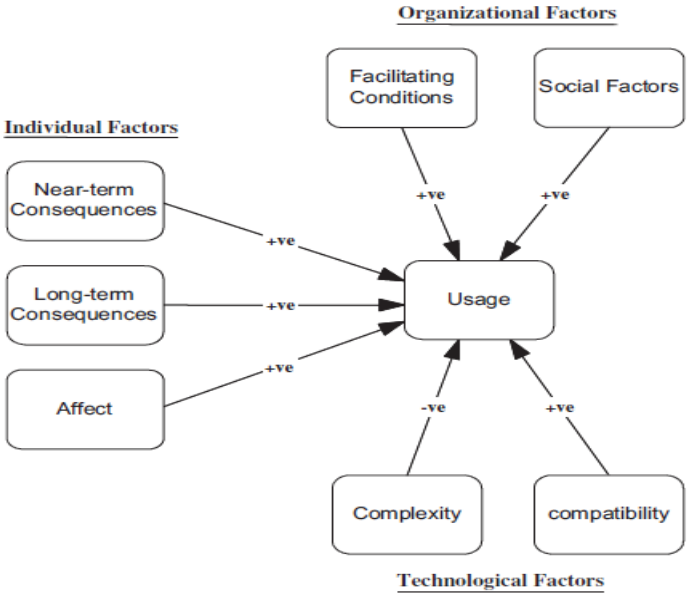

Figure 4. ERP Adoption Research Model (Source: Chang et al. (2008))

2.3 MES Functions and Characteristics

Manufacturing Execution System (MES) is a management system that became popular after the 1990s in terms of real-time data acquisition from shop floor to follow production status, material flow, resource usage rate and the production/quality steps at operation stage level. It enables stakeholders to make statistical and performance analyses. Basically, it is a module of ERP system. It has coordination functions between shop floor and ERP and is a layer of communication between business and control systems. MES provides effective integration between production processes and enterprise business systems. The primitive communication between ERP and MES is stated in Figure 5. MES coordinates functions on the shop floor to optimize

the plant activities and can be defined as the manufacturing operation management system. MES can use data from not only sensor and barcode systems but also other tracking systems. It translates these data into meaningful information for users.

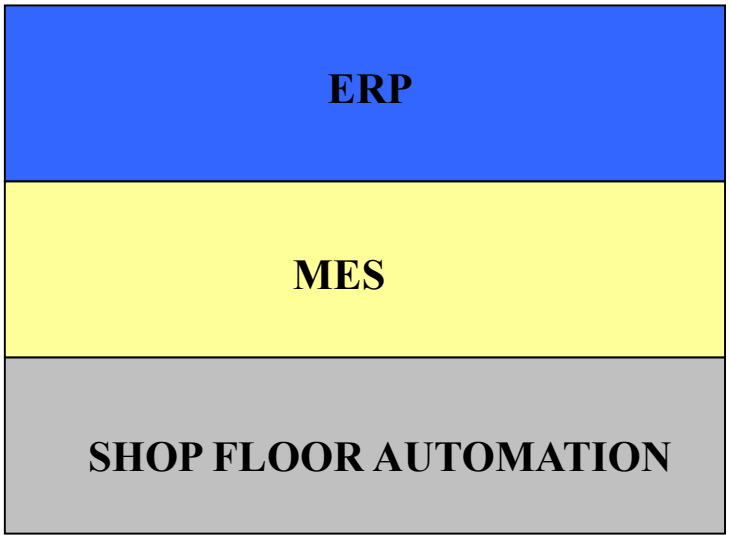

Figure 5. ERP and MES Primitive Communication

Source: This figure is adapted from https://www.isa.org/isa95/ and Americas' SAP Users' Group 2006 Annual Conference Report accessed on 03.16.2018.

Instrumentation, Systems, and Automation Society (ISA) Standard (1995 level) defines how to link Enterprise and Controls systems using the MES layer. Moreover, it explains functionality of these systems. The drivers of resource management system are the reduced cycle time, asset efficiency and agile manufacturing. ISA 95 has five levels for manufacturing management. Integration of manufacturing operations system is difficult, expensive and time demanding. ISA offers a guide to start. These integration projects typically take one or more years. The success rate is low because of some technical and organizational factors. Figure 6 depicts the relationship between information exchanges between layers of information systems, which is related to ERP.

From this figure, we understand that MES's functions are related to:

- *Production Capability Information* means what is available for use,

- *Product Definition Information* relates to how to make a product,
- *Production Schedule* means what to make and use, and
- *Production Performance* relates to what was made and used.

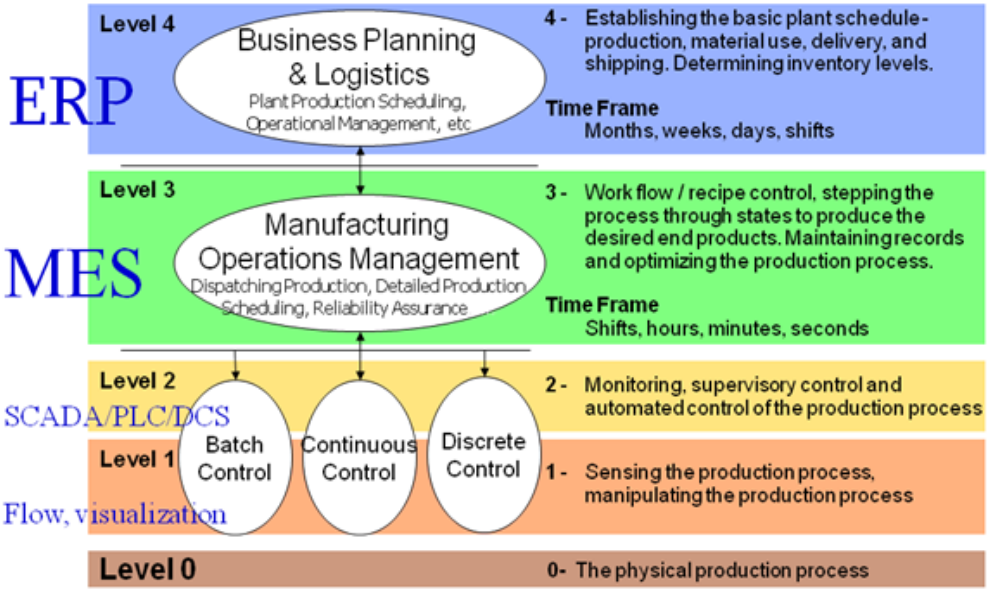

Figure 6. ISA 95 MES-ERP Relationship

Source: This figure is adapted from https://www.isa.org/isa95/ and Americas' SAP Users' Group 2006 Annual Conference Report accessed on 03.16.2018.

ISA informs that MES has ten business functions which are;

- Detail scheduling,
- Process optimization,
- Recipe management,
- Performance management,
- Process analysis,
- Resource management,
- Production execution,
- WIP material management,

- Production history and
- Quality management.

On the other hand, ERP is associated with demand planning, sales and distribution, supply chain planning, cost accounting, material, production and warehouse management as well as human resource management. MES is needed when there are many shared resources, thousands of parts, complex procedures and many semi-finished or finished products.

The Information Systems enables to standardize work processes and eliminate legacy. Similarly, MES objectives stated below are related to IS general concepts:

- Redesign of manufacturing/production management system which covers paperless production, new tracking system of production that real-time production/material/quality tracking and acquisition of data easily (transferring data between manufacturing sites to enterprise level), minimize data access time and manual data entry, enables production scheduling,
- Lean processes in each process that means reviewing production and quality processes to obtain rapid and flexible structure,
- Minimizes human faults and faults in workflows,
- Integrated production management system with ERP,
- Presents product genealogy, electronic signatures,
- Enables strategic level support system such as business intelligence application,
- Provides resource management system (efficiency analysis, bottleneck management, available to promise analysis and capacity management etc.), determines resource usage in terms of machines (repair & maintenance operations by preventative maintenance) and technician, minimizes cycle time, reduce work-in-process inventory,
- Improves quality by applying statistical process control methods: data analysis, production status reports, material usage analysis, time and method studies,

- Enables to minimize product, project and production cost in terms of optimized use of human resources, decreased equipment downtimes, energy reduction by pacing,
- Interfaces between ERP and supply chain management,
- Supports shipping and raw material handling (all logistics),
- Makes easier to work order management, roll change management,
- Views anticipated capacity or resource shortages,
- Shows current shop floor, production to plan metrics, material shortages,
- Presents configurable dispatch list driven execution and configurable work content and sequential display of work instructions, and
- Allows for performance analysis for production line.

In brief, the benefits of MES are increased throughput, improved quality, decreased costs in terms of inventory carrying costs, product introduction time and product development costs, regulatory compliance and recall costs and optimized logistics because of affecting production, maintenance, laboratories and material handling.

Defense Industry is generally based on discrete manufacturing. Therefore, MES is used for resource management, production execution, material management, production history, quality management, and performance management in this industry. MES coordinates functions on the shop floor and provides integration between production processes and enterprise systems, and a robust integration between ERP and MES is required for flexibility and visibility.

According to Siemens[3], MES presents greater efficiency, profitability, and productivity and is crucial to guarantee overall component integration, ensuring maximum quality and production optimization across all global facilities. Furthermore, Oracle[4] reports that in discrete manufacturing, MES provides rich, out-of-the-box capabilities to perform the daily tasks of the shop floor operator and

[3] Available in siemens.com.tr/dijitalfabrikalar accessed on 03.16.2018.

[4] Available in https://www.oracle.com/assets/062099.pdf accessed on 03.16.2018.

supervisor and helps focus on improving the productivity of them. Besides, it enables shop floor operators and supervisors to perform, record, and monitor shop floor activities in a highly efficient and effective manner in addition to providing key performance and status indicators for managers about the shop floor. Increased shop floor visibility and reduced costs of ownership might also be achieved by using MES.

In spite of the benefits of MES, there are many problems similar to the ERP systems. It promises standardization and automation. However, companies would prefer developing their own inside MES, which is tailor-made for sustaining their agility. Secondly, implementation licensing and consultancy for both implementation and maintenance bring about huge cost. Lastly, the implementation and adoption bring some risks since radical changes within organization require long time to fully realize the benefits of the system (Orhan, 2006).

CHAPTER 3

METHODOLOGY AND DATA

This chapter mainly describes the research methodology and the overall research process. It starts with the case study approach and MES implementation history. The second section elaborates on the research design, critical success factors of MES and hypotheses in this thesis. The third and last section gives information about sampling and data collection procedure as well as the research instruments used.

This thesis is basically based on a single case study which includes quantitative and quantitative analysis. However, quantitative analysis is the primary analysis method in this thesis that uses survey questions (*see section 3.3*) and principal component analysis for data reduction (*see section 4.1*). Later, the thesis employs simple ordinary least squares (OLS) estimations (*see section 5*). On the other hand, qualitative analysis (*see sections 3.3.1 and 5.1*) is only utilized for increasing the validity and reliability of this study.

3.1 Case Study Approach and Firm Profile

This study is conducted using the case study approach to investigate the adoption of MES in a defense industry company. According to Benbasat et al. (1987), case study approach is important for information systems research strategy because it first enables to generate theories from practice. Second, the case method allows the researcher to find out answers to "how" and "why" questions about the nature and complexity of the processes taking place. Many new topics emerge each year because of the rapid pace of change in the IS field. Significant insights may be gained through the use of cases in a dynamic field such as IS. Researchers state that technology has shifted to organizational issues rather than technical issues in the IS field, thus case research might be helpful in identifying the causal effects of the success or failure of

adoption by using the views of different stakeholders. Case studies examine a phenomenon in its natural setting and employ multiple methods of data collection to gather information from one or a few entities such as people, groups, or organizations. The case research strategy is mostly used for exploration and hypothesis generation. Hence, this can be a legitimate way of adding to the body of case study approach in the IS field.

In this study, *single case study design* is used for description, explanation and exploration in order to obtain appropriate data for analyzing and providing different issues related to critical success factors of MES. Single case study is most useful at the outset of generation and critical case testing (Yin, 1984, cited in Benbasat et al., 1987). Nevertheless, single case study does not need any site selection because the site is predetermined. This study is carried out based on a defense industry company which has discrete manufacturing[5] areas and uses MES application. To our knowledge, this is the first study that investigates critical success factors of MES.

In this company, the process of MES adoption encompassed roughly two waves: i-) development, test, pilot phase between 2012, and 2014 ii-) go-live phase after 2014. The decision to invest in MES was made by top management and production planning department for paperless production management and to obtain more centralized and standardized operations management (Jones et al., 2011).

MES affects production, quality control, quality assurance, production planning, project management and design departments and more than 600 employees are affected by this system. As mentioned above, many departments have relationships with MES. Therefore, there are many factors which influence MES adoption, and technical and organizational success (e.g. Nah et al., 2001; Ngai et al., 2008). For this reason, it is worth investigating the factors that affect the diffusion of MES in the selected firm.

[5] Discrete manufacturing is generally defined as limited volume manufacturing but it has very high complexity in manufacturing environment.

3.2 Qualitative Analysis

Qualitative data sources include observation and participant observation, interviews and questionnaires, focus groups, archival records such as documents and texts, physical artifacts (devices, tools etc.) as well as the researcher's impressions and reactions (e.g. Benbasat et al., 1987; Yıldırım and Şimşek, 2005, cited in Orhan, 2006). In this study, interview technique is used as a data collection method. The questions that are used in face-to-face interviews are presented in section 5.1. Interviews and questionnaires are used in this thesis because they are not only complement to each other in extracting organizational information about the firm but also help us to understand the MES adoption process in the firm.

The aim of the qualitative analysis is to support the quantitative analysis. It enhances the thesis arguments especially on the organizational and individual effects of MES. Interviews with five people were conducted in 2017 and 2018. The respondents work in the MES-related areas. Three of them are managers in production related areas (production planning manager, operation manager and production department manager). Others are quality assurance manager and integration manager. Each interview took half an hour on average. The results of the interviews are discussed in the robustness section (see section 5.1). Before starting each interview, all respondents were informed about the goals of the research and confidentiality was guaranteed. Interviews were not recorded but detailed notes were taken.

3.3 Research Questions, Quantitative Analysis and Hypothesis

New systems contain uncertainty and failure because of adaption of human and legacy (past) systems. Therefore, examination of these systems' effects is not straightforward because of stakeholders' views (cultural issues, resistance to change) and technical and business issues.

In this study, there are three questions to investigate the MES adoption and implementation effects:

i. What critical success factors affect MES Success? Why are these factors critical to MES implementation and adoption?

Firstly, culture (organizational characteristics) might be the most significant factor. Companies or employees who work for companies generally do not change voluntarily. Thus, the culture related factors have to be included in the research.

Secondly, technological factors and innovative characteristics may affect MES adoption since sometimes these kinds of IS systems are not user-friendly applications and adaption into the current system is too hard and painful.

ii. Does MES help employees to perform their job (individual effects)?

