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MARMARA UNIVERSITY
INSTITUTE FOR GRADUATE STUDIES IN
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DEVELOPMENT OF A CHANGE MANAGEMENT MODEL FOR MANUFACTURING SYSTEMS

M. Batuhan AYHAN

THESIS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
INDUSTRIAL ENGINEERING

SUPERVISOR
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İSTANBUL, 2010

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I would like to thank to the people from whom I received kind assistance in various parts of preparing the thesis, especially my supervisor, Prof. Dr. Ercan ÖZTEMEL. I owe thanks to him for introducing this fascinating research area. I am indebted to him for the guidance, dedication, encouragement and endless support throughout this work.

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October, 2010 **M. Batuhan AYHAN**

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İMALAT SİSTEMLERİ İÇİN BİR DEĞİŞİM YÖNETİM MODELİNİN GELİŞTİRİLMESİ

Değişim yönetimi günümüzün en ilgi çeken araştırma alanlarından birisidir. Değişim hayatın her alanında sabit olan tek şey olduğu ve sürekli farklı formlara girdiği için kapsamlı bir değişim yönetim modeline ihtiyaç duyulur. Literatürde birçok farklı değişim yönetimi modeli bulunmasına karşın, imalat sistemleri odaklı bir yönetim modeline rastlamak oldukça zordur.

Bir imalat firmasının karşılaşacağı değişim unsurları, bir başka sektörden herhangi bir kurumunkinden doğal olarak farklılıklar gösterecektir. Bu çalışma hem imalat sitemlerine özgü değişim unsurlarını belirlemekte hem de bu unsurlar üzerinden değişimi yönetebilme yetkinliğini ölçmeyi amaçlamaktadır. Belirlenen unsurlar Teknolojik, Süreçsel, Müşteri Tabanlı, Yönetimsel ve Çevresel değişim faktörleri olarak 5 başlıkta toplanmış her bir unsurdaki değişimi yönetme yetkinliğinin nasıl değerlendirileceği ortaya konmuştur. Konu hakkında uzman akademisyenler ve endüstri temsilcileri ile gerçekleştirilen anket çalışması sonucu bu 5 unsurun ve ilgili alt unsurların göreceli önem dereceleri tayin edilmiştir.

Geliştirilen modelin uygunluğu bir imalat firmasının 2006 ile 2009 yılları arasındaki değişim yönetim yeteneğinin ölçülmesi ile doğrulanmıştır. İlgili firmadaki analizlerin tamamlanması ve göreceli önem derecelerinin hesaplanması ile değişim yönetim yetkinliği yaklaşık olarak %50 bulunmuştur. Bulunan genel skorun yanı sıra 5 unsurdan hangilerinde eksikliği olduğu tespit edilmiş ve bu eksiklikleri gidermek için bazı iyileştirme önerileri sunulmuştur.

Ekim, 2010 **M. Batuhan AYHAN**

ABSTRACT

DEVELOPMENT OF A CHANGE MANAGEMENT MODEL FOR MANUFACTURING SYSTEMS

Nowadays, change management is one of the most interesting research areas. Since the change by itself does not change and continuously transforms to different structures, a comprehensive change management model is essential to keep up with it. Although there have been different models in the literature, it is hard to confront with one of those focusing on the manufacturing systems.

The change elements of a manufacturing enterprise are naturally different from those of other organizations. This study both aims to define the specific change elements of a manufacturing system and to measure the capability of being able to manage the change through these elements. Note that, these elements are categorized into 5 groups namely; Technological, Process Based, Customer Oriented, Managerial, and Environmental changes. Also, the methodology to assess the change management capability for each factor is released in this study. By performing a survey through the academicians and industrial representatives, who possess related expertise, the relative importance degrees of 5 factors and their sub-factors were determined.

The adequacy of the developed model is validated through an assessment scheme as proposed in a manufacturing company where the respective data were available in between 2006 and 2009. By performing the required analyses and evaluating the relative importance degrees, the change management capability of the company in question is resulted as about 50%. In addition to the general score, drawbacks about the factors are also listed and the methods to overcome these pitfalls are recommended

October, 2010 **M. Batuhan AYHAN**

CLAIM FOR ORIGINALITY

DEVELOPMENT OF A CHANGE MANAGEMENT MODEL FOR MANUFACTURING SYSTEMS

Change management is a wide research area depending on its increasing importance in recent years. Although so many models have been presented to manage the change, it is hard to confront with a specific one aimed for manufacturing systems. This study aims to fulfill the requirement of a change management model by establishing a promising one.

Since the manufacturing enterprises continuously faces with the rapid changes and they are naturally forced to change if they want to become successful in business. In order to achieve desired level of competency in following the respective changes, the manufacturing organizations need a systematic approach or a model, which will keep them being aware of the changes occurring around. Depending on this necessity, the proposed model provides an original analytical tool to assist the change management for companies.

Furthermore, the basic properties of manufacturing systems, of which depends on the changes are defined to be Technological, Process Based, Customer Oriented, Managerial, and Environmental changes. Depending on these aspects, this study provides the first comprehensive analysis to measure the capability to manage the change for the manufacturing companies.

Conclusively, this study is a pioneer in the subject of change management via focusing on the manufacturing systems, supporting them to manage the change, and measuring the capability of change management with respect to defined five aspects. This study sets a baseline model for the concept, which is ready to be enhanced by the contributions of other academicians. Note that the content of this thesis purely developed (original in its nature) in this study and information utilized from different sources are acknowledged.

October, 2010 Prof. Dr. Ercan ÖZTEMEL M. Batuhan AYHAN

LIST OF SYMBOLS

AC : Adaptation Capability

A_n : Actual value for the n^{th} year

AWU_t : Average Worker Utilization at time t

AWU_{t+1} : Average Worker Utilization at time t+1

B_j : Bottleneck Time of j^{th} work center

CC : Capability for "Customer Change"

CF : Score of Controlling Function

CL : Comply with Legislation

CMC : Change Management Capability

CoorF : Score of Coordinating Function

EC : Capability for "Environmental Change" management

FC : Forecasting Capability

FC_i : Forecasting Capability for aspect i.

F_n : Forecast value for the n^{th} year

F_Q : Forecasting Quantity/Day

F_R : Forecasting Revenue

F_S : Forecasting Scrap Ratio

F_T : Forecasting Throughput Time

GR : Result of Get Ratio Metric

GRR : Result of Growth Ratio Metric

HE : Human Effect

H_1 : 1^{st} factor of Human effect -Average Worker Experience-

H_2 : 2^{nd} factor of Human effect -Change in Technological Investment/Worker-

H_3 : 3^{rd} factor of Human effect -Rotation Ability-

IC : Innovation Capability

Inv_1 : First Factor of Innovation -Percentage Change in Product Portfolio-

Inv_2 : Second Factor of Innovation -New Product Ratio-

Inv_3 : Third Factor of Innovation -Sales Amount Ratio of New Products-

Inv_4 : Fourth Factor of Innovation -Sales Revenue Ratio of New Products-

KE : Knowledge Effect

KR : Result of Keep Ratio Metric

K_1 : First Factor of Knowledge effect -Change in Training Hour/Worker-

K_2 : Second Factor of Knowledge effect -Degree of Response Generation-

K_3 : Third Factor of Knowledge effect -Enterprise Knowledge Index-

LF : Score of Leading Function

MC : Capability for "Managerial Change"

MI_n : Machine Investment value for n^{th} year

MI_{n-1} : Machine Investment value for $n-1^{th}$ year

OF : Score of Organizing Function

OS : Organizational Structure

PC : Capability for "Process Change"

PF : Score of Planning Function

PS : Properness to Standards

ST_j : Standard Time of j^{th} work center

TB_j : Total Bottleneck of j^{th} work center

TBR_j : Total Bottleneck Ratio of j^{th} work center

TBR_t : Total Bottleneck Ratio at time t

TBR_{t+1} : Total Bottleneck Ratio at time t+1

TC : Capability for "Technological Change"

T_{std} : Standard working time in the sector for maximum experience

TE : Tool Effect

T_1 : First factor of Tool effect -Degree of Machine Replacement-

T_2 : Second factor of Tool effect -Level of Automation-

T_3 : Third factor of Tool effect -IT Utilization-

U_i : Utilization of i^{th} worker

UPC : Unit Production Cost

UPC_t : Unit Production Cost at time t

UPC_{t+1} : Unit Production Cost at time t+1

UPT : Unit Production Time

UPT_t : Unit Production Time at time t

UPT_{t+1} : Unit Production Time at time t+1

VA : Voluntary Activities

W_{AC} : Weight of Adaptation Capability

W_{AWU} : Weight for Average Worker Utilization

$\mathbf{W_{C}}$: Weight for Controlling Function

$\mathbf{W_{CL}}$: Weight for Comply with Legislation

$\mathbf{W_{Coor}}$: Weight for Coordinating Function

$\mathbf{W_{EC}}$: Weight for "Environmental Change"

$\mathbf{W_{FC}}$: Weight of Forecasting Capability

$\mathbf{W_{FQ}}$: Weight of Forecasting Quantity/Day

$\mathbf{W_{FR}}$: Weight of Forecasting Revenue

$\mathbf{W_{FS}}$: Weight of Forecasting Scrap Ratio

$\mathbf{W_{FT}}$: Weight of Forecasting Throughput Time

$\mathbf{W_{GR}}$: Weight of Get Ratio Metric

$\mathbf{W_{GRR}}$: Weight of Growth Ratio Metric

$\mathbf{W_{HE}}$: Weight of Human Effect

$\mathbf{W_{H1}}$: Weight of Worker Experience

$\mathbf{W_{H2}}$: Weight of Change in Technological Investment/Worker

$\mathbf{W_{H3}}$: Weight of Rotation Ability

$\mathbf{W_{i}}$: Weight for aspect i.

$\mathbf{W_{IC}}$: Weight of Innovation Capability

$\mathbf{W_{Inv1}}$: Weight of percentage change in Product Portfolio

$\mathbf{W_{Inv2}}$: Weight of New Product Ratio

$\mathbf{W_{Inv3}}$: Weight of Sales Amount Ratio

$\mathbf{W_{Inv4}}$: Weight of Sales Revenue Ratio

$\mathbf{W_{KE}}$: Weight of Knowledge Effect

$\mathbf{W_{K1}}$: Weight of Change in Training Hour per Worker

$\mathbf{W_{K2}}$: Weight of Response Generation

$\mathbf{W_{K3}}$: Weight of Enterprise Knowledge Index

$\mathbf{W_{KR}}$: Weight of Keep Ratio Metric

$\mathbf{W_{L}}$: Weight for Leading Function

$\mathbf{W_{MC}}$: Weight for "Managerial Change"

$\mathbf{W_{O}}$: Weight for Organizing Function

$\mathbf{W_{OS}}$: Weight for Organizational Structure

$\mathbf{W_{P}}$: Weight for Planning Function

$\mathbf{W_{PC}}$: Weight for "Process Change"

$\mathbf{W_{PS}}$: Weight for Properness to Standards

$\mathbf{W_{TBR}}$: Weight for Total Bottleneck Ratio

W_{TC} **:** Weight for “Technological Change”

W_{TE} **:** Weight of Tool Effect

W_{T1} **:** Weight of Machine Replacement Effect

W_{T2} **:** Weight of Automation Level Effect

W_{T3} **:** Weight of IT Utilization Effect

W_{UPC} **:** Weight for Unit Production Cost

W_{UPT} **:** Weight for Unit Production Time

W_{VA} **:** Weight for Voluntary Activities

Δ**AWU** **:** Change in Average Worker Utilization

Δ**MI** **:** Change in Machine Investment Value

Δ**TBR** **:** Change in Total Bottleneck Ratio

Δ**UPC** **:** Change in Unit Production Cost

Δ**UPT** **:** Change in Unit Production Time

φ : Degree (Percentage) of Automation

LIST OF ABBREVIATIONS

ADKAR	: Awareness, Desire, Knowledge, Ability, Reinforcement
CRM	: Customer Relationship Management
DMS	: Database Management System
DSS	: Decision Support System
EKM	: Enterprise Knowledge Management
ERP	: Enterprise Resource Planning
IDIC	: Identify, Differentiate, Interact, and Customize
ISO	: International Organization for Standardization
IT	: Information Technology
İGDAŞ	: İstanbul Gaz Dağıtım Anonim Şirketi
KAS	: Kayalar Armatür Sanayi
KASPA	: Kayalar Armatür Sanayi Pazarlama
KMPI	: Knowledge Management Performance Index
Mang.	: Management
MIS	: Management Information System
OECD	: Organization for Economic Co-Operation and Development
PEOU	: Perceived Ease of Use
PERT	: Program Evaluation and Review Technique
PU	: Perceived Usefulness
R&D	: Research and Development
SMART	: Specific, Measurable, Achievable, Relevant, and Time-Specific
SME	: Small and Medium Enterprise
TAM	: Technology Acceptance Model
TIG	: Tungsten Inert Gas
TL	: Turkish Lira
TRA	: Theory of Reasoned Action

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I. INTRODUCTION

"Change is the only thing that does not change" defined by Greek Philosopher Heraclitus. Things are always changing. In the last several decades the world faced undeniable progress and changes nearly in all aspects of life. The 21st century possesses two key elements in this respect. These are the "knowledge" and the "technological changes". While increasing the importance of knowledge and technological changes which are exposing the knowledge economies and knowledge societies, the knowledge itself becomes the power bringing superiority to the owner or originator. This power in turn brings up the concept of change in all areas including manufacturing. Hence, the industries should take this into account and sustain a well established vision for the future.

It should be noted that the concept of change is not new. It has existed since the beginning and appeared in different forms. That was the reason behind the main streamline of society from agricultural society till the knowledge economy. It was realized in the past that even very small developments have caused big changes for the society. The factors, which are affecting the change, are becoming different in the 21st century than ever before. In this century it is more obvious that; the change occurs more frequently and it is an unavoidable phenomenon. Based on the possibilities provided by the knowledge and technology, only industries, which are capable of generating the knowledge faster, will take the advantage of it over its rivals.

The rapid change in the world, led to the concept of "Change Management" in the respective literature. Change management is called as the art of aligning company culture and its processes with the changing world (Argüden, 2004). Change management is stated as one of the most important factors of successful leadership and management capabilities and studied deeply in the literature (Hayes, 2010; Carter et al., 2001). It does not have a single process structure to be implemented in all kinds of enterprises. This definitely implies that each enterprise should adopt itself to the change in accordance with own-dynamics.

Change management plays an important role in any organization since the task of managing the change is not an easy one. An area of change that needs a special attention should be selected and certain models, methods, techniques and tools need to be used for handling that.

The change process could also be considered as one of the main sources of driving forces for problem solving. The change could be triggered by a certain problem that the company facing.

Managing the changes in an organization requires a broad set of skills like, analytical skills, people skills, system skills, and business skills. Financial and organizational impacts of the changes should be evaluated by using analytical skills. Operations and systems in the organization should be reconfigured in such a manner that the desired financial impacts are assured.

By successful management of change the organizations have the capability to give a reactive or a proactive response to the changes that happen internally or externally. Knowing the change management and its processes would help an organization and to be stable. Since the change is so vital, it should be managed in a proper way for the sake of successful business.

Manufacturing systems may be called as one of the organizations mostly affected by the changes in different aspects. For example, any change in technological developments or any improvement in manufacturing processes will definitely affect them through reducing costs or production times. Furthermore, managerial functions of the companies evolve by utilizing recent techniques such as Management Information Systems. Hence the changes in these management functions should be embedded. Moreover, since the customer demand continuously change, manufacturing companies should also try to satisfy those. In order to fulfill these requirements a change management model for manufacturing systems is essential.

Depending on these arguments, the main objective of this study is to create a Change Management Model for the Manufacturing Systems. Based on its importance, the change management and various well known models for change management are reviewed in the next section of the thesis. After careful analysis of these models, fundamental requirements for a change management model for the manufacturing systems are established. Based on these, a comprehensive change management model is developed. The model is composed of mainly five dominant change factors including; Technological Change, Process Based Change, Customer Oriented Change, Managerial Change, as well as the Environmental Change.

I.1. CHANGE MANAGEMENT MODELS

In order to develop a well oriented and structured change management model for manufacturing systems, well known management models is analyzed at first.

In the new era, enterprises experience a rapid change process during the transformation from industrial societies to the knowledge societies. The companies which can follow up this change process can sustain competitive advantage. It would not be wrong to say that, the companies which cannot adopt themselves to the changing factors of the era will have shorter life cycles.

If the organizational change is well managed, it will help lead the company to a successful future. It is therefore important to model the changes systematically as, the change occurs in global dimensions and management of change needs the visualization and understanding of all components. In order to gain this systematical approach to management, some change management models are developed.

ADKAR is the widely known model and first to be mentioned (Hiatt, 2006). According to this model to ascertain the change successfully, one of the most inevitable conditions is the acceptance of change by both entrepreneurship and the staff. ADKAR comprises of 5 stages. These are Awareness, Desire, Knowledge, Ability, and Reinforcement.

Similarly, A different change management model including 7 steps is shown in Figure I-1 (Checkland, 1999). According to this model, change was viewed as 2 stages. The first stage is the Real World Stage where the constructed problem is stated, expressed, improved, compared and the feasible desirable changes occurred. The second stage is the Systems Thinking Stage where the root definitions of relevant systems and conceptual models are developed. Although the relations between the steps are clearly defined, performance metrics for each step is missing.

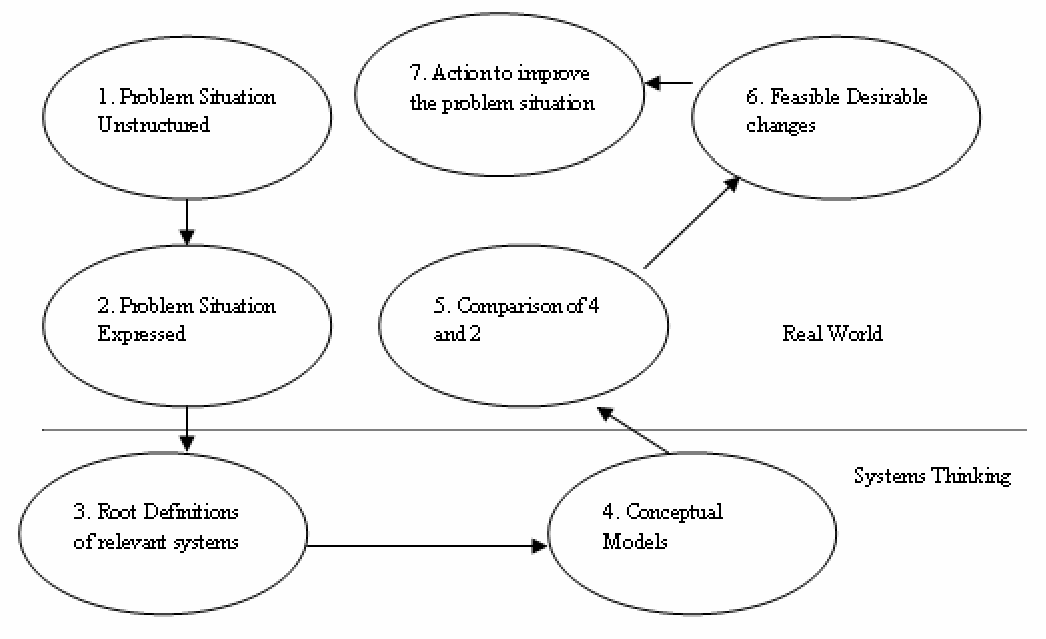

Figure I-1: Checkland's Change Management Model (Checkland, 1999)

Banathy's change management model includes social properties and future system environments (Banathy, 1991). Since, there is not a clear division between the components of the system; it is more effective to understand the whole picture. As seen in Figure I-2, the interaction between the components of the model is emphasized. However, there is a lack of methodology on how to measure the efficiency to manage the change.

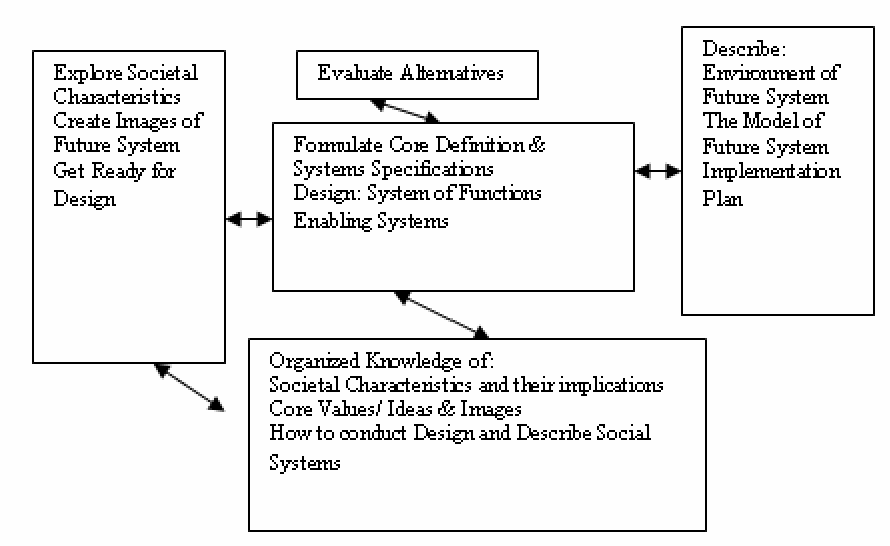

Figure I-2: Banathy's change management model (Banathy, 1991)

The McKinsey 7-S Model was created by Peters and Waterman (2004) while they were working for McKinsey & Company. The McKinsey 7-S model is a holistic approach to company organization, which collectively determines how the company will operate. There are 7 different factors that are a part of the model. They are mainly shared values, strategy, structure, systems, style, staff, and skills, which all work collectively to form the model as shown in Figure I-3.

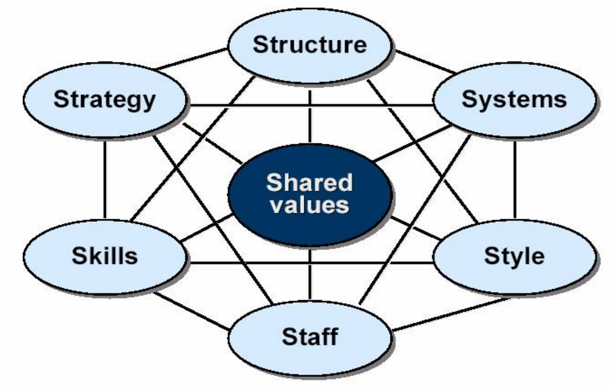

Figure I-3: McKinsey 7S Model (Peters and Waterman, 2004)

Shared values such as the mission of the company are in the center of the model because it indicates what the organization believes in and stands for. Strategy represents what the company plans to react any changes of its external surroundings. The structure refers to the organizational architecture of the company. Systems are the portion of the model that represents "the procedures, processes and routines that characterize how the work should be done". Staff is quite obvious in the fact that it is a proper representation of who is employed by the organization and what they do within the organization. Style signifies the organizational culture and management styles that are utilized within the organization. Skills indicate the abilities and competencies of either the employees or the organization holistically. Although it is an effective way to diagnose and understand the organization and a guide for organizational change, it does not encounter sector specific changes. Besides there is no indication of how the changes are going to be handled. It is possible to sustain current situation through effective management of the existing organization without any implementation of the change.

Similarly, Lewin's Change Management Model was created in the 1950s by a psychologist named Kurt Lewin recognizing three stages of change, which are still widely used: threes stages are called as “unfreeze”, “transition” or “change”, and “refreeze” as shown in Figure I-4 (Lewin, 1951).

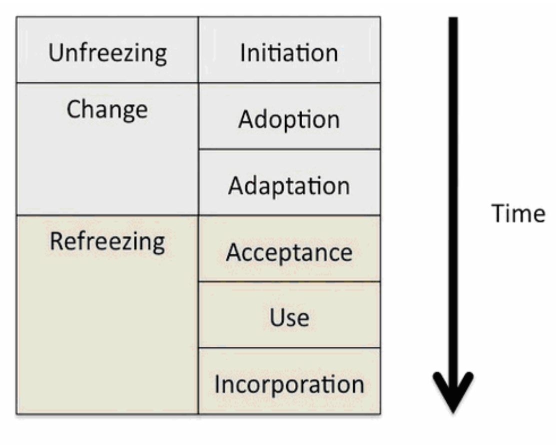

Figure I-4: Lewin's change management model (Lewin, 1951)

The first stage called "Unfreezing" is built on the theory that human behavior is established by past observational learning and cultural influences. The change requires adding new forces for change or removal of some of the existing factors that are affecting the behavior. Once there is sufficient dissatisfaction with the current conditions and a real desire to make some change exists, it is necessary to identify what exactly needs to be changed. Based on this, the change occurs in the second stage, where the transition, adoption and adaptation take place. Refreezing is the final stage where new behavior which includes acceptance of the new system usage and incorporation becomes habitual.

Although it is a simple and easily understood model for the change; the model is prepared to manage the change for human perspective. However, the manufacturing companies possess more complicated views than the one possessed by an individual employee.

Another change management model can be the one called Kotter's change model which includes eight steps as shown in Figure I-5 (Kotter, 1996).