MES may help people to find and access data easily and also allows to make improvements in an easy manner by using the system. On the other hand, the factors which behind employees' resistance to using MES are crucial and their daily job habits affect the use of MES.

iii. Is MES a beneficial solution for the organization?

To analyze this, first we have to understand MES functions for the companies. There might be several effects on firms such as time savings, reduced search costs, traceability and performance management and changes in the way people work etc.

In this thesis, we have to search for the critical factors of MES adoption and whether MES is beneficial for the individuals and the organization. These three questions are pillars of this study. Actually, the employees' resistance most probably comes from their habits which are related to paper based production period. Moreover, MES provides paperless production and employees have the fear to lose their job and to experience a change in their job definition. Lastly, there is too much pressure from top management to do their job using MES. Therefore, leadership of top management is important to break the resistance. The study also investigates technicians' or engineers' habit change after the MES implementation and their views on the fear of losing job.

MES systems implementation and adoption success might affect the items listed below (e.g. Ngai et al., 2008, Nah et al., 2001):

- Cross-functional cooperation,
- Social factors, habits, culture, behavior of employees,
- Top management, peer/user support,
- The availability of resources, geographic limitation,
- Better information sharing,
- Ease of use,
- Motivation of employee,
- Age gap between workers,
- Usefulness and benefit of system,
- Quality and efficiency of tasks,
- Innovation culture of the company,
- End-user involvement,
- Involvement of different functional areas,
- Culture and decision making, management style and labor skills,
- Vendor-related critical success factors,
- Business process reengineering for implementation,
- The needs and business processes of the organization,
- Change management culture,
- Technical compatibility,
- Perceived complexity,
- Business plan/vision/goals/justification,
- Communication,
- ERP teamwork and composition,
- Monitoring and evaluation of performance,
- Project champion
- Project management
- Organizational characteristics etc.

In this study, a comprehensive research through the relevant literature has been conducted since 2015. Some articles especially affect this research such as the updated Delone and McLean's IS Success Model (2002), Bradford and Florin's ERP research model (2003) and ERP Research Model of Chang et al. (2008). The model proposed in this thesis, which is presented in Figure 7, states that organizational factors, technological factors and innovative characteristics might influence MES adoption and implementation success in terms of individual impact. Organizational impact of MES is covered in the discussion section drawing on the interviews of some users (i.e., *the qualitative analysis*) and observations in the company.

In the following sections, we develop hypotheses to support the model from MES adoption in Figure 7. Organizational factors and technological/innovative factors are independent variables; and individual impact in terms of use and performance are used as dependent variables in this study.

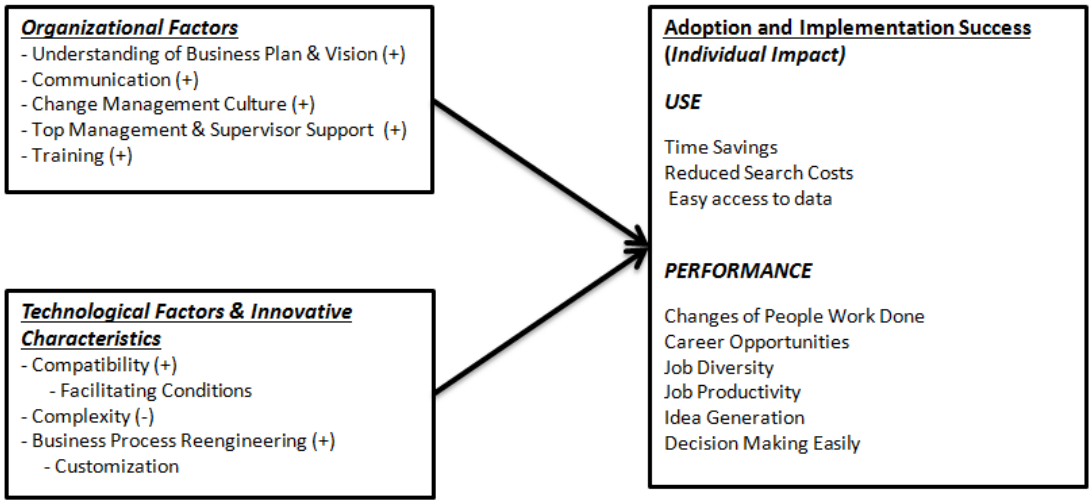

Figure 7. Research Model of the Thesis

3.3.1 Organizational Factors

Organizational characteristics influence the successful implementation of innovation (Rogers, 1983). According to Ozorhon and Cinar (2015), organizational factors can be top management support, team competence, team composition and team members

as well as depiction of clear goals and objectives. Bradford and Florin (2003) take top management, consensus in objectives and training as organizational critical factors. In this study, understanding of business plan/vision, communication, change management culture, top management/supervisor support and training are selected as critical factors of MES implementation and adoption.

3.3.1.1 Understanding of Business Plan and Vision

Business plan and vision are needed to better steer a project. Business plan outlines the proposed benefits, resources, costs, risks, scope and timeline of project (Nah et al., 2001). It should be identified and tracked by the project manager. Generally, if employees know the plan and project process, implementation of the system might be easier and employees are more adaptable to the new system. What's more, management's communication with each stakeholder before or during the project is crucial for consensus on the business plan. Based on these arguments, the following hypothesis is made:

H1: The better understanding of the business plan and vision is positively related to MES adoption and implementation success.

3.3.1.2 Communication

Expectations of each stakeholder change day by day, which influences the success of systems. Project management team should explain the scope, objectives and activities in advance to all levels of the organization as well stakeholders such as the affected employees and some key users who are each the department representative of the ERP module and the end-user, respectively.

Ngai et al. (2008) argue that effective communication is one of the success factors that influence the acceptance of technology and ERP implementation environment. The process of communication, and collecting the requirements and comments of stakeholders might have an impact on the success of the system. Besides, open and

honest communication is needed for the involvement of stakeholders. Thus, the following hypothesis will be tested:

H2: Better communication of MES objectives and benefits is positively related with adoption and the success of the implementation.

3.3.1.3 Change Management Culture

Change management culture is crucial for the adoption of the project and obtaining the desired success. Organization should have common aims and shared values for success. Lack of these creates barriers to integrate the new system into the organization. Moreover, strong willingness, shared values and openness to change allow employees to accept the new technology. They might also help for better implementation and adoption. Before the implementation of new technology (e.g. MES), users should be involved in the design and implementation process. Effective change management enables to adapt the organization and staff to the new business processes and systems (Kenaroğlu, 2004).

Training and education are important processes in change management to overcome and balance resistance. These enable the users to understand the overall concepts of the new system (e.g. ERP/MES) and thus provide acceptance and readiness to use the new system (Ngai et al., 2008).

Based on these rationales, the following hypothesis is presented:

H3: Having a change management culture/organization is positively related to the MES implementation and adoption.

3.3.1.4 Top Management Support & Supervisor Support

Each project starts with a charter which comprises the approval of top management. Their support is needed for the effective implementation and they should show their willingness and involvement during the implementation and adoption of project.

Moreover, they must allocate the needed resources like human capital, time, financial capital and infrastructure. The support of top management ensures that the project has a high priority within the organization and receives the attention of employees. The lack of adequate resources may inevitably lead to failure of an IS project (Garg, 2010). Employees are generally distant from the top management. However, they are closer to their supervisors than to the top management; thus, the support of the first line manager may be more important than that of the top management to understand the usefulness of the IS program. Based on these rationales, the following hypothesis is presented:

H4: The degree of top management/supervisor support has a positive relationship with MES implementation/adoption success.

3.3.1.5 Training

MES includes high complexity because of its technology structure or user interface. Employees need training to understand how the system runs and whether it is possible to change the old business processes or not. In addition, they should learn to use the system and be aware that their mistakes affect the whole structure, the database and the data other people use. Training increases the achievement of the organizational performance measures and affects user satisfaction.

During implementation, there should be on-site support for all stakeholders. Furthermore, support tools or unit (e.g. help desk, online user manual) may be critical to meet users' requests after installation (Wee, 2000). Training and support play an important role in terms of end-user involvement. Top management should be aware of the importance of training and allocate the necessary resources for this purpose (Ozorhon and Cinar, 2015). Based on these rationales, the following hypothesis is proposed:

H5: The level of training about MES is positively related to MES implementation/adoption success.

3.3.2 Technological Factors and Innovative Characteristics

According to Bradford and Florin (2003), research model compatibility, complexity and business process reengineering features of the information system are associated with the technological and innovative characteristics of MES. In this study, these three factors are used to analyze the MES adoption/implementation in terms of innovation.

3.3.2.1 Compatibility

Compatibility is related to the process of new technology integration to the existing one. This characteristic covers not only the infrastructure of the environment but also the adaptation between software and hardware. Compatibility could increase user satisfaction and facilitate business. Besides, it is expected that the higher the compatibility, the higher the system usage (Chang et al., 2008). Based on these rationales, the following hypothesis is made:

H6: The degree of the compatibility of environment (Hardware & Software) is positively related to MES implementation/adoption success.

3.3.2.2 Complexity

Complexity is the degree to which an innovation is perceived as difficult to understand and use. Some innovations are readily understood by most members of a social system or organization, while others are more complicated and will be adapted more slowly (Roger, 1983). This is opposite for the ease of use.

In general, new ideas that are simple to understand will be adopted more rapidly than an innovation that requires the adopter to develop new skills and understandings. Resistance to innovation involves lack of skills and knowledge of employee, employee's lower satisfaction from the new systems and lastly the user-friendliness of the application. Complexity is associated with the ease of use and learning of a system, the response time of the system and the user-friendly screens of the system.

These are similar to DeLone and McLean's (2003) system quality variables. Besides, complexity is sometimes related to the predictability and reliability of the system (Wu and Wang, 2006).

Based on the above arguments, the following hypothesis is postulated:

H7: The level of complexity of MES is negatively related to MES implementation/adoption success.

3.3.2.3 Business Process Reengineering

IS Software may not completely fit the company's operations. In this case, there are two options: First, software package should be customized to better fit the company's needs. Second, the company must change its old business manner (i.e., the way things operate and tasks are completed) and conform it to software package. In general, it is inevitable that business processes are molded to fit the new system. The second option is costlier than the first one (Bingi et al., 1999).

Customization brings higher implementation costs and needs more time to go live. For these reasons, company prefers to use IS/ERP/MES package "as is". When firms reengineer their business processes to conform to the package, the benefits from the implementation are sometimes maximized, and so does the stakeholder satisfaction (Bradford and Florin, 2003). For these reasons, the following hypothesis is proposed:

H8: The degree of business process reengineering of MES is positively related to MES implementation success.

3.3.3 Control Variables

Education level, employment status, experience with ERP systems and experience in the current company are selected as control variables.

Education level covers two groups: high school or associate degree level (technical schools etc.) and undergraduate degree or above. Employees' education level might affect their viewpoints about MES, and also the greater satisfaction could occur.

Employment status is related to employees' position. There are two categories, which are blue-collar and white-collar. While blue-collar implies technician level, white-collars are engineers and managers.

Experience with ERP Systems reflects respondent's past experience with the ERP systems. It enables respondents to compare MES functions to their prior experience.

Lastly, *Experience in the current company* divides employees into two groups. First is 0-5 years of experience and the second is 6+ years of experience in the current company.

3.3.4 Adoption and Implementation Success Measures

MES has lots of benefits for the user and the companies. When we examine the individual impacts (end user's perspective); time savings, reduced search costs, changes of how employee complete tasks, career opportunities, job diversity, easy access to right data, task productivity and idea generation are the salient ones. On the other hand, capacity/resource usage tracking, traceability, performance management, reduced cycle times, efficiency and improved innovation capabilities are the main organizational effects.

In this study, individual impacts are used to measure the adoption and implementation success factors of MES. The user use and the perceived user (individual) performance are selected for analyzing the critical success factors of MES adoption.

Organizational impacts such as cost, productivity and customer service level perspective are discussed in the qualitative part in the robustness section (see Section 5.1).

3.3.4.1 User Use

Use refers to individuals' response to the use of MES. It is examined to understand the actual use, the depth of use and the importance of use. In this work, user

satisfaction, and accessing the right data and information are used to analyze the "User Use" success measure.

3.3.4.2 Perceived User (Individual) Performance

Several dimensions are used to measure the individual impact of IS: improved individual productivity, task performance improvement, decision effectiveness and quality and time to make decision (Zhang et al, 2005). Moreover, information sharing and information quality are important factors as far as individual impact is concerned.

In the present study, changes in the way people work, performance management, communication, time savings, decision making, and learning culture are utilized for individual performance measure.

Appendix A presents the summary of the above variables.

3.4 Data and Questionnaire

The aim of this study is accomplished by conducting a survey in the quantitative part of study and by having in depth interviews which include some open-ended questions in the qualitative part of the study. The research instruments were submitted to Human Research Committee of Applied Ethics Research Centre (HRCAERC) of Middle East Technical University for approval. The approval document is given in Appendix B. After the approval was obtained, the research instruments were applied to the company workers during 2016. This section gives the details of the survey.

3.4.1 Questionnaire and Measures

The survey items are presented in Appendix C and items are measured with different scales such as 5-point Likert-type (scale ranging from 1=strongly disagree to 5=strongly agree for avoiding misunderstanding), dichotomous (yes/no) and on metric scale (e.g. working years, position are metric scale).

The questionnaire concentrates on MES Adoption and Implementation Success Factors. To ensure data validity and reliability of the survey instrument, an iterative process of personal interviews was performed with four knowledgeable individuals who are the thesis supervisor and three company employees before distributing the survey to the participants. Their comments helped improve the quality of the survey. The survey is comprised of five parts. The first part is related to general information regarding the respondents, and the other parts are associated with both independent and dependent variables (Organizational Factors, Technological Factors & Innovative Characteristics, Individual and Organizational Impacts of MES).

The main frame of the survey (the research model) is designed based on DeLone and McLean IS success model. The questions about independent variables (organizational and technological factors) are adapted from Bradford and Florin (2003), and Chang et al., (2008). For instance, questions 11, 17, 18, 19 in Questionnaire Part B are similar to Bradford and Florin's questions: "Learning to use the ERP system has been easy for employees" and "Overall, the ERP system has been easy for employees".

DeLone and McLean (2003), Wu and Wang, (2006), and Bernroider (2008) research questions are used for dependent variables (Individual and Organizational Impacts). Furthermore, some control variables (education level, employment status, experience with ERP systems and experience in current company) are used in the thesis. Therefore, survey has different questions to analyze different points of view.

3.4.2 Survey Data Collection

The survey is specifically made for the predetermined company in 2016. Each participant has already had at least 2 years of experience in the company. Also, the MES was being implemented for 1.5 years when the survey was applied. Before the application of the survey, each participant is informed about the aim of the study and the filling procedure of the survey.