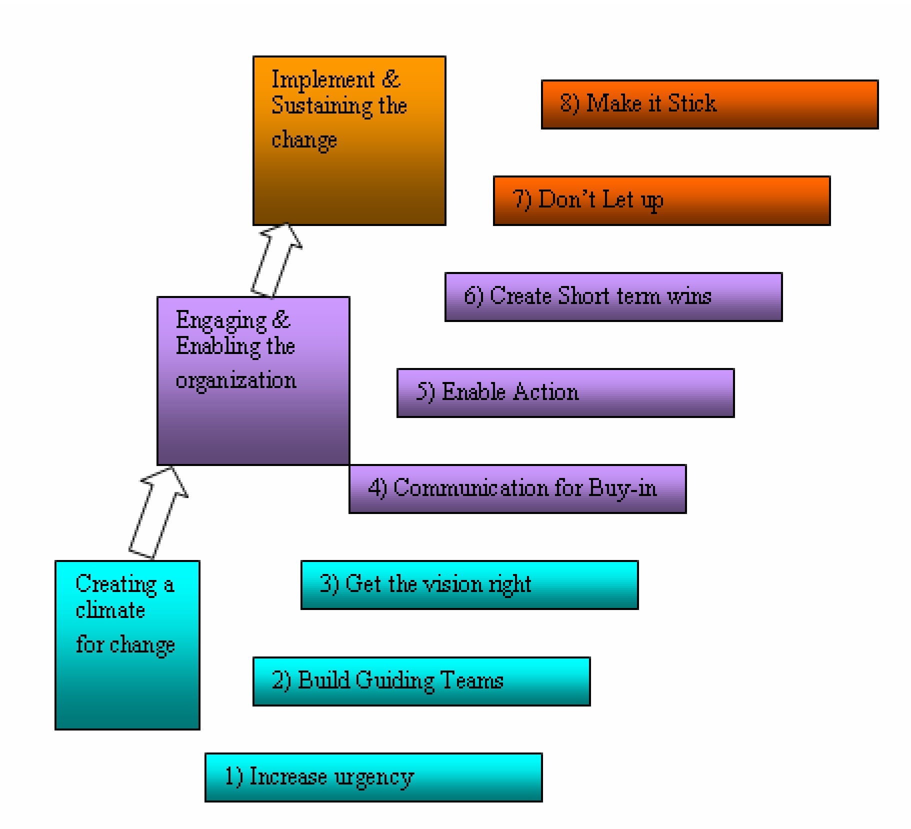

Figure I-5: Kotter's change management model (Kotter, 1996)

The model enforces the following. In the first step employees should be convinced that this change is necessary for the company to survive. The next step is to build a team for the change, which has to be of some respected employees within the company. The third step is to construct the vision, which will show clear direction on how the change will be better the future of the company and respective activities. The fourth step is to communicate this vision to sustain full understandability of the employees. The fifth step is to empower the employees to execute the change. By creating short term goals at the sixth step, the employees are assisted to accept the change by showing them progress. The seventh step is about persistence. The final step is to make the change permanent by moving fitting it into the company's culture and practices. Although it is a step by step model, which is easy to follow any steps cannot be skipped or the change process will completely fail.

In a recent study to prepare a handbook of change management, a model, which is similar to that of Lewin's, is proposed including three main stages unfreeze, move, and freeze as shown in Figure I-6 (Baekdal et al., 2006). In the related study, this model is adjusted to different change projects due to their complexities.

Although the main frame is very logical to unfreeze, move, and freeze the change, the measurement methodology is not mentioned clearly.

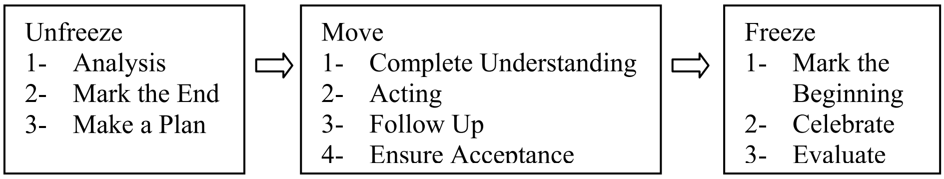

Figure I-6: Baekdal's change management model (Baekdal et al., 2006)

Clarke and Garside also proposed a change management model including the performance metrics (Clarke and Garside, 1997). This model includes 5 components namely; Commitment, Social and Cultural Aspects, Communication, Tools& Methodology, and Interactions. They have defined 6 scales for each component and a maturity matrix denoting the levels of implementation. According to their study, the results of managing the change for the audited company are depicted in radar graph example of which is shown in Figure I-7. Although it is providing a performance metric to analyze the change, it does not take all of the relevant characteristics of a manufacturing company, for example the customer desires into account.

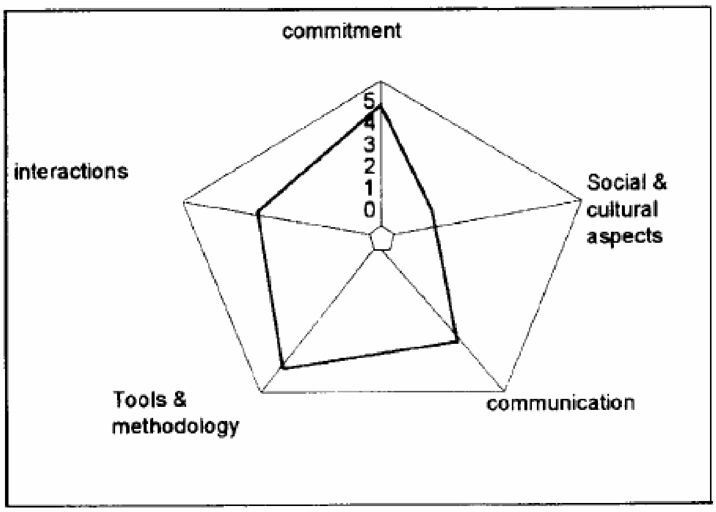

Figure I-7: Radar graph analysis of the model (Clarke and Garside, 1997)

In another study an equation is defined to make the change successful. This formula provides a model to assess the relative strengths affecting the likely success or otherwise of organizational change programs (Beckhard, 1969).

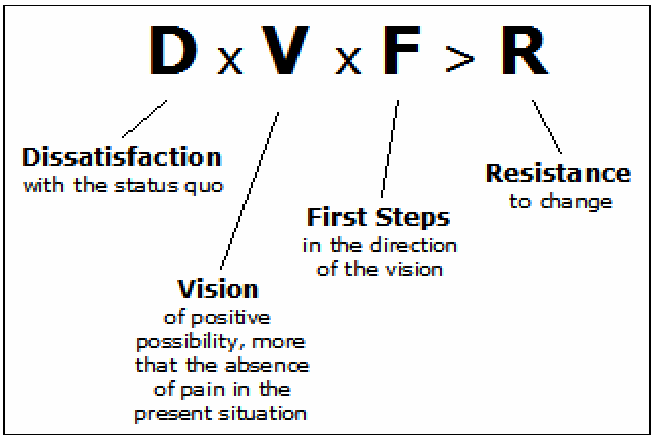

Figure I-8: Equation of change (Beckhard, 1969)

As shown in Figure I-8, three factors must be present for meaningful organizational change to take place. These factors are:

D: Dissatisfaction with how things are now;

V: Vision of what is possible;

F: First, concrete steps that can be taken towards the vision.

R: Resistance,

If the multiplication of these three factors is greater than Resistance, change is possible. Because of the multiplication of D, V and F, if any one is absent or low, then the result will be low and therefore not capable of overcoming the resistance. Although it is a promising methodology and widely accepted by the change leaders, the metric system to analyze each of the factors is not precisely set.

Although there are plenty of change management models in literature, there is no evidence that an existing model focuses on the manufacturing companies and their relevant properties. Hence it is required to establish a model investigating the changes for manufacturing companies as well as evaluating the success rate to manage this change. This provides a clear baseline for this study.

I.2. THE NEED FOR A CHANGE MANAGEMENT MODEL FOR MANUFACTURING SYSTEMS

In the previous section, change management concept and some of the change management models are explained. When these models are investigated, the foci of the models are seen to be the management functions of change and also the technological changes in the extension of management. On the other hand, it is hard to mention about the existence of a change management model focusing on the manufacturing systems.

The developments of computer and communication technologies increased the rate of service sector for the world trade. This cause the need for a well established knowledge management capabilities to traditional manufacturing functionalities. Transforming to a knowledge society is only possible through following the developments in knowledge related technologies. Note that, it is not easy to follow the changes in this respect. In order to easy this process and adopt the changes in manufacturing structure, a change management model is required in the manufacturing systems.

As mentioned before, it is hard to see an approach to observe the changes in manufacturing systems in the change management models. Although the manufacturing functions are not fully excluded in the existing management models, the main motivation of them is on managerial aspects.

I.3. DRIVING FORCES FOR MANUFACTURING CHANGE AND DRAFT MODEL

In the previous sections some of the change management models are investigated and the requirement for a model focusing on manufacturing systems is stated. To develop a model for manufacturing systems, the forces that lead to the changes in production are investigated at first. However there are so many factors, it is better to gather these factors into 5 main clusters. These factors are listed as the Technological, Process Based, Customer Oriented, Managerial and Environmental change elements.

Technological changes are one of the most important factors needed in order to model the change in manufacturing systems. It is clear that technological developments are continuously on progress. The manufacturing systems are vitally dependent on the new technologies to be compatible in the market by decreasing cost or increasing profit margin. Hence the technological developments should be well followed and managed to sustain the technological competency. In order to follow the changes *Technological Forecasting* should be planned and performed accurately at first. Depending on the accurate and precise forecasts about the forthcoming future technologies, the manufacturing company can produce new products by *Technological Innovation* activities. When the *Technological Adaptation* phase is completed successfully, these innovative products will provide great profits by sustaining the market leadership in a short time. Therefore, in order to manage the technological changes these three phases must be well managed and the success of these phases should be measured.

Process Based changes mainly rise from the technological changes. However the technological changes are well analyzed and followed up, if these changes are not implemented into the manufacturing systems as new methods, it causes great problems in the future. Some recent examples of these process based changes can be listed as the changing from mass production to flexible production systems, and from implementing make to stock policy to the generating the policy of “make to order”.

On the other hand, *Customers* and their needs and desires are the main reasons for the existence of any manufacturing system. The rapid change of customer aspects resulted in the change of customer needs not only in the product variety but also the delivery times of the products. The changes in customer requirements can be classified as the changes in demands, changes in delivery methods and times. Hence to manage the change for manufacturing systems, the customer changes should not be neglected, since they are the main reason for an enterprise to survive.

Moreover, a manufacturing system should not only regard technological, process based and customer oriented changes but also the *Managerial Changes*. It is obvious that technological changes affect the way of organizational behaviors and their management styles. With this aspect, new management techniques such as Virtual Management, Decision Support Systems and Artificial Intelligence based manufacturing management techniques are widely used in new organizational styles.

In case of ecological change, some manufacturing processes are stated to be hazardous for the environment for example mining gold via asbestos. If the manufacturing system invests in new methods and technologies with neglecting the environmental problems, then the future plans may turn to nothing but a huge amount of cost since the new method may be forbidden by the government. Every manufacturing company should take into account of *Environmental Changes* in case of preventing punishment by the government or sustaining international standards for environmental protection.

Based on the above arguments, a manufacturing change management model is proposed including these 5 factors (See Figure I-9). In the forthcoming chapters the relation between these factors and manufacturing systems are deeply investigated and a methodology is presented to measure the capabilities to follow the changes in each of them.

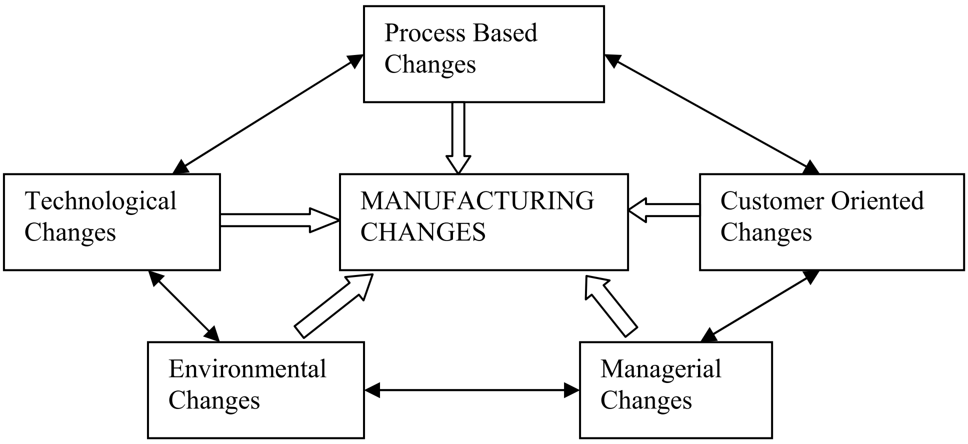

Figure I-9: Proposed model for managing the changes in manufacturing systems

II. TECHNOLOGICAL CHANGE

Before explaining the factors related to technological change in manufacturing systems, it is better to provide some definitions in order to create a common understanding.

Technology is briefly defined as all the physical processes which transform the inputs to outputs and the social arrangement accompanying this transformation (Kırım, 1990). Similarly, the technological change is stated as all the improvements of this transformation process including the development of the product. On the other hand, innovation which has a similar meaning with technological change is defined as the development and application of new ideas to create "*value*" (Lebret et al., 2006).

Based on the innovative behavior, technological changes mainly rise from the Research and Development (R&D) activities having the obvious property of applied research. One of the important features of this is that, this type of changes, are problem focused and each even small incremental step can provide important developments. Another important aspect to note is that the technological changes not only decrease the cost but also increase the firm performance in energy, raw material, labor, machines, and the other aspects. In order to achieve these benefits respective changes must not only be the responsibility of R&D departments and instead, is to be handled by every department or responsible body.

Objective of the technological changes can vary. Most widely they can be listed as; decreasing the cost, improving the quality, product differentiation, and utilizing the capacity, etc. To attain these objectives the important factors leading to benefits should be analyzed. This chapter provides an overview of such analysis.

II.1. FACTORS LEADING TO TECHNOLOGICAL CHANGE

It is obvious that the bases of the technological developments are the changes in automation and information systems. It is a clear fact now; information management systems integrated with the computer networks provide the efficiency of management of the institutional knowledge for the sake of better utilization of technology. The proposed change management model in this study is designed to take this fact into account. Most of the firms counter with crucial costs just for disregarding the studies of the infra-substructure of these systems. Lots of unnecessary inventory are kept in the storage areas, and the necessary ones are therefore being supplied with additional costs. It is intended to prevent these additional costs by sustaining a change management model within the entrepreneurship.

Since technological changes are one of the triggering factors of the companies to achieve effectiveness and efficiencies of their production units, they have to be managed carefully. In order to best achieve this, it is important to integrate the technological developments into the manufacturing system in a well determined and planned manner which can be assured through a well defined and implemented change management model.

In order to manage the technological change in this manner, it is crucial to decide on the best technology to be invested. Because searching for improper technologies provide nothing but unprofitable products for the manufacturing companies. Moreover, it is important to be aware of the return on investment value of the new technologies prior to investing scarce funds for them. Therefore, forecasts about benefits of the new technologies have to be accurate and precise. This clearly indicates the need for measuring the capability of performing *"Technological Forecasting"* in sustaining better initiating the change programs.

After forecasting the expected returns of the related technologies, the promising ones should be considered to be implemented through investment, researched or in house development in order to market technologically innovated products. Similar to technological forecasting the capability of *"Technological Innovation"* of the manufacturing system also needs to be measured as the second important aspect of change management model with respect to technological achievements.

After developing innovative products, they should be adapted to the manufacturing system taking the tools and equipments used, employees working on the manufacturing system as well as the knowledge utilized for the new products into account. Thereby the capability of *"Technological Adaptation"* is the third aspect technological change management which surely includes "Tool Effect", "Human Effect", and "Knowledge Effect" of the adaptation capability.

Since managing and following the changes in technological developments are vitally important for manufacturing systems, the capability for this is analyzed in the following sections. As the technological change management model stands on 3 important aspects, namely forecasting, innovation and adaptation capabilities as stated above, the methodology to measure the capability for each of these aspects are explained.

II.2. TECHNOLOGICAL FORECASTING

In order to create successful technological innovations and to adapt them into the manufacturing systems, the first thing to do is to forecast the trend in generating and implementing new technologies for the area of business in question. Technological forecasting is an extensively studied area and some methodologies are already presented in the literature as summarized below followed by a general methodology to measure the capability of technological forecasting in an enterprise.

II.2.1. Literature Survey

Technological forecasting is defined as foreseeing the technological innovation, scientific developments, and estimating the benefits and occurrence time of scientific inventions (Barutçugil, 1981). It is the process of predicting the future characteristics and timing of technology. If it is possible, the prediction will be quantified, made through a specific logic, and will estimate the timing and degree of change in technological parameters, attributes, and capabilities.

In another definition; technological forecasting is considered to be the prediction of characteristics or use of technology (Martino, 1980). Its main aim is identified as predicting the future technological capabilities, attributes, and parameters.

The importance of Technological Forecasting appears to be a principal impetus in economic development. Foreseeing technological advancements that will shape the future in this respect is of immense importance for many industrial, financial, or social enterprises, since they can be deeply influenced by emerging innovations.

Companies capable of undertaking technology forecasting can benefit in numerous ways including (Fey and Rivin, 1999);

- Taking the advantage over their competitors and dominate the market
- Being able to perform optimal planning and allocation of resources (investment, personnel, budget, inventory, etc.)
- Increasing effectiveness in monitoring of the market monitoring
- Maximizing financial gains and minimizing the losses
- Improving the quality of decision making

In order to achieve these benefits, there are so many methods proposed to form successful technological forecasts in literature (See for examples, Martino, 1980; Martino, 1993; Barutçugil, 1981; Fey and Rivin 1999; Meredith, 1995). In general those can be classified into 2 types of studies; Numerical Data Based Techniques, and Judgment Based Techniques. A brief analysis is provided below.

A. Numerical Data Based Techniques;

   1. Trend Extrapolation: It consists of inferring the future from the past. If there has been a steady stream of technological change and improvement, it is reasonable to assume that the stream will continue. There are 4 approaches for trend extrapolation; (Meredith, 1995)

      i. *Statistical Curve Fitting:* One of the best statistical procedures, which fit the past data to one or more mathematical functions such as linear, logarithmic, or exponential, is selected by statistical tests and the future trends in functional capabilities is forecasted.

      ii. *Limit Analysis:* Ultimately, all growth is limited and there is an absolute limit to progress. This method seeks the improvements how close to this limit. If a current technology is approaching its limit, it is important to recognize this limit to prevent dead R&D invests.

iii. *Trend Correlation:* In general, one technology is a precursor to another. Extrapolation of the precursor allows a forecast of the follower to be extended beyond the lag time.

iv. *Multivariate Trend Correlation:* It consists of forecasting the combinations and strengths of several precursors for the following technology.

2. Trend Extrapolation, Qualitative Approaches: It includes adjusting the statistical results by applying personal judgments. Generated forecasts are less precise but need not to be less accurate, and may be more accurate than the single statistical methods (Meredith, 1995).
3. Growth Curves: Technologies go through an invention phase, an introduction phase, a growth phase, and a maturity phase. Recognizing the technology's phase will support on the R&D decisions (Meredith, 1995).
4. Envelop Curves: It is a combination of growth curves and trend analysis. It regards more than one aspect to forecast future technological developments.
5. Substitution Model: When a substitution in technology begins, the new process or products initiates to demonstrate its advantage over past technology. The substitution is assumed to proceed to completion.

B. Judgment-Based Techniques

1. Monitoring: Occasionally, technological surprises occur. Monitoring allows the forecaster to stay abreast of technologies as they develop through 7 stages namely; Initial Idea, Postulation of Theory, Verification of Theory, Laboratory Demonstration, Field Trial, Commercial Introduction, Widespread Adoption (see Meredith, 1995 for more information).
2. Network Analysis: It is a formalization and extension of monitoring. There are two methods to implement. Possible capabilities that might result from current scientific research can be analyzed by *exploratory* forecasting. In the second method; desired capabilities to achieve is forecasted by *prescriptive* methods. This methodology is well explained in the literature (Meredith, 1995).

3. Scenarios: It attempts to describe a future technology together with its environment by forming a scenario which is a hypothetical view of future. As explained by Meredith, generally 3 kinds of scenarios for the Base, Pessimistic, and Optimistic situations are established (Meredith, 1995).
4. Morphological Analysis: It makes assumptions about what people will want in the future and then investigate the possible ways to achieve them. It relies on a matrix called Morphological box (Meredith, 1995), in which a well known existing situation is started to analyze. Alternate methods are analyzed to find improvements in technology, and the candidate solutions are examined for efficiency to be selected.
5. Relevance Trees: They are used to select a specific research project by defining objectives, goals, tasks, and sub-objectives in a hierarchical order to ensure to achieve all possible ways for the main objective. Meredith provides detail information about this methodology (Meredith, 1995).
6. Delphi Method: It is the best known judgmental approach and it gathers subjective judgments from individuals as written or remote distance to prevent interactions. These judgments are summarized and presented to participants. Evaluations are performed and a result is achieved to select the best alternative (Barutçugil, 1981).
7. Cross-Impact Analysis: It requires nominal forecasts for each trend that affect the technology and utilizes a generic model which contains the cross impacts. The cross impact model is generated by carrying out a Monte Carlo simulation to forecast the future technology (Martino, 1980).

Technological forecasts are much more different than a simple weather forecasting. The accuracy of a technological forecast is not known in advance. There is also no account taken for self altering forecasts. The value of the forecast is in its usefulness, not in its coming true. It is more important that forecasters educate forecast users to the idea that the goodness of a forecast lies in its utility not in whether it eventually comes true (Martino, 1993).

Although the aforementioned literature delineate some methodologies for technological forecasting, it is hard to observe an evidence of measuring the success rate of these forecasts. They are mostly based on the usefulness of the methodology rather than the accuracy of the results. Even if they are capable to set proper methods to forecast different technologies, the accuracy of the models is not prime importance. However, to manage the forecasting new technologies, the capability for technological forecasting needs to be measured. Hence, based on the measuring metrics for Technological Forecasting, which is established in the next section, a methodology to measure the capability is introduced for manufacturing systems in general.

II.2.2. Capability of Technological Forecasting

Most of the studies to forecast the technology are dependent on the specific attribute of the products which is somehow misleading. The focus to measure the forecasting capability should rather be on the general technological aspects of the respective manufacturing systems more than only one aspect. If the forecast is desired to be accurate it should encompass all of the aspects of related sector. It is found that the Throughput Time, Quantity/ Day, Scrap Rate, and the Revenue of new technologies could be good indicators for representing a good forecasting

II.2.2.1. Throughput Time

It is the period required for a material, part, or subassembly to pass through the manufacturing process. Note that, this aspect is not only dependent on the technological developments. It is obvious though, the technological developments, for example a new machine or tool usage, will definitely decrease the flow time of the production. Basically forecasting capability in estimating the throughput time is calculated by comparing the actual and forecasted values for each product. However it is cumbersome to cope with and record the actual and forecasted values when there are hundreds of product types. Therefore the average throughput time can be found by dividing the available working hour over total capacity, representing a unit production time on average.

In order to measure the capability in estimating the throughput time in this way, the first step is to look for the existence of a technological improvement; note that, when there is no technological improvement whatsoever then there will not be a need to forecast the effects of it.

At the second step, actual throughput time for the products should be recorded. However, the throughput time for each product may vary. Instead of dealing with flow time of each unit, average flow time of the products can be calculated by dividing the available working time per day by the actual daily capacity of the system. Following formulation results the actual average flow time of the system for a day.

$$\text{Actual Average Throughput Time} = \frac{\text{Available Working Time / Day}}{\text{Actual Capacity /Day}} \qquad \textbf{(II.1)}$$

At the third step, forecasted throughput time is required to measure for the sake of comparison of actual and forecasted values. Similarly, average forecasted throughput time is calculated by dividing the available working time over the forecasted capacity as shown in following formulation.

$$\text{Forecasted Average Throughput Time} = \frac{\text{Available Working Time / Day}}{\text{Forecasted Capacity / Day}} \qquad \textbf{(II-2)}$$

At the last step, the capability of forecasting is assessed by comparing the forecasted and actual average flow times. This comparison represents the capability to forecast technological developments for the particular year in question. For the sake of generalization, the capability can be calculated on a yearly base. And the average of these results denotes the general forecasting capability of the manufacturing system.

Table II-1 indicates an example case including actual and forecasted daily capacities and available working hours per day as well as calculating the actual and forecasted averaged throughput times for an instance of a 4 year period.

Table II-1: Throughput Time Forecasting Analysis for a Hypothetical Enterprise

	Year 1	Year 2	Year 3	Year 4
Actual Daily Capacity (units)	700	700	1,250	5,000
Available Working Time (min.)	540	540	540	540
Forecasted Capacity (units)	No Forecast	No Forecast	1,200	4,000
Actual Average Throughput Time (min/unit)	540/700=0.771	0.771	0.432	0.108
Technological Improvement	No Exist	No Exist	Exist	Exist
Forecasted Average Throughput Time (min/unit)	No Need	No Need	540/1200=0.45	0.135
Capability (%)	No Exist	No Exist	$(1-\frac{\lvert 0.45-0.432\rvert}{0.432})*100$ =95.83	75.00
Average Forecasting Capability for Throughput Time (%)			$\frac{95.83+75.00}{2}=85.41$	

In this example case; actual daily capacities are recorded for 4 years as well as the available daily working times. Since there are no forecasted values for the first two years, the values of third and fourth years are recorded. When the available working time is divided by the actual daily capacity, actual average throughput times are found as 0.771, 0.771, 0.432, and 0.108 for respective years. Since there is no technological improvement in the first and second years it is naturally not decided to make any technological investment, it is not required to forecast the outcomes of the developments. Hence measuring the forecasting capability for the first two years is redundant.

However technological improvements are assumed to occur for the third and fourth years. Due to these improvements, daily production capacities are forecasted to be 1200 and 4000 units respectively. Based on these capacity forecasts, forecasts for average throughput time are calculated by dividing available daily working time over the forecasted daily capacity and found as 0.45 and 0.135.

By comparing the actual and forecasted average throughput times of the third and fourth years, capabilities to forecast this aspect are calculated as 95.83% and 75% respectively. Taking the average of these two values results in the average capability to forecast the throughput time aspect of the manufacturing system and found as 85.41%. This score represents that, the company is 85.41% successful about forecasting revenue of the new technology with respect to throughput time aspect of the manufacturing system. In other words, they are mostly aware of the outcomes before investment.

II.2.2.2. Quantity/Day

This is another important aspect of element of technological change. Although it looks like similar to throughput time, it posses some differences. Although the throughput time indicates the production *speed*, the quantity/day represents the production *capacity* of the system. This capacity is not only dependent on the employees working rate, but also high technology machinery usage or highly trained-skilled workers. Hence, forecasting the capacity of the system is an indicator of forecasting the technological machinery used in the system.