There are more than six thousand employees who are directly affected by MES. Most of employees are technicians (70%, blue-color) who are generally considered as the

data entry group, and others are the engineers/managers (30%, white-color) who are considered as the data user group. 75% of white color employees have a production-related job, while others have quality-related jobs.

One hundred employees filled the survey which is distributed as hardcopy, and each informant completed the survey (a response rate of 100%). One-thousand-survey output is sufficient for statistically meaningful analysis. According to Hair et al. (2010), to obtain the desired result, at least thirty observations are needed. Thus, it can be said that this study is sufficient for analysis.

CHAPTER 4

DESCRIPTIVE ANALYSIS

This section gives brief information about the survey especially about the characteristics of respondents and their views about MES. The profile of the survey respondents is shown in Table 5.

The respondents perform manufacturing related jobs. 93% of respondents are males and 7% are females. %33 of the company employees used similar ERP systems before. 65% respondents state that they are blue-collar workers. Half of the respondents have worked for more than five years in the company. About 65% of respondents are between 25 and 35 years of age. Lastly, approximately 50% of respondents have an undergraduate or a higher education level.

Table 6 reports the descriptive statistics of independent, dependent and control variables. In organizational factors, all variables' means are greater than 3. On the other hand, complexity mean is less than 3. In the survey, some variables (independent or dependent) have more than one question; thus, Table 6 covers more than one row for these variables. Among the organizational factors, top management support and change management culture have the highest values because they are the driving forces of change and there might be a relationship between them. When one looks into the technological factors, it is seen that business process reengineering has the highest value since employees generally want user friendly application and change in application for easy use. This argument is supported by examining the complexity results which are the lowest within technological factors. On the other hand, employees have to use MES to perform their job; therefore, "user use 1" variable has the highest value but they do not believe that MES supports their career opportunity when we examine the result of "Perceived User Performance 2" variable. The reason

might be that their company or sector does not require IS application knowledge as a prerequisite to employ someone.

As stated before, there are four control variables. Some analyses (cross-tabulation analysis etc.) are made not only using these variables but also using five questions from the questionnaires which are related to frequent and intensive use, firm corporateness view, job performance effect, user satisfaction and user-friendly application[6]. Figure 8 specifies the general results of these five variables. According to these results, MES has intensive use but employees think that MES is not a user-friendly application. Moreover, user satisfaction is low. The reasons for these findings might be that user interface is problematic, employees have some resistance to use MES and they do not know how to utilize the current data and how to analyze it.

The t-test is performed to understand whether results differ by control groups *(see Table 7)*. The t-test results are discussed below.

Education level statistically affects job performance, user satisfaction and the view towards user-friendliness of the application. The respondents with an undergraduate degree or a higher education level have higher rates in all five questions than the others apart from the user-friendly application view. Only 28% of the participants believe that MES has an easy-use structure and is a user-friendly software package. The reason might be the MES user interface or user screen for entering/reaching data. In face-to-face meetings and interviews, most employees said that the user interface should be changed and MES interface can look like a social-media screen.

Employment status also influences similar dependent variables (three dimensions stated above) as in the case of education level. Besides, its impact on corporateness is positive. The corporateness view is changing due to employee's role. The reason may be the business manner of employees which is changing from employee to employee. Moreover, white-collars have more awareness about IT system than blue-colors and

[6] Questions are C-25, A-1, C-26, C-39, B-11 in the survey, respectively.

they are more vulnerable to use IT system. They might think that IT system leverages company to higher levels and increases corporateness level.

Experience in the current company influences user satisfaction and user-friendly application view. The more experienced ones have greater satisfaction than the less experienced ones. The reason may be that they want a change in their company. Thus, they might believe that MES can make it possible.

The general use of MES application is about 87.50%. White-collar or high education level employees are a bit more satisfied than others. Furthermore, the more experienced ones tend less to use MES application compared to the less experienced workers in the company.

Last but not least, there are no differences between each group for frequent use and experience with the ERP systems. They do not have any significant difference regarding these five dimensions. For frequent use, the use of MES in daily jobs may be made obligatory by top management or supervisors.

Table 5. Profile of Survey Respondents

	Frequency/Percentage
Gender	
Male	93 (93%)
Female	7 (7%)
Education Level*	
Undergraduate degree or above	47 (47.5%)
Associate degree/High School	52 (52.5%)
Position **	
Production/Integration	69 (69%)
Process Engineering	6 (6%)
Production Planning	11 (11%)
Quality Assurance/Control	13 (13%)
Employment Status	
Blue-Collar	65 (65%)
White-Collar	35 (35%)
Experience with ERP Systems	
ERP Used Before	33 (33%)
Not Used Before	67 (67%)
Age Scale	
Less than 25 year	2 (2%)
26-35 year	63 (63%)
36-45 year	24 (24%)
More than 45 year	11 (11%)
Experience at Work	
0-5 years	8 (%8)
6-10 years	37 (%37)
10-15 years	18 (%18)
16-20 years	14 (14%)
More than 20 years	23 (23%
Experience in the Current Company	
0-5 years	51 (51%)
6-10 years	15 (15%)
11-20 years	30 (30%)
More than 20 years	4 (4%)

Notes. *1% omitted, ** 1% other position such as IT

Table 6. Descriptive Statistics of Variables

	Mean	*Std. Dev.*	*Min.*	*Max.*
Independent Variables				
Organizational Factors				
Understanding of Business Plan & Vision	3.58	0.996	1	5
Communication	3.29	1.334	1	5
Change Management Culture	3.85	0.946	1	5
Top Management&Supervisor Support 1	3.94	0.940	1	5
Top Management&Supervisor Support 2	3.63	0.973	1	5
Training 1	3.33	1.192	1	5
Training 2	3.50	1.137	1	5
Training 3	3.54	0.968	1	5
Technological Factors & Innovative Characteristics				
Compability	3.25	1.166	1	5
Complexity 1	2.7	1.114	1	5
Complexity 2	3.02	1.115	1	5
Complexity 3	3.18	1.137	1	5
Complexity 4	2.76	1.067	1	5
BPR 1	3.57	1.008	1	5
BPR 2	4.16	1.166	1	5
BPR 3	3.60	1.49	1	5
Control Variables*				
Education Level	1.46	0.501	1	2
Employment Status	1.35	0.479	1	2
Expericence with ERP Systems	1.67	0.472	1	2
Experience in Current Company	1.48	0.502	1	2
Dependent Variables				
User Use 1	4.20	0.819	1	5
User Use 2	3.72	1.020	1	5
User Use 3	3.61	0.998	1	5
User Use 4	3.09	1.216	1	5
Perceived User Performance 1	3.16	1.31	1	5
Perceived User Performance 2	2.67	1.32	1	5
Perceived User Performance 3	3.21	1.13	1	5
Perceived User Performance 4	3.14	1.23	1	5
Perceived User Performance 5	3.33	1.16	1	5
Perceived User Performance 6	2.93	1.23	1	5
Perceived User Performance 7	3.48	1.08	1	5
Perceived User Performance 8	3.19	1.20	1	5

Notes. *There are two categories for each one (see section 3.3.3).

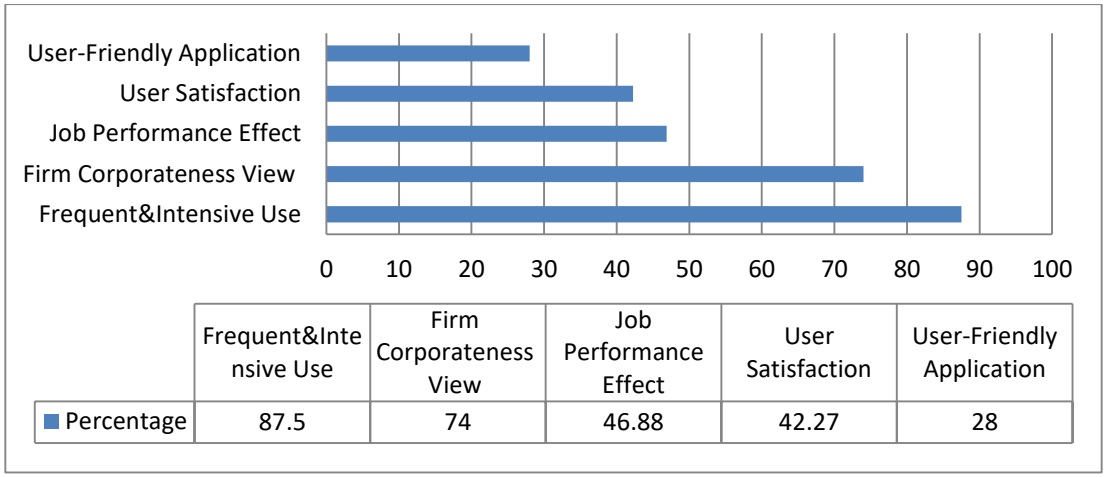

Figure 8. MES General Outlook

Table 7. Cross Tabulation of Control Variables and Outcome Variables

	Frequent&Intensive Use		Firm Corporateness View		Job Performance Effect		User Satisfaction		User-Friendly Application	
	Percentage	***t*-test**	**Percentage**	***t*-test**	**Percentage**	***t*-test**	**Percentage**	***t*-test**	**Percentage**	***t*-test**
General Result	87,50%		74,00%		46,88%		42,27%		28,00%	
Education Level						*		**		**
High School or Associate Degree	85,70%		69.2%		38,77%		32,00%		38,46%	
Undergraduate degree or above level	89,13%		80.8%		51,02%		47,82%		14,89%	
Employment Status				***		*		*		*
Blue-Collar	85,40%		66,15%		40,32%		33,33%		33,85%	
White-Collar	91,17%		88,57%		58,82%		58,82%		17,14%	
Experience with ERP Systems										
ERP Used Before	90,60%		78,79%		46,88%		50,00%		24,24%	
Not Used Before	85,90%		71,64%		46,88%		38,50%		29,85%	
Experience in Current Company								*		**
0-5 years	91,67%		72,55%		37,50%		32,65%		19,60%	
6+ years	83,34%		75,51%		56,25%		50,00%		36,73%	

Notes. *** Significant at 1%. ** Significant at 5%. * Significant at 10%.

4.1. Data Validity and Reliability

To test the model presented in Figure 7, stepwise linear regressions analysis is performed separately for each dependent variable (user use and perceived user performance) (*see Chapter 5*). Before the regression analysis, correlation of each variables and factor analysis are done.

Factor analysis, in the sense of exploratory factor analysis (EFA), is a statistical technique for data reduction. It reduces the number of variables in an analysis by describing linear combinations of the variables that contain most of the information and admit meaningful interpretations[7]. Its primary goal is to define the underlying structure among the variables in the study (Hair et al., 2010). There are four methods in Stata which are principal-factor, principal-component factor, iterated principal-factor and maximum-likelihood factor used for estimation and analyzing the correlation. In this study, principal-component factor is used as the extraction method because it best fits the survey data.

After data collection, the survey measures are subjected to a simplification process to assess their reliability and validity properties. An exploratory factor analysis is conducted including 24 measured items of 6 independent or dependent variables by using a principal component factor with varimax rotation. The cutoff point is decided based on the result of eigenvalues (which should be greater than 1) (Hair et al. 2010), and results are presented in Table 8. Six factors are extracted from these items through exploratory factor analysis. The factors are listed below (for more details, see Appendix A):

- user use,
- perceived user performance,
- top management and supervisor support,
- training,

[7] Available in https://www.stata.com/manuals13/mvfactor.pdf accessed on 03.16.2018.

- complexity and
- business process reengineering.

Table 8 presents the psychometric properties, factor loading, eingenvalue of main factor, cumulative variance explained and Cronbach's alpha for each construct. In order to evaluate the psychometric properties of the measurement model, convergent validity, which refers to the degree of confidence, is used.

According to Hair et al. (2010), factor loading should be greater than 0.50, and also it is generally considered sufficient for practical significance. Most of the factor loadings of the items in this research model is greater than 0.70. Cronbach's alpha is used to measure reliability and internal consistency of the factors that range from 0 to 1. It should be greater than 0.6 for better reliability. Most of the Cronbach's alpha of the items in this study is greater than 0.60, while some of them (BPR and top management) is greater than 0.5. Thus, all the factors in the measurement model have adequate reliability and convergent validity. Discriminant validity is evaluated to ensure that items do not cross load on multiple factors using varimax rotation.

Table 8. Validity and Reliability Analysis

	Item	Factor Loading	Eigenvalue of Main Factor	Cumulative Variance	Cronbach α
Dependent Variables					
User Use			2,31	0,5773	0,7517
	User U.se 1	0,5316			
	User Use 2	0,8358			
	User Use 3	0,8188			
	User Use 4	0,8109			
Perceived User Performance			4,89396	0,6117	0,9115
	Perc. Use Perf. 1	0,769			
	Perc. Use Perf. 2	0,7683			
	Perc. Use Perf. 3	0,7722			
	Perc. Use Perf. 4	0,7411			
	Perc. Use Perf. 5	0,7624			
	Perc. Use Perf. 6	0,7729			
	Perc. Use Perf. 7	0,8036			
	Perc. Use Perf. 8	0,8617			
Independent Variables					
Organizational Factors					
Top Management&Supervisor Support			1,41416	0,7071	0,5855
	Top Management	0,8409			
	Supervisor	0,8409			
Training			2,05427	0,6848	0,7732
	Training 1	0,8986			
	Training 2	0,8336			
	Training 3	0,7429			
Technological Factors & Innovative Characteristics					
Complexity			2,36561	0,5914	0,7606
	Complexity 1	-0,5546			
	Complexity 2	0,8413			
	Complexity 3	0,8435			
	Complexity 4	0,7991			
Business Process Reengineering			1,52834	0,5094	0,5047
	BPR1	0,7563			
	BPR2	0,5258			
	BPR3	0,8246			

Notes. Understanding of Business Plan & Vision, Communication, Change Management Culture and Compatibility variables are single question because of this reason these are omitted. Survey items used in this study is showed in Appendix A.

CHAPTER 5

RESULTS

By using linear regression analysis (ordinary least square regression) which is modeling the relationship between independent and dependent variables, hypotheses are tested to understand the relationship between eight independent variables and two success measures according to the research model in Figure 7. Before doing this, correlation matrix is created and presented in Table 9.

Based on this correlation matrix, the pattern of the relationships between the variables can be observed as follows:

- User use is negatively correlated with complexity construct. On the other hand, other variables are positively correlated with user use except control variables.
- Perceived user performance has similar results like user use.
- Education level correlates negatively with the understanding of business plan and vision and top management support. Besides, employment status is negatively correlated with the understanding of business plan and vision, and communication. These show that blue-color employees need more top management support, and understanding of business plan and communication in order to obtain better implementation success.

According to Bradford and Florin (2003), linear regression analysis can be used for exploratory analysis with relatively small sample sizes. For this study, six different regression models are performed for each success measure. We first add only independent variables, and then we add the control variables one by one; lastly, all independent and control variables are included in the regression model. R1 column of Table 10 and Table 11 shows only the regression model involving independent

variables, while R2 column shows the model with both independent and control variables. No significant change is observed in the model when the control variables are added one by one except for the employment status.

The results of the first model, regression of user use success measure on the independent variables, are presented in Table 10. The results reveal an R^2 of 0.66, proposing a very good fit for the model. Four variables are significant in this regression: Communication, Top Management and Supervisor Support, Complexity and Business Process Reengineering, respectively.

The results of the second model, regression of perceived user performance success measure on the independent variables, are presented in Table 11. The results reveal an R^2 of 0.56, proposing a good fit for the model. Four variables are significant in the model: Communication, Compatibility, Business Process Reengineering and Employment Status. Table 12 and Figure 9 summarize the results for all the hypothesized relationships.

It is interesting to note that employment status is significant for perceived user performance, negatively. Data entry and data user viewpoints are different from each other. Data users who are generally white-color employee do not know how to access data and use it. Furthermore, the change in their business manner is not straightforward. However, white color staff use data from MES for any analysis and they believe that their performance is increasing by reaching data easily and accurately. In other respects, data entry employees think that entering data is too time consuming and they actually do not want to do it. Moreover, data entry ones sometimes have a negative effect on data user ones, seeing that data entering is time-consuming.

According to the regression results, top management support has a significant impact on user use, significantly. Ehie and Madsen (2005) say that over two-thirds of the ERP projects are started by top management support. Therefore, their encouragement and support through the project implementation and adoption cycle are invaluable.

Both communication and business process reengineering are also noteworthy for these two success measures because understanding the project and user needs are important for better implementation success. Communication is important for understanding is of the business plan, user involvement, resolve conflicts and logic of the system.

Tatari et al. (2008) emphasize that business process includes some trade-offs between customization of the IS to legacy (current) business processes and reengineering the current business process to fit the IS. These two alternatives may cause some problems such as scope-creeps, application problems, and cost increase. In our study, some application problems are observed because of less business process reengineering.

Complexity and compatibility are the technological factors and both are significant in regression analysis. Especially, complexity is significant on user use measure and it shows that employee wants some improvement in application such as user screen customization, governance on data center, increase in business analytics reports etc. When we examine white-collar views about MES, they say that it is not a user-friendly application because reaching data is not straightforward.

Table-13 summarizes all the results and also gives comparison of this study with the other studies in the literature. According to this table, top management is the most cited variable in the literature, while BPR and communication are found to be the most significant factors in our study. This means that companies should give importance to these factors before IS implementation.

Table 9. Correlation Matrix

Variables	Under. of Bus. Plan&Vis.	Comm.	Change Mana. Culture	Top Mana.&Super. Supp.	Train.	Compa.	Complex.	BPR	Education Level	Employ. Status	Exp. with ERP System	Exp. in Current Comp.	User Use	Per. User Perf.
Understanding of Business Plan	1													
Communication	0.57***	1												
Change Management Culture	0.56***	0.61***	1											
Top Management and Supervisor S.	0.48***	0.41***	0.58***	1										
Training	0.38***	0.45***	0.39***	0.38***	1									
Compatibility	0.27***	0.21**	0.31***	0.27***	0.35***	1								
Complexity	-0.21**	-0.17*	-0.14	-0.17*	-0.3***	-0.35***	1							
Business Process Reengineering	0.43***	0.36***	0.39***	0.40***	0.32***	0.24**	-0.07	1						
Education Level	-0.23**	-0.17*	-0.15	-0.21**	-0.10	-0.08	-0.03	0.01	1					
Employment Status	-0.21**	-0.20**	-0.06	-0.09	-0.06	-0.05	0.08	0.05	0.79***	1				
Expericence with ERP Systems	0.01	0.022	0.04	0.12	-0.08	0.10	-0.13	-0.17	-0.28***	-0.24**	1			
Experience in Current Company	0.16	0.03	0.06	0.07	-0.04	0.15	-0.14	-0.05	-0.15	-0.03	0.03	1		
User Use	0.58***	0.55***	0.54***	0.52***	0.47***	0.39***	-0.35***	0.59***	-0.03	-0.10	-0.03	-0.05	1	
Perceived User Performance	0.45***	0.55***	0.51***	0.42***	0.46***	0.36***	-0.23**	0.53***	-0.10	-0.18*	-0.08	0.06	0.75***	1

*Notes. *** Significant at 1%. ** Significant at 5%. * Significant at 10%.*

Table 10. Linear Regression Results: User Use effect factors of MES

		(R1)	(R2)
Organizational Factors	*Understanding of Business Plan & Vision*	0.077	0.080
		(0.105)	(0.103)
	Communication	0.222	0.214
		(0.084)***	(0.089)***
	Change Management Culture	0.002	0.046
		(0.105)	(0.104)
	Top Management&Supervisor Support	0.128	0.167
		(0.085)	(0.086)*
	Training	0.036	0.007
		(0.087)	(0.092)
Technological Factors & Innovative Characteristics	*Compatibility*	0.050	0.072
		(0.068)	(0.073)
	Complexity	-0.245	-0.230
		(0.078)***	(0.080)***
	Business Process Reengineering	0.347	0.303
		(0.089)***	(0.088)***
Control Variables	*Education Level*		0.240
			(0.238)
	Employment Status		-.223
			(0.260)
	Expericence with ERP Systems		-0.139
			(0.156)
	Experience in Current Company		-0.173
			(0.140)
	Constant	-1.219	-1.009
		(0.480)	(0.661)
	n	85	84
	R-squared	0.64	0.66

*Notes: Robust standard errors in parentheses. Dependent variable is User Use. Coefficients are standardized coefficients. *** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares regression is used.*

Table 11. Linear Regression Results: Perceived User Performance Effect Factors of MES

		(R1)	(R2)
Organizational Factors	*Understanding of Business Plan & Vision*	-0.068	-0.113
		(0.104)	(0.123)
	Communication	0.265	0.240
		(0.088)***	(0.101)**
	Change Management Culture	0.128	0.159
		(0.103)	(0.116)
	Top Management&Supervisor Support	0.024	0.043
		(0.109)	(0.113)
	Training	0.097	0.114
		(0.090)	(0.096)
Technological Factors & Innovative Characteristics	*Compatibility*	0.115	0.118
		(0.065)*	(0.070)*
	Complexity	-0.065	-0.044
		(0.078)	(0.087)
	Business Process Reengineering	0.345	0.330
		(0.080)***	(0.086)***
Control Variables	*Education Level*		0.284
			(0.192)
	Employment Status		-0.490
			(0.261)*
	Expericence with ERP Systems		-0.165
			(0.196)
	Experience in Current Company		0.199
			(0.172)
	Constant	-1.572	-1.251
		(0.470)	(0.838)
	n	85	84
	R-squared	0.54	0.56

*Notes: Robust standard errors in parentheses. Dependent variable is Perceived User Performance. Coefficients are standardized coefficients. *** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares regression is used.*

Table 12. Hypothesis Testing Results

Hypothesis	Variables	User Use Effect	Perceived User Performance Effect
H1	*Understanding of Business Plan & Vision*		
H2	*Communication*	(+) ***	(+) **
H3	*Change Management Culture*		
H4	*Top Management&Supervisor Support*	(+) *	
H5	*Training*		
H6	*Compatibility*		(+) *
H7	*Complexity*	(-) ***	
H8	*Business Process Reengineering*	(+) ***	(+) ***

**** Significant at 1%. ** Significant at 5%. * Significant at 10%.*

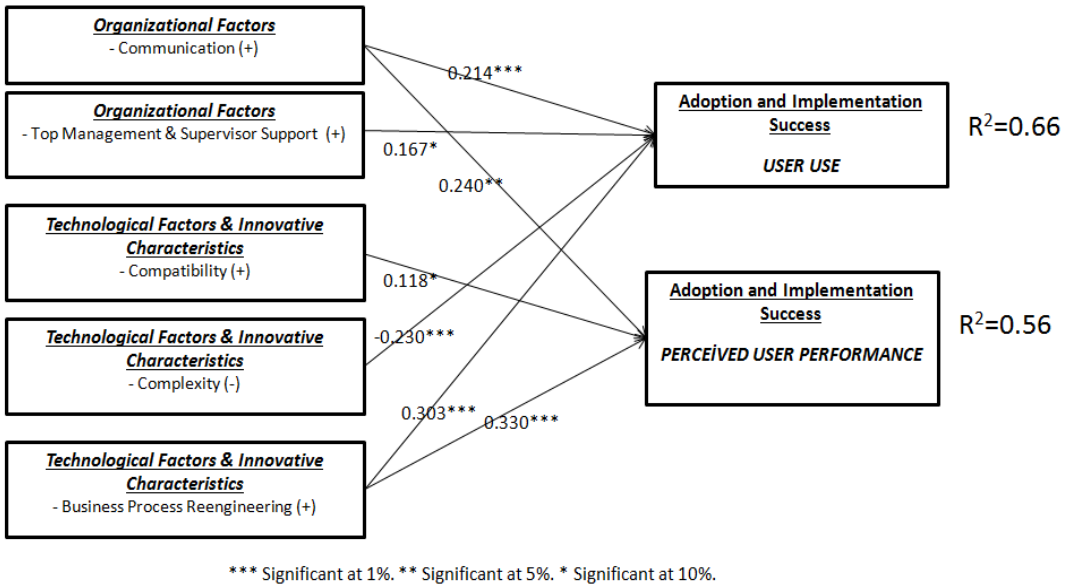

Figure 9. Hypothesis Testing Schema

Table 13. Comparison Table Between Literature and Thesis

Dimensions	***Variables***	Bradford, Florin (2003)	Sarker, Lee (2003)	Ehie, Mads. (2005)	Zhang et al. (2005)	Wu,. Wang (2006)	Bernroid. (2008)	Chang et al. (2008)	Wang, Liao (2008)	Tatari et al. (2008)	Petter, McLean (2009)	Garg (2010)	Ozorhon Cinar (2015)	Thesis (2018)
Orga. Factors	*Understanding of Business Plan & Vision*	O			X		X			X			X	O
	Communication		O				X			O			X	X
	Change Management Culture				O			X					O	O
	Top Management& Supervisor	X	X	X	X		X			O		X	X	X
	Training	X			X					X		X	O	O
Tech. Factors	*Compatibility*	O		O	X			X						X
	Complexity	X			X	X		O	X		X			X
	Business Process Reengineering	O		X	X					X				X

Notes. “X” means that this factor (row) is statistically significant in this article (column). "0" means that this variable used in this article but not statistically significant.

5.1. Robustness of the Study

In this study, the quantitative analysis revealed that communication, top management and supervisor support, compatibility, complexity and business process reengineering are critical success factors. On the other hand, the qualitative analysis shows similar results to the quantitative analysis. This section gives the details of qualitative analysis (*See section 3.2 for data collection process of qualitative analysis*).

According to qualitative results, all practitioners believe that business process reengineering is needed for attaining the goal of MES's because defense industry has high quality necessities and the best practices of MES actually do not fit the company requirements, and thus, some customization is required from employees.

In addition to BPR, top management and complexity are mentioned more during the interviews. Employees believe that if top management supports any project, it can be useful for company and they must do what is necessary for success. In other words, using of new system must be mandatory to obtain better efficiency. Moreover, if an employee does not comply with the new system, he/she could not perform his/her job accurately and shows poor performance. Workers complain about MES user interface such as job route entry and job status entry screens since they are too complicated and data entry is not easy. Thus, they also want that screen can be like a social-media screen to make it more user-friendly.

Employees also believe that compatibility is a big problem in terms of easy use and accessibility. They always complain that there is only one-way data access point and reaching all data from one point such as manager cockpit or governance of all data point etc. are required. Furthermore, some areas (such as energetic region where is explosive production area) have not good access to MES and barcode systems do not work properly. What is more, wireless technology is forbidden in defense industry; therefore, using MES real time is sometimes impossible.

Communication and understanding the aim of the project are important for employees to feel a part of the project. Respondents of qualitative analysis argue that these two are indispensable for better adoption.

In contrast to quantitative analysis results, change management is more significant in qualitative analysis. Practitioners say that resistance to change and prejudice are too high during implementation and they prevent the implementation and diffusion of the system.

According to Oslo Manual (OECD, 2005), there are four types of innovations which are product, process, marketing and organizational innovation. Interview participants think that MES is a process innovation in general. However, it might be a radical innovation for their company because of the driving force behind the MES, which causes some management changes in production.

Employees generally believe that MES enables company to have an easy access to data, to monitor production and to make quick decisions. Table-14 gives us more details (some key words) about the interviews based on the five questions listed below (and also see Section 3.2 for the detailed interview process):

1. What are the goals of/gains from the MES project? Could you list the individual and organizational achievements? (Individual Impact (Use and Performance): Time savings, reduction in research cost, change in business communication, easy access to data, Corporate Impact: Detection of resource utilization, traceability, performance and career management)
2. What are the challenges you face during the project process? What categories can be created if you want to categorize them? (Technological Factors: MES's compliance with the company system (hardware and software compliance) MES complexity, process reorganization, Organizational Factors: Project/Product/Process Variety, Industry Constraints, Employee Culture, Failure to understand MES Vision, Communication, Change Resistance).

3. Do you think the project is now applied at the desired level and according to the criteria (collecting real-time data, analyzing the gathered data) by the company? If you needed to score this, what score would you give over 5? (... / 5)
4. If you want to start the project now, which processes would you like to change? What are your learned lessons?
5. If we take this project as a kind of change management because all the processes related to production with this project are examined or changed, what kinds of changes are expected to be made in the future?

   Is there a change in the organizational structure of the company with this project? Is it expected to occur?

   Has the role of processes which have not any owner been determined?

   According to Oslo Manuel, there are four types of innovations (product, process, organization and marketing innovations). Radical and incremental innovations (Schumpeter) are also found in the literature. Could you explain which innovation fits MES at the company level?