Similar to Throughput Time, in order to measure the capability of forecasting the Quantity/Day, actual monthly production levels for each year should be recorded at first. Dividing this value by the number of working days in a month provides the actual daily production level. Note that this should also be divided by the number of workers to eliminate the effect of worker size. Beyond this, monthly production levels have to be forecasted due to technological changes (if any) for each year. Similarly these forecasted values should also be divided by the number of working days and the number of workers to achieve forecasted daily production level of the same production line. Consequently the comparison between the forecasted and actual daily production levels provides the forecasting capability for each year.

Table II-2 indicates a hypothetical example including actual and forecasted monthly production levels, the number of workers and working days as well as calculated values of the actual and forecasted daily production levels for a 4 year time period.

Table II-2: Quantity / Day Forecasting Analysis for a Hypothetical Enterprise

	Year 1	Year 2	Year 3	Year 4
Actual Monthly Production Level (units)	30000	50000	75000	117000
# of Workers	7	10	22	36
# of Working Days in a Month	22	22	22	22
Actual Daily Production	30000/ (7*22) = 194.8	227.2	154.9	147.7
Technological Improvement	No Exist	No Exist	Exist	Exist
Forecasted Monthly Production Level	No Forecast	No Forecast	60,000	75,000
Forecasted Daily Production	Not Exist	Not Exist	123.90	94.60
Capability (%)	Not Exist	Not Exist	80.00	64.10
Average Forecasting Capability for Quantity/Day (%)				$\frac{80.00+64.10}{2}=72.05$

According to this sample case, actual daily production levels are calculated by dividing actual monthly production levels over the number of workers and the working days. They are calculated as 194.8, 227.2, 154.9, and 147.7 for each year. When there is no technological change assumed, then there is not going to be a need for forecasting average daily production level. The forecasted daily production levels for the third and fourth years are calculated in a similar way and found as 123.9, and 94.6 respectively. Depending on the actual and forecasted values, capability for forecasting Quantity/day is found as 80% and 64.10%. By taking the average of these scores, the percentage capability of the enterprise to forecast the Quantity/ Day is 72.05%. This score denotes the success rate of forecasting the outcome of technology implemented with respect to quantity/day aspect. That is, they are 72% capable to forecast quantity/day results before they implement.

II.2.2.3. Scrap Ratio

This is in fact the indicator of quality, which is an important aspect of the technology management in manufacturing. If the main aim is to manage the technological changes successfully, the changes in this respect should be foresighted and the quality of the products should naturally be improved through them. It is clear that, the scrap ratio will most probably diminish in case of implementing new technological machinery or systems even if working with the same workers and environment. Successful capability of forecasting of the Scrap Ratio is therefore imported as it is definitely affected by the changes in technological investments.

In order to measure the success rate of this forecast, actual scrap ratio should be recorded at first. Scrap ratio of the manufacturing system should then be forecasted due to technological changes if any exists. By comparing the actual and forecasted values, capability to forecast scrap ratio could be assessed. Table II-3 indicates a similar hypothetical example including actual and forecasted scrap ratios as well as calculating the respective forecasting capabilities for a 4 year time period.

Table II-3: Scrap Ratio Forecasting Analysis for a Hypothetical Enterprise

	Year 1	**Year 2**	**Year 3**	**Year 4**
Actual Scrap Ratio (%)	15	15	8	3
Technological Improvement	No Exist	No Exist	Exist	Exist
Forecasted Scrap Ratio (%)	No Forecast	No Forecast	11	5
Capability (%)	No Exist	No Exist	62.50	33.33
Average Forecasting Capability for Scrap Ratio (%)				$\frac{62.50+33.33}{2}=47.92$

Based on this sample case, actual scrap ratios are recorded as 15, 15, 8, and 3% for 4 years. Since there are no technological changes assumed in the first two years, there is no need to forecast the scrap ratio. On the other hand, forecasted scrap ratios for the third and fourth years are recorded as 11%, and 5% respectively. Depending on the actual and forecasted values, capability for forecasting this aspect is calculated for the third and fourth years and found as 62.5% and 33.33%. By taking the average of these scores, the percentage capability for forecasting the Scrap Ratio aspect is found as 47.92%. Since it is less than 50%, it is an indicator of failure to forecast the outcome of new technology before implemented with respect to scrap ratio.

Although the actual scrap ratio is better than they expect, they could be understood as unsuccessful to foresee this improvement.

II.2.2.4. Revenue

This is another example of technological aspects of the manufacturing system. To manage the technological changes, new investments on machinery or other systems are inevitable. But, it is desired to know how much revenue, the new investment will gain. In order to this information, a forecasting study should be carried out.

In order to assess the success to forecast the revenue of new technologies, actual revenue and forecasted revenues are compared for each year. Capabilities of each year are averaged to find out the capability of forecasting the revenue for the period analyzed. Table II-4 indicates an example of a revenue analysis including actual and forecasted revenues as well as calculating the capabilities for a 4 year time period.

Table II-4: Revenue Forecasting Analysis for a Hypothetical Enterprise

	Year 1	**Year 2**	**Year 3**	**Year 4**
Actual Revenue (TL)	2,000,000	3,000,000	3,500,000	5,000,000
Technological Improvement	No Exist	No Exist	Exist	Exist
Forecasted Revenue (TL)	No Forecast	No Forecast	3,500,000	4,000,000
Capability (%) (Actual Revenue / Forecasted Revenue * 100)	No Exist	No Exist	100	80
Average Forecasting Capability for Revenue (%)				$\frac{100+80}{2}=90$

In order to conclude this section, some important points should be reviewed. Four capabilities namely; *Throughput Time*, *Quantity/Day*, *Scrap Ratio* and *Revenue* are important indicators that are not only but highly affected by the changes in technologies. In order to manage the change in this respect, forecasting studies should be carried out for each of these capabilities. Degree of Forecasting Capability (FC) is calculated as the weighted summation of these 4 indicators as represented in the following equation.

$$FC = \frac{(W_{FT} * F_T) + (W_{FQ} * F_Q) + (W_{FS} * F_S) + (W_{FR} * F_R)}{W_{FT} + W_{FQ} + W_{FS} + W_{FR}} \quad \textbf{(II.3)}$$

Where;

FC: Forecasting Capability

F_T: Forecasting Throughput Time W_{FT}= Weight of Forecasting Throughput Time

F_Q: Forecasting Quantity / Day W_{FQ}= Weight of Forecasting Quantity / Day

F_S: Forecasting Scrap Ratio W_{FS}= Weight of Forecasting Scrap Ratio

F_R: Forecasting Revenue W_{FR}= Weight of Forecasting Revenue

Note that the weight values related to respective indicators were determined by the author and his supervisor on the basis of the assessment carried out through a survey conducted by both the academicians and industrial representatives. The methodology of the survey and the results are summarized in Chapter VII.

II.3. TECHNOLOGICAL INNOVATION

After being able to perform accurate enough forecasting in the technological changes, the proposed model requires to the capability of innovative activities to be assessed for better manufacturing change management as the innovation is one of the very promising source of change. The studies about technological innovation and techniques to assess the success rate of this are summarized in this section. After assessing the respective research in the literature, a quantifiable methodology is introduced as part of the proposed model to measure the capability of technological innovation.

II.3.1. Literature Survey

The definition of innovation may change according to different situations, where it is implemented and analyzed. It is defined as turning knowledge into economic activity (Tang, 2006). For him, innovation is a process of discovery, learning, and application of new technologies and techniques from many sources. According to another study, technological innovation is defined as the results of the study of the interaction between technology and economy (Betz, 2003).

On the other hand, in Oslo Manual prepared by OECD (Organization for Economic Co-operation and Development), innovation is divided into two segments, as the product innovation and the process innovation. Both types comprise implemented technologically new products, processes and significant technological improvements in products and processes. It is called as a product innovation if a new product or significantly improved one has been introduced on the market whereas, the process innovation deals with the changes within a production process (OECD, 1995).

According to the same manual, product innovation can take two broad forms; technologically new improved products. A technologically new product is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge. A technologically improved product is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems

In another study about the public sector innovation in London, innovation is stated as the successful exploitation of new ideas (Wilson, 2007). In this understanding, the new ideas themselves may take any number of forms, including new products and processes, new organizational techniques, new markets, and new sources of supply. The key point in this definition is the term “successful exploitation”. That is, every new idea or product cannot be assumed as innovation unless they succeed in market creating a value for the originator. Similar to other aspect of technological change, the literature lacks in defining a way to measure the success rate of innovation for a certain enterprise.

In the concept of software innovation, it is referred as the act of creating something new, normally something breakthrough in nature that did not have significant prior existence in the same form (Misra et al., 2005). However the definitions can change from case to case, within the knowledge based economy;

innovation is seen to play a central role. Additionally it is hard to set a scale to measure the success rate of innovation for each case.

Productivity is one type of a scale to measure innovation. During the past fifty years, productivity has been the main output of innovation as companies increased production capacity and volume. In the simplest term, more people produced more goods by working faster and using bigger machines. But many of the measures of the economy are still based on the outdated "worker and machine" models.

Innovation is not only about ideas or patents. It is about people working on new things and in new ways. But existing measures do not explain who the workers are or what they are doing. To understand how innovation influences the economy, new measures are needed at the firm-wide and at the project level (Kingsland, 2007). Furthermore, without evaluation data and metrics, no information is available for the enterprises to establish the processes and applications that improve innovation. Many firms repeat the same processes or discover the same information repeatedly as they have no collaborations in storing information and sharing the results. However, new kinds of measurements need to be developed to determine if innovations are really making a difference.

Some metric units are suggested to measure the innovation in a recent study (Phillips and Hering, 2005). These can be listed as number of ideas generated, evaluated, converted to products, and the revenue generated from new products. In an another study, innovation measures are stated as; Labor Productivity, Patent Filling, New Venture Creation, and the Size of High Technology Sectors (Lebret et al., 2006). In the latter, those measures are recorded over a time period, and a brief analysis of Swiss performance in innovation is handled. A similar study was carried on about the realization of innovation in SMEs (Small and Medium Enterprise) by Çalıpınar and Baç (Çalıpınar and Baç, 2007). In that study, some metric units are used to devise a regression analysis model between the measures and the number of innovations. The number of employees, R&D Investment, Patent Costs, the Age of the Company, Export Income, and Advertisement Expenditures are taken as a baseline metrics. Although it is a well oriented regression analysis, some measures are not obviously suitable to calculate the degree of innovation. Although the number of employees is stated as an important factor in defining the capability of adaptation to new technologies, it is not clearly defined how to achieve this.

Although various definitions and measuring methods for innovation are suggested in the literature, there is not a widely and commonly accepted one on how to measure the innovation. Innovation is a nebulous concept. It should not be happenstance or accidental, but a sustainable, measurable business process. It is understandable that it is hard to measure the innovation since it is inherently subjective and imprecise, like measuring creativity or art. However a promising quantifiable methodology is presented in the next section for this purpose as part of defining the capability of technological innovation based on the product portfolio of the manufacturing companies.

II.3.2. Capability of Technological Innovation

Depending on the above discussions, the important aspect of innovation is basically creating something that adds value. So, defining and measuring this value could be an adequate element in evaluating the capability of manufacturing systems. Since the basic activity of the manufacturing companies depends on the products they produce, the change in the product portfolio will enlighten the capability of innovation for the two subsequent periods compared.

Keeping this in mind, the change in product portfolio needs to be analyzed using four basic indicators namely; “Change in Product Portfolio”, “New Product Ratio”, “Sales Amount Ratio of New Products”, and “Sales Revenue Ratio of New Products”. They are briefly explained below.

II.3.2.1. Change in Product Portfolio

At first, the total number of product types of the current and previous year is compared to find out the “Change in Product Portfolio Ratio” which is denoted as the first factor of innovation (Inv_1), calculated as;

$$Inv_1 = \frac{(\#\text{ of Product Types}_t - \#\text{ of Product Types}_{t-1})}{\#\text{ of Product Types}_{t-1}} \qquad \textbf{(II.4)}$$

Where,

Inv_1: First factor of innovation -Percentage Change in Product Portfolio-

In the best case the number of product types can be doubled between two periods, which results this ratio as 100%. However for the superior case of increasing the number of products more than twice of the previous year, leads to a value greater than 100%. At this situation the result can be adjusted to 100% for the reason of setting a scale between 0 and 1.

II.3.2.2. New Product Ratio

Although the first indicator deals with the number of product types, it may mislead wrong deductions in case of not producing some of the previous product types. For example, if the company produced 10 types of products in previous year and still producing 5 of them in the current year with the addition of 10 new product types, change in product portfolio indicates 50% for the innovativeness. However 10 of the 15 product types are new for the current year, which results a rate of 66.66%. Therefore the new product ratio of the current year is to be analyzed additionally. This is calculated by dividing the number of new product types over the total number of product types as in the following formulation.

$$\mathrm{Inv}_2 = \frac{\#\text{ of New Product Types}_t}{\text{Total }\#\text{ of Product Types}_t} \tag{II.5}$$

Where,

Inv_2: Second factor of innovation -New Product Ratio-

II.3.2.3. Sales Amount Ratio of New Products

However the change in product types cannot only reveal the innovation capability at all. It should be noted that, producing different types of products does not always create value if they are not sold at the market. The sales amount of the new products should therefore be divided by the total sales amount to release the effect of new product types on the total sales quantity. This is calculated as such;

$$\mathrm{Inv}_3 = \frac{\text{Sales Amount of New Products}_t}{\text{Total Sales Amount}_t} \tag{II.6}$$

Where,

Inv_3: Third factor of innovation -Sales Amount Ratio of New Products-

II.3.2.4. Sales Revenue Ratio of New Products

Although Sales Amount denotes the marketability of the new products, still it has some drawbacks. The new products cannot be called as innovative products in case of the low sales revenue of them even if the sales amount is respectively high. In other words, the new products can be sold at high amounts but adding low value for the total sales revenue. To prevent this occasion, sales revenue of the new products are divided by the total sales revenue to reflect the effect of new products on the total revenue.

$$Inv_4 = \frac{\text{Sales Revenue of NewProducts}_t}{\text{Total Sales Revenue}_t} \qquad \textbf{(II.7)}$$

Where

Inv_4: Fourth factor of innovation -Sales Revenue Ratio of New Products-

In order to clarify the formulations an example is illustrated in Table II-5, including the number of product types, sales amount and revenues for the new and existing products for a two year period analysis.

Table II-5: Product Portfolio Analysis for a Hypothetical Example.

Product Portfolio Analysis	**2006**	**2009**		
		Product Families in the Previous Year	*New Product Families*	*Total*
Number of Product Families	82	66	172	238
Total Sales Amount	268321	754007	554581	1308588
Total Revenue (TL)	2565461.225	5771944.7	2286324.175	8058268.875

When this example case is observed the following conclusions can be drawn. The number of product families increased from 82 to 238 different types from 2006 to 2009. This increase is a good indicator for the change in product portfolio and leads to 190% increase. To set a scale it is adjusted to 100% representing the complete success for the product portfolio change. Therefore;

$$Inv_1 = \frac{(238-82)}{82} = 190\% \Rightarrow 100\% \qquad \textbf{(II.8)}$$

The second indicator, which is the new product ratio, investigates the number of new products over total number of products and found as 72.27%.

$$Inv_2 = \frac{172}{238} = 72.27\% \quad \textbf{(II.9)}$$

As explained before, sales amount ratio of the new products deals with the quantity of the new products sold at the market compared to the total number of products sold. Hence, it is calculated as the following;

$$Inv_3 = \frac{554581}{1308588} = 42.38\% \quad \textbf{(II.10)}$$

When it is compared with the previous indicator, although the 72.27% of the products portfolio comprises of new products, the new products are responsible for only 42.38% of total sales amount. One of the reasons for this may be the recent introduction of the products to the market, or the new products may not be welcome or accepted by the market.

Sales revenue ratio of the new products examines the value added to total revenue by the new products and it is found as;

$$Inv_4 = \frac{2286324.175}{8058268.875} = 28.37\% \quad \textbf{(II.11)}$$

It is a remarkable score compared with the 72.27% of new product ratio. Although most of the products are new, only 28.37% of total revenue is achieved from the new products. That shows, the new products are not so profitable or cannot add great value on the total revenue.

To conclude this section, 4 important indicators namely; *Change in Product Portfolio, New Product Ratio, Sales Amount Ratio of New Products, Sales Revenue Ratio of New Products* are introduced. Based on these indicators Degree of Innovation Capability (IC) is calculated as the weighted summation of these 4 indicators as in the following equation.

$$IC = \frac{(W_{Inv1} * Inv_1) + (W_{Inv2} * Inv_2) + (W_{Inv3} * Inv_3) + (W_{Inv3} * Inv_3) + (W_{Inv4} * Inv_4)}{W_{Inv1} + W_{Inv2} + W_{Inv3} + W_{Inv4}} \quad \textbf{(II.12)}$$

Where,

IC : Innovation Capability

Inv_1: First Factor of Innovation -Percentage Change in Product Portfolio-

Inv_2: Second Factor of Innovation -New Product Ratio-

Inv_3: Third Factor of Innovation -Sales Amount Ratio of New Products-

Inv_4: Fourth Factor of Innovation -Sales Revenue Ratio of New Products-

W_{Inv1}= Weight of percentage change in Product Portfolio

W_{Inv2}= Weight of New Product Ratio

W_{Inv3}= Weight of Sales Amount Ratio

W_{Inv4}= Weight of Sales Revenue

The weight values are defined as in the case of forecasting.

II.4. TECHNOLOGICAL ADAPTATION

As the third step of technological change management model, technological adaptation takes place after forecasting the new technologies and performing innovative activities. It is clear that, innovative products should be well embedded into the manufacturing systems to fully utilize. Therefore, Technological Adaptation is considered to be another important aspect of the change process. The studies about technological adaptation and techniques to assess the success rate of this are summarized in this section. After assessing the researches about this subject in the literature, a quantifiable methodology is introduced to measure the capability of technological adaptation in the further section.

II.4.1. Literature Survey

Technological adaptation is a wide area to be searched. Although there are some metrics to analyze the adaptation success of the companies for changes, the adaptation rate to new technologies have not adequately been investigated. Note that, the essence of technology adaptation is to make an analysis of structure change in organization, in order to adjust to the impact brought about by technology (Wu and Ho, 2005).

In the literature, there is a tendency to discuss technology transfer for handling technological changes. There are various studies about the technology transfer.

However every organization has its own goal and culture, there is no single technology transfer process that fits to all organizations and occasions. Rather, there are several key steps or activities included in most technology transfer processes; Awareness, Relationship with Requirements, Assimilation, and Implementation are some of the important ones. The process also typically involves a variety of players, from transferors who create the technology and prove the concept, to those who embed the technology in a useful product, service, tool, or practice, and finally to transferees, who embrace it, further develop it, commercialize it, and ultimately use it (Wang et al., 2003).

Facilitating technology transfer, understanding its role, and evaluating its impact require a clear set of metrics for measurement. Thus, the difficult tasks of specifying appropriate metrics and collecting the respective data are important and necessary. Moreover, a single metric may be undesirable or impractical since the benefits can accrue to diffuse populations and along diverse pathways, in some cases the benefits do not emerge until well after the technology is deployed (Wang et al., 2003). In the same study some metrics are proposed to measure the success of technological transfer in 5 categories with their definitions (see Table II-6): Although these are promising metrics, they cannot be applied to all manufacturing sectors. For example, the number of applied research or patents may not always indicate the capability of the organization to adapt itself to technology transferred.

Table II-6 Five general ways of measuring technology transfer

METRIC	DEFINITIONS
Patents, Licenses, Revenue	Number applied for/granted, basic/applied research, country, affiliation
Manufacturing Innovations	Number of innovations applied for by the Small Business Association
Web Hits to Science Database	Page hits, average time spent on page, number of downloads
Transfer Mechanisms	Number of sign-in visitors, meetings, documents sent/requested, exchanges
Knowledge Spillovers	Estimated statistical relationships of innovation activity

In an another study aiming to measure the technology capacity in developing countries; 9 inputs are identified as independent variables, 5 outputs are defined as the dependent variables for technological adaptation (Ortiz et al., 2007). These 9 inputs are; Qualification, Commercializing, Design, Research and Development, Organizational Modernization, Technology Incorporated to the Capital, Technology non-Incorporated to the Capital. 5 output variables are listed as; Certification, Innovation of Process, Product Innovation, License, and Patent. Measurement models of all of the inputs and outputs are described in that study. Figure II-1 is proposed to graphically indicate the gap between desired value and real value of technological variables. Within these 12 variables, only the 11th and 12th ones satisfy the desired values at 100%. However, the 8th variable is incapable of meeting the desired values.

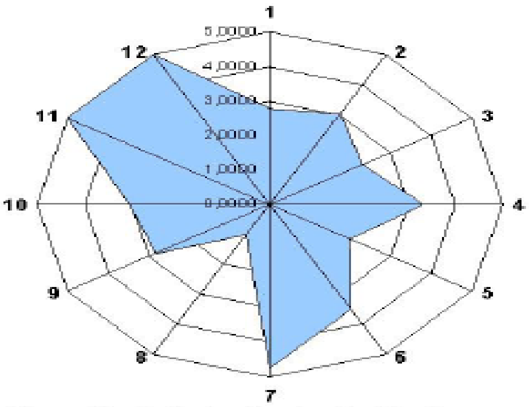

Figure II-1: Radar graph-textile company (Ortiz et al., 2007)

The literature survey also indicated that, “Technology Acceptance Model (TAM)” and its derivations are widely used to interpret the success of technological adaptation (Bagozzi et al., 1992). TAM is an information systems theory that models how users come to accept and use the technology. Two initiators for this model to measure the acceptance of technology are suggested as (Davis, 1989);

- **Perceived usefulness** (PU) - This was defined as "the degree to which a person believes that using a particular system would enhance his or her job performance".
- **Perceived ease-of-use** (PEOU) - Davis defined this as "the degree to which a person believes that using a particular system would be free from effort"

TAM is one of the most influential extensions of Ajzen and Fishbein’s Theory of Reasoned Action (TRA) in the literature (Ajzen and Fishbein, 1980). TAM replaces many of TRA’s attitude measures with the two technology acceptance measures— ease of use, and usefulness. On the other hand the components of TRA are three general constructs; Behavioral Intention, Attitude, Subjective Norm. TRA suggests that a person's behavioral intention depends on the person's attitude about behavior and subjective norms such as,

Behavioral Intention= Attitude + Subjective Norm

In the following studies Ajzen introduced the Theory of Planned Behavior by adding a new component, "perceived behavioral control" (Ajzen, 1985). Since, behavioral intention cannot be the exclusive determinant of behavior where an individual's control over the behavior is incomplete. Based on this, the equation is redesigned as;

Behavioral Intention= Attitude + Subjective Norm+ Perceived Behavioral Control

Furthermore, in order to explain the amount of variance in the tool utilization, Dishaw and Strong extended TAM with another model called Task Technology Fit (Dishaw and Strong, 1999). Task Technology Fit model addresses utilization of tools from a different perspective by utilizing task requirement, Tool Functionality, and Tool experience factors. In their study with their questionnaire, a correlation analysis is performed to understand the variance in tool utilization. Classical TAM model can explain the variance in utilization by 36% whereas Task Technology Fit can explain 41%. When the two models are integrated it is found out that, integrated path model can explain 51% of variance in utilization (Dishaw and Strong, 1999). Since TAM and their derivatives generally focus on behavioral science for information systems and focus on the human aspects of the change (Davis et al., 1989), the rest of this part is devoted to measure technological adaptation. Hence, technological adaptation should include tool-equipment and knowledge adaptation as well as human adaptation.

II.4.2. Capability of Technological Adaptation

In the previous part some Technology Transfer and Technological Acceptance models and their derivatives are reviewed. However, none of them can fulfill the requirement of a Technological Adaptation model to manage the change in technologies with respect to tool knowledge and human aspects. Because, by the term of technological adaptation not only the human effects but also tool and knowledge effects should be taken into account. Previous models generally depend on human sociology or the transfer of technologies.

By the help of concepts from the literature survey as summarized above, the Technological Adaptation within an enterprise can be investigated in mainly 3 areas; Tool Effect, Human Effect, and Knowledge Effect.

II.4.2.1. Tool Effect

Tool effect is one of the most important factors for the integration of new developed technologies to the facilities. It can be very logical for a company to be very innovative if it can highly adapt its machine and tools into the emerging and developing technologies. In order to understand the Tool Effect of Technological Adaptation, 3 sub factors are defined to be of importance and measured. These are Degree of Machine/Tool Replacement, Level of Automation, and Utilization Rate of Information Technologies. The methodology provided to measure these factors is explained below.

a) Degree of Machine Replacement:

Machine replacement rate, which designates the average changes in machine investment in successive years of the analysis, is calculated by comparing the machine investments of two successive years according to following formulation.

$$T_1 = \frac{\text{Machine Investment}_t - \text{Machine Investment}_{t-1}}{\text{Machine Investment}_{t-1}} \quad \textbf{(II.13)}$$

Where,

T_1: First factor of Tool effect -Degree of Machine Replacement-

According to formulation degree of machine replacement rate, which can be denoted as T_1 representing the first indicator of Tool Effect, can take any value between “-1” and “∞”. Although there is an investment in previous year if there are not any machinery investments for the current year this ratio will result as “-1” representing a lack of investment for the current year. Hence this score can be adjusted to 0% for this aim. On the other side, although there is not an investment in previous year, if there is an investment for the current year this ratio will result as “∞”. Hence this score can be adjusted to 100% success for measuring the change in machinery investment. The low level of investment does not matter, since this analysis is carried for successive periods, the level of investment shows its effect for next years.

b) Level of Automation:

This rate is also important for defining the adaptation level. Level of automation is the ratio of the values of automated machines divided by the values of all machines. Moreover while calculating the ratio of automated machines; partially automated machines will be multiplied with a factor of automation to reflect the partial automation capability. That is, if the machinery is assumed as 75% automated, then the value of that machinery is multiplied by this factor. If T_2 represents the second indicator of Tool Effect, it is calculated as,

$$T_2 = \frac{\text{ValueofFullyAutomatedMachines} + (\varphi * \text{ValueofPartiallyAutomatedMachines})}{\text{Value of Total Machines}} \qquad \textbf{(II.14)}$$

Where,

T_2: Second factor of Tool effect -Level of Automation-

φ: Degree (Percentage) of Automation

c) Utilization of Information Technologies:

Information technology is widely used in every aspect of corporate activities and is becoming essential for conducting business. The benefits of IT utilization vary due to the sector of the company. For example, possible benefits of IT on a construction project are listed as increasing accountability, communication, personal productivity and decreasing paper works, travel time, construction errors, delays, etc. (Saidi, 2002). In general, without depending on the sector, information technologies can increase the productivity of workers, efficiency of processes, and satisfaction of customers by transmission, sharing, processing, and analyzing the information with the help of developing computer based technologies. Therefore most of the companies should take into account of IT technologies more than before. According to another recent study, the past tendency indicates that IT investments increase or decrease in association with the moves of overall capital investments (Yodokowa, 2006). Companies should also take a more active approach to increase IT investment.