Table 14. Summary Results from the Interviews

Ques. #	Practitoner #1	Practitoner #2	Practitoner #3	Practitoner #4	Practitoner #5
1	Increase in Competitiveness, Production Monitoring Remotely, Easy Access Data, Analyze Data Easily	Changes in Business Manner, Easy Data Access, Increase in Traceability, Quick Decision-Making	Data Gathering, Scheduling, Production-Tracking, Assure Right Data, Career Development	Environmental Solution (Paperless Production), Easy Data Access, The Necessities of the time, Easy Workflow and Failure Mode and Effects Analysis	Increase in Productivity, Work Flow Tracking, Online Error Tracking and Solving, Increase in Traceability, Business Process Reengineering at Production and Quality Processes, Easy Access to Data, Enabling Resource Anaysis, Digitizaliton of Production
2	**Business Process Reengineering Needed**, New Technology (Barcode) Embedded to MES, **MES Interface Complexity (Floor Change, Record Change Sheet Screen**), Change Resistance of Technician Level, Manager Cockpit Needed	Organizational Culture Resistance (Especially technician level), Problems in Vision&Mission Dissemination, **Convince (Communication)**, Awareness in MES Benefits, **System Complexity**, **One-way Data Access (Compability)**	Organizational Culture Resistance, Trained at all levels, **Top Management Support, Business Process Reengineering**	**Top Management Support**, **Business Process Reengineering**, Organizational Culture Resistance (Especially technician level)	Organizational Culture Resistance (Resistance to Change, Prejudice), Defense Industry Constraints (Non-use of Wireless Technology and Mobile Device, and also Exproof Device Requirement), **Complexity and Compability of Software (Best Practices)**, **Business Proses Reengineering**
3	Resource Reports and Real-time production tracking are indicator of MES use efficiently. (4.5 out of 5)	Not use in MES objective direction. (2.5 out of 5)	The objectives seized but some improvement needed. (3.5 out of 5)	Paperless Production objective obtained. (4 out of 5)	Ownership Problem, Not use production and quality KPIs, Might be use in root-cause analysis (3 out of 5)
4	**User Interface Changement (RCS, FC, DR)**, Add Barcode System to MES effectively	Project Vision Dissemination (Lack of Corporate Information), Key user can not tell the system accurately, Resistance to Change. **User Interface Changement**, Facilitating Data Entry	Project Dissemination Process Redesign (Energetic Region Dissemination etc.)	Active Barcode System Use, **User Interface Changement**	Needed much more BPR (such as Discrepancy Report, Production Following Report (Trav) etc.), Active Barcode System Use, Changes needed in work done from different production department for allignment (Job Shop, Assembly Line)
5	Process Innovation, Instruction Redesign, Use in Marketing Purpose Drawbacks: Theoretical Implemenation Initially, Problem in Pilot Application	Radical and Process Innovation. Ensure to close gray spots	Radical and Process Innovation. Ensure data reliability. New unit opened.	Radical and Process Innovation	Radical and Process Innovation, Step to Digitilization, New Concepts Shaped such as Production Line Depot, Data Entry to ERP from employee who perform the job. New unit opened.

CHAPTER 6

DISCUSSION

As shown by the analyses detailed in previous chapters, there is a comprehensive body of information about MES implementation and adoption issues in Defense Industry, which focuses on both research and development as well as manufacturing. MES helps company to follow production status, material flow, resource usage rate and following production/quality steps in operation stage level. Now, company use MES outputs for better manufacturing management compared to the past. Both qualitative and quantitative analyses, communication, top management & supervisor support, compatibility, complexity and business process reengineering are coming in view as the most significant critical factors for adoption. In addition, qualitative analyses revealed change management as a significant phenomenon.

This study explains and confirms that communication and business process reengineering are the most critical success factors for MES adoption (*see Figure 9*). Communication is an organizational factor while business process reengineering is a technological factor. Ngai et al. (2008) suggest that business process reengineering can be added to the organization-related factors. In this regard, organizational factors might be more worthwhile for IS implementation as explained by Zhang et al. (2005), Tatari et al. (2008) and Garg (2010).

Communication is crucial to avoid misunderstandings as it hampers potential conflicts during the implementation process of IS system. In addition, it provides user involvement: users may develop a sense of ownership of the project. Building confidence between implementation team members via communication plays an important role in success. Communication is also needed to align all parties to create a common understanding of the project, leading to a consensus over project goals. Ozorhon and Cinar (2015) revealed that communication is indeed significant. In

addition, other literature (e.g. Zhang et al., 2010; Madsen, 2005) sometimes added this factor in top management, clear goals and objectives and project management factors. Communication also reflects a unique culture, the corporate identity of an organization. Openness in communication might increase the impact of MES.

The business knowledge, work processes and practices could vary among organizations. When organizational needs related to MES are identified in advance, it leads to faster implementation of objectives. These are indicators of the ideal business process reengineering performed in an organization. Ehie and Madsen (2005), Zhang et al. (2005) and Tatari et al. (2008) found that BPR are one of the most critical success factors for ERP implementation. Firms should deliver tools and practical experience needed to integrate new processes, roles, and responsibilities to their employees for change internal work practices. Training in new technologies such as ERP, MES etc., top management support and change management culture can introduce a certain level of change and ensure a successful transition of MES.

On the other hand, the era of legacy systems[8] might become a hurdle to both business process reengineering and MES implementation, and lead to additional requirements for the MES project team to satisfy. For instance, MES practitioners state that some user interfaces should be changed to reach more user-friendly application. As a result, the company earns new terminologies that are related to production logistic. Moreover, new report formats which are in failure in MES implementation by using best practices packages are occurred by project team. These and the in-depth interview with all parties show that customization is required. Besides, interviews show that MES packages sometimes fail to satisfy local requirements (e.g. energetic area requirements). In addition, the more customization is expected to lead to higher user satisfaction, leading to positive impacts on individual productivity, resulting in organizational productivity improvements according to the interview.

[8] Legacy system is past or unimproved system used in informatics.

Top management is the key enabler to overcome many problems such as the resistance of other employees, achieving business process reengineering and any dysfunctional aspect of the organizational structure or the business processes (Negahban et al., 2012). The most important practical implication of this finding is that strong and committed leadership at the top management level, at the project management level, and of the IS function must be given significant priority throughout the life of an ERP or IS implementation project (Sarker and Lee, 2003). Technology use is sometimes voluntary and mandatory. Top management has a critical role for mandatory environment. On the other hand, user involvement is also crucial for voluntary environment. Apart from this primary support of top management, political and behavioral support is also important for the development to run smoothly, especially when there is significant resistance from the staff. Furthermore, the attitudes, beliefs and experiences of managers might have adverse impacts on the IS success and top management support (Ngai et al., 2008). In this study's literature review, eight of the twelve articles that we have reviewed previously (*see Table 4*) comprise qualitative or quantitative analysis methods that cite top management support as a critical intervention.

Complexity has an inverse relationship with MES implementation and adoption. Comparable results are reported in many other studies such as Wu and Wang (2006), Wang and Liao (2008), Petter and McLean (2009) and may others. For instance, Wu and Wang (2006) found that user attitude is influenced by beliefs about complexity of system, which then impact on user use and embody user's attitude. Moreover, it only ensures standard IS use and does not alter user perceived performance or benefits. On the other hand, complexity is related to easy use of user screens. It is shown that employees prefer the screen to be user friendly and resemble a social media interface.

Zhang et al. (2005) and Chang et al. (2008) also found equivalent results like our study in terms of compatibility construct. Compatibility compromises hardware and software communication and companies may have different constraints in this regard. For instance, defense industry has a wireless problem and so tablets might not be used widely when using MES in shop floor. Therefore, before implementation of such a

system, company should think similar constraints which can be company or country specific. This construct has not been researched in detail (to the best of our knowledge) so that our study result may be one of the beginning researches.

Despite the similarities between other studies, this study reveals that communication and business process reengineering is more important than other studies (e.g. Bradford and Florin (2003); Zhang et al. (2005); Tatari et al. (2008); Garg (2010) etc.) since others emphasizes on understanding on business plan, top management support or training. Moreover, this work contains both quantitative and qualitative approach for analysis and validation therefore it is more comprehensive. Besides, blue-color employees' views are considered in this study and their view is changing in corporateness, job performance effect, user satisfaction and user-friendly application constructs.

The implementation and deployment of IS systems are not an easy process because it contains high levels of complexity and uncertainty: too many people are related to these projects, implementation budget is usually high, and pressure of top management is huge. Therefore, stress levels of the project manager are usually high. Information systems enable companies to reach digitalization and automation of company goals. However, cultural issues, functionality requirements (different stakeholders' necessities), IS practices (IS has best practices structure but it may be barrier of business process reengineering), communication, top management support, user and vendor involvement, complexity of IS etc. are key factors for good implementation and adoption. Hence, before applying IS technology in a company, following steps should be considered:

- Defining company requirements,
- Prioritizing requirements,
- Checking requirements whether they match the purchase application/software infrastructure or not (Business process reengineering is critical at this point. Moreover, compatibility between hardware and software and complexity of software is crucial for success.),

- Strengthening the IT department power such as reorganization or enable it C-level representation such as Chief Digital Officer (This is important for top management support),
- Organizing awareness seminars or pre-trainings (These include change management awareness and software structure trainings) before implementation,
- Last but not least, there should be a communication plan for these project implementation and adoption. Also, project management group has power for implementation and they should define communication frequency between all stakeholders.

6.1 Steps to Digitalization and Industry 4.0

In an era where globalization is highly intense, digitalization of company processes is vital for an enterprise. Companies need to keep up with the requirements and expectations of their external and internal customers in a timely manner. ERP and MES have important impacts on meeting expectations and to seize the Industry 4.0. Companies need to put more attention on the implementation of IS systems in their technology plan.

Furthermore, MES systems require timely data input to ensure availability of end product of the system in a timely and accurate manner. Companies could elevate their operational performance and monitor their key performance indicators to enhance their efficiency.

Traditional employees generally rely on printed reports. However, the world is changing. According to Siemens[9], Industry 4.0 which digital transformation and help to industry or people for reducing time-to-market, enhancing flexibility, increasing quality, and increasing efficiency. Furthermore, it needs a holistic approach to optimize the entire value chain not only process industry that is involving extraction

[9] Available in https://www.siemens.com/global/en/home/company/topic-areas/future-of-manufacturing/digital-enterprise.html#FrequentlyAskedQuestions and http://www.industry.siemens.com/topics/global/en/digital-enterprise-suite/Documents/PDF/Special-Publication_Digital-Plant_atp03-15_english.pdf accessed on 03.16.2018.

of raw materials but also discrete manufacturing is generally defined as limited volume manufacturing but it has very high complexity in manufacturing environment. Industry 4.0 enables task productivity, task innovation, customer satisfaction, management control and less asymmetric information through accessing data easily. There are lots of expectations from digitalization. Hence, all parties related to digitalization have some responsibilities such as government support or investment and collaboration between industry, university, research center, technology providers and government are significant.

Some think that employment crisis might occur due to Industry 4.0. However, it is actually a strong claim, since this era opens new work areas and employment opportunities, especially in mechatronic and information technology. People who work in these areas should be appreciate this change.

On the other hand, open platforms, do it yourself culture, additive manufacturing via 3D printer, lights-out manufacturing (7/24 running plant with robotic and automation technology) artificial intelligent, big data and disruptive innovation viewpoint obligate industry to make a big leap to digitalization. In the light of the above information, Industry 4.0 or Smart Manufacturing is a real, not a hype.

MES fills the gap between business systems and plant shop floor, creating the conditions for an efficiency increase at the plant and within the supply chain operations. Moreover, it makes real time production adjustment possible, together with just-in-time delivery, workflow management and electronic work instructions. It is center of between PLM/ERP and automation technology. For this reason, MES plays an important role for seizing the future digital world. Policy makers must be more careful than before during implementation of IS system because of the benefits and impact of digitalization mentioned above. There should be a digitization policy at the governmental level, which includes government's investment plan and is open for use of all sectors. Companies may decide their digitalization (Industry 4.0) strategy by checking the country policy and their own experience. For instance, there are lots of different business conditions and government/legal standards so firms in a country

should accommodate country-specific business practices. These also may result in different data, functionality and output requirements which a foreign software package might not be able to satisfy. Hence, Software (such as MES) adopting firms must evaluate and select a software package carefully to reach successful implementation.

Digitalization is not easy and painful process for company and government. By using the results of our qualitative and quantitative analysis, there can be following mechanism for better adoption of digitalization. Hence, government digitalization policy document includes the following mechanisms or steps for success:

- Understanding the function of digitalization (e.g. awareness seminars help to understand),
- Constituting steering committee which is consisted of both top management and other employee or sharing platforms (Since these increase the communication and commitment. Platform can be consisted of combination of private sector, unions, research center, university and government.),
- Constituting project management office (Since they are responsible of training, deployment of projects, understanding of requirements, enabling business process reengineering of IS tools etc.)
- Defining current systems' lacks and making requirements analysis (e.g. technology roadmaps are needed to easy understand.),
- Involving country culture pieces (e.g. if the willingness of change in country is low, there should be some activities to increase it.),
- Prioritizing critical research and development/digitalization activities,
- Developing new education policy (state level) and training strategy (both company and state level) are needed to achieve digitalization goals and obtaining new capabilities. State should allocate money to it and manage it. (IT based education is important for Industry 4.0 and Digitalization. Data analytic knowledge might be compulsory before graduation for all departments. Moreover, state gives importance to trainee blue-color level person for surviving with digitalization),

- Creating new technological investment plan (e.g. technological infrastructure investment such as information communication center investment, data center, wireless technology, cloud computing, cyber security, autonomous robotic etc.),
- Developing support mechanism to company for their investment in digitalization (e.g. government account for some investment cost of digitalization tools. Investment plan includes both big companies and small companies.),
- Enforcing obligation in public purchase (e.g. if state buys an automobile from a company, it makes obligatory the company use a system such as PLM, MES, ERP etc.),
- Changing employment policies and some regulations (e.g. strategic workforce planning, re-organizational structure, co-operation with partner and subcontractors, IT based qualification for role and responsibility, change management team role etc.),
- Supporting for local know-how/software producers and smart manufacturing factories (e.g. supporting local software producers (such as ERP, MES producers etc.) is needed for preventing business process reengineering problems, compatibility issues and complexity in software adaption.) (TÜSİAD, 2016),
- The last but not the least, following sustainability and evaluating impacts of above mechanisms.

The reasoning of above mechanisms is required to compete other countries or companies which have low-cost labor. Above mechanisms can increase open innovation because easy access to information, enables to reach smart things easily such as intelligent manufacturing, meet innovative, produce national and indigenous products more easily, declines time-to-market process, reduce wastage rate and production cost. The future age will comprise of three things that are intelligent in all thing, digitalization of everywhere and interaction of all systems (e.g. machine-to-machine, human-to-machine etc.) (TÜBİTAK, 2017). The critical success factors are

found in this study take into consideration before implementation and adoption of digitalization for success.

6.2 Limitations and future research

The research model installed is based on a single case study from one organization. Hence, generalizing the research findings need further research and validation such as assessment on a variety of samples in similar as well as different contexts. For instance, study from different firms, culture and country and different IS tools which are related to ERP or MES should be performed to evaluate the model and strengthen its precision power. The sample size of study quantitative analysis is relatively less so that the study might be both less convincing and accurate and less representative of industry or country. Moreover, the study evaluates only MES, kind of ERP or module of ERP and not purely ERP. Therefore, there might be adding the all ERP-related technology in a further study. However, to my knowledge, this is the first study to evaluate MES implementation and adoption success factors.

The use of technicians, engineers and certain managers is a proxy for understanding of organizational level use of MES. This level of examination is selected since they usually use MES in their jobs. Next studies different views should be added the study such as directors', vice-president view. However, IS systems' evaluation generally only white-color employees are taken into consideration by researchers. On the contrary to this, we also take blue-color level into consideration and mentioned above parts their view could be different from others.

Over and above, other critical exogenous variables, such as the level of service quality such as IT personnel support and consultant issues, software package selection, vendor effect, end-user involvement and characteristic and lastly project team competence/leadership can be involved next studies.

Software vendor and vendor consultants committed help to create better solutions, especially for business process reengineering since consultants may be a cause of ERP failures for organization.

On the other hand, end-user involvement and characteristics are important because their characteristic can affect the ERP project success, negatively or positively (Zhang et al., 2005) Successful implementation of MES systems requires close coordination among various stakeholders within the company. In order to have an effective and fast decision making, the project management team must be empowered and they should create good plans for successful MES implementation (Sarker and Lee, 2003).

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APPENDICES

A. SURVEY ITEMS USED IN THIS STUDY

Variables	Analysis Items	Question Section and Number in Survey
Understanding of Business Plan & Vision	Understanding of Business Plan & Vision	A-2
Communication	Communication	A-3
Change Management Culture	Change Management Culture	A-4
Top Management&Supervisor Support	Top Management	A-5
	Supervisor	A-6
Training	Training 1	A-7
	Training 2	A-9
	Training 3	B-14
Compatibility	Compatibility	B-13
Complexity	Complexity 1	B-11
	Complexity 2	B-17
	Complexity 3	B-18
	Complexity 4	B-19
Business Process Reengineering	BPR 1	B-20
	BPR 2	B-21
	BPR 3	B-23
Education Level	Education Level	Intro-3
Experience in Current Company	Experience in Current Company	Intro-5
Employment Status	Employment Status	Intro-7
Experience with ERP Systems	Experience with ERP Systems	Intro-9
User Use	User Use 1	C-25
	User Use 2	C-30
	User Use 3	C-35
	User Use 4	C-39
Perceived User Performance	Perc. Use Perf. 1	C-26
	Perc. Use Perf. 2	C-31
	Perc. Use Perf. 3	C-32
	Perc. Use Perf. 4	C-33
	Perc. Use Perf. 5	C-34
	Perc. Use Perf. 6	C-36
	Perc. Use Perf. 7	C-37
	Perc. Use Perf. 8	C-38

B. HRCAERC APPROVAL

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Gönderen: Prof. Dr. Canan SÜMER
İnsan Araştırmaları Etik Kurulu Başkanı

İlgi: Etik Onayı

Sayın Yrd.Doç.Dr. Semih AKÇOMAK'ın danışmanlığını yaptığı yüksek lisans öğrencisi Hasan YAVUZ'un "Üretim Yönetim Sistemi'nin Şirket İçinde Yayılımı ve Şirkete olan Etkileri" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2016-FEN-022** protokol numarası ile **01.03.2016-01.07.2016** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER
İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Meliha ALTUNIŞIK
İAEK Üyesi

Prof. Dr. Ayhan SOL
İAEK Üyesi

Prof. Dr. Mehmet UTKU
İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR
İAEK Üyesi

Yrd .Doç .Dr. Pınar KAYGAN
İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK
İAEK Üyesi

C. QUESTIONNAIRE FORM

Dear Respondent,

This survey is prepared for graduate thesis that has been conducting at Middle East Technical University Science and Technology Policy Studies. This study aim is to search *"The adoption, individual and organizational impacts of Manufacturing Execution System (MES) in a company"*. For this purpose, you can fill the survey questions by your expression.

To answer the questions that make up the questionnaire, you will get an average of 15 minutes.

We would appreciate your reply without leaving all the questions blank, thank you for your contributions. You can place an "X" or "□" mark on your markings.

Introduction: Findings from the questionnaire will be used for scientific purposes only. Do not include your name on the questionnaire forms. Participation in this survey is voluntary.

Thank you in advance for your contribution to this research.

Thesis Consultant:

Associate Prof. Semih Akçomak

Prepared by:

Hasan Yavuz

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In this section you are asked about your personal information. Please tick the option that matches your situation.

1. **Gender:**
   Female ( )
   Male ( )

2. **Age:** _____

3. **Education Level:**

Primary School ( )

High School ( )

Undergraduate ( )

Graduate ( )

Doctorate ( )

4. How long have you been in your working life? _____

5. How many years have you been working at your current business?

_____

6. What is your business (number) in your working life for current workplace?_____

7. **Position:**

Engineer* ( ) Manager ** ( )

Production Technician ( ) Administrative Officer ( )

Quality Technician ( )

**Engineer represents Engineer, Expert Engineer and Senior Engineer.*
*** Manager represents Chief Engineer, Department Manager and Director*

8. Department:

Production/Integration ( )	Process ( )
R&D (Design) ( )	Production Planning ( )
Information Technologies ( )	Quality ( )
Other ( )	

9. Have you previously used a manufacturing execution system (MES) or an enterprise resource planning system (ERP) similar to the MES project?

Yes ( ) No ( )

NOTE 1: *When responding to the questions, mark the relevant statement by taking the columns: Strongly Disagree, Disagree, Neutral (Undecided), Agree, Strongly Agree.*

NOTE 2: *The Not Applicable (N/A) column will be highlighted if you have no information about it. This column is in some parts.*

A. Please indicate below MES related questions taking into account the organizational character of your workplace and the institutional culture.agr.					
Please read carefully each of the following phrases and your opinion about your participation in the degree is not within the scope of evaluation ranging from "I definitely do not Participate" to "I Participate Strongly" specify one of the answer options by placing an X in it.	**Strongly Dis.**	**Disagree**	**Neutral**	**Agree**	**Strongly Agr.**
1. MES Project is a project that affects the corporateness of our company positively.					
2. At the beginning of the MES Project, the purpose or objectives of the project were transferred correctly.					
3. During the implementation of the MES Project, the views of me or the directorate have worked with have been taken into consideration.					
4. The MES project is an example of our company's changing culture.					
5. Top management wants to use MES while fulfilling the tasks required by my job.					
6. I am doing the requirements of the MES because top management /line manager think that it is useful for our business.					
7. I believe that the training given to learn MES is sufficient.					
8. When I use MES, I get sufficient the support from my friends.					
9. During the implementation of the MES project, I received the necessary support from related department (Production Planning & Management Information Systems).					
10. My previous training (ERP-like software, etc.) speeded up my use of MES.					

B. Please describe how you participate in the followings MES project design and application, taking into account the technical and perceived difficulties of the system during the MES project implementation and the simplification of the processes.						
Please read carefully each of the following phrases and your opinion about your participation in the degree is not within the scope of evaluation ranging from "I definitely do not Participate" to "I Participate Strongly" specify one of the answer options by placing an X in it.	**Strongly Dis.**	**Disagree**	**Neutral**	**Agree**	**Strongly Agr.**	**N/A**
11. MES is easy to use and user friendly software package.						
12. MES is easy to use because it is compatible with the systems (software & hardware) we use in the current situation. (Only engineer level will answer.)						
13. Due to MES project, there is a sufficient infrastructure (computer, ERP access, etc.) and it enables to use MES, easily.						
14. When I want to know the points I do not know about MES, I know that there are relevant information notes, documents and videos.						
15. I can reach people who will provide the necessary help when I encounter technical problems with MES.						
16. When I want to know the points I do not know about MES, I can easily access the relevant information notes, documents and videos.						
17. It took a long time to learn and use MES.						
18. I have worked hard to learn and use MES.						
19. In general, I believe that MES is a complex and difficult software package.						
20. When MES is used, it is understood that improvements and regulations are made in the old system (paper based production).						
21. Improvements should be made to ease the use of MES users.						
22. I can contribute to improvements in MES.						
23. At the time of MES establishment, process simplification was made at the desired level (removal of unused processes existing in the old system or elaboration of processes for which the process owner is uncertain). (New employees (those who entered after 2014) will not respond.)						
24. I can get the data I can use in MES analysis. (Only engineer level will answer.)						

C. Please answer the following questions by considering the work you have done and your contribution to your own development by consideration of MES Project.						
Please read carefully each of the following phrases and your opinion about your participation in the degree is not within the scope of evaluation ranging from "I definitely do not Participate" to "I Participate Strongly" specify one of the answer options by placing an X in it.	**Strongly Dis.**	**Disagree**	**Neutral**	**Agree**	**Strongly Agr.**	**N/A**
25. I use MES very often and intensively.						
26. MES has made a positive impact in my current performance.						
27. Thanks to the information I have from MES, I can do my analysis more quickly, easily and efficiently. (Eg. process optimization (6-sigma studies), poor quality costs report, error analysis studies, preparation of an as-built list, etc.) (Only engineer level will answer.)						
28. Thanks to MES, we can produce better quality outputs / results / reports.(Only engineer level will answer.)						
29. I can reach the internal portal (intranet) of the company thanks to the computers installed in the workshops with MES and I can have more information about our company. (Only the technician level will answer.)						
30. I can easily get to work and related information from MES.						
31. I think that I can get career opportunities in the future with MES (e.g, learning ERP has contributed to me).						
32. MES has increased the diversity of my work (tasks in job description have diversified).						
33. Thanks to MES, my communication with the stakeholders in the projects I have worked on increased.						
34. I can get a quick decision about the work via data obtained from MES.						
35. Thanks to MES, I can reach the correct data.						
36. My work efficiency has increased with the MES project.						
37. MES enables me to learn new information.						
38. MES has provided me to give a new ideas. (For example, I can make proposals for process improvement.)						
39. I am generally satisfied with MES.						
40. I will be able to respond more quickly to the work that is expected to be approved as a result of the workflow at the MES. (Eg. RCS, FC & UDF & BUDF approval etc.) (Only engineer level will answer.)						

D. Please answer the following questions considering the impact of the MES project on your company.

(Only the workshop supervisor, planning engineer and manager will answer)

Note: If you do not have any comments / questions about the questions, tick the Not Applicable (N/A) column. The option Neutral is the option to mark when you are unstable.

Please read carefully each of the following phrases and your opinion about your participation in the degree is not within the scope of evaluation ranging from "I definitely do not Participate" to "I Participate Strongly" specify one of the answer options by placing an X in it.	**Strongly Dis.**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**N/A**
41. MES ensures real-time traceability of materials.						
42. MES reduces the waiting times for semi-finished products / finished products.						
43. MES is helping productivity by reducing paperwork.						
44. MES has reduced its production inventory (WIP Inventory) as it provides real-time traceability of materials, semi-finished products and finished products.						
45. MES allows the right scheduling in production.						
46. MES ensures accurate calculation of resource usage (man, machine, etc.) in production.						
47. MES helps to see bottlenecks by making it easier to proactively act.						
48. In MES, more accurate decisions can be made in procurement of resources (workbench and manpower).						
49. MES has increased productivity in production by reducing waiting times (waiting for approval, batch waiting, etc.).						
50. MES ile birlikte şirketimizin bilgi sistemleri hizmetlerinde gelişme olmuştur. (Ör: Ağ hizmeti her atölyeye 24 saat verilebilmektedir.)						
51. Since the production can be monitored in real time with MES, the management reporting period has been shortened.						
52. MES has provided our company's corporate memory.						
53. MES has increased the sharing of information in our company.						
54. MES has provided increased communication in our company.						
55. MES can provide resource performance indicators that can create input into career management and individual performance management.						

56. MES has ensured that our company has a systematic knowledge of all production lines.						
57. Thanks to MES, it is predicted that customer satisfaction will increase by transferring our correct production outputs (documents, inspection reports, etc.) and production capacity.						
58. MES has caused organizational change in the company (establishment of new units, changes in job descriptions, etc.).						

E. Please let us know what else you would like to include:

D. TURKISH SUMMARY / TÜRKÇE ÖZET

Küreselleşme ve operasyonların uluslar arası olması, ortakların, tedarikçilerin ve müşterilerin ulusal sınırlar içinde ve genelinde entegrasyonunda temel faktörler olarak öne çıkmaktadır ve böylece bütünleşik tedarik zincirlerinin elde edilmesi amaçlanmaktadır. Modern pazarın küresel niteliğinden dolayı, aktif oyuncuların üretim, lojistik ve araştırma-geliştirme açısından faaliyetlerinin uluslar arası olmasını gerektirmektedir. Geçmişte şirketler, kalite ve fiyat gibi bir ya da iki rekabetçi performans hedefine dayanarak rekabet etmek için çalışırdı. Lakin günümüzde bu durum değişiklik gösterdi. Mevcut piyasalar daha fazla esnek davranmanın yanı sıra fiyat ve kaliteyi de talep etmektedir ve bugünün organizasyonları tüm rekabetçi hedeflere dayalı olarak rekabet etmektedir. Günümüz dünyası muazzam bir meydan okuma içermekte ve daha fazla koordinasyon ve işbirliğine ihtiyaç duymaktadır.

Kurumsal Kaynak Planlama (KKP), Ürün Yaşam Döngüsü Yönetimi, Üretim Yönetim Sistemleri (ÜYS) ve diğerleri gibi Bilgi Sistemleri (BS), şirketlerin ihtiyaçlarını esneklik ve cevap verme açısından karşılayabilir. Bunlar, şirket kaynaklarını etkili bir şekilde yönetmek için kullanılan yazılım paketleridir. İş yazılım paketleri olabilecek KKP sistemlerine baktığımızda, girdiye standartlaştırılmış (önceden belirlenmiş) prosedürler uygularlar ve böylece kurumda bundan elden edilen verileri kolayca kullanır ve yayar. Lakin, bu standart iş prosedürlerini iş süreçlerine ve ilişkili iş akışlarına entegre etmek bazen kolay değildir. KKP sistemlerinin finans, imalat, tedarik zinciri yönetimi, proje yönetimi, müşteri ilişkileri yönetimi, ÜYS (bir tür KKP modülü veya atölye seviyesi ile yönetim seviyesi arasında bir katman olarak bilinmektedir) gibi çok fazla modülü vardır.

KKP sistemi, verimlilik, hizmet kalitesi ve servis maliyetlerindeki düşüş konularında önemli iyileştirmeler sağlayarak, daha etkin karar alma sağlamakta ve pazarda zaman kaybını azaltmaktadır. KKP, 1960'larda malzeme ihtiyaç planlaması olarak başladı ve daha sonra üretim kaynak planlamasına evrildi. 1980'li ve 1990'lı yıllar arasında, malzeme ihtiyaç planlaması ve üretim kaynak planlaması, küreselleşme ve

örgütlenme gerekliliğinden yoksundu. Lakin 1990'lardan sonra KKP ve ÜYS çözümleri ortaya çıktı ve şirketler bu tür çözümlere önem verdi. SAP, Oracle, Baan, PeopleSoft, Siemens gibi bazı şirketler bu alanda büyük yatırımlar yapmışlardır. Oracle ve SAP şirketleri, KKP çözümlerinde lider kurumlardır. KKP, kaynak planlamasını bir kuruluş için üst bir bakış açısıyla bakılmasını sağlar. KKP sistemleri, KKP konseptlerini kurumsal olarak uygulamakta ve tüm iş işlevlerini etkilemektedirler. KKP sistemlerinin kullanımından birçok fayda sağlanmıştır. KKP avantajları arasında, organizasyon içinde daha iyi bilgi paylaşımı, iyileştirilmiş planlama ve karar kalitesi, daha yüksek verimlilikle sonuçlanan işler, iş birimleri arasındaki daha sorunsuz koordinasyon ve müşteri taleplerine ve sorgulamalara daha hızlı yanıt verme süresi bulunmaktadır. Bu faydaların bilerek KKP kullanan kuruluşlar, müşteri sadakatini ve memnuniyetini artıracaktır ve daha büyük pazar payını elde etmek için müşteri ilişkileri yönetimine yatırım yapacaklardır.