At this point an important question arises with the success rate of IT investment. This question can be answered by measuring the IT utilization. In order to measure IT utilization, some of the best known and fundamental applications of IT are investigated. These crucial applications are identified to be the Database Management System (DMS), IT Infrastructure, Management Information Systems (MIS), Decision Support Systems (DSS), and Expert Systems. By analyzing the use of these 5 systems will provide an indication of IT utilization capability of the enterprises. Six different situations can be encountered in using these IT related systems.

Case 0: No implementation
Case 1: No implementation , personalized employment
Case 2: Partial implementation, partial employment
Case 3: Partial implementation, Full employment
Case 4: Full implementation, partial employment
Case 5: Full implementation full employment

The levels of implementation as described above can be measured by a 6 scale Likert measure as 0 indicating the absence of system and 5 indicating the fully implementation and fully utilization of the system. Table II-7 shows examples of weights for such an application. Note that the weights will be subject to sector and will be defined either by expert view or through a questionnaire.

Table II-7: Weights and Scale of each IT application

Application	Respective Weights (Example)	Case 0	Case 1	Case 2	Case 3	Case 4	Case 5
DMS	30	0	6	12	18	24	30
Infrastructure	25	0	5	10	15	20	25
MIS	20	0	4	8	12	16	20
DSS	15	0	3	6	9	12	15
Expert Systems	10	0	2	4	6	8	10
Total	100						

In this table some important questions should be answered. First one is about the weights for each application. These weights are ranked in decreasing order of importance from top to down. They share the total 100 points according to their importance order with 5 points difference between them. Since employing a database system is more important than having a capable infrastructure, its weight is 5 points more than the latter one. Also the infrastructure has 5 more points since it is more important than utilizing a management information system. The reason for having an interval of 5 points increments is that it may provide a clear distinction between different factors. However, the user of the model may implement his own scheme which does not harm the model.

Second important issue is about the selection of these systems. Database management systems are vital for the utilization of IT. As organizations store an increasing amount of information and knowledge in databases they are attempting to manage that knowledge in more efficient ways (O'Leary, 1998).

Infrastructure refers to informal and formal channels of communication, software development tools, by members of particular groups. In other words, by the help of a well organized infrastructure, communication is enhanced and the advantage of database management system reveals.

MIS is a planned system of collecting, processing, storing and disseminating data in the form of information needed to carry out the functions of management (Kottler and Keller, 2006). It supplies the internal controls of a business such as; applications of people, documents, technologies, and procedures by management accountants. It is required to solve business problems such as costing a product, service or a business-wide strategy, etc.

DSS is a computerized system used for supporting rather than automating decisions. A more specific definition is stated as an interactive, flexible, and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making (Turban, 1995). It is required to utilize data and knowledge, to provide an easy-to-use interface, and allow for the decision maker's own insights. Moreover, expert systems and executive information systems are forthcoming topics of information technologies and can be taken into account as the advanced application systems.

While analyzing the IT utilization of the manufacturing system, the system will be observed if any of these applications are used and the usage rate will be investigated. If database management system is fully implemented and fully employed then it fits for the 5th case and takes 30 points. The overall degree of IT utilization is calculated as the summation of all the points for each case with respect to related system application. If T_3 denotes the level of IT utilization for the tool effect component of Technology Adaptation, it is calculated as;

$$T_3 = \frac{\sum \text{Related System Application Points}}{100} \qquad \textbf{(II.15)}$$

Where,

T_3 : Third factor of Tool effect –IT utilization-

After measuring the *degree of Machine Replacement*, *Level of Automation*, and *IT Utilization*, the Tool Effect (TE) on Technological Adaptation can then be calculated as, a simple weighted ratio which is

$$TE = \frac{(W_{T1} * T_1) + (W_{T2} * T_2) + (W_{T3} * T_3)}{W_{T1} + W_{T2} + W_{T3}} \qquad \textbf{(II.16)}$$

Where,

TE: Tool Effect

T_1: First factor of Tool effect -Degree of Machine Replacement-

T_2: Second factor of Tool effect -Level of Automation-

T_3: Third factor of Tool effect -IT Utilization-

W_{T1}: Weight of Machine Replacement Effect

W_{T2}: Weight of Automation Level Effect

W_{T3}: Weight of IT Utilization Effect

The weight values are defined as in the case of forecasting capability.

II.4.2.2. Human Effect

The role of Human Effect on Technology Adaptation is more important than expected and it creates more obstacles than supports. Generally, organizations invest a great deal of their resources to obtain the necessary hardware and software technologies together with insignificant investment in the human aspect of technology (Szewczak and Khosrowpour, 1997). It takes time for people to change and to adapt to new environments, and new procedures. Most of the time, people prefer stability, as consistency often proves to be more convenient and less frustrating to them. Also technological change needs to address the satisfaction and motivation of the users of the technological system (Zakaria and Yusof, 2001).

In one of the studies, the relationship between innovativeness and size of the company (number of workers) or the sectoral structure is investigated. The strong relation between innovation and company size is supported by a wide range of empirical studies (Koschatzky et al., 2001; Tether et al., 1997).

As observed in the literature, technological adaptation is strongly dependent on the human aspects (Koschatzky et al., 2001). In order to understand the human effects on technological adaptation, some related issues and respective factors are to be studied. These issues are nominated as; Average Worker Experience, Technological Investment per Worker, and Rotation Ability. The methodology provided to measure the effects of these factors is explained below.

a) Average Worker Experience:

It simply designates the average time of workers to be employed. At the first look, it seems to be a negative factor on technological adaptation for a worker to work at the same company for a long time horizon. However, it could be obvious that, the experienced workers have more capabilities to understand and implement the new technological developments.

In order to define the worker experience, standard working time ($T_{std.}$) in the related sector should be defined at first. It denotes the time necessary to achieve the maximum experience. This time can be assumed as 10 years for the automotive sector by expert opinions. After defining the standard working time, the experience of the worker can be the ratio of working time in the related sector within last $T_{std.}$ time.

$$\text{Experience of a Worker} = \frac{\text{Working in Sector in Last } \mathrm{T_{std}}}{T_{std}} \qquad \textbf{(II.17)}$$

When the experience ratio of each worker is averaged, Average Worker Experience, which is denoted as the H_1, can be calculated as the following formula.

$$\mathrm{H_1} = \frac{\sum \text{Exp. of All Workers}}{\#\text{ of Workers}} \qquad \textbf{(II.18)}$$

Where,

H_1: First factor of Human effect -Average Worker Experience-

b) Change in Technological Investment per Employee:

Technological investment per employee ratio is expected to be high when the technological adaptation is successful. If the R&D expenditures and technological investment is high, the automation level increases. This will surely, diminish the number of workers.

However, the ratio of technological investment per employee is not adequate. The percent change in this ratio should be analyzed within a certain period to assess the capability to follow and adapt to the new technologies. That is, percent change in technological investment is divided by the percent change in worker numbers for successive years.

$$H_2 = \left(\frac{\text{Investment}_t - \text{Investment}_{t-1}}{\text{Investment}_{t-1}}\right) / \left(\frac{\#\text{Employees}_t - \#\text{Employees}_{t-1}}{\#\text{Employees}_{t-1}}\right) \qquad \textbf{(II.19)}$$

Where,

H_2: Second factor of Human effect -Change in Technological Investment/Employee-

According to above equation, H_2, which represents the second factor of Human Effect, can take values between "-∞" and "+∞". For the values of less than 0 are assumed to be 0. Since, the negative values in the change of technological investment per worker demonstrates that a decrease in this ratio. If this ratio diminishes, then the technological adaptation cannot be stated as a successful operation. Similarly, the values greater than 1 signal an increase in each year's investment per worker ratio, as well as a successful technological adaptation.

c) Rotation Ability:

According a recent study, rotation is commonly applied in the work place, especially in the industrial sector, at the initiative of both workers and employers (Vezina, 2004). Job rotation supplies benefits both for the companies and the workers. For the companies; investment in staff development is a major key to survival and growth, but it carries a cost in terms of releasing key staff and finding the right training. For the workers, job rotation will improve their knowledge, skills and qualifications through supplementary training and general education, increasing effectiveness in their role and improving job security. Additionally, in unhealthy working environments, job rotation will be obligatory more than a suggestion. A work analysis must cover the entire system, and if the workplace cannot be changed (e.g. at an assembly line) job rotation will be helpful to increase the efficiency of workers (Knauth et al., 2005).

Rotation ability is also an indicator of technological adaptation. It is clear that if all workers can work at each step of manufacturing process with just a little more training, then the overall manufacturing system is not dependent on humans. In other words technological adaptation is so successful that, each worker can perform each technological aspect of the manufacturing process. Hence calculating the rotation ability is considered to be a sign for the technological adaptation. Calculating rotation ability is simply the ratio of number of workers proper to be assigned at different work centers over total number of workers. Hence H_3, representing the third factor of Human Effect can be calculated as the following formula.

$$H_3 = \frac{\text{\# of Flex Workers}}{\text{\# of Workers}} \quad \textbf{(II.20)}$$

Where,

H_3: Third factor of Human effect –Rotation Ability-

After measuring 3 factors, to calculate the Human Effect (HE) on Technological Adaptation, a simple weighted calculation is performed as the following.

$$HE = \frac{(W_{H1} * H_1) + (W_{H2} * H_2) + (W_{H3} * H_3)}{W_{H1} + W_{H2} + W_{H3}} \quad \textbf{(II.21)}$$

Where

HE: Human Effect

H_1: First factor of Human effect -Average Worker Experience-

H_2: Second factor of Human effect -Change in Technological Investment/Worker-

H_3: Third factor of Human effect -Rotation Ability-

W_{H1}: Weight of Worker Experience

W_{H2}: Weight of Tech. Investment per Worker

W_{H3}: Weight of Rotation Ability

The weight values are defined as in the case of forecasting.

II.4.2.3. Knowledge Effect

Knowledge is something that connects the people to the new technology. Therefore the workers should be informed about the change and its benefits at first to minimize the resistance to change. This can be handled by concerned ***Training*** and information of the workers.

Apart from ***Training, Response Generation*** can be stated as the second element of knowledge effect on technological adaptation. It will measure the easiness and usefulness of knowledge to be achieved when it is required. If every worker achieves the required knowledge when it is needed, during the adaptation stage of technology, then it is clear that the success of this adaptation can increase.

Furthermore, it is important to increase the ***Enterprise Knowledge.*** By the term of enterprise knowledge, sustaining a knowledge management system. Obviously, this will increase the success of technological adaptation for the new technologies. Following is the explanation of these elements and possible measurement methods.

a) Change in Training Hour per Worker:

An organization needs to train people phase by phase for different groups and at different times and also entails different approaches for different groups of users (Zakaria and Yusof, 2001). That is due to the fact that all individual or group users will not need the same type, detail, or quantity of training (Ward and Bawden, 1997). Hence, in order to increase the capability to adapt new technologies, more training hours for each worker should be provided.

Since the technological adaptation is a continuous process, the workers should be trained for each year. For this reason percent change in training hours is divided by the percent change in number of workers for successive years to reflect the change for this aspect as shown in following equation.

$$K_1 = \left(\frac{\text{Training Hour}_t - \text{Training Hour}_{t-1}}{\text{Training Hour}_{t-1}}\right) / \left(\frac{\#\,\text{workers}_t - \#\,\text{workers}_{t-1}}{\#\,\text{workers}_{t-1}}\right) \qquad \textbf{(II.22)}$$

Where,

K_1: First factor of Knowledge effect -Change in Training Hour/Worker-

According to above formulation, K_1, which represents the first factor of Knowledge Effect can take values between "-∞" and "+∞". For the values of less than 0, are assumed to be 0. Since, the negative values in the change of training hour per worker demonstrates that a decrease in this ratio. If this ratio diminishes, then the technological adaptation cannot be stated as a successful operation. Similarly; for the values of greater than 1, signals an increase in each year's investment per worker ratio. Hence a successful technological adaptation is triggered. Therefore, K_1 can be assigned a value between "0" and "1".

b) Response Generation Rate:

The time of response generation is also important while adapting the new technology developed. While performing the manufacturing to produce new product, only a few people know what to do and how to do those. Therefore a clear instruction guide should be prepared before passing through the manufacturing phase. This manual should not only list the activities' sequence but also include the Responsible Worker, Executive Officer, and also Expected Response Time in case of an unknown or unexpected event. Controversially for upper managerial operations, executive officer may desire the results of an operation from the responsible worker. In this instance it is again very important to get the desired knowledge in a reasonable time period. To clarify the issue following Table II-8 is provided an example of an "Instructions Manual".

Table II-8: An example of an Instructions Manual

Steps	Operation	Responsible Worker	Executive Officer	Expected Response Time	Actual Response Time	Delay
1	…..	Worker A	Specialist A	10mins.	5mins.	0
2	…..	Worker B	Specialist A, B	4mins.	6mins.	2mins.
3	…..					
…						

In this table, expected response time for the transfer of the knowledge for both the direction should be pre-determined by the expertise. While implementing the new technology to produce the new products, actual response time for this knowledge transfer is recorded. If actual time is greater than expected time, then there occurs a delay within this transfer. It may be suggested to set higher expected response times. However this will definitely lead to lower customer satisfaction. The degree of response generation, represented by K_2 as the 2^{nd} factor of the knowledge effect, can be calculated as;

$$K_2 = 1 - \frac{\sum \text{Delay Time}}{\text{Assessment Time Horizon}} \quad \textbf{(II.23)}$$

Where,

K_2: Second factor of Knowledge effect –degree of response Generation-

By the term of Assessment Time Period the time horizon which is selected to analyze the change capability of the firm is denoted. If the change capability of the firm is investigated on a yearly base, total delay time of knowledge transfer for every operation and for each Instructions Manual is added and divided by the number of workdays in a year. As it is understood by the formula; K_2 may take values between $(-\infty, 1)$. However the values less than 0 are easily called a disaster for response generation rate. Therefore for the values less than 0, the degree of response generation equals to zero.

c) Enterprise Knowledge Index:

Before explaining the enterprise knowledge, the knowledge itself should be defined. Although there are various definitions in the literature, data, information, and knowledge terms are misunderstood and misused in general. Data is the raw material gathered through different channels about the phenomenon. However, information is to know something about a phenomenon, and knowledge is to know how that phenomenon will react to any change (Arslankaya, 2007).

Data is the entire of all images to define some facts for the phenomena. In general data never changes from time to time. Information is the process of operating data. Knowledge is the phase of creating value from information. Knowledge is produced from information as similar to the production of information from data (Barutçugil, 2002). The transfer of information from node to node is very easy and fast. However transfers of knowledge from person to person are difficult and slow.

Although there are so many concepts about knowledge such as the classifications and types, the rest of knowledge components will not be mentioned in detail. Since the changes in Enterprise Knowledge is the core of this part. Other important aspects of knowledge can be investigated in the literature (Taşkın and Adali, 2004; Drucker, 1999; Barutçugil, 2002; etc.).

However, Knowledge Management is an important subject and defined as achieving, sharing, developing, and utilizing of the productive knowledge to increase the enterprise performance (Barutçugil, 2002). Yogesh Malhotra, who is one of the experts of the area, stated that knowledge management serves to solve adaptation, continuity, competition problems of enterprises under the rapid change environments (Malhotra, 1998). Comprehensively, knowledge management is a human-machine interaction system, which gathers data from inside the enterprise or outside the firm, transforms into information, stores information, communicate to required nodes in order to support decision systems, increase efficiency, enhance management, planning, and auditing operations in all levels of the company (Anameriç, 2005).

On the other hand; enterprise knowledge denotes the recorded or unrecorded knowledge which is produced within that enterprise or accepted from outer sources (Odabaş, 2003). An Enterprise Knowledge Management (EKM) entails formally managing knowledge resources in order to facilitate access and reuse of knowledge, typically by using advanced information technology (O'Leary, 1998). An enterprise knowledge management model is a hierarchical network of rules that enables an agent to explain, anticipate, and predict events and interaction patterns: in the enterprise's knowledge management and in the enterprise's environment.

However, the subject of this part is to measure the capability for the Enterprise Knowledge, a Knowledge Management Performance Index (KMPI) is defined in a recent study, having 5 factors such as Knowledge Creation, Knowledge Accumulation, Knowledge Sharing, Knowledge Utilization, and Knowledge Internalization into account (Lee et al., 2005).

For each factor, there are some constructs defined to measure the efficiency of the related component. For each constructs there are some statements, of which the application rate of the constructs, are queried through the survey with the responsible person in the company. This survey is listed with the factors, constructs and the statements in Table II-9.

Table II-9: Enterprise Knowledge Index Questionnaire

Factor	Construct	Items
Knowledge Creation	Tasks Understanding	I often use an electronic bulletin board to analyze tasks.
		My predecessor introduced me to my tasks.
		I fully understand the core knowledge necessary for my tasks.
	Information Understanding	I obtain useful info. And suggestions from brainstorming
		I am ready to accept to new knowledge and apply it to my tasks when necessary
		I understand computer programs needed to perform the tasks and use well.
		I search info. for tasks from various knowledge sources administrated by organization
Knowledge Accumulation	Database Utilization	We refer to corporate database before processing tasks
		We search through customer and task related databases to obtain knowledge necessary for the tasks.
	Systematic Mang. of Task Knowledge	We try to store expertise on new tasks design and development
		We try to store legal guidelines and policies related to tasks
		We are able to systematically administer knowledge necessary for the tasks and store it for further usage
	Individual capacity for Accumulation	We document such knowledge needed for the task
		We summarize education results and store them
Knowledge Sharing	Core Knowledge Sharing	We share information and knowledge necessary for the tasks
		We improve task efficiency by sharing information and knowledge.
	Knowledge Sharing	We promote sharing of information and knowledge with other teams
		We developed information systems like intranet and electronic bulletin boards to share information and knowledge
Knowledge Utilization	Degree of Knowledge Utilization	Teamwork is promoted by utilizing organization-wide information and knowledge
		Electronic data interface is extensively used to facilitate processing tasks
		Work flow diagrams are required and used in performing tasks
	Knowledge Utilization Culture	There exists a culture encouraging knowledge sharing
		There exist incentive and benefit policies for new idea suggestions through utilizing existing knowledge
		There exist research and education programs
Knowledge Internalization	Capability to Internalize Task Related Knowledge	I have a unique mastery of the tasks
		I can learn what is necessary for new tasks
		I can use the internet to obtain knowledge for the tasks
		I can refer to best practices and apply them to my tasks
	Education Opportunity	Employees are given educational opportunities to improve adaptability to new tasks
		University administrated education is offered to enhance employees' ability to perform the tasks
	Level of Organization Learning	Professional knowledge such as customer knowledge and demand forecasting is managed systematically
		Organization-wide standards for information resources are built
		Organization-wide knowledge and information are updated regularly and maintained well.

Application rate of each construct is assessed by defining a Likert Scale including the values range from 1 to the number constructs for each factor. That is, for the Knowledge Creation factor; since there are seven items, seven questions are should be replied based on a 7 scale, in which “1” represents the case of “totally disagree” and “7” represents the case of “totally agree”. Average score of 7 questions represents the “Knowledge Creation” value. In similar way, “Knowledge Accumulation”, “Knowledge Sharing” , “Knowledge Utilization”, and “Knowledge Internalization values are calculated. Based on these values Enterprise Knowledge Index, which is called the third factor of Knowledge Effect, is assessed through taking the average of these 5 values.

$$K_3 = \frac{\text{Creation} + \text{Accumulation} + \text{Sharing} + \text{Utilization} + \text{Internalization}}{5} \qquad \textbf{(II.24)}$$

Where,

K_3: Third factor of Knowledge effect -Enterprise Knowledge Index-

After measuring 3 factors, to calculate the Knowledge Effect (KE) on Technological Adaptation, a simple weighted calculation is performed.

$$KE = \frac{(W_{K1} * K_1) + (W_{K2} * K_2) + (W_{K3} * K_3)}{W_{K1} + W_{K2} + W_{K3}} \qquad \textbf{(II.25)}$$

Where

KE: Knowledge Effect

K_1: First factor of Knowledge effect -Change in Training Hour per Worker-

K_2: Second factor of Knowledge effect -Degree of Response Generation-

K_3: Third factor of Knowledge effect -Enterprise Knowledge Index-

W_{K1}: Weight of Change in Training Hour per Worker

W_{K2}: Weight of Response Generation

W_{K3}: Weight of Enterprise Knowledge Index

Note that the weight values are also defined as similar to others

In order to conclude the part designed to measure the capability of Technological Adaptation it is better to summarize the 3 effects and indicators for each effect. Technological adaptation capability is computed through 3 effects. Tool Effect is assessed by the degree of machine replacement, level of automation, and IT utilization rate. Human effect is evaluated by average worker experience, technological investment for each worker and the rotation ability of them. The last one knowledge effect is found by calculating the change in training hour for each worker, degree of response generation, and the enterprise knowledge index. Note that, the weights for each indicator of corresponding effects as well as the weights of effects should be summed up to 100 to form a scale between 0 and 100. Based on this information Adaptation Capability (AC) is found by a simple weighted calculation.

$$AC = \frac{W_{TE} * TE + W_{HE} * HE + W_{KE} * KE}{W_{TE} + W_{HE} + W_{KE}} \quad \textbf{(II.26)}$$

Where,

AC: Adaptation Capability

TE: Tool Effect W_{TE}: Weight of Tool Effect

HE: Human Effect W_{HE}: Weight of Human Effect

KE: Knowledge Effect W_{KE}: Weight of Knowledge Effect

II.5. CAPABILITY TO MANAGE TECHNOLOGICAL CHANGE

As the initial step to manage the change in manufacturing systems, it is important to manage the change in technology successfully. Therefore technological change factors are deeply investigated and found out 3 important factors as outlined above. They are Technological Forecasting, Technological Innovations, and Technological Adaptation. A brief summary of each is given below.

First step in managing the change of technology is definitely to forecast the new technologies successfully. Especially some important aspects of the new technologies should be forecasted before investing the scarce financial resources. These aspects are defined to be; ***Throughput Time*** of the manufacturing system, capacity based on the ***Quantity/ Day*** value of the system, ***Scrap*** **Ratio** to check the quality, and the expected ***Revenue*** of the new technology.

In the second step, according to new technologies successful innovations has to be performed. The success rate of the innovations is evaluated through 4 indicators namely; **Change in Product Portfolio, New Product Ratio, Sales Amount Ratio of New Products, Sales Revenue Ratio of New Products**.

In the third step these innovations should have to be adapted to the manufacturing system. To measure the capability to adapt to new technologies, the effect of **tool** and machinery used, the resistance of the **employees**, and the **knowledge** required and used for this adaptation are studied in detail.

As a summary of the whole Technological Change Management model, these 3 phases and components of each are listed as well as the respective weights for each component in Table II-10. After measuring, the capabilities for forecasting, innovation, and adaptation abilities, a simple weighted calculation is performed to find out the overall success rate for managing the Technological Change (TC).

$$TC = \frac{(W_{FC} * FC) + (W_{IC} * IC) + (W_{AC} * AC)}{W_{FC} + W_{IC} + W_{AC}} \quad \textbf{(II.27)}$$

Where;

TC: Capability for Technological Change

FC: Forecasting Capability W_{FC}: Weight of Forecasting Capability

IC : Innovation Capability W_{IC}: Weight of Innovation Capability

AC: Adaptation Capability W_{AC}: Weight of Adaptation Capability

Table II-10: Technological Change Factors and Respective Weights

TECHNOLOGICAL CHANGE FACTORS	WEIGHTS
FORECASTING	**0.29**
Throughput Time	0.30
Quantity/Day	0.20
Scrap Ratio	0.20
Revenue	0.30
INNOVATION	**0.33**
Change in Product Portfolio	0.30
New Product Ratio	0.20
Sales Amount Ratio of New Products	0.25
Sales Revenue Ratio of New Products	0.25
ADAPTATION	**0.38**
TOOL EFFECT	**0.30**
Machine Replacement Rate	0.30
Automation Level	0.30
IT Utilization Rate	0.40
HUMAN EFFECT	**0.30**
Average Worker Experience	0.50
Technological Investment/Worker	0.20
Rotation Ability	0.30
KNOWLEDGE EFFECT	**0.40**
Training Hour/Worker	0.30
Response Generation Rate	0.30
Enterprise Knowledge Index	0.40

III. PROCESS CHANGE

Manufacturing change has several aspects. In addition to technological changes, changes in the production processes should also be studied. The change management in manufacturing would not be mature unless the process related changes are followed. That is to say that the process changes should be embedded into manufacturing systems in an efficient way. Therefore the proposed model requires measurement of the success rate of the integration of process changes as other main pillars of change management.

III.1. LITERATURE SURVEY

Although the term of "process" is used in a wide area from science to computing or from biology to chemical reactions, in general a process can be defined as a structured, measured set of activities designed to produce a specific output for a particular customer or market (Davenport, 1993). A business process begins with a customer's need and ends with the satisfaction of that particular customer. That to take attention of practitioners to the fact that a well oriented process should be designed to create certain value for the customer and should not include unnecessary (non-value added) activities for the enterprise. The outcome of a well designed process should therefore be an increase in effectiveness (value for the customer) and an increase in efficiency (less costs for the company).

In order to achieve successful outputs, all of the manufacturing processes should be managed in a well organized and integrated manner. That is why, the process management is defined as the ensemble of manufacturing activities including planning and monitoring the respective performances (Becker et al., 2003). Process Management is the application of knowledge, skills, tools, techniques and systems in order to define, visualize, measure, control, report and improve the processes with a certain goal to satisfy customer requirements and generate profit to the company. Since the main objective of this study is to develop a general Change Management Model for manufacturing systems, the term “process” is referred as the methods implemented to manufacture final or semi products.

As stated before, technological process innovation is as much important as the technological product innovation. Even if the new technological products are developed, they would not have a great impact on the market unless the process innovation occurs. Because of the reason that; to pass through mass production of the prototype innovative products and decrease the cost, contemporary innovative process techniques are required. Hence the definition of technological process innovation can be given as the technologically adoption to a new or significantly improved production methods. These methods may involve changes in equipment, or production organization, or a combination of these changes, and may be derived from the use of new knowledge (OECD, 1995).

Depending on the definition of process innovation, the changes in production processes should be managed to achieve successful results. Companies redesign processes to achieve improvements in their performances. Successful changes, which do not always need to be radical, require effective formulation of process alternatives for manufacturing. It is also important to assess the value of change by examining the expected performance of the process alternatives as well as the evaluation and implementation of the selected (improved) process.

Identification of the right measures for a process is not straightforward. There are various process modeling methods that test the performance and feasibility of the process alternatives. Some of these models may include; systems analysis and design technique (Ross and Schoman, 1977), a composite stage activity framework for business process change applied to public sector (Stemberger and Jaklic, 2007), and data flow diagrams through fisheye views (Tureteken and Schuff, 2007). Although there are various methods for process modeling, it is always considered to be critical to define the metrics to measure the process improvements.

Although business process improvement is often measured in terms of lead time, service time, wait time, and resource utilization, in a recent study process improvement is assessed by Task Activity, Bottleneck, Resource Utilization, and Cycle Cost analyses (Lee and Ahn, 2008). However this methodology is performed for general organizational processes, and tries to assess the performance of alternative processes before their implementation. This method can also be suitable for assessing the manufacturing process changes with little adjustments. The description of the modified approach is given below. The main components of this model are the

- ✓ *Average Worker Utilization*,
- ✓ *Total Bottleneck Ratio*,
- ✓ *Unit Production Time,* and
- ✓ *Unit Production Cost*

of the system.

In order to measure the success rate of following the change in manufacturing processes, it is required to form a Process Change Model. That was the one of main motivation of the overall Manufacturing Change Measurement model presented in this thesis. The logic of this process change measurement model can be summarized as follows. First information regarding Average Worker Utilization, Total Bottleneck Ratio of the system, Unit Production Time, and Unit Production Cost are collected and analyzed. When a process innovation occurs, these 4 factors are analyzed again with the data of new or improved manufacturing process. Then, the resulting changes in these 4 factors are weighted to indicate the success or failure rate of following the process change. This methodology is explained in detail below.

III.2. AVERAGE WORKER UTILIZATION

Worker utilization indicates the extent to which workers are over or under utilized. Since it is one of the most important indicators of process efficiency, any change in average worker utilization will signal the failure or success of the process change. Hence to analyze the success rate of following the change in manufacturing processes, the change in worker utilization should be viewed closely.

Worker utilization shows how much work is performed relative to the respective capacity of the employees. In order to assess the worker utilization, labor hour required to produce the daily production amount should be divided by the available working hour per day.

$$\text{Utilization} = \frac{\text{Required Labor Hour}}{\text{Available Labor Hour}} \quad \textbf{(III.1)}$$

Available working hour per day is the total amount of available working time of all employees responsible in the production process. Since all of the employees take role in the production process, it is the multiplication of working hour in a day by the number of workers as;

$$\text{Available Labor Hour} = \#\text{ of Workers} * \text{Working Hour/Day} \tag{III.2}$$

On the other side, labor hour required to produce the daily production amount is the total time needed to produce the products. Hence, it is the multiplication of the standard time to produce a single unit with the total amount of production. The standard time of the production can be measured by time studies in "minutes" unit. Therefore to transform into "hours" unit, this multiplication is divided by 60, to find out the required labor hour.

$$\text{Required Labor Hour} = \frac{\text{Standard Time (min.)} * \text{Daily Production}}{60} \tag{III.3}$$

In case of more than one work center, utilizations of each worker in each work center are calculated and the average worker utilization is calculated as the following.

$$AWU_t = \frac{\sum_{i=1}^{I} U_i}{I} \tag{III.4}$$

Where;

AWU_t : Average Worker Utilization at time t

U_i : Utilization of i^{th} worker

i : 1, 2, 3, …, I for the workers

Since, the main goal is to asses the change in manufacturing process, average worker utilization is calculated in similar way after the process change occurs. The change in process with respect to this aspect is found out by calculating the percentage change in average worker utilization;

$$\Delta AWU = \frac{AWU_{t+1} - AWU_t}{AWU_t} \tag{III.5}$$

Where;

ΔAWU : Percentage Change in Average Worker Utilization

AWU_t : Average Worker Utilization at time t

AWU_{t+1} : Average Worker Utilization at time t+1

If the result is negative, it is an indicator of decreasing the resource utilization leading to 0% success in this respect. It may be over 100% increase, which is adjusted to 100% as representing a fully improvement in average worker utilization

In case of any change in worker numbers or number of shifts does certainly affect the worker utilization independent of the process change at first glance. However any successful change in the manufacturing process should provide the increase in worker utilization regardless from the company policy about the number of workers.

III.3. TOTAL BOTTLENECK RATIO

Total bottleneck time of the manufacturing processes is important to be analyzed since the bottlenecks between the work centers limit the production rate and the productivity. In order to achieve a successful change in the manufacturing process it is expected to diminish the bottleneck times between the operators. Therefore, to measure the success rate of the change in process, the change in total bottleneck time is to be found. Similar to worker utilization, total bottleneck time of the previous manufacturing process is compared with the one of the process after any change. Any decrease in this respect is considered to the indicator of a successful change in the process.

First of all, bottleneck of each work center is calculated by the difference of its standard time with the previous one. If the standard time of the latter one is greater than the previous one, there will be a bottleneck time equal to the difference of the standard times.

$$B_j = \begin{Bmatrix} ST_j - ST_{j-1} & ;ST_j > ST_{j-1} \\ 0 & ;otherwise \end{Bmatrix} \qquad \textbf{(III.6)}$$

Where;

B_j : Bottleneck time of j^{th} work center

ST_j : Standard Time of j^{th} work center

j : 2,3,…, J work center numbers

Bottleneck time for the first work center is definitely zero, since the raw materials are assumed to be arriving the manufacturing facility as they are need. If the standard time of the work center is less than the previous one, then there is no bottleneck in the related work center, because it waits for the previous work center.

However this difference is just for a single unit production. If this unit bottleneck time is multiplied with the number of products then the total bottleneck of the work center is achieved.

$$TB_j = B_j * \text{Number of Products} \qquad \textbf{(III.7)}$$

TB_j= Total Bottleneck of j^{th} work center

When the total bottleneck time of the work center is divided by the total capacity – which is the total working hours of the work center-, bottleneck ratio of the related work center is calculated.

$$TBR_j = \frac{TB_j}{\text{Total Capacity}_j} \qquad \textbf{(III.8)}$$

TBR_j : Total Bottleneck Ratio of j^{th} work center

At the end, the summation of total bottleneck ratios depicts the performance of the manufacturing process. In order to analyze the success rate of the change in manufacturing process, the percentage change in total bottleneck ratio is found out by;

$$\Delta TBR = [1 - \frac{TBR_{t+1} - TBR_t}{TBR_t}] \qquad \textbf{(III.9)}$$

Where;

ΔTBR : Percentage Change in Total Bottleneck Ratio

TBR_t : Total Bottleneck Ratio at Time t

TBR_{t+1} : Total Bottleneck Ratio at Time t+1

Since the decrease in total bottleneck ratio is desired, it is subtracted from 1. If the result is negative, it is an indicator of increasing the total bottleneck ratio, leading to 0% success in this respect.

III.4. UNIT PRODUCTION TIME

One of the other important aspects of the manufacturing process is the production time of each unit. Since producing more units in less time is a signal of process efficiency, any change in unit production time should be analyzed to measure the success rate of following the process change. It is easy to calculate the unit production time by adding up the standard times of each work center in the process.

$$\mathrm{UPT} = \sum_{j=1}^{J} \mathrm{ST}_{\mathrm{j}} \qquad \textbf{(III.10)}$$

Where;

UPT= Unit Production Time

ST_j= Standard Time of j^{th} work center

j=1, 2, 3, .., J work center numbers

In case of more than one product, it leads to the variation in unit production times. However, the average unit production time of each product represents the performance of the system.

Any change in manufacturing process definitely changes the unit production time due to the changes in standard times of each work center. In order to measure the success rate of process change, percentage change in Unit production time is calculated.

$$\Delta \mathrm{UPT} = [1 - \frac{\mathrm{UPT}_{t+1} - \mathrm{UPT}_{t}}{\mathrm{UPT}_{t}}] \qquad \textbf{(III.11)}$$

Where;

Δ UPT: Percentage Change in Unit Production Time

UPT_t= Unit Production Time at time t

UPT_{t+1}= Unit Production Time at time t+1

III.5. UNIT PRODUCTION COST

In the financial review of the manufacturing processes, the cost of unit production is as much important as the other components described above. In order to analyze the success rate of any change in the manufacturing process, the change in unit production cost should therefore be analyzed.

The unit production cost (UPC) can easily be calculated by dividing the total production cost over the number of products for the period in question. That is;

$$\text{UPC} = \frac{\text{Total Production Cost}}{\text{Total Number of Products}} \qquad \textbf{(III.12)}$$

When a change occurs in the process, then the success of following the respective change can be evaluated by the percentage change in unit production cost. That is calculated as;

$$\Delta\text{UPC} = [1 - \frac{\text{UPC}_{t+1} - \text{UPC}_t}{\text{UPC}_t}] \qquad \textbf{(III.13)}$$

Where,

ΔUPC : Percentage Change in Unit Production Cost

UPC_t : Unit Production Cost at time t

UPC_{t+1} : Unit Production Cost at time t+1

III.6. CAPABILITY TO FOLLOW PROCESS CHANGE

In order to measure the capability to follow the process change first the change should exist. If the company who wants to assess its change capability desires to develop the existing process and makes changes in manufacturing methods, the aforementioned change components of the process should be evaluated for possible change indications. A certain type of methods to measure the change capability of each of these components, are clearly defined as provided above.

To evaluate the overall success rate of following the change in manufacturing processes, the result of the measurement of each component is weighted and accordance with the guidelines provided by a questionnaire as explained in Chapter VII. According to the survey, the degrees of importance of each component are given in Table III-1.

Table III-1: Weights of Process Aspects

PROCESS CHANGE ASPECTS	WEIGHTS
Average Worker Utilization	0.26
Total Bottleneck Ratio	0.24
Unit Production Time	0.21
Unit Production Cost	0.29

Taking these weights into account, the overall success rate of following the Process Changes (PC) in manufacturing can be calculated as;

$$PC = \frac{(W_{AWU} * \Delta AWU) + (W_{TBR} * \Delta TBR) + (W_{UPT} * \Delta UPT) + (W_{UPC} * \Delta UPC)}{W_{AWU} + W_{TBR} + W_{UPT} + W_{UPC}} \quad \textbf{(III.14)}$$

Where;

PC : Capability for Process Change

W_{AWU} : Weight for Average Worker Utilization

W_{TBR} : Weight for Total Bottleneck Ratio

W_{UPT} : Weight for Unit Production Time

W_{UPC} : Weight for Unit Production Cost

Δ AWU : Change in Average Worker Utilization

Δ TBR : Change in Total Bottleneck Ratio

Δ UPT : Change in Unit Production Time

Δ UPC : Change in Unit Production Cost

This study proves that it is possible to measure the capability of a company to follow the changes in manufacturing processes from various aspects. Especially Average Worker Utilization, Total Bottleneck Ratios, Unit Production Time, and Unit Production Cost can be considered as certain indicators of driving forces for following the change. However, this part of the study should be extended to other components in order to define the overall change capability in manufacturing systems. The next Chapter will describe the change measurement methodology for customer driven aspects.

IV. CUSTOMER ORIENTED CHANGE

Customers are one of the driving forces for the enterprises to follow the changes. Even if the company capable of following the changes in technology or manufacturing processes, it is inevitable to fail in business while failing to respond properly to customer demands. This fact directed the attention of this research towards studying the customer related changes when developing a change management system for manufacturing.

The first part of this chapter is devoted to the literature survey for the customer management models. After highlighting possible inadequacies of generally implemented models, the focus will be given to the advanced Customer Change Management Model developed as part of change management model explained in this thesis. The proposed model has three metrics in order to measure the capability to follow the changes possessed by customers or related issues. These are; Get Ratio, Keep Ratio, and Growth Ratio. They are explained in the following sections of this chapter.

IV.1. LITERATURE SURVEY

Basically, a customer is a buyer or a user of the paid product of an individual or an organization. Any enterprise which spends all effort on product innovation, operational efficiency and low price must have customers in order to create some gain out of the respective efforts. When customer types are studied in the literature, generally there are two different types such as Individual Consumers and Entrepreneurship Customers (Yükselen, 1998). Properties and purchasing structure of these 2 types are deeply investigated in literature.

Addition to characteristics, consuming behavior of the consumers and entrepreneurship customers depend on various different factors, which are listed in the Table IV-1(Yükselen, 1998). As illustrated; consuming behaviors of individual consumers are highly affected by psychological and social factors, whilst the entrepreneurship customers are dependent on the organizational and personal interaction. In order to sustain a customer management model all of these factors should be analyzed. Moreover most of the factors for example cultural and social ones are not static and continuously evolving. Since the basic management models establish on the assumption of static properties of customers, the main aim of this chapter is to follow up the changes in customer demands and consuming behaviors in most effective way.

Table IV-1: Factors that affect the consuming behavior (Yükselen, 1998)

Individual Consumers	Entrepreneurship Customer
▪ Cultural	▪ Environmental
▪ Social	▪ Organizational
▪ Personal	▪ Personal Interaction
▪ Psychological	▪ Personal

On the other hand, the customer interaction is also an important to follow the changes in customers. At the most simple level, a company deals with a customer through 3 basic stages (Gentle, 2002);

- ✓ **Sales:** It covers; identifying and targeting potential customers, contacting, commitment to buy, and finally contracting.
- ✓ **Delivery:** Installation or implementation of the particular product or service.
- ✓ **After Sales:** Activities that are concerned with the ongoing relationship, like billing, customer service, and general enquiries.

In reality, this interaction is a circular relationship, which can cycle back to the sales phase with the customer buying more -or other- products. In Table IV-2; aforementioned 3-stage customer life cycle is given with basic operations in each stage (Gentle, 2002). Sales operations initiate with defining the customer segments and ends with taking order from the customers. However, the delivery operations is not only delivering the products but also some initials tasks such as credit checking, approving the order, and ending tasks such as billing the customer. In modern customer management systems, customer interactions does not end with delivery operations, but also after sales operations are required such as, resolving some problem issues. Moreover, in post modern customer management styles, aggregating after sales information and analyzing these data is essential in order to create new sales in the future.

Table IV-2: Customer Interaction with basic operations (Gentle, 2002)

SALES	DELIVERY	AFTER-SALES
Define Segments	Credit Check	Handle Enquiries
Target Prospects	Approve Order	Resolve Issues
Approach Prospects	Verify Order	Provide Information
Present Proposal	Enter Order	
Negotiate	Provide Order Status	
Close Deal	Deliver Order	
Take Order	Bill Customer	

Up to now, consuming behaviors of customers and the interaction steps between the customer and enterprise are explained. Depending on this discussion, customers are not only product buyers but also social living structures to be managed. Therefore, Organizations need to manage their customers effectively to remain competitive in the interactive era. In recent years, the best way to manage the customers is proposed to have a Customer Relationship Management system. According to some executives, Customer Relationship Management (CRM) is a technology or software solution that helps track data and information about customers to enable better customer services (Peppers and Rogers, 2004).

CRM consists of the processes a company uses to track and organize its contacts with its current and prospective customers. CRM software system can be accessed, and information about customers and customer interactions can be entered, stored and accessed by employees in different company departments. Typical CRM goals are to improve services provided to customers, and to use customer contact information for targeted marketing.

While the term CRM generally refers to a software-based approach to handling customer relationships, most CRM software vendors points out that a successful CRM effort requires a holistic approach. That is all of the required information about the customers and consuming behaviors should be embedded to the software as well as the employee education about the user interface should be sustained CRM initiatives often fail because implementation was limited to software installation, without providing the context, support and understanding for employees to learn, and take full advantage of the information systems.

There are several different approaches to CRM, with different software packages focusing on different aspects. Generally, Customer Service, Campaign Management and Sales Force Automation form the core of the system. In addition, computers can enable enterprises to keep track individual customer needs and estimate the future potential revenue the customer will bring to the enterprise. Moreover, in another study 3 aspects are denoted as important to manage the customer relations as; Satisfaction, Loyalty, and Supporter (Şentürk, 2010).

In a recent study, a CRM system so called IDIC (Identify, Differentiate, Interact, and Customize) which is a 4 step implementation model for managing customer relationships is proposed (Peppers and Rogers, 2004). This system has the following elements.

- ✓ **Identify Customers:** An enterprise must be able to recognize a customer when he comes back, in person, by phone, online, or wherever.
- ✓ **Differentiate Customers:** Customers represent different levels of value to the enterprise and they have different needs from the enterprise.
- ✓ **Interact with Customers:** A conversation with a customer should pick up where the last one left off.
- ✓ **Customize Treatment:** The enterprise should adapt some aspect of its behavior toward a customer, based on that individual's needs and value.

Moreover characters of relationship are deeply investigated in the same study

- ✓ **Mutuality:** Enterprise and customer have to participate in and be aware of the existence of relationship.
- ✓ **Interaction:** When two parties interact, they exchange information.
- ✓ **Iterative:** Every successive interaction represents iteration on all the previous ones that have gone before it.
- ✓ **Ongoing Benefit:** Each party in a relationship has an incentive to recover from mistakes.
- ✓ **Uniqueness:** Relationships are constituted with individuals, not populations.

- ✓ **Trust:** It provides the strength of relationship.

Although CRM applications generally bear successful results on managing the customer relations, there is still a lack of understanding the changes in customer demands. Since if CRM application treats the customers as only the numbers, customers will not be satisfied in further years. Since the customers are social living entities, they desire and deserve to be behaved as they are. That is, depending on the fact that the requirements and demands are changing over time, managing them as if they were in the past is in adequate. Moreover, based on the increasing competition in the market structure, the change in customer properties should be well managed in order to prevent losing customers to the rivals. Therefore a new concept, which is called Customer Change Management, should be developed to manage the changes in customer demands.

IV.2. CUSTOMER CHANGE MANAGEMENT

As stated before, traditional CRM models are not sufficient to manage the changes in customer profiles. Since the customers are treated as static product buyers, the dynamic structure of consuming behaviors is regarded. Even if the consuming information is aggregated and some analysis is carried out, further demand changes cannot be managed. In order to put a model to manage the customer change, first of all the change in customer profile should be understood.

The technological revolution has led the changes in customer behavior. Customers, who were only product buyers without any alternative products or rival companies, now demand products just the way they want, and additionally flawless customer service. Enterprises realize that they really know little or nothing about their individual customers. Customers, meanwhile, want to be treated less like numbers and more like the individuals they are, with distinct, individual requirements and preferences.

The change in customer demands and requirements is part of the reason that enterprises are committing themselves to keep and grow their most valuable customers and getting new profitable ones. Recent consumers and businesses have become more sophisticated about shopping for their needs across multiple channels (Peppers and Rogers, 2004).

Massive Marketing, which was affected by the Mass Production systems, was the main property of traditional marketing concept. However, there is a transformation from Market Share term to Customer Share term. Customer Share aims to sell more than one type of product to the same customer and sustain the active and loyal structure of the customer. This can only be handled with the transformation from one way marketing to interactive marketing. Furthermore, in the rapid competitive market structure, Product Based marketing should be replaced with Customer Based marketing in order to keep existing customers (Acuner, 2001).

The existence of change in customer structure can be supported with various examples in literature (see for example Acuner, 2001; Peppers and Rogers, 2004). However, the main subject of the study is not to verify this change but to manage the change. In order to manage the changes in customer profiles in most efficient way, a comprehensive model is proposed in the next section.

IV.3. CUSTOMER CHANGE MANAGEMENT MODEL

So far, the importance of the customer for enterprises, the changing structure of customer profiles, the inadequacy of CRM applications for the changing customer structure and the requirement for a customer change management model are explained in detail. However, by the term Customer Change Management, the objective is to follow the changes in customer demands and requirements. Since the demands and profile of customers change spontaneously, the enterprise cannot control these changes but can follow and foresight future changes. The first aspect of the Customer Change Management Model as proposed will focus on measuring the capability to follow the change in customer demands. In order to follow the change in customer demands manufacturing system should adapt itself to “Customer demand effect on production”. For instance, getting smaller sizes of mobile phones are proper examples of the customer effects on production.

In addition to the first aspect, the model should also measure the capability to create new customers. Although the customer change cannot be controlled, it can be leaded. Manufacturing of a new developed product will bear new demands on customers. For instance, mobile phones or I-phones are proper examples for the

“Production effect on customer demands”. Before developing these technological products, nobody would require such items.

Hence the overall Customer Change Management Model should embrace the two aspects of customer changes namely; Customer demand effect on production and Production effect on customer demand. Based on these two aspects, the proposed model comprises of three metrics; Get Ratio, Keep Ratio, and the Growth Ratio. Each of these metrics is explained in the following sections.

IV.3.1. Get Ratio:

It is the ratio of new customers' revenue over total revenue of the previous period. Get Ratio (GR) aims to find out the capability to create new customers. That is;

$$GR = \frac{\sum (\text{Revenue of New Customers})_t}{\sum (\text{Revenue})_{t-1}} \qquad \textbf{(IV.1)}$$

This ratio is required to analyze the capability to lead the changes in customer demands. Since, the customer demands can be affected by production then new customers can be created. Basically, the superior case for a manufacturing company is to have new customers' revenue as much as the total previous revenue. If this is the case, then the company has the chance of doubling its revenue –if previous revenue can be sustained. Therefore, although this ratio can be greater than 1, it is assumed to be equal to 1 representing the hundred success for creating new demands and customers.

IV.3.2. Keep Ratio

It is the ratio of existing customers' revenue over the revenue of profitable customers of previous period. Keep Ratio (KR) measures the capability to retain profitable customers, to win back profitable customers, and eliminate unprofitable customers (Peppers and Rogers, 2004).

$$KR = \frac{\sum(\text{Revenue of Existing Customers})_t}{\sum(\text{Revenue of Existing Customers})_{t-1}} \quad \textbf{(IV.2)}$$

Profitable customers are those who pay more than the cost of the item. At first glance unprofitable customers may seem illogical. However, in some cases, for loyal or massive customers sales under the cost of the product may be endured for a while.

Keeping customers is also about knowing which customers is the right to keep. In other words, if there exists an unprofitable customer in the previous period, total revenue will be less than the revenue of profitable customers. Hence to measure the capability of keeping customers the revenue of profitable customers should be regarded. Therefore the ratio is calculated by dividing the existing customers' revenue over the revenue of profitable customers of previous period. This ratio is also important for marketing. Since according to some executives getting new customer is 5 times more costly than keeping existing ones (Kottler and Keller 2006). Therefore to achieve the hundred percent success for keeping the existing customers, this ratio is required to be 1. Although this ratio can be greater than 1, it is assumed to be equal to 1 representing the hundred percent success for keeping the existing profitable customers.

On the other hand this ratio reflects the capability to follow the customer changes. If the customer changes cannot be followed successfully, Keep Ratio will obviously decrease. Since the existing customers are not so much satisfied and they are no more customers of the related enterprise.

IV.3.3. Growth Ratio

It analyzes the capability to upsell additional products, cross sell other products to customers, referral and word of mouth benefits, and reduce service and operational costs (Peppers and Rogers, 2004). The general way to increase the customer growth rate is to increase the amount of revenue generated from that customer by up selling or cross selling techniques. It measures the percentage change of products sold to existing customers. The Growth Ratio (GRR) is calculated as;

$$GRR = \frac{\sum(\Delta \text{ in \# of Products Sold Existing Customers})_t}{\sum(\text{\# of Products Sold Existing Customers})_{t-1}} \quad \textbf{(IV.3)}$$

It regards both the capability to follow and lead the customer changes. Since, if the customer demand changes are followed efficiently then the growth rate will not be negative. In addition, if the customer demands are leaded by advanced products, customers will purchase additional or cross products, which will increase the growth ratio.

It is also required to eliminate the misconception effect of profit/item changes on keep ratio. For instance, if the customer purchases 100 units of product A with $1profit per item, it makes $100 revenue for that year. If in the next year, only 20 units of product A are sold to the same customer with $6 profit per item, this will make $120 revenue. According to this example Keep Ratio will be 1.2, which is adjusted to 1, representing the 100% success for keeping that customer. However, if the units sold are taken into account, the Growth Ratio will give (20-100)/100=-0.8, which is adjusted to 0, representing the null capability to increase the sales for existing customer. Therefore, not only the Keep Ratio but also the Growth Ratio is important to calculate the capability to follow the changes in customer demands. In order to visualize the formulation the following example case will be useful.

<u>Numerical Example:</u>

Let us assume that in the first year there are 5 customers of the company purchasing 3 different products with different profit/ item values and quantities shown in following Table IV-3.

Table IV-3: Sales information for the first year.

Customer	Product	Quantity	Profit/Item ($)	Revenue($)
1	A	110	1	110
2	A	50	1	50
	B	100	2	200
3	B	100	2	200
4	C	50	3	150
5	D	10	-1	-10

As it is seen in Table IV-3, the 5^{th} customer is unprofitable for any reason, and s/he must be eliminated in the next year to achieve a successful Keep Ratio. Moreover total revenue for the first year is \$700; however, the profitable total revenue is equal to \$710.