ÜYS ise kağıtsız atölye takibi yapılmasını imkan vermektedir. Ayrıca, kritik bilgilerin elde edilmesini ve atölyeden veri toplanmasını ve diğer kurumsal sistemler gibi gerçek zamanlı işlem yapabilmesini sağlamaktadır. Buna ek olarak, atölye personelinin atölye faaliyetlerini yüksek düzeyde kayıt altına almasını ve izlemesini sağlamaktadır. Gerçek zamanlı üretim/malzeme takibi sağladığı için planlama bölümlerinin olası problemleri veya darboğazları tespit etmesini ve önlemesini sağlamaktadır.

KKP, ÜYS veya diğer yazılım paketleri, pazara giriş, esnek ve ucuz tasarım ya da üretim ve ayrıca kaynak kullanımı açısından yerel ve küresel rakiplerle rekabet edebilmek için şirketlere yardımcı olmaktadır. 2011'de Alman Hükümeti ve Siemens tarafından lanse edilen Endüstri 4.0, siber fiziksel dünyayı (akıllı fabrika), ürün yaşam döngüsünü, KKP'yi, ÜYS'i, makineden makineye iletişimi, dikey-yatay sistem entegrasyonu, robotik sistemleri, nesnelerin internetini (IoT), büyük veriyi, bulut bilişimi ve sanal gerçekliği kapsamaktadır. Ancak bazı firmalar bu sistemlerin farkında değiller ya da bazıları bu bilgi sistemlerinin uygulanmasını başaramamaktadırlar. Endüstri 4.0 ya da dijitalleşmenin temel amacı, endüstriyel tasarım/üretim ile ilgili her bir sistemi gerçek zamanlı takip ederek anlamlı veri etmek ve bu verileri kullanarak analizler yapabilmektir.

ÜYS, iş yapmak için entegre bir yaklaşımı savunan yeni bir yönetim teknolojisidir. Kuruluşlar, genel şirket performansını iyileştirmek için bu teknolojiyi uygulamaktadır. KKP veya ÜYS kullanımı gönüllü olmadığı için, çalışanlarının yazılım programının anlam ve avantajlarının ne olduğunu tam anlayamamaktadırlar. Bu nedenle, sistemin bakış açısının kullanıcı perspektifinden anlaşılması, kurumların çalışanlarını yeni zorluklarla yüzleşmeleri için hazırlamalarına ve bu teknolojileri kullanabilmesi için şirket çalışanlarına eğitim vermeleri önemlidir. BS literatüründe araştırmacılar başarının bir kuruluşun iş birimlerinin veya departmanlarının, sadece verimli ve etkin bir şekilde çalışmasını bağlı olmadığını, aynı zamanda BS faaliyetlerinin ve BS ile ilgili kararların nasıl olduğunu anlaşılması gerektiğini vurgulamaktadır. Ayrıca, genel BS stratejilerini ve hedeflerini gerçekleştirmek için çalışanların birlikte çalışması gerektiğini vurgulamaktadır.

BS'lerinin yukarıda bahsi geçen önemi, bilgi yönetiminin başarısının ve BS yönetim eylemlerinin ve BS yatırımlarının değerinin ve etkinliğinin anlaşılmasında kritik olan faktörlerin ölçülmesini gerektirmektedir (DeLone ve McLean, 2003). KKP ve ÜYS sistemleri, 1990'lar ve 2000'ler arasında bilgi teknolojilerinin kurumsal kullanımında en önemli gelişme olarak nitelendirilmiştir. Bununla birlikte, kurumsal sistemlerin uygulanması veya benimsenmesi sadece maliyetli ya da karmaşık bir girişim değil, aynı zamanda acı verici bir süreçtir. Bazı şirketler KKP veya ÜYS aracılığıyla önemli verimlilik elde ederken, diğerleri başarısız uygulama, bütçe aşımları ve hayal kırıklığı yaratan performanstan şikâyetçi olmaktadır (Örn. Fryer, 1999; Campbell, 2000).

Bu tez çalışmasında temel amacımız, ÜYS'nin benimsemesinin, ÜYS'nin faydalarından faydalanabilmek için benimsenen ÜYS elde etme süreçlerindeki temel unsurları ele alarak tanımlanabilecek kritik başarı faktörlerine odaklanmaktır. Bu nedenle, BS paketinin uygulayıcılarının ve kullanıcılarının hem bireysel hem de organizasyonel olarak nasıl etkilendiklerini görmek ve ayrıca bu etkilenme ve yayılma sürecini sadece organizasyonel faktörleri değil, teknolojik faktörleri de dikkate alarak inceliyoruz. Kapsamlı bir araştırma için, bu tez bir vaka çalışması yaklaşımını takip etmektedir. Seçilen vaka, ÜYS, KKP ve ürün yaşam döngüsü gibi BS sistemini de kullanan Türkiye'nin en büyük savunma şirketlerinden biridir. Bu çalışma, ÜYS'nin

nasıl benimsediğini ve ÜYS'nin benimsemesinin çalışanın iş sonuçlarına ve örgütsel değişikliklerine nasıl katkıda bulunduğunu araştırmaktadır. ÜYS'nin benimseme süreci özellikle, Endüstri 4.0'a ya da dijitalleşmeye uyumun altını çizen Türkiye gibi bir ülkede araştırmaya değerdir.

Proje uygulama başarısı, zaman, bütçe ve beklenen kapsamın karşılanma boyutlarından ölçülebilir. Kantitatif analiz kullanılarak, bu tezde bireysel kullanım ve bireysel performans etkisi açısından kapsam gereksinimin karşılanması vurgulanmıştır. Ayrıca nicel analizin bulgularını doğrulamak için nitel analiz kullanılmıştır. Kantitatif analizde, bu savunma sanayi firmasında çalışan yaklaşık yüz çalışanına bir anket uygulanmıştır. Bu anketi hem beyaz yaka çalışan hem de mavi yaka personel doldurmuştur. Literatürde KKP'nin benimsenmesinde ile ilgili çalışmalarda, sadece bir proje yöneticisine veya bir şirketin önemli kullanıcılarına odaklanmaktadır. Ancak, bu çalışmada sadece proje yöneticileri ve anahtar kullanıcılara değil, aynı zamanda bu tezin bir yeniliği olan ana işi veri girişi olan ve atölyede çalışan mavi yaka çalışanlara da odaklanılmaktadır. Tüm paydaşların bakış açılarının toplanması bulguların geçerliliğini arttırmaktadır. Nitel analizde nicel analizi desteklemek için ÜYS projesi ile ilgili alanlarda çalışan beş farklı çalışanla (genelde orta düzey yöneticiler) bire bir görüşmeler yapılmıştır ve onların görüşleri toplanmıştır.

Öte yandan bu tez literatüre BS'nin uygulanması ve yayılması için gerekli olan kritik başarı faktörlerini anlamaya dört farklı yenilik ile katkı sağlamaktadır. İlk olarak, bilgimize göre, bu çalışma bu alandaki hem nicel hem de nitel araştırma yaklaşımlarını kullanan ilk araştırmadır. Literatürdeki çalışmaların çoğu, sadece bir çeşit araştırma yöntemi odaklanıp, onu da nicel yaklaşımı olarak belirlemektedir. İkincisi, mavi yaka çalışanın görüşleri de araştırmada göz önünde bulundurulmuştur ve araştırmanın metodoloji tasarımı bu nedenle daha kapsamlı bir analiz içermektedir. Üçüncüsü, bildiğimiz kadarıyla, bu araştırma ÜYS'nin benimsemesini Türkiye'de inceleyen ilk çalışmadır. Son olarak, bu çalışma politika yapıcıların veya şirket yöneticilerinin BS alanında daha iyi karar verme ve uygulama başarısı elde etmeleri için kritik başarı faktörlerini anlamalarına yardımcı olmaktadır. Bu nedenlerden

dolayı, bu çalışma ÜYS uygulaması ve yayılması hakkında gelecekteki araştırmalar için bir başlangıçtır.

Bu araştırma aşağıdaki sorular araştırılarak başlanmıştır:

i. ÜYS başarısını etkileyen kritik başarı faktörleri nelerdir? Bu faktörler neden ÜYS uygulaması ve benimsenmesi için kritik öneme sahiptir?
ii. ÜYS, şirket çalışanlarına işlerini yapmaları için yardımcı olur mu (bireysel etkiler)?
iii. ÜYS, organizasyonlar için faydalı bir çözüm mü?

Bu tezde, ÜYS'nin benimsenmesini etkileyen kritik faktörler ve ÜYS'nin bireyler ve organizasyon için yararlı olup olmadığını araştırılmaktadır. Yukarıdaki bu üç soru bu çalışmanın kilometre taşlarıdır. ÜYS'nin uygulamasına bakıldığında çalışanların direnişlerinin büyük ihtimalle kağıtlı üretim dönemiyle ilgili alışkanlıklarından geldiği de düşünülmektedir. Ayrıca, ÜYS kağıtsız üretim sağlamaktadır ve çalışanlar bu durumdan dolayı hem işlerini kaybetme hem de iş tanımlarında değişiklik olma korkusu içindedirler. Son olarak, üst yönetimden ÜYS kullanarak işlerin yapılması için çok fazla baskı vardır. Bu nedenledir ki, üst yönetimin liderliği çalışan direnişini kırmak için önemlidir. Bu çalışma ayrıca, ÜYS'nin uygulamasından sonra teknisyenlerin ve/veya mühendislerin alışkanlıklarını değişmesini de irdelemektedir.

ÜYS sistemlerinin uygulanması ve benimsenme başarısı aşağıdaki maddelerden etkilenebilir (ör., Ngai ve ark., 2008, Nah ve ark., 2001):

- Çalışan işbirliği,
- Sosyal faktörler, alışkanlıklar, kültür, çalışanların davranışları,
- Üst yönetim/eş kullanıcı desteği,
- Kaynakların kullanılabilirliği, coğrafi kısıtlama,
- Daha iyi bilgi paylaşımı,
- Kullanım kolaylığı,
- Çalışanların motivasyonu,
- İşçiler arasındaki yaş farkı,

- Sistemin faydası,
- Görevlerin kalitesi ve verimliliği,
- Şirketin inovasyon kültürü,
- Son kullanıcı katılımı,
- Farklı işlevsel alanların katılımı,
- Yönetim stili ve iş gücü becerileri,
- Uygulama için iş süreçlerinin yeniden yapılandırılması,
- Kuruluşun ihtiyaçları ve iş süreçleri,
- Değişim yönetimi kültürü,
- Teknik uyumluluk
- Algılanan karmaşıklık,
- İş planı/vizyon/hedefler,
- İletişim,
- KKP takım çalışması ve kompozisyonu,
- Performansın izlenmesi ve değerlendirilmesi,
- Proje şampiyonu
- Proje Yönetimi
- Organizasyon özellikleri vb.

Bu çalışma için, 2015 yılından itibaren literatürde kapsamlı bir araştırma yapılmıştır. Özellikle Delone ve McLean (2002)'ın BS başarı modeli, Bradford ve Florin (2003)'in KKP araştırma modeli ve Chang ve ark.(2008)'ın KKP araştırma modeli gibi araştırmalar bu çalışmayı etkilemektedir. Bu bilgiler ışığında anket verilerini kullanarak tez için oluşturulan modelde, organizasyonel faktörler ve teknolojik faktörler olmak üzere iki ana bağımsız değişken kullanılmıştır. Organizasyonel faktörler sırasıyla iş planı ve vizyonu anlama, iletişim, değişim yönetimi kültürü, üst yönetim ve süpervizör desteği ve eğitim olarak sıralanmaktadır. Teknolojik faktörler ise yazılım ve donanım uyumluluğu, sistem karmaşıklığı ve iş süreçlerinin yeniden tasarımı şeklindedir. Bu iki ana faktör ÜYS'nin benimsenmesini ve uygulama başarısını bireysel etki açısından etkileyebilmektedir. Yayılım ve uygulama başarısındaki bireysel etkiyi kullanım ve performans ile ilgili iki farklı bağımlı

değişken ile incelenmiştir. Kullanım değişkeni zaman kazanımı, veriye kolay ulaşım ve araştırma maliyetlerinde azalma ile ilişkili iken performans değişkeni ise iş yapış tarzında değişim, kariyer fırsatları, iş çeşitliliği, iş verimliliği, fikir üretme ve kolay karar verebilme ile ilgilidir.

Bağımsız değişkenler ile bağımlı değişkenleri arasındaki ilişkiyi incelemeden önce betimsel analiz yapılarak, anket verilerinin genel durumu incelenmiştir. Akabinde regresyon analizi yapabilmek ve veri azaltabilmek için faktör analizi kullanılmıştır, ve böylelikle verilerde süreklilik sağlanmıştır. Sonrasında niceliksel analiz tiplerinden regresyon kullanılarak her iki ana bağımsız değişkenin alt değişkenlerinden hangilerinin bireysel etki yarattığı analiz edilmiştir. ÜYS'nin örgütsel etkisini ise bazı kullanıcılarla bire bir görüşme yaparak (örn., Kalitatif analiz) ve şirketteki gözlemlerden faydalanarak açıklanmıştır. Tez kapsamında ortaya çıkan sonuçlar ise aşağıdaki paragraflarda detaylı olarak açıklanmıştır.

Yukarıda anlatıldığı gibi savunma sanayinde hem araştırma hem de geliştirme ve üretim üzerine odaklanan ÜYS uygulaması ve bunun dışında birçok bilgi sistemi uygulaması bulunmaktadır. ÜYS, işletme seviyesinde üretim durumunu, malzeme akışını, kaynak kullanım oranını ve üretim/kalite aşamalarını takip edilmesine yardımcı olmaktadır. ÜYS kullanımı geçmişe kıyasla daha iyi üretim yönetimi için şirkete birçok çıktı sağlamaktadır. Hem nitel hem de nicel analizlerde, iletişim, üst yönetim ve süpervizör desteği, yazılım ve donanım uyumluluğu, sistem karmaşıklığı ve iş sürecinin yeniden yapılandırması, ÜYS yayılması ve benimsenmesi için en önemli kritik faktörler olarak ortaya çıkmıştır. Ek olarak, nitel analizler değişim yönetimini önemli bir olgu olarak ortaya koymuştur.