In the second year 2^{nd} and 5^{th} customers are lost, and a new customer (6^{th} customer) releases. Sales quantities and profit/item values are shown in Table IV-4.

Table IV-4: Sales information for the second year.

Customer	Product	Quantity	Profit/Item (\$)	Revenue (\$)
1	A	50	1	50
	B	50	2	100
3	A	150	1	150
4	C	30	6	180
6	A	50	1	50
	B	10	2	20

According to given information Get Ratio is calculated by dividing the new customer's (6^{th} Customer's) revenue with previous total revenue.

$$GR = \frac{50+20}{700} = 0.10 \tag{IV.4}$$

Keep Ratio tries to measure the capability to keep the revenue of existing customers revenue as the same as the revenue of previous profitable customers. Hence, revenue of existing customers (1^{st}, 3^{rd}, and 4^{th} customers) is divided by total revenue of profitable customers (1^{st}, 2^{nd}, 3^{rd}, and 4^{th}) of previous year.

$$KR = \frac{150+150+180}{110+250+200+150} = 0.68 \tag{IV.5}$$

Growth Ratio tries to measure the capability to increase the number of products sold to the existing customers. Hence, numbers of products sold to the existing customers (1^{st}, 3^{rd}, and 4^{th}) are subtracted with number of products sold to the existing customers (1^{st}, 3^{rd}, and 4^{th}) for previous year. This subtraction is divided by the number of products sold to the existing customers for previous year to find out the percentage change of products sold.

$$GRR = \frac{(100+150+30)-(110+100+50)}{110+100+50} = 0.08 \tag{IV.6}$$

10% of Get Ratio states the capability of acquiring new customers is 10% of the previous year revenue. 68% of Keep Ratio is interpreted as the 68% of success rate for keeping the existing profitable customers. 8% of Growth Ratio indicates the increase of number of products sold to the existing customers. Keep Ratio is much more than the Growth Ratio, because of the 4^{th} customer. Although the revenue earned from 4^{th} customer increases, the number of product sold to the 4^{th} customer decreases. Therefore this will make an increase in Keep Ratio, however a decrease in Growth Ratio.

As the last step to form the Customer Change Management Model, some weights can be assigned to Get, Keep, and Growth Ratios according to importance of their nature. For the example case, if 33%, 39%, and 28% of weights are assigned to Get, Keep, and Growth ratio metrics, the overall capability index to follow and lead the changes in customer demands occur to be;

$$CC = \frac{(W_{GR} * GR) + (W_{KR} * KR) + (W_{GRR} * GRR)}{W_{GR} + W_{KR} + W_{GRR}} \quad \textbf{(IV.7)}$$

Where;

CC : Capability for Customer Change

GR : Result of Get Ratio Metric — W_{GR}: Weight of Get Ratio Metric

KR : Result of Keep Ratio Metric — W_{KR}: Weight of Keep Ratio Metric

GRR : Result of Growth Ratio Metric — W_{GRR}: Weight of Growth Ratio Metric

$$CC = 0.33 * 0.10 + 0.39 * 0.68 + 0.28 * 0.08 = 0.3206 = 32.06\% \quad \textbf{(IV.8)}$$

That is, the capability to follow and lead the changes in customer demands of the analyzed hypothetical manufacturing company is 32.06%. It is 68% good at *Keeping* its customers however, 10% and 8% good at *Getting* new customers and *Growing* existing customers. In this hypothetical example, it can be concluded that, it is unsuccessful for leading the changes so some more studies are required to understand and manage the respective changes in customer related issues such as demand.

V. MANAGERIAL CHANGE

In this chapter the capability to manage the changes in managerial functions of a manufacturing company is going to be analyzed. This stage is as important as to manage the technological changes. Since the management of change in manufacturing will not be as effective as it should be unless the technological change management is supported by the managerial change aspects.

This chapter is mapped as the following. In the first part, some general definitions about management and its functions are provided. In the second part, evolution of management science is elucidated by historical perspective through predefined functions. A methodology is proposed, in the third part, in order to determine which functions are to be employed. Depending on this, calculating the capability to follow the managerial changes is finally explained.

V.1. MANAGEMENT

In general management is defined as the process of achieving desired results through efficient utilization of human and material resources as well as the tacit resource of knowledge (Drucker, 2007). Due to a broadband definition of management, it is the attainment of organization goals in an effective and efficient manner through planning, organizing, leading, and controlling organizational resources (Daft, 2008).

According to this comprehensive definition of management, a set of functions are important to be performed for an effective management style. The definitions emphasize mainly on four functions of management including planning, organizing, leading, and controlling (Daft, 2008). Coordination must be added to these functions in the era of modern management concept. Each of these functions will be explained in the following part for the sake of defining possible driving forces in managerial changes.

V.1.1. Planning

Planning, which may be the most important functions of management, is defined as defining the tasks and use of resources needed to attain organizational goals (Daft, 2008). It includes establishing enterprise objectives, developing premises about the environment in which they are to be accomplished, selecting a course of actions, initiating activities necessary to translate plans into action, and evaluating the outcome of that plan (Bedelan, 1986). Briefly planning is the art of answering the following questions in an enterprise.

- What is to be performed? : It requires the definition of tasks
- Why is it performed? : It requires the direct or indirect objectives of tasks
- When is it performed? : It requires the schedule of tasks
- How is it performed? : It requires the processes of tasks
- Where is it performed? : It requires the location of tasks
- Who is going to perform? : It requires the responsible employers of tasks

Plans can be classified according to the planning periods (short vs. long range) or frequency of use (standing vs. single use).

Short vs. Long Range Plans: Although there is no general agreement for the length encompassed by either term, most long range plans span 3 to 5 years (Bedelan, 1986). Short and long range plans are interrelated in at least 2 respects. First, short and long range plans compete for the allocation of resources. Second, short range plans should be compatible with long range plans.

3 criteria can be suggested to answer the question about defining the time period of a plan. First one is determined by how far into the future an enterprise's fixed commitments can be extended. The second criterion concerns the degree of uncertainty associated with the future. Third criterion is the lead time –the amount of time required to ready a good or service for sale. According to these criteria enterprise may settle both short and long range plans aligned with business objectives.

In some cases **Rolling Plans** can take place to reflect the high changing rate of environment. An enterprise may develop a 5-year plan of future operations updating on annual basis. As the current year of a 5-year plan is due, the plan is to be extended or rolled forward to include a "new" fifth year (Bedelan, 1986).

Standing Plans: These plans are used again and again; focus on managerial situations that recur repeatedly. Since they are same for all repetitive actions they may be denoted as operational decisions more than a plan. They include; *policies, procedures,* and *rules. (*Daft, 2008*)*

Policies: They are general statements that serve to guide decision making. Policies, which are subject to interpretation, are broad guidelines.

Procedures: A procedure is a series of related steps that are to be followed in an established order to achieve a given purpose. They prescribe exactly what actions are to be taken in a specific situation.

Rules: Rules either prescribe or prohibit action by specifying what an individual may or may not do in a given situation.

Single Use Plans: These plans are developed to implement relatively unique courses of actions and unlikely to be repeated. They include; *budgets, programs,* and *projects.*

Budgets: They deal with the future allocation and utilization of various resources to different enterprise activities over a given time period.

Programs: they are typically intended to accomplish a specific objective within a fixed time.

Projects: They are usually a subset or component part of a specific program. For example; a project to develop a new or improved product can be a part of a total program designed to increase market share (Bedelan, 1986).

V.1.2. Organizing

As a general definition organizing, it is the deployment of organizational resources to achieve strategic goals (Daft, 2008). Besides, an organization structure is defined as; the set of formal tasks assigned to individuals, formal reporting relationships including authority, responsibility, number of hierarchical levels, and span of manager’s control, and the design of systems to insure effective coordination of employees. This structure is depicted by an organization chart. There are various types of organization charts. A traditional organization chart is constructed in hierarchical structure, with individuals toward the top of the hierarchy having more authority and responsibility than individuals toward the bottom. Organization charts can be decided on different departmentalization choices. These departmentalization alternatives are explained in below (Daft, 2008).

Function Based: It departmentalizes workers and other resources according to the types of activities being performed (see Figure V-1).

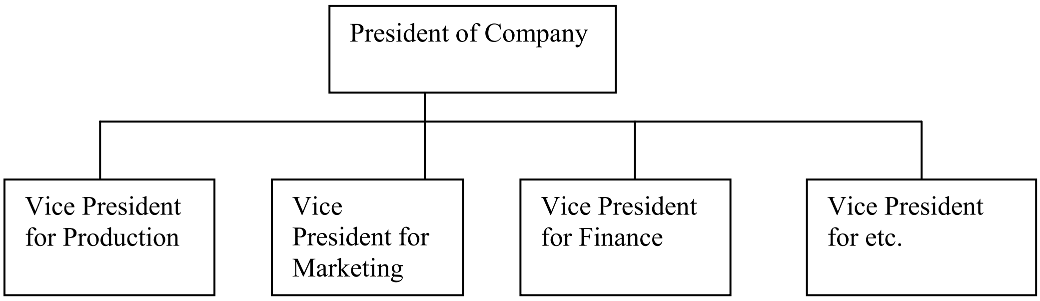

Figure V-1: Function Based organization structure

Product Based: As shown in Figure V-2, in this type of organization, the resources are departmentalized according to the product(s) produced.

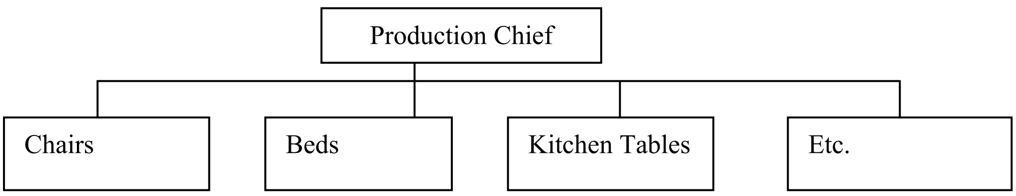

Figure V-2: Product Based organization structure

Territory Based organizations are structured in accordance with the place the work is being done or the geographic market area on which the management system is focusing its operations. This type of organization is shown in Figure V-3.

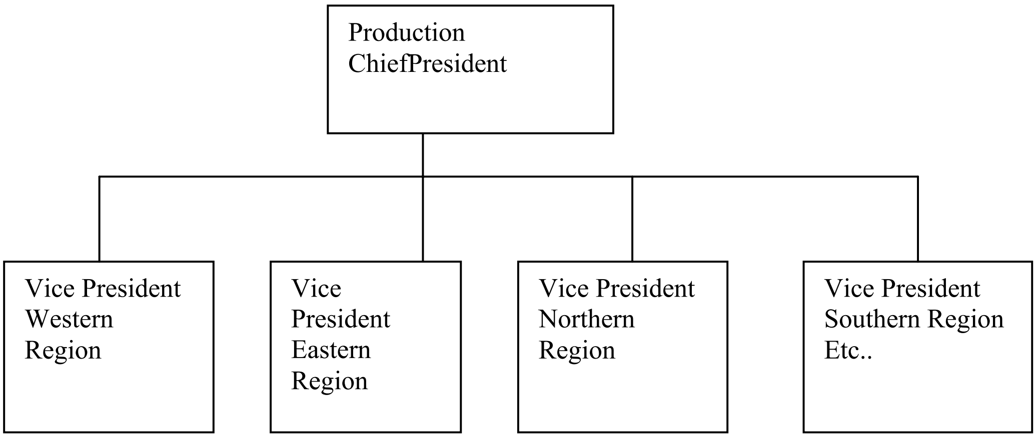

Figure V-3: Territory Based organization structure

Customer Based: This type of organization establishes the departments in response to major customers of the enterprise and structured as shown in Figure V-4**.**

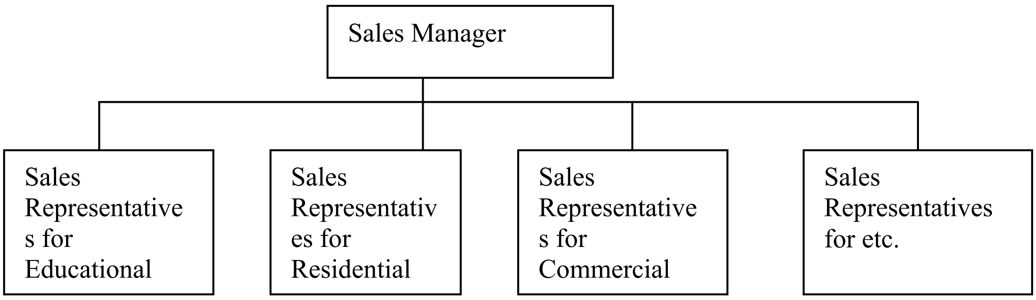

Figure V-4: Customer Based organization structure

Manufacturing Based: This type of organization departmentalizes according to major phases of the process used to manufacture products (see Figure V-5).

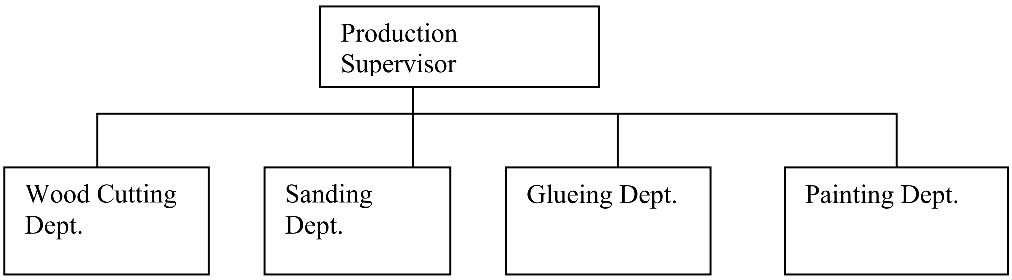

Figure V-5: Manufacturing Based Organization structure

Enterprises could implement one or more than one organizational structures due to their properties. The important thing is to settle the balance in the hierarchical orders of the structures between different layers.

V.1.3. Leading

Leading is the art of influencing individual or group activities toward achievement of enterprise objectives. Within an organization, leader typically has 5 different sources of powers as (Daft, 2008)

- **Legitimate Power:** It comes from a formal management position in an organization and the authority granted to it.
- **Reward Power:** It stems from the leader's authority to grant rewards on other people.
- **Coercive Power:** It refers to the leader's authority to punish or recommend punishment.
- **Expert Power:** It is the result of a leader's special knowledge or skill regarding the tasks performed by followers.
- **Referent Power:** It comes from leader personality characteristics that command subordinates' identification, and respect so they wish to follow the leader.

Leadership style is the behavior a leader exhibits while guiding organization members in appropriate directions. There are various studies about the leadership styles and their effects in the literature (See for example Murray, 2010; Drucker, 2007)

Although there are some other classifications in the literature, leading behavior styles can be grouped into 5 categories as given below (Daft, 2008).

Dictative Leadership: Leader informs subordinates what is expected of them and provides specific guidance on how to do it

Structural Leadership: Leading authority is shared through the department managers.

Supportive Leadership: Leader is friendly, approachable, and shows concern for the personal needs of subordinates.

Participative Leadership: Leader consults with subordinates and asks for their suggestions before making decisions.

Referent Leadership: Leader uses his knowledge and experience for the benefit of the enterprise outside the company.

V.1.4. Controlling:

Organizational control is defined as the systematic process through which managers regulate organizational activities to make them consistent with the expectations established in plans, targets, and performance standards (Daft, 2008). Briefly, controlling is making something happen in the way it was planned to happen. It is important to anticipate the problems, to adjust plans for these problems, and to take corrective actions for these problems. There are various controlling methods which can be classified as the following (Daft, 2008; Drucker, 2007);

Upon Request Control: The controls performed when desired.

Scheduled Control: The schedules of controls are predefined.

Adaptive-Flexible Control: Controlling system can be updated according to current developments and situations.

Continuous Self Control: Each employee is responsible for the work performed and controls perpetual.

Integrated Control: It is the method of integrating all controlling methods within the enterprise to access all control related data.

In order to control the management activities, controls should be performed both when desired and a time schedule basis. Moreover, the controlling method should be adaptive to respective changes and continuously standing. Additionally, there should be an integrated control system to monitor all management activities. On the other hand to perform these controlling methods there are some tools to be employed. From the simplest tools to the most complicated ones these can be listed as;

Individual Tool: Managers can determine what is happening in an enterprise by relying on information provided by others or finding by themselves.

Budget Tool: Budgets are plans that deal with the future allocation and utilization of various resources to different activities over a given period of time. They are used to evaluate enterprise's operations.

Project Tool: Gannt charts and PERT (Program Evaluation and Review Technique) are two of the various tools which can be implemented for controlling specific enterprise projects.

Performance Based Tool: In this approach, performance metrics to be met are set for each organizational unit.

<u>Computer Based Tool:</u> In this approach all of the controlling activities are performed via the usage of computer systems.

V.1.5. Coordinating

Within the organization, all departments are related to each other. Only through the successful use of communication skills, these departments can be coordinated well enough to enhance management objectives. Sustaining effective and efficient ways of communication is therefore a major function of the management in order to provide efficient and effective coordination within the organization.

Daft states that the communication can take place in two different forms; through formal Channels or Informal Channels (Daft, 2008).

A. **Formal Channels:**

The chain of command or task responsibility defined by the organization flows through predefined channels. Managers should establish and maintain formal channels of communication in 3 dimensions.

1. **Downward Communication:**

Messages and information sent from top management to subordinates in a downward direction to encompass the following topics**;** Implementation of goals, Job instructions, Procedures, Practices, Performance feedbacks, Indoctrination.

2. **Upward Communication:**

Messages flow from lower to the higher levels in the organization's hierarchy. They include the following types of information; Problems, Suggestions for improvements, Performance reports, Financial and accounting information.

3. **Horizontal Communication:**

It is the lateral or diagonal exchange of messages across co-workers. It may occur within or across the departments. The purpose is not only to inform but also to request support and coordinate activities. It includes; intradepartmental problem solving, Interdepartmental coordination, and staff advice to line departments.

B. **Informal Channels:**

Informal communications coexist with formal communications but may skip hierarchical levels, cutting across vertical chains of command to connect virtually anyone in the organization. Two types of informal channels are used in many organizations.

1. **Management by Wandering Around:**

In this type of communication, managers mingle with employees, develop positive relationships, and learn directly from them about their department, or organization.

2. **Grapevine:**

Grapevine links employees in all directions, ranging from the president through middle management, support staff, and employees. It will always exist even if it is not officially approved. It can become a dominant force when formal channels are closed.

V.2. MANUFACTURING MANAGEMENT TYPES

In this part the change in managerial functions of manufacturing systems are studied. Five basic functions of management will guide for following up managerial changes. General properties of Manufacturing Management types will be settled through defining different characteristics of Planning, Organizing, Leading, Controlling, and Communication. Following sections provides information regarding this in chronological order.

V.2.1. Shop Management (16th – 18th Century)

It is the management type before the industrial revolution. Since, there exists only a small shop and the owner of the shop works as both the manager and the worker of the shop. There is no need for detailed management functions because of the simplicity of the manufacturing. General characteristics of these 5 management functions of Shop Management are explained in the following parts.

Planning: Only the ***Rules,*** which are stated by the manager, are used in creating manufacturing plans. There can be a list of “Do’s” and “Do Not’s”.

Organizing: Since, there exist only a few products and the main aim is to produce only those, the organization of the manufacturing facility is structured as *Product Based*.

Leading: The manager is the only leader of the company, and s/he *Dictates* the workers

Controlling: Controlling only takes place when a certain type of information is required. Therefore *Upon Request* controlling method is employed since the production rate is very low and no need to stock an inventory *Individual controlling* tools are sufficient enough for the management.

Communication: The coordination and the communication within the enterprise are sustained only by the management directions in a *Directive* way.

V.2.2. Functional Management (18^{th} – 20^{th} Century)

By the industrial revolution; productivity, product portfolio, number of customers has significantly increased. Departmentalization was/is also required to manage the organization. Therefore scientific techniques were/are required to manage the respective manufacturing activities. 5 management functions are clearly required in this type of manufacturing management. Properties of these functions for this era are listed as in the following provided that the properties of shop management is sustained in certain manufacturing areas

Planning: *Procedures* are the basic property of this management since they are necessary for each department. However procedures are not only enough to reflect the planning function. *Rules*, which are the basic property of previous Shop Management type, can be still required to manage the activities within each department.

Organizing: Since departmentalization is one of the main characteristics in this type of organizations, the enterprise is organized as *Functional Based* type. However, while adapting to functional organization, producing products, which is the main aim of company should not be discarded. Therefore the superior organization type is Functional Based including *Product Based* characteristics.

Leading: Leaders of each department will definitely force their department to achieve the general management objectives. They are responsible to implement the rules within their departments. Therefore *Structural* leading type is implemented.

Controlling: Although *Upon Request* and *Individual Control* exist, they are not adequate in controlling the activities due to the increasing size of the enterprise. Predefined *Scheduled Controls* should therefore be executed depending on the *Budget Control* of each department and their operations.

Communication: Since departmentalization is inevitable, *Directive* communication of the leader would not produce adequate level of coordination. *Departmental Communication* is recommended and implemented in order to create sufficient level of cooperation within and between the departments.

V.2.3. Process Management (1970-1995)

When the importance of human relations and their interactions are understood as important factor to reach the success, the organizations set team working styles. Teams, which consist of different employees from different departments and organizational hierarchical levels, work on to accomplish the same aim. In the team working to achieve effective utilization of resources, clear definition of responsibilities, prioritization of important tasks, and rapid decision making processes, process management techniques are essential. Based on its importance and gains, process management should have some initials to succeed.

- To define the processes
- To analyze the relations between the processes
- To determine the process owners and leader
- To determine process elements (input, output, supplier, and customer)
- To prepare process maps
- To set criteria and standards to evaluate process performance
- To improve process according to evaluation

Properties of management functions for this era are listed in the following.

Planning: *Rules* and *Procedures* are preceding property of this management since they are necessary for each department and operation. Since the employees are grouped as teams and each team have different processes, these process have to be planned regarding with the Process Management issues. Hence the planning function should be performed by the *Planned Processes.*

Organizing: Although *Product Based* and *Functional Based* types exist for the organization, to utilize the human interactions, employees are grouped as teams having the responsibility of different processes. Additionally by the process management techniques, the operations are not dependent on employees. If the processes are well defined and managed, any employee can work on the process through training of process documents. Hence a *Process Based* organization type is an obligatory property of Process Management.

Leading: Since employees are grouped in teams, the team leaders should be *Supportive* to the teammates to achieve the goals of the team.

Controlling: To have an *Adaptive and Flexible* control methodology is required in order to updating the control system to the recent conditions. This methodology will be responsible for each of the *Project Control* of the related processes.

Communication: Communication and coordination should be based on entrepreneurial information systems such as; Enterprise Resource Planning (ERP) or *MIS* solutions, to make the easy access to the information by authorized employees.

V.2.4. Management by Objectives (1955-2000)

It is a process of agreeing upon objectives within an organization so that management and employees can understand what they are going to be doing in the organization. It was first popularized by Peter Drucker in his book "The Practice of Management" (Drucker, 1955). Management by Objectives introduced the SMART criteria (Specific, Measurable, Achievable, Relevant, and Time-Specific) to management concept. Properties of this type of management functions are explained below.

Planning: Although *Rules*, *Procedures,* and *Projects,* still remain to plan the management *Programs,* which are typically intended to accomplish a specific objective within a fixed time period, is implemented to satisfy the overall objective of the company.

Organizing: Although *Product Based*, *Functional Based* and *Process Based* types can still exist for the organization, a *Customer Based* organization type becomes essential to achieve the business objectives. In fact, the customers were/are actually defined/defines the objectives of the company.

Leading: The leaders should be in *Participatory* behavior with the employees to achieve the objectives of the enterprise. Because the decisions which have been agreed by a quite number of employees, will be more supported.

Controlling: Controlling function should be performed by each individual worker in order to satisfy the objectives in a *Self Continuous* methodology. Additionally there should be a *Performance Based* Controlling tool to standardized controlling function.

Communication: In order to perform the communication within the enterprise, every work solution analysis should be completed by utilizing the internet technologies. Internet coordination is more than an MIS, which is utilized in process management. In MIS coordination, every report is prepared by the computers, but there is a need to meet physically in any case. However, by Internet Coordination, for example "Net Meeting", it is aimed to minimize the requirement to meet physically.

V.2.5. Virtual Management (1985-…)

In the new era of the Post Modern Approach, with the developments of new technologies and utilizing from the internet, management concept is evolving to another facet. Virtual Management is about managing people at a distance using the technology. It seeks to separate certain responsibilities of managers from the actual site of production, the workers and resources at that site. It means maintaining close working relationships with colleagues in many locations, without the need for as many meetings as traditionally needed. Although Virtual Management can reduce travel costs up to 50%, it is a high risk strategy unless corporations are committed. It requires investment in technology as well as in team training. In virtual management, not only the managers can lead and control the employees virtually, but also the employees generally called virtual teams can plan, organize, and communicate the required issues to perform the responsible tasks locating in different parts. Home office approach is one of the new trends implementing virtual management techniques. However, the vital importance of new communication techniques usually internet, tele-conferencing should not be discarded in this management type.

Depending on the new improvements of technology, management functions totally mutate based on intranet, and internet technologies.

Planning: In Virtual Management, there are still *Rules*, *Procedures*, *Projects*, and *Programs* in order to reflect the previous tasks of planning function. However, *Rolling Plans* are the superior technique for planning. Since, the competitive environment is rapidly changing and getting harder day by day and Rolling Plans are responsible to reflect the changes in the plans without running the whole planning function.

Organizing: In this new era, companies can still organize themselves in *Product Based*, *Functional Based*, *Process Based*, and *Customer Based* types. *Territory Based* type is specific to Virtual Management. Since the focus on organization should be according to the place the work is being done or the geographic market area.

Leading: In post modern approach the most important characteristic of the leader is to be *Referent*. Leaders should use their experience and information for the benefit of the enterprise not only inside but also outside the company. Subordinates will definitely identify, respect and follow to a prestigious and well-known leader.

Controlling: Although all previous control methods can still remain, and also they are widely used, the specific control technique for Virtual Management is the *Computerized Control*. All required information should be recorded on the computers, and by the help of decision support systems, leader can achieve the desired information whenever it is needed in a short time. Similar to computerized control, all of the control activities should be *Integrated* to sustain the flexibility to achieve the required information.

Communication: Coordination of the enterprise should be performed by *Artificial Intelligent* systems without human beings. For example, although "Purchasing Order List" can be prepared by ERP systems, "Purchasing Order" should also be executed by the agent based communication system automatically. Since in the territory based organizations, it is aimed to be less dependent on the workers.

V.3. MEASURING THE CHANGE IN MANAGEMENT FUNCTIONS

As it is stated before, the scope of this chapter is to measure the capability to follow the changes in management activities of manufacturing systems. To measure this capability which type of management functions are employed in the manufacturing system should be analyzed. Hence the matching of each manufacturing management type with its specific method to perform the related management functions is shown in Table V-1.

Table V-1: Specific Management Functions for each Management Type

Mang. Type	**Planning Function**	**Organizing Function**	**Leading Function**	**Controlling Function**		**Coordinating Function**
				Method	**Tool**	
Shop Mang.	Rules	Product	Dictative	Upon Request	Individual	Directive
Functional Mang.	Procedures	Functional	Structural	Scheduled	Budget	Departmental
Process Mang.	Planned Processes	Process	Supportive	Adaptive	Project	MIS/ERP
Mang By Objectives	Programs	Customer	Participatory	Continuous -Self	Performance Based	Internet
Virtual Mang.	Rolling Plans	Territory	Referent	Integrated	Computer	Artificial Intelligent

The most important thing about Table V-1 is the additive structure of each specific method for each function. In other words; if the company uses "Procedures" accompanying with "Rules", it will indicate that the company uses the planning methods of "Functional Management" and it has been managed according to techniques used in the period of 18th -20th centuries.

In order to measure the capability to follow the changes in management functions, each function is investigated separately and a certain set of weights are assigned. The respective calculations are explained below.

V.3.1. Measuring the Capability to Follow Changes in Planning Methods

As explained in previous sections and shown in Table V-1; the development of Planning Methods is from the primitive case "Rules" to the Post-Modern case "Rolling Plans".

In order to verify that a company is really capable of following the changes in management in accordance with Planning Functions, it has to employ all five methods indicating the respective change and evolvement. If this is the case then it is easy to say that, the company is utilizing all the recent techniques for planning, and it is compatible with planning functions of "Virtual Management". In order to measure this capability, Table V-2 is prepared. Note that, each planning method is scored starting from 1 to 16 due their relative importance. These scores are determined as 2^k to understand which planning method is employed. Since if the score is 3, then it is definite that rules and procedures are the methods for planning function

Table V-2: Scoring for Planning Methods

SITUATION	STATE	METHOD	SCORE
Is there a set of rules (written or unwritten) that is mostly dependent on management perspective?	YES	RULES	1
	NO	-	0
Are the procedures of the rules defined to implement the rules?	YES	PROCEDURES	2
	NO	-	0
Is the process management followed during the planning function?	YES	PLANNED PROCESSES	4
	NO	-	0
Does the production planning function cooperate with other enterprise plans?	YES	PROGRAMS	8
	NO	-	0
Can the online changes be adapted without running the whole planning system?	YES	ROLLING PLANS	16
	NO	-	0

V.3.2. Measuring the Capability to Follow Changes in Organizing Methods

In order to denote that a company follows the changes in Organization Function of management in the best way, it is expected to be capable of employing all of those 5 methods explained before. Respective scoring is designed and shown in Table V-3.

Table V-3: Scoring for Organizational structuring

SITUATION	STATE	METHOD	SCORE
Is the organizational structure is based on the products?	YES	PRODUCT BASED	1
	NO	-	0
Is the organizational structure is based on departments responsible for different professions?	YES	FUNCTIONAL BASED	2
	NO	-	0
Is the organizational structure is based on the processes of the activities and related performances?	YES	PROCESS BASED	4
	NO	-	0
Is the organizational structure is based on customer expectations and related performances?	YES	CUSTOMER BASED	8
	NO	-	0
Are there any distribute units to exploit competitive market?	YES	TERRITORY BASED	16
	NO	-	0

V.3.3. Measuring the Capability to Follow Changes in Leading Methods

In order to denote that a company follows the changes in Leading Function of management in the best way, it should employ all of the 5 methods described above. In order to measure this capability same scoring procedure is employed here as well. Table V-4 indicates respective scores.

Table V-4: Scoring for Leading Functions with different methods

SITUATION	STATE	METHOD	SCORE
Are the required rules predefined and written to perform leading function?	YES	DICTATIVE	1
	NO	-	0
Are the rules employed by the structural regulations and directions?	YES	STRUCTURAL	2
	NO	-	0
Are the leaders supportive to subordinates?	YES	SUPPORTIVE	4
	NO	-	0
Do the leaders consult with subordinates in a participative behavior?	YES	PARTICIPATORY	8
	NO	-	0
Do the leaders use knowledge and experience for the benefit of the enterprise outside the company?	YES	REFERENT	16
	NO	-	0

V.3.4. Measuring the Capability to Follow Changes in Controlling Methods

Controlling function is analyzed in two aspects; Control Methods and Control Tools. In order to denote that a company follows the changes in Controlling manufacturing in the best way, it should similarly employ all of 5 methods explained before. If one of the methods or tools is missing, it will diminish the success rate of managing change depending on the method type. In order to indicate this, similar scores are developed for controlling functions for methods and tools as shown in Table V-5 and Table V-6 respectively.

Table V-5: Scoring Controlling methods in the order of evolvement

SITUATION	STATE	METHOD	SCORE
Is the control function performed by upon request?	YES	UPON REQUEST	1
	NO	-	0
Is the control function scheduled?	YES	SCHEDULED CONTROL	2
	NO	-	0
Can the control system be updated depending on the recent conditions?	YES	ADAPTIVE-FLEXIBLE CONTROL	4
	NO	-	0
Is the control function performed by each employee continuously within the enterprise?	YES	CONTINUOUS CONTROL	8
	NO	-	0
Is the control function integrated with other functions within the enterprise?	YES	INTEGRATED CONTROL	16
	NO	-	0

Table V-6: Scoring for Controlling tools in the order of evolvement

SITUATIONS	STATE	TOOLS	SCORE
Are the control elements defined individually?	YES	INDIVIDUAL CONTROL	1
	NO	-	0
Are the control elements based on budget control?	YES	BUDGET CONTROL	2
	NO	-	0
Are the control elements based on projects control?	YES	PROJECT CONTROL	4
	NO	-	0
Are the control elements based on the performances?	YES	PERFORMANCE BASED CONTROL	8
	NO	-	0
Are the control elements integrated and computerized?	YES	COMPUTERIZED CONTROL	16
	NO	-	0

Depending on these two aspects; methods and tools, the capability to follow the changes in controlling function is the average scores of them assuming an equal importance for both.

V.3.5. Measuring the Capability to Follow Changes in Coordination Methods

Relevant Coordination methods with their respective scores are provided in Table V-7.

Table V-7: Scoring for Coordination activities in the order of progress

SITUATION	STATE	METHOD	SCORE
Are Communication and coordination performed by only managers' directions?	YES	DIRECTIVE COORDINATION	1
	NO	-	0
Are Communication and coordination performed according to departmentalization?	YES	DEPARTMENTAL COORDINATION	2
	NO	-	0
Are Communication and coordination performed by utilizing managerial information systems (ERP, MIS, etc.)?	YES	MIS COORDINATION	4
	NO	-	0
Are all the work solutions performed by internet coordination? (i.e. Net Meeting)	YES	INTERNET COORDINATION	8
	NO	-	0
Are Communication and coordination performed by Artificial Intelligent systems	YES	ARTIFICIAL INTELLIGENCE COORDINATION	16
	NO	-	0

V.3.6. Capability to Manage Managerial Change

In conclusion of this chapter; the capability to follow the managerial changes is measured by investigating five managerial functions; Planning, Organizing, Leading, Controlling, and Coordinating. On the other side, the progress in manufacturing management systems are inspected and classified as in progressive stages starting from Shop Management, continuing to Functional Management, Process

Management, Management by Objectives, up to Virtual Management. Each of these management types are represented in a Radar Graph as shown in

Figure **V-6**. When the manufacturing management evolves in time, these methods should progress to the following stages. Hence the capability to follow the managerial changes is assessed through analyzing which management methods are employed within the organization in question. The overall score obtained by calculating the score for each function will denote the success of following Managerial Change.

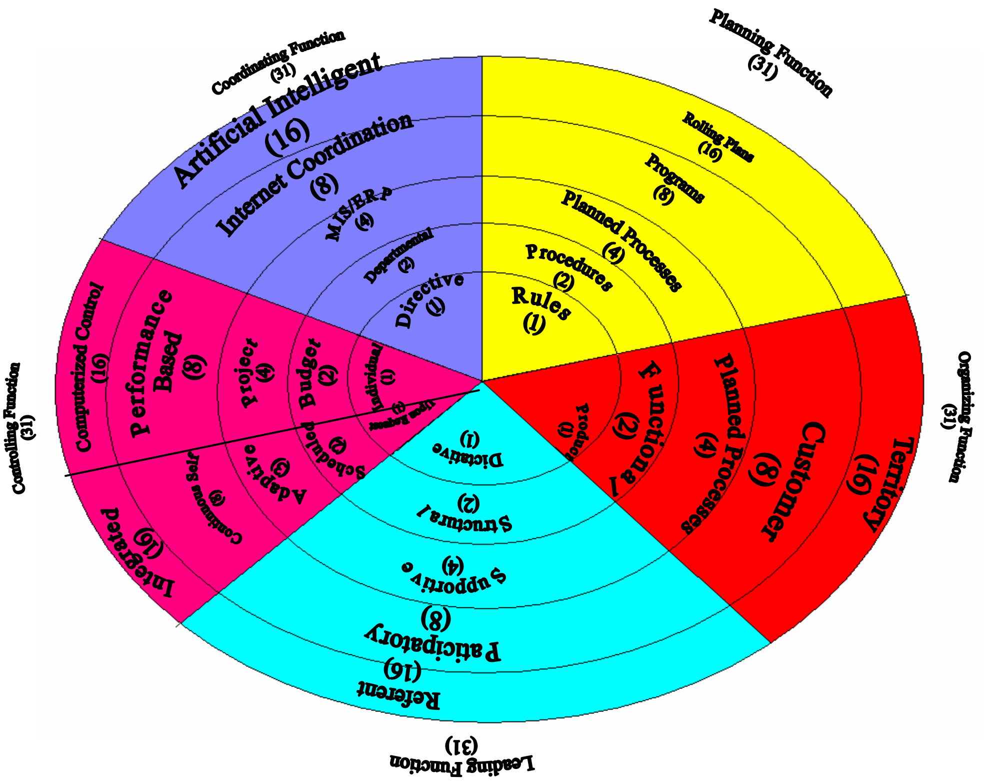

Figure V-6: Radar graph of specific methods for management functions

To evaluate the overall success rate in being capable of following the managerial change, the percentage scores of these functions are weighted through questionnaire explained in Chapter VII. According to this survey, the importance degrees of these functions are listed in Table V-8.

Table V-8: Relative importance degree of management functions

MANAGEMENT FUNCTIONS	WEIGHTS
Planning	0.25
Organizing	0.17
Leading	0.22
Controlling	0.21
Coordinating	0.15

Depending on these weight assignments, the overall success rate to follow the change in managerial functions is weighted averaged.

$$MC = \frac{(W_P * PF) + (W_O * OF) + (W_L * LF) + (W_C * CF) + (W_{Coor} * CoorF)}{W_P + W_O + W_L + W_C + W_{Coor}} \quad \textbf{(V.1)}$$

Where;

MC : Capability for Managerial Change

W_P : Weight for Planning Function

W_O : Weight for Organizing Function

W_L : Weight for Leading Function

W_C : Weight for Controlling Function

W_{Coor} : Weight for Coordinating Function

PF : Score of Planning Function

OF : Score of Organizing Function

LF : Score of Leading Function

CF : Score of Controlling Function

CoorF : Score of Coordinating Function

VI. ENVIRONMENTAL CHANGE

Environment is one of the vital factors on manufacturing systems. Since the natural resources are becoming more scarce, manufacturing systems should now pay more attention to the environment and respective changes. It should be noted that, every manufacturing company depends on the environmental resources in a direct or indirect way.

In this chapter, definition and the importance of environment concept for manufacturing systems are presented. Following that, ecological change and respective consequences on manufacturing systems are briefly discussed.

VI.1. ENVIRONMENT

An environment is what surrounds a thing or an item. It could be a physical environment that includes the built environment, natural environment -air conditions, water, land, and atmosphere. In this thesis scope the natural environment is emphasized. Natural environment is defined as, all kinds of objects that affect the human being in all aspects such as air, water; solid, flora and fauna of the nature can be listed as the components of environment (Karpuzcu, 2007).

The environment is an essential factor for all kinds of manufacturing systems. Manufacturing systems are totally dependent on the environment in which they are operating. Any change in this environment would then definitely affect the manufacturing systems. Hence it is required to be aware of the environmental changes when trying to be compliant with the change as whole.

VI.2. ENVIRONMENTAL CHANGE

Environmental change is certain basically caused by high level of industrialization. Although the industrialization is stated to be a key factor for the development of a country, it is one of the primary reasons of the environmental change brought about by consuming the natural resources, energy consumption, generating waste and pollution. Quantity and effect of industrial waste and pollution will increase unless the distillation is performed by the treatment facilities. It is clear that, the environmental changes such as -global warming, climate change, decline of the natural resources would definitely affect the manufacturing systems. New technologies for environmental safety should be implemented in order to secure the natural ambience. That was the reason behind extending the change management model to take environmental changes into account. Although the examples of environmental change can be listed more, the main aim of this chapter is to investigate the relation between the environmental change and the manufacturing systems.

VI.3. ENVIRONMENTAL CHANGE MANAGEMENT

There is a need for certain types of indicators in order to sustain the capability to follow changes leading to protect the environment. The most important one is to comply with the laws and the regulations. These regulations are assumed to be revised due to the changes in the environment and they should reflect the utmost protection possible. Complying with the legislations will therefore, ensure adaptation to the changes in environment to some extend regarding the manufacturing systems. Otherwise, manufacturing activities should stop.

Another important indicator is to comply with the international environmental protection standards. Even though the manufacturing company obeys the laws and the regulations, it may not be totally compatible with the standards. It is therefore important to satisfy the standards to indicate the capability to protect the environment. Since the standards are evolving, this may indicate the capability of the manufacturing organization to adopt environmental changes in its operations. One of the most widely valid and the certified standards is ISO 14001. Since these certificates are revised depending on the changes in the environment, possession of an ISO 14001 certificate and updating it periodically is considered to be an important sign of managing the environmental change.

In addition to those mentioned above, in order to manage the environmental changes, another requirement is to align its “Organizational Structure” to environmental changes. To fulfill this requirement, the existence of an organizational unit, which deals with the environmental changes, assesses the changes and makes strategic plans depending on the foresights of the changes, is assumed to be an important indicator for successful environmental change management.

Although it is not as important as “Complying with the legislations” and “Sustaining the standard certificates”, performing voluntary environmental protection activities, provides a successful indicator for environmental change management. Through the voluntary activities, not only the environmental change can be assessed more effectively, but also the company can increase the customer portfolio reputation by the “Environmental Friendliness”. In the following sections, each of these indicators is deeply explained and performance metrics are provided in order to calculate the capability to follow the changes in environmental protection.

VI.3.1. Complying with Legislations

A general manufacturing company should comply with respective environmental legislations set by the government or local authorities. Before starting the business, the company should prepare the “Environment Impact Evaluation” report due to standards set by the Ministry of Environment. Moreover, while performing the manufacturing activities, the company should obey to the required regulations. These regulations may include, “Air Quality Control Regulations” for the gas emissions, “Waste Water Discharge Standards Regulations” for the waste water, “Solid Waste Control Regulations” to remove or to reuse the solid waste of manufacturing. Additionally, the company should mind the “Noise Pollution Control Regulations” to prevent the noise pollution of the environment. The standards and respective procedures for these regulations can be found in the literature (Tünay, 1996; Ministry of Environment and Forestry, 2009).

However, standards for these regulations vary depending on the manufacturing sector, and environmental location that the company established. For instance, Waste Water Discharge Standards are different for textile manufacturing sector from metal industry. Therefore, dealing with these standards for various manufacturing sector is not the subject of this study. Instead, the general Environmental Change Management model will have to look for the fulfilling rate of the respective legislations whatever forces they impose.

If the company does not comply with any of the legislations, then it is unavoidable to be penalized. In order to put a metric to measure the rate of “Complying with Legislation”, first thing to be checked is to search any “Shut Down” penalty by official authorities in a certain time period analyzed. If the company is penalized as “Shut Down” for a time period once or more, then it means that, the manufacturing processes are extremely hazardous for the environment. Therefore for this case the degree for “Comply with Legislation” (CL) will clearly take the value of “0”.

Similarly, the company may be penalized as “Product Withdrawal from the market”. In this case the manufacturing processes may be defined as crucially hazardous for the environment, and will take the value of “0.1” for the degree of CL.

However in some cases, the manufacturing company may be fined as “financial punishment” depending on some shortages according to the legislation. In this case, the level of financial punishment is important to evaluate the degree of CL. If the level of the financial punishment is high, it refers to the low CL level and. On the contrary, if the level of financial punishment is low, the level of shortages to legislation is low, revealing a higher degree of CL.

For this analysis, two important questions arise. First of them is, to assess the level of financial punishment as high or low. In fact, the level of punishment varies for different sectors and also for different companies. For instance, a financial punishment of $1M can be defined as a low punishment rate for an automotive company. On the other hand, the same amount of punishment can be unaffordable for a small textile company. The level of financial punishment will therefore be defined as sector-company dependent on the analysis.

After defining the level of financial punishment as high, medium, or low, the second important point is to define the degree of complying with legislation depending on the financial punishment level. By utilizing a questionnaire by the experts’ opinions, high level of financial punishment will lead to a low degree of CL, such as 0.2, designating a low level of meeting the legitimate standards. On the contrary, a low level of financial punishment will result in a high degree of CL, defined as 0.8. For the medium level of financial punishment the degree for CL is assigned as 0.5.

Furthermore, the contradictions to legislation may not require a financial punishment but a reprehension by the authorities. In this case, the degree of CL is evaluated depending on the reprehension type. If the company takes a single reprehension in the time period analyzed, then the degree of CL is defined as 0.7. However, if the company takes repetitive reprehensions –more than one- then the degree of CL is expected to be low as 0.3. Figure VI-1 summarizes the calculation methods for CL in any case.

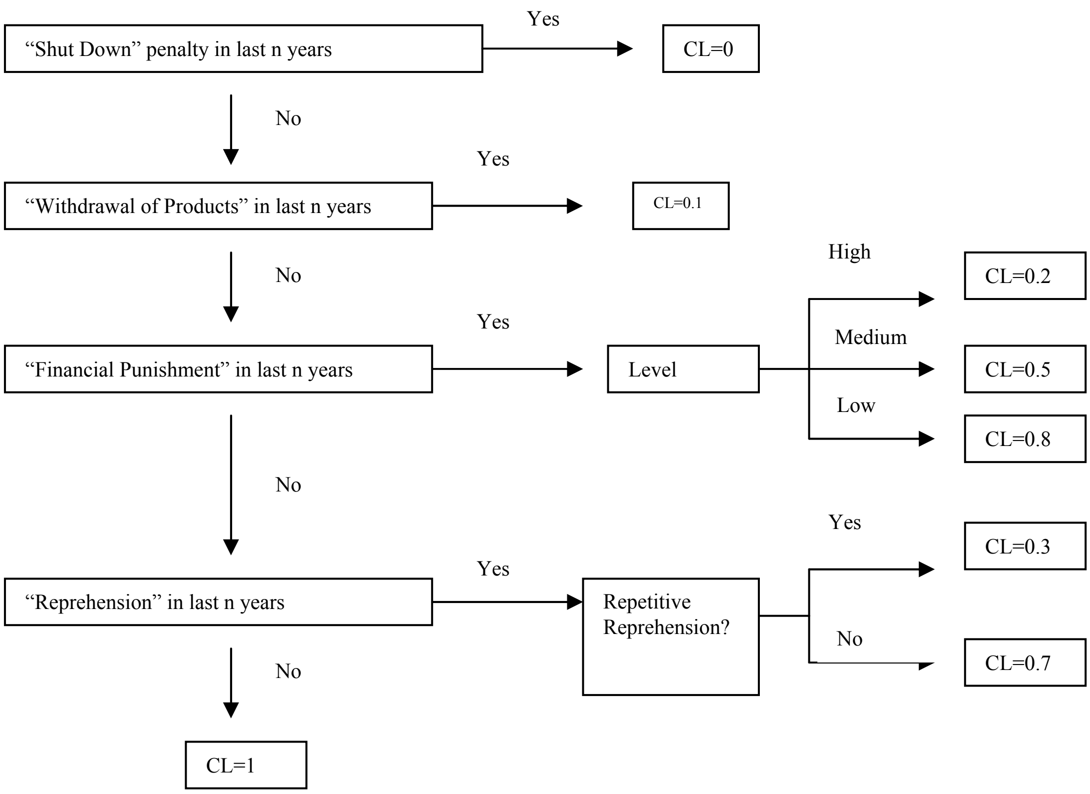

Figure VI-1: Questionnaire to measure the Compliance with Legislations rate

In Figure VI-1 the methodology to measure the degree of compliance with legislations is set through a flow chart scheme including all possible instances. Due to this methodology, to attain 100% success for compliance, the company in question should not take any shutdown penalty, withdrawal of products, financial punishment, or any reprehension

VI.3.2. Properness to Standards

Although complying with legislation is legally sufficient enough to perform manufacturing activities, the organization should sustain the properness to international environmental protection standards. Attaining these standards is crucial to follow since these standards are prepared and revised depending on the changes in the environment. ISO 14001, which is the most reputable and widely used international standard, is a good tool to evaluate the environmental effects of the manufacturing company.

Therefore, obtaining and keeping ISO 14001 certificate is a good indicator to evaluate the environmental change management of the manufacturing organization. If the company does not possess the certificate, the degree of "Properness to Standards (PS)" will definitely be zero.

Similar to CL, possession of this certificate once is not adequate to follow and manage the environmental changes. It is also necessary to keep the standards and update its validity. If the company is not obliged to any revisions depending on the periodical review of the standards performed by independent standards approval agencies, the manufacturing company does not only handle the certificate but also updates and sustains the validity of the standards. In that case, the degree of "PS" value will be 1, indicating hundred percent successes for following the environmental changes based on the international standards.

On the contrary, if the company is obliged to some revisions of the standards, the nature of the revisions is important. If these revisions are easy to overcome with a few process adjustments, then they are recognized as minor revisions. Since the minor revisions do not lead to important failures or loss of international standards, the degree of "PS" can be assumed as 0.8, representing a near optimum solution to continue to change as standards emerge.

However, if it is a burden of adjustments to amend the revisions, it means the company has lots of things to fix and has to perform major revisions. In this case, it is important to smooth out the problems at once. If the company cannot fix these major revisions, it is inevitable to receive more major revisions in the forthcoming periods. These repetitive major revisions will be a sign of the threat to lose the certificate in following periods. Repetitive major revisions for the standards in the period analyzed, will therefore lead to incapability of following international environmental standards and hence the degree of "PS" value can be settled as "0.1".

Beside this, the company can fix the major revisions at once and sustain the validity of the standards again. In other words, although the company has the certificate, it may have some problems to sustain the standards. Therefore, the degree of "PS" value would be less than 1 and assumed to be 0.4. In order to clarify the arguments about the "Properness to Standards" schematic representation as shown in Figure VI-2 is provided.

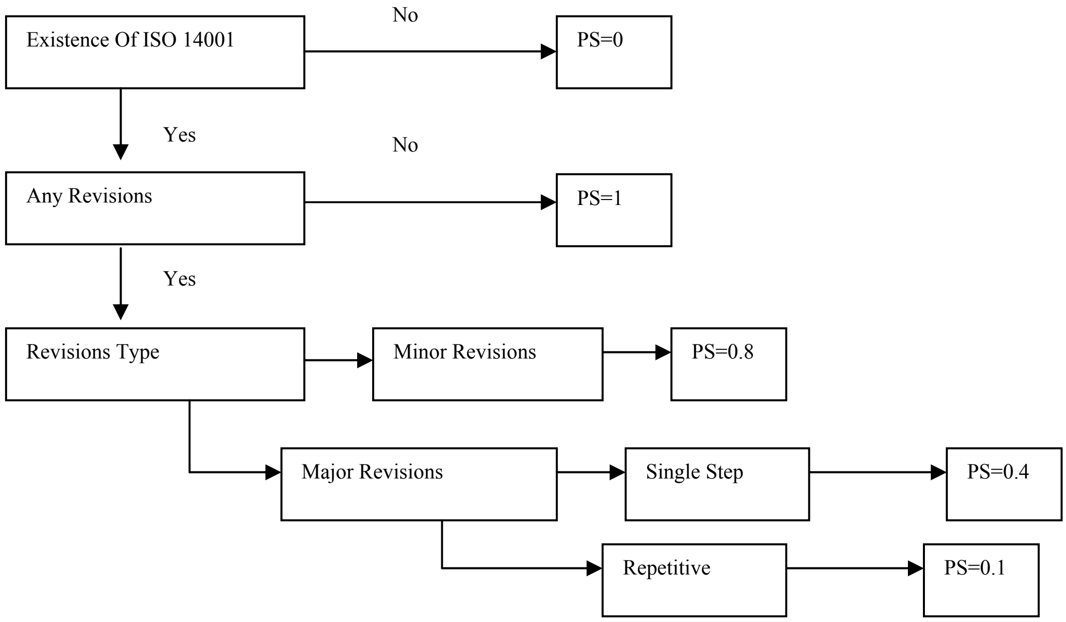

Figure VI-2: Questionnaire to measure the Properness to Standards rate

Based on the methodology depicted in Figure VI-2, in order to comply with international standards the existence of ISO 14001 is an obligation but not adequate. The company should not take any revisions at all to achieve 100% success for this aim.