Bu çalışma, iletişim ve iş sürecinin yeniden yapılandırmasını, MES'in benimsenmesi için en kritik başarı faktörleri olduğunu belirtmektedir. İletişim, organizasyonel bir faktördür, iş süreçlerinin yeniden yapılandırılması ise teknolojik bir faktördür. Ngai ve ark. (2008) ise iş süreçlerinin yeniden yapılandırılmasının organizasyonla ilgili faktörlere eklenebileceğini ileri sürmektedir. Bu doğrultuda, iş süreçlerinin yeniden yapılandırmasını da organizasyonel faktörlere dahil ettiğimizde, Zhang ve ark. (2005)

tarafından açıklandığı gibi, BS uygulamasında örgütsel faktörler daha etkili olabilmektedir.

İletişim, BS uygulama süreci sırasında olası anlaşmazlıkları engellediği için yanlış anlamaları önlemek açısından çok önemlidir. Ayrıca, kullanıcı katılımını sağlayıp, kullanıcıların projeye sahiplik duygusunu geliştirebilir. Uygulama ekibi üyeleri arasındaki iletişimi, etkin iletişim yollarıyla kurmak, başarıda önemli bir rol oynamaktadır. Projede ortak bir anlayış oluşturmak, tüm tarafları hizalamak ve proje hedefleri üzerinde bir fikir birliğine varmak için de iletişim kurmak gerekmektedir. Ozorhon ve Çınar (2015) çalışmalarında iletişimin gerçekten önemli olduğunu ortaya koymaktadır. Ek olarak, diğer çalışmalar (örn: Zhang ve ark, 2010; Madsen, 2005) bazen bu faktörü üst yönetime, açık hedefleri ve amaçlari anlamaya ve proje yönetim faktörlerine ekleyebilmektedir. İletişim ayrıca bir kültürün, bir kurumun kurumsal kimliğini yansıtmaktadır. İletişimdeki açıklık, ÜYS'nin benimsenme etkisini artırabilmektedir.

İş bilgisi ve iş süreçleri uygulamaları organizasyonlar arasında farklılık gösterebilir. ÜYS ile ilgili organizasyonel ihtiyaçlar önceden tanımlandığında, hedeflerin daha hızlı uygulanmasına yol açabilmektedir. Bunlar bir organizasyonda gerçekleştirilen ideal iş süreci yeniden yapılanmasının göstergeleridir. Ehie ve Madsen (2005), Zhang ve ark. (2005) ve Tatari ve ark. (2008), iş süreçlerinin yeniden yapılandırılması KKP uygulaması için en önemli kritik başarı faktörlerinden biri olduğunu tespit etmişlerdir. Firmalar, iç iş uygulamalarını değiştirmek ve çalışanlarına yeni süreçleri, rolleri ve sorumlulukları entegre etmek için gerekli araçları ve pratik deneyimleri sağlamalıdır. KKP, ÜYS vb. yeni teknolojilerin öğretilmesi, üst yönetim desteği ve değişim yönetimi kültürü, kurumun belirli bir değişim seviyesinde olduğunu ve ÜYS'nin başarılı bir şekilde uygulanacağını gösterebilir.

Öte yandan, eski sistem yapısı hem işletme sürecinin yeniden yapılandırılmaması hem de ÜYS uygulamasında bir engel oluşturabilir ve ÜYS proje ekibinin yok etmesi gereken ek ihtiyaçlara neden olabilir. Ör; ÜYS uygulayıcıları, daha iyi kullanıcı dostu uygulamalara ulaşmak için bazı kullanıcı arayüzlerinin değiştirilmesi gerektiğini

belirtmektedir. Ayrıca, en iyi uygulama paketlerini kullanarak ÜYS uygulamasında başarısız olunduğu için yeni rapor formatları proje ekibi tarafından gerçekleştirilebilmektedir. Bu iki örnek, BS teknolojisi uygulanmadan önce tüm taraflarla derinlemesine görüşme yapılması ve kişiselleştirmenin gerekli olduğunu göstermektedir. Ayrıca, birebir görüşmeler ÜYS paketlerinin bazen yerel gereksinimleri karşılayamadığını da göstermektedir (Ör; Enerjik bölgede barkod sisteminin çok aktif çalışamaması gibi). Buna ek olarak, daha fazla kişiselleştirmenin daha yüksek kullanıcı memnuniyetine yol açması beklenmektedir. Nicel analize göre iş süreçlerinin yeniden yapılandırılması bireysel üretkenlik üzerinde olumlu etkilere yol açtığı tespit edilmiştir. Bire bir görüşmelerde ise kurumsal üretkenlik iyileştirmelerine yol açtığı tespit edilmiştir.

Üst yönetim, diğer çalışanların direnişini engelleme, iş süreçlerini yeniden yapılandırma ve örgütsel yapının ya da iş süreçlerinin herhangi bir işlevsizliği gibi birçok sorunun üstesinden gelme için en önemli araçtır (Negahban ve ark., 2012). Bu bulgunun en önemli pratik çıkarımı, KKP veya BS uygulama projesinin yaşam döngüsü boyunca, üst yönetim seviyesinde, proje yönetim seviyesinde ve BS fonksiyonu seviyesinde güçlü ve özverili destek ilgili projenin uygulamasındaki sorunların çoğunluğunu çözebilmektedir (Sarker ve Lee, 2003). Teknoloji kullanımı bazen gönüllü olurken ve genelde zorunludur. Üst yönetim zorunlu kullanım ortamı için kritik bir role sahiptir. Öte yandan, gönüllü kullanım ortamı için kullanıcı katılımı çok önemlidir. Üst yönetimin bu temel desteğinin yanı sıra, özellikle personelden önemli ölçüde direnç olduğunda, uygulama ve benimsenmenin sorunsuz bir şekilde yürütülmesi için politik ve davranışsal destek vermesi de önemlidir. Ayrıca, orta seviye yöneticilerin tutumları, inançları ve deneyimleri BS başarısı ve üst düzey yönetim desteği üzerinde etkiye de sahiptir (Ngai ve ark., 2008). Bu çalışmadaki literatür taramasında, daha önce gözden geçirdiğimiz on iki makaleden sekizi üst yönetim desteğini kritik müdahale olarak gösteren niteliksel veya nicel analiz yöntemlerini içermektedir. Bizim çalışmamızda da üst yönetimi aktörü kritik başarı göstergeleri arasında bulunmuştur.

Sistem karmaşıklığı ile ÜYS uygulaması ve benimsenmesi arasında ters bir ilişkisi vardır. Bu durum Wu ve Wang (2006), Wang ve Liao (2008), Petter ve McLean (2009) gibi başka birçok çalışmada rapor edilmiştir. Örn; Wu ve Wang (2006), kullanıcı tutumunun, sistem kullanımının karmaşıklığına dair inançlardan etkilendiğini, bunun da kullanıcı kullanımı üzerinde etkili olduğunu ve kullanıcının tutumunda olumsuzluğa sebep olduğunu belirtmektedir. Öte yandan, karmaşıklık kullanıcı ekranlarının kolay kullanımı ile ilgilidir. Çalışanların ekranın kullanıcı dostu olmasını ve sosyal medya arayüzüne benzemesini tercih ettiği görülmektedir.

Zhang ve ark. (2005) ve Chang ve ark. (2008) da uyumluluk yapısı açısından bizim çalışmamızda olduğu gibi eşdeğer sonuçlar bulmuştur. Uyumluluk kapsamında, şirketler donanım ve yazılım iletişiminden ödün verip ve bu konuda farklı kısıtlamalara sahip olabildikleri görülmüştür. Örn; savunma sanayinin kablosuz ağ kullanma sorunu vardır ve bu nedenle tabletler ÜYS'in atölyede uygulanması aşamasında proje kapsamına alınamamıştır. Bu örneklerden dolayı böyle bir sistemin uygulanmasından önce şirket ya da ülkeye özgü olabilecek benzer kısıtlamaları düşünmelidir.

Bu çalışma ile diğer çalışmalar arasındaki benzerlik seviyesi yüksek olmasına rağmen bu çalışma iletişim ve iş süreci yeniden yapılandırmasının diğer çalışmalardan daha önemli olduğunu ortaya koymaktadır. Örn; Bradford ve Florin (2003), Zhang ve ark. (2005), Tatari ve ark. (2008), Garg (2010)'un çalışması iş planına uyma, üst yönetim desteği veya eğitimin en önemli başarı göstergeleri olduğunu belirtmektedir. Yukarıdaki farklılığa ek olarak, bu çalışmadaki analiz yöntemleri hem de nicel ve nitel yaklaşımları içerir ve bu nedenle daha kapsamlıdır. Ayrıca, bu çalışma mavi yaka çalışanların görüşleri de göz önünde bulundurmaktadır. Pozisyona göre kurumsallaşma, iş performansına bakış açışı, kullanıcı memnuniyeti ve kullanıcı dostu kriterlerinde görüş farklılıkları olduğu tespit edilmiştir.

BS sistemlerinin uygulanması ve benimsenmesi kolay bir süreç değildir çünkü yüksek düzeyde karmaşıklık ve belirsizlik içerir: bu projeler çok fazla insanla ilişkilidir, uygulama bütçesi genellikle yüksektir ve üst yönetimin baskısı çok büyüktür. Bu

nedenle, proje yöneticilerinin stres düzeyleri genellikle yüksektir. Bilgi sistemleri, şirketlerin dijitalleşme ve şirket hedeflerinin otomasyonuna ulaşmalarını sağlar. Bununla birlikte, kültürel konular, işlevsellik gereksinimleri (farklı paydaşlar gereklilikleri), BS hazır uygulamaları (BS hazır yazılımları en iyi uygulama yapısına sahip olmakla birlikte, iş sürecinin yeniden yapılandırılması için engel teşkil edebilir), iletişim, üst yönetim desteği, kullanıcı ve satıcı katılımı, BS'in karmaşıklığı uygulama ve benimseme için anahtar faktörlerdir. Bu nedenle, bir şirkette BS teknolojisini uygulamadan önce aşağıdaki adımları göz önünde bulundurmalıdır:

- Şirket gereksinimlerini tanımlamak,
- İhtiyaç önceliklendirmesi yapmak,
- Satın alınan uygulama ile şirket altyapısının eşleşip eşleşmediğine dair gerekliliklerin kontrol etmek (İş süreci yeniden yapılandırması bu noktada kritik öneme sahiptir. Ayrıca, donanım ve yazılım uyum ile yazılımın karmaşıklığı da başarı için çok önemlidir.),
- Bilgi teknolojileri departmanını yeniden yapılandırmak, departmanın gücünün artırılması veya C-seviyesi temsili sağlamak (Bu durum üst düzey yönetim desteği için önemlidir),
- Uygulama öncesi farkındalık seminerleri veya ön bilgilendirme eğitimleri düzenlemek (Bunlar değişim yönetimi bilincini artırır ve yazılım yapısını öğrenmeyi sağlar),
- Son olarak, projenin uygulanması ve benimsenmesi için bir iletişim planı oluşturulabilir.

Dijitalleşme, şirkeler veya hükümetler için kolay olmayan ve acı verici bir süreçtir. Kalitatif ve kantitatif analizimizin sonuçlarını kullanarak, dijitalleşmenin daha iyi benimsenmesi için yukarıdaki şirket düzeyi önerilerin dışında aşağıdaki ülke düzeyindeki uygulamalar için mekanizma önerileri oluşturulmuştur:

- Dijitalleşmenin işlevinin anlaşılması (örn; farkındalık seminerleri anlamaya yardımcı olabilir),

- Hem üst düzey yönetim hem de diğer çalışanlar veya paylaşım platformlarından oluşan yönetim kurulu oluşturulması (Bunlar, iletişim ve bağlılığı artıracaktır.),
- Proje yönetim ofisi oluşturulması (İlgili ofis eğitimden, projelerin uygulanmasından, ihtiyaçların anlaşılmasından, BS araçlarında iş süreçlerinin yeniden yapılandırılmasından sorumlu olacaklardır.),
- Mevcut sistemlerin eksikliğinin tanımlanması ve ihtiyaç analizi yapılması (örn; sistemin kolay anlaşılması için teknoloji yol haritalarına ihtiyaç vardır.),
- Kritik araştırma ve geliştirme / dijitalleşme faaliyetlerine öncelik verilmesi,
- Dijitalleşme hedeflerine ulaşmak ve yeni yetenekler edinmek için yeni eğitim politikası (devlet seviyesi) ve eğitim stratejisi (hem şirket hem de ülke seviyesi) geliştirmesi (BS tabanlı eğitim, Endüstri 4.0 ve dijitalleşme için önemlidir. Veri analitik bilgisi, tüm lisans eğitimleri için mezun olmadan önce zorunlu olabilir.),
- Yeni teknolojik yatırım planı oluşturulması (örneğin, bilgi iletişim merkezi, veri merkezi, bulut bilişim, siber güvenlik, otonom robotik vb. teknolojik altyapı yatırımları yapılabilir),
- Dijitalleşmeye yatırımları için şirketlere destek mekanizmaları geliştirmesi,
- Kamu alımında şirketlere BS kullanım zorunluluğu getirmek (örn; bir şirket başka şirketten bir otomobil satın alırsa, şirketin KKP, ÜYS gibi bir sistemi kullanması zorunlu kılınabilir),
- İstihdam politikalarının ve bazı düzenlemelerin değiştirilmesi (örn; stratejik işgücü planlaması, yeniden örgütlenme yapısı, alt yüklenicilerle işbirliği, rol ve sorumluluk takibi için BT tabanlı yeterlilik, değişim yönetimi takımının rolü gibi çalışmalar yapılabilir),
- Yerel yazılım üreticilerinin ve akıllı üretim fabrikalarının desteklenmesi (örn; yerel yazılım üreticilerinin (KKP, ÜYS üreticileri vb.) desteklenmesi, iş süreçlerinin yeniden yapılandırılması uyumluluk sorunlarını ve yazılım uyarlamalarındaki karmaşıklığı önlemek için gereklidir.) (TÜSİAD , 2016),

- Son olarak, yukarıdaki mekanizmaların sürdürülebilirliğini ve etkilerini takip edilmek de çok kritiktir.

Sonuç olarak tez kapsamında ÜYS'nin uygulaması ve benimsenmesindeki kritik başarı faktörleri incelenmiştir. Bu doğrultuda nitel ve nicel analizler yapılarak iletişim, üst yönetim desteği, sistem karmaşıklığı, yazılım ve donanım uyumu, değişim yönetimi ve iş süreçlerinin yeniden yapılandırılması ÜYS ve benzer sistemlerin yayılmasında anlamlı değişkenler olarak bulunmuştur.

E. TEZ FOTOKOPİSİ İZİN FORMU

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