VI.3.3. Organizational Structure

In previous sections the importance of "Complying with Legislation" and "Properness to Standards" are explained with their methodologies to find out the capability degrees of each. Although those are important factors to evaluate the environmental change management for a manufacturing system, they are not enough to fully comprehend environmental changes. Additionally, the manufacturing company should adapt its organizational structure to analyze environmental changes, and utilize the environmental analysis while planning the future strategies.

To do this environmental analysis, there should be an "Environmental Tracking Unit" within the organization. Some of the main tasks of this unit can be stated as; to follow up the environmental changes, preparing periodical environmental effect evaluation reports. Depending on these reports, "Environmental Tracking Unit" has the capability to determine the best strategy for the company and evaluate the alternative investment plans by foreseeing the environmental changes in the future. Also, this unit should be responsible for providing and maintaining the filtration facilities of which are necessary to prevent the water pollution, gas emissions, and noise effects of the manufacturing system.

If the organizational structure comprises of an "Environmental Tracking Unit", which is responsible to prepare periodical environmental effect reports, utilizes these reports while determining the future strategies, and future investments, and takes the responsibility to maintain the required treatment facilities, then the organizational structure is proper to manage the environmental change. Table VI-1 indicates scoring procedure for following environmental changes.

Table VI-1: Scoring the Organizational Structure for environmental protection.

Organizational Structure	**STATUS**				
Is there an « Environmental Tracking Unit »?	YES (1)			NO (0)	
Does the company prepare Environmental Effect Evaluation reports?	ALWAYS (1)	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)
Are these reports utilized while determining the enterprise strategy?	ALWAYS (1)	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)
Are the future investments evaluated depending on the environmental changes?	ALWAYS (1)	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)
Are the required treatment facilities periodically maintained?	ALWAYS (1)	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)

If the organizational structure has the pre-mentioned unit, it will take the value of 1 representing a good approach to manage the environmental change. For the following 4 situation; if the mentioned activities are always performed, it will take the value of 1 indicating an effective way of managing the change in organizational structure.

Depending on the weight assignments; the answers to these questions are achieved with a survey with the managers, and the averages of the weights represents the degree of environmental change management with respect to Organizational Structure (OS). For the instance case (scoring as shaded areas in the tables); this degree is calculated as follows;

$$OS = (1 + 0.5 + 0.25 + 0 + 0.5) / 5 = 0.45 \qquad \textbf{(VI.1)}$$

Note that 45% for the degree of organizational structure indicates the existence of an “Environmental Tracking Unit” but this unit is not fully utilized to perform its activities.

VI.3.4. Voluntary Environment Protection Activities

Although performing voluntary environmental activities is not as much important as “Complying with Legislation” or “Properness to Standards”, it provides the “Environmental Friendliness” as company reputation. Performing voluntary activities will also provide some intellectual knowledge and experience which will reveal important advantages in the competitive market structure where the natural resources decline.

For these reasons, performing voluntary activities has an important role to manage the environmental change. The efficiency of the activities represents the success rate of the voluntary activities. To do so, the existence or partial existence of following activities will denote some scores and the averages of these points’ leads to the degree of “Voluntary Activities”. Table VI-2 provides related scores.

Table VI-2: Scoring Voluntary Environmental Protection Activities

ACTIVITIES	APPLICATION		
Are the products environmental friendly?	YES (1)	PARTIAL (0,5)	NO (0)
Are the processes environmental friendly?	YES (1)	PARTIAL (0,5)	NO (0)
Does the company publish any literature to increase the environmental care?	YES (1)	PARTIAL (0,5)	NO (0)
Does the company organizes any conferences to increase the environmental care	YES (1)	PARTIAL (0,5)	NO (0)
Does the company support environment organizations?	YES (1)	PARTIAL (0,5)	NO (0)

For the example case possessing the capabilities as shaded area in Table VI.2, the score for "Voluntary Activities" (VA) is calculated by taking the average score for the listed applications.

$$VA=\frac{0.5+1+0+0.5+0.5}{5}=0.5 \quad \textbf{(VI.2)}$$

Note that 50% for the degree of voluntary activities denotes a semi-environmental friendly company in the customer portfolio reputation.

To summarize the Environmental Change Management in the proposed model, the manufacturing company must first "Comply with respective Legislation". Otherwise it is inevitable to continue its activities. In addition, it should attain and sustain "Properness to International Standards". Basic component to sustain "the Standards" is to achieve ISO 14001, which is an international standard for environmental protection. Above all of these, the company should organize its structure to follow the environmental changes. Therefore, the "Organizational Structure" of the company is considered to be important to utilize the environmental changes while setting the future plans and strategies. Last but not least, the manufacturing company should perform "Voluntary Environmental Activities" in order to grow an environmental friendly company. Methodologies to manage and measure the efficiencies of these 4 factors are explained in detailed in previous sections. Depending on these 4 factors, capability for "Environmental Change (EC)" is calculated as in the following way;

$$EC = CL * \frac{(\mathrm{PS}+\mathrm{OS}\ +\mathrm{VA})}{3} \quad \textbf{(VI.3)}$$

Where;

EC: Capability for "Environmental Change" management

CL: Represents the "Comply with Legislation" factor

PS: Represents the "Properness to Standards" factor

OS: Represents the "Organizational Structure" factor

VA: Represents the "Voluntary Activities" factor

It is important to note that "Complying with Legislation" is essential to sustain manufacturing activities. This implies that if there is a legal problem then having other change elements in order does not mean anything to support environmental change management.

On the other hand, the importance of “Complying with Standards”, “Creating Organizational Structure”, and “Performing Voluntary Environmental Activities” are assumed to be equal. The relation of importance between these factors may be the subject of a future study

VII. SURVEY

In order to determine the relative importance of each of the change management model components as described so far, it is required to consult required expertise and a structured questionnaire is designed for this purpose. In this section, a general structure of the questionnaire is explained as shown in Table VII-1 and it is presented at the Appendix 1.

The questionnaire first describes the model components. The proposed change management model for manufacturing systems is composed of 5 main elements namely; Technological Change, Process Oriented Change, Customer Oriented Change, Managerial Change, and Environmental Change. Each of these elements has sub elements as detailed in previous chapters. The survey is therefore prepared to assess the respective weights of these 5 main elements and their sub elements. After explaining each element and sub elements briefly in the survey, the relative importance of 5 main elements of the model is sought from the experts. This was the baseline for the first question of the questionnaires as shown in Table VII-1.

Table VII-1: First question of the questionnaire

Please distribute 100 points to the listed change elements accordance with relative importance to follow the change in a manufacturing company. If you think about any missing elements, please write down and explain in "Notes" section.

Change Elements	Relative Point
1. Technological Change	
2. Process Oriented Change	
3. Customer Oriented Change	
4. Managerial Change	
5. Environmental Change	
Other	
TOTAL	100
Notes:	

According to survey results, averaged relative scores for each change elements for a manufacturing company are given in Table VII-2.

Table VII-2: Responses to first question of the questionnaire

Change Elements	**Relative Point**
1. Technological Change	27.45
2. Process Oriented Change	21.18
3. Customer Oriented Change	23.26
4. Managerial Change	16.49
5. Environmental Change	11.62
Other	
TOTAL	100
Notes:	

According to these results, the most important element to follow the change for a manufacturing company is thought to be following the technological changes. It is logical since the technological changes are one of the most crucial triggering effects of change in any side of human beings. The second important factor occurs to be following the customer oriented change. Since the competition increases in market structure in recent time, following and leading the change in customer demands or requirements is naturally important. Following the process change, which is interrelated with the technological change, is the third important factor depending on the fact that, new technologies should be well implemented into the manufacturing processes. Although following managerial change takes the fourth place it should not be discarded at all. As the last, following the environmental change is thought to be as the least important factor.

Respondents of the survey are selected from two main areas. Since both industrial and academic perspectives are beneficial to assess the respective weights, the survey is sent to both industrial and academic representatives.

The survey is sent to 315 industrial representatives who are mainly responsible for the production departments. According to 98 replies of the survey, Table VII-3 summarizes the respective weights for each of the model components and their sub elements.

Table VII-3: Summary of the result of the questionnaire from industry

COMPONENTS & SUB ELEMENTS	WEIGHTS
TECHNOLOGICAL CHANGE	0.2827
Forecasting	0.2804
Innovation	0.3236
Adaptation	0.3960
PROCESS CHANGE	0.2199
Average Worker Utilization	0.2408
Total Bottleneck Ratio	0.2480
Unit Production Time	0.2071
Unit Production Cost	0.3041
MANAGERIAL CHANGE	0.1617
Planning	0.2330
Organizing	0.1507
Leading	0.2389
Controlling	0.2325
Coordinating	0.1449
CUSTOMER ORIENTED CHANGE	0.2316
Get Ratio	0.3189
Keep Ratio	0.3888
Growth Ratio	0.2923
ENVIRONMENTAL CHANGE	0.1041
Comply with Standards	0.4087
Organizational Structure	0.3898
Voluntary Activities	0.2015

According to these results; to follow the change in manufacturing systems; technological and customer oriented changes are the most important elements to be managed with 28.27% and 23.16% of importance respectively. In the opposite, the environmental change is released to be the least important one to be taken into account to manage the overall change. This is quite logical and implies the correctness of the results.

On the other hand the survey is sent to the academicians of industrial engineering departments of 23 different universities. According to the 109 replies of the 433 survey sent; following Table VII-4, summarizes the respective weights for each of the model components and their sub elements.

Table VII-4: Summary of the questionnaire results from academicians

COMPONENTS & SUB ELEMENTS	WEIGHTS
TECHNOLOGICAL CHANGE	0.2664
Forecasting	0.2969
Innovation	0.3444
Adaptation	0.3587
PROCESS CHANGE	0.2037
Average Worker Utilization	0.2720
Total Bottleneck Ratio	0.2324
Unit Production Time	0.2206
Unit Production Cost	0.2750
MANAGERIAL CHANGE	0.1680
Planning	0.2679
Organizing	0.1835
Leading	0.2078
Controlling	0.1789
Coordinating	0.1619
CUSTOMER ORIENTED CHANGE	0.2336
Get Ratio	0.3428
Keep Ratio	0.3902
Growth Ratio	0.2670
ENVIRONMENTAL CHANGE	0.1283
Comply with Standards	0.4326
Organizational Structure	0.3587
Voluntary Activities	0.2087

Similar to the respondents of the industrial experts, technological and customer oriented changes are revealed as the most important factors to be followed in order to manage the change in manufacturing systems with the importance degrees of 26.64% and 23.36% respectively. Although the respective weights differ from the ones of the industrial respondents, they are still the most important factors. Similar to industrial experts, Matching with the Table VII-4; academics also founds that the environmental change is the least important factor with the importance degree of 12.83%.

In order to assess the relative weights for each of these components and sub elements, respondents from industry and academicians are simple averaged since both respondents alike with each other. Following Table VII-5 summarizes the respective weights.

Table VII-5: Summary of the survey results.

COMPONENTS & SUB ELEMENTS	WEIGHTS
TECHNOLOGICAL CHANGE	0.28
Forecasting	0.29
Innovation	0.33
Adaptation	0.38
PROCESS CHANGE	0.21
Average Worker Utilization	0.26
Total Bottleneck Ratio	0.24
Unit Production Time	0.21
Unit Production Cost	0.29
MANAGERIAL CHANGE	0.17
Planning	0.25
Organizing	0.17
Leading	0.22
Controlling	0.21
Coordinating	0.15
CUSTOMER ORIENTED CHANGE	0.23
Get Ratio	0.33
Keep Ratio	0.39
Growth Ratio	0.28
ENVIRONMENTAL CHANGE	0.11
Comply with Standards	0.42
Organizational Structure	0.37
Voluntary Activities	0.21

Based on these survey results, these weights are used to evaluate the overall capability to manage the change for a manufacturing company.

VIII. IMPLEMENTATION

The proposed Change Management model for manufacturing systems is implemented in a company producing gas armatures. The company is called Kayalar Armatür Sanayi, shortly mentioned as KAS for the forthcoming sections. Before the implementation of the proposed change management model in KAS, a brief description of the company is explained.

VIII.1. COMPANY INFORMATION

KAS is a company of the group KAYALAR settled in 1970. KAYALAR group has 3 main company KAS for production of armature and flex, KASPA for marketing of the products, and a Stock Company for providing supply of raw materials to KAS factories. KAS is located in Samandra on a 10000m^2 in house area for manufacturing of two main product families namely, Armature and Flex in two separate facilities. Since the flex production facility has an incremental development from the new general manager is assigned, the capability to manage the change in flex facility is selected in this study for the proof of concept.

In the flex production facility there are mainly two processes; Hose Production and Flex Production. Hose production takes place at the second floor of the facility and performed by automated machinery system through the transformation of metal sheet into hose. However, flex production takes the outputs of hose production as the input and provides the final product after different operations. Since the hose production is simple and consists of only the process of transforming metal sheet to hose, flex production is chosen as the implementation area.

The validity and verification of the model is checked during the implementation stage for the period from 2006 and 2009. Since the general manager of flex production facility was changed in 2006, the capability of following the change from 2006 to 2009 was required by the manager. The analysis of this capability generally included some interviews with the general manager of the flex production facility as well as some observation and information gathering about the flex production process. The general schema of the flex production process, which consists of 6 work centers, is given in Figure VIII-1.

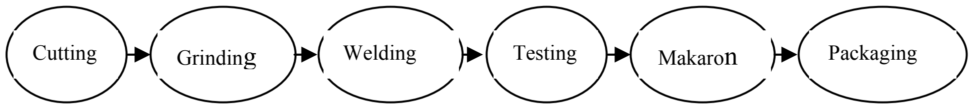

Figure VIII-1: A Schema of Flex Production Process

During the period from 2006 to 2009, the machine numbers for each of these work centers changed due to number of products launched. Additionally, there have been some technological changes in the manufacturing system as well as the product variety and quantity.

VIII.2. CHANGES IN THE COMPANY

Initial change has started in 2006 by assigning a new general manager, to the facility. Therefore some managerial aspects, for example leading characteristic of the system, have definitely changed.

Moreover, in 2008 the welding technology is changed from induction welding to tig (Tungsten Inert Gas) welding. Induction welding is a form of welding that uses electromagnetic induction to heat the metal piece. The welding apparatus contains an induction coil that is energized with a radio-frequency electric current and welds the metal piece. However, in tig welding, a tungsten electrode heats the metal you are welding and the inert gas (most commonly Argon) protects the weld puddle from airborne contaminants. Tig welding produces clean, precise welds on any metal. This technological change in the company brought about some process changes reducing the standard production time. Tig welding also reduced the scrap ratio of the production, which surely led some changes for environmental effects.

Furthermore, in 2009, a 4-handle welding machine is purchased. Since welding operations could be performed on 4 points, this machine decreased the welding operation time as well as to change in manufacturing process. On the other hand, since KAS sells all of its products through KASPA, the sole customer does not change. In the light of this information, the capability to follow the change by KAS FLEX is analyzed through 5 components namely; Technological Change, Process Oriented Change, Customer Oriented Change, Managerial Change, and Environmental Change as the model delineates. The result of the analysis is provided in the following Chapters

IX. TECHNOLOGICAL CHANGE IN KAS FLEX

As proposed by the change management model, managing the technological change is vital for every manufacturing company. To handle the technological change in a successive manner, a good forecast of the technological change is the first step to attain. In the second step, technological changes should be performed depending on the forecasts and some innovation on products should be realized and product portfolio should be aligned with the technological progress. Last but not least, to produce the new innovative products the whole production system should be adapted to technological changes. Therefore following parts are devoted to analyze and measure the capabilities for technological forecasting, innovativeness, and adaptation of KAS, a flex pipe producing company. Note that this section will be a kind of proof of concept for measuring the capability to follow the technological change in a manufacturing system. Implementation of the methodology proposed will be detailed and respective issues will be discussed.

IX.1. TECHNOLOGICAL FORECASTING IN KAS FLEX

Within the analysis period between 2006 and 2009, it is realized that there was no technological change implemented on the flex production process in 2006 and 2007. There is therefore no need to make a forecast of the outcomes of the technological change for these two years. However, in 2008 welding technology is changed from induction welding to tig welding. Additionally, in 2009 a new welding machine with 4 handles is added to welding center. The outcomes of these changes should therefore be compared with the forecasted results according to pre-defined 4 technological aspects in flex production process namely; ***Throughput Time, Quantity/Day***, ***Scrap Ratio***, and ***Revenue***.

The general methodology to calculate the technology forecasting capability for each of the aspects, following formulation is used.

$$FC_i = [1 - \frac{|F_n - A_n|}{A_n}] \qquad \textbf{(IX.1)}$$

Where;

FC_i: Forecasting Capability for aspect i.

F_n : Forecast value for n^{th} year

A_n : Actual value for n^{th} year and

n= 2006, 2007, 2008, 2009

When the forecasting capabilities of each aspect for each year are found, overall forecasting capability of the related aspect is calculated by taking the average of each year. Consequently, overall forecasting capabilities of each aspect are averaged with their relative weights gathered through the questionnaire. Respective assessment is discussed below.

IX.1.1. Forecasting the Throughput Time

In order to measure the capability to forecast the throughput time, actual and forecasted capacity in each shift -accompanying with the working time- for each year is taken from the company records in KAS FLEX production facility and given in Table IX-1

Table IX-1: Actual and forecasted capacity for each year

	2006	**2007**	**2008**	**2009**
Actual Capacity/Shift (unit)	700	700	1,250	5,000
Forecasted Capacity/Shift	No Forecast	No Forecast	1,200	4,000
Working Time/Shift (min.)	540	540	540	540

Depending on this information, actual and forecasted throughput time of each unit can be calculated by dividing the working time over the capacity values. Percentage forecasting capability for throughput time can be measured by comparing the actual and forecasted values. The overall forecasting capability for throughput time is the average of 4 years. However, since there is no technological change in the first and second years, only the forecasting capabilities of the third and fourth years are averaged and found as 85.42% for the throughput time forecasting capability. Forecasting capability for each year and the overall percentage forecasting capability for throughput time are given in Table IX-2.

Table IX-2: Forecasting the Capability of forecasting the Throughput Time

Throughput Time Forecasting	**2006**	**2007**	**2008**	**2009**
Actual Throughput Time (min/unit)	540/700= 0.771	0.771	0.432	0.108
Forecasted Throughput Time (min/unit)	No Forecast	No Forecast	0.450	0.135
Forecasting Capability (%)	Not measured	Not measured	95.830	75.000
Average Forecasting Capability of Throughput Time (%)	$\frac{95.83+75.00}{2}=85.42$			

As indicated in Table IX-2; since there are not any technological change implemented in 2006 and 2007, forecasting capability for throughput time is calculated through 2008 and 2009 and found as 85.42%. This score represents a high degree for this capability since the forecasted and actual respective values are very close. Hence the company can be stated as successful to forecast the throughput time of the manufacturing process.

IX.1.2. Forecasting the Quantity/ Day

In order to measure the capability of forecasting Quantity/Day, actual and forecasted average monthly production levels -accompanying with the number of workers and working days- for each year is taken from the company records and given in Table IX-3.

Table IX-3: Actual and forecasted average monthly production levels

Production Levels	**2006**	**2007**	**2008**	**2009**
# of Workers	7	10	22	36
# of Working Days	22	22	22	22
Actual Average Monthly Production Level	30,000	50,000	75,000	117,000
Forecasted Monthly Production Level	No Forecast	No Forecast	60,000	75,000

Depending on this information, actual and forecasted daily production levels can be calculated by dividing the monthly production level over the number of working days. Since the effect of technological change is in question, monthly production level should also be divided by the number of workers to eliminate the effect of worker size. Technological Forecasting capability for each year and the average forecasting capability for Quantity/Day for KAS FLEX are calculated as given in Table IX-4.

Table IX-4: Forecasting Capability for Quantity/Day

Quantity/Day Forecasting	**2006**	**2007**	**2008**	**2009**
Actual Daily Production	30,000/ (7*22) = 194.805	227.273	154.959	147.727
Forecasted Daily Production	No Forecast	No Forecast	123.967	94.697
Forecasting Capability (%)	Not measured	Not measured	80.000	64.100
Average Forecasting Capability for Quantity/Day (%)	$\frac{80.00 + 64.10}{2} = 72.05$			

Being able to forecast the amount of production quantity per day by 72.05% means the company is aware of the yield of technological changes in accordance with this aspect with 72.05%. When the forecasted and actual average monthly production levels are compared, it is seen that the company has underestimate production levels. Although the actual levels are greater than the forecasted values, the differences between these values diminish the forecasting capability of quantity per day aspect of the manufacturing system.

IX.1.3. Forecasting the Scrap Ratio

Similarly, to be able to measure the forecasting capability for Scrap Ratio, actual and forecasted scrap ratios for each year is sought from company records. Based on the information obtained as shown in Table IX-5, the forecasting capability for each year and the average capability for forecasting the scrap ratio are calculated. Note that KAS FLEX seems to be capable of forecasting its scrap ration by nearly 48%. Although it seems good for the actual scrap ratio being less than the forecasted value, forecasting capability is not very successful. The company can only estimate the 48% of the decrease in actual scrap ratio.

Table IX-5: Capability of Forecasting the Scrap Ratio

Scrap ratio Forecasting	**2006**	**2007**	**2008**	**2009**
Actual Scrap Ratio (%)	15.00	15.00	8.00	3.00
Forecasted Scrap Ratio (%)	No Forecast	No Forecast	11.00	5.00
Forecasting Capability (%)	No Need	No Need	62.50	33.33
Average Forecasting Capability for Scrap Ratio (%)	$\frac{62.50+33.33}{2}=47.92$			

IX.1.4. Forecasting the Revenue

In order to measure the capability to forecast the Revenue of the company, actual and forecasted Revenues for each year is used from the company records. Based on the information obtained, the forecasting capability for each year and the average capability for forecasting the Revenue are calculated as given in Table IX-6. Since there is not any forecasting value for the revenue aspect, the overall forecasting capability for the revenue is set to zero. This means that; although 2 important technological changes occur in the flex production process, there is a lack of information and forecasting study about how the changes will affect the revenue.

Table IX-6: Forecasting Capability for Revenue

	2006	**2007**	**2008**	**2009**
Actual Revenue (TL)	2,565,461	4,456,065	6,224,000	8,058,268
Forecasted Revenue (TL)	No Forecast	No Forecast	No Forecast	No Forecast
Forecasting Capability (%)	Not measured	Not measured	0	0
Average Forecasting Capability for Revenue (%)	**0**			

After analyzing the forecasting capability of 4 technological aspects in KAS FLEX, the overall technological forecasting capability is assessed by taking the weighted average of each aspect. Table IX-7 summarizes the result of this analysis. Note that weight values are sought through expert view as explained in Chapter VII. The overall Technological Forecasting Capability in KAS FLEX is found to be 49.62%. That was achieved by;

$$FC = \frac{\sum_{i=1}^{4}(w_i * FC_i)}{\sum_{i=1}^{4} w_i} \quad \textbf{(IX.2)}$$

Where;

FC : Forecasting Capability

W_i : Weight for aspect i

FC_i : Forecasting Capability for aspect i

i : Throughput Time, Quantity/Day, Scrap Rate, Revenue

Table IX-7: Technological Forecasting Capability

Technological Aspects	**Weight**	**Forecasting Capability**
Throughput Time	0.3	85.42
Quantity/Day	0.2	72.05
Scrap Ratio	0.2	47.92
Revenue	0.3	0.00
Capability of Technological Forecasting (%)		**49.62**

Generally, it can be concluded that KAS FLEX is only about 50% capable of forecasting 4 important technological change aspects. This score indicates the existence of some forecasting studies, but in average it is not fully successful. Although it is highly and moderate successful of forecasting throughput time and quantity per day aspects respectively, it is not capable to estimate the scrap ratio correctly. The remarkable point is about the revenue aspect. Since there is not any forecasting study for this one, the company can be stated to be unconscious of the return on investment of new technologies.

IX.2. TECHNOLOGICAL INNOVATION IN KAS FLEX

In the second step of the implementation of the model with respect to being able to follow the technological change, technological innovation capability is analyzed in KAS FLEX. In order to find out innovation capability of the company, product portfolio of the flex production facility is analyzed for the time period of 2006 to 2009.

In 2006, 106 different types of product were produced and sold. However, it is found out that there are some similar products. For instance product id 1051 is only different from the product id 1050 by coating it with a yellow plastic material called as “makaron”. Although it adds a value to the existing product, it is not a totally new product. So the individual products 1050 and 1051 can be grouped in the product family of 1050.

Through performing this product family classification, there were 82 different product families in 2006. Total sales amount of these products was equal to 268,321 with total value of 2,565,461.225 TL.

Similarly, when the product portfolio of 2009 is analyzed, it is seen that 66 of previous 82 product families were still being produced and sold. In addition to the previous products, there were 172 different new product families. Total sales amount of the previous and new product families are calculated as 754,007 and 554,581 respectively. Moreover, total values of the previous and new product families sold 5,771,944.7TL and 2,286,324.175TL respectively. All of the product portfolio analysis carried out in the company for the time period between 2006 and 2009 is summarized in following Table IX-8.

Table IX-8: Product Portfolio Analysis for 2006 and 2009 in KAS FLEX

Product Portfolio Analysis	**2006**	**2009**		
		Previous Product Families	*New Product Families*	*Total*
Number of Product Families	82	66	172	238
Total Sales Amount	268,321	754,007	554,581	1,308,588
Total Value (TL)	2,565,461.225	5,771,944.7	2,286,324.175	8,058,268.875

Based on the product portfolio analysis, technological innovativeness capability can be calculated through 4 indicators of the proposed model, namely; Change in Product Portfolio, New Product Ratio, Sales Amount Ratio of New Products, Value Ratio of New Products.

IX.2.1. Change in Product Portfolio

While the company produced 82 different product families in 2006, number of product families increased to 238 in 2009. It indicates an increase in portfolio over 190%. Since for the best case the portfolio is assigned to be 100%, the result is adjusted to 100% representing a great deal of increase in the product portfolio. That means the company was so much active in designing new products which will add value to company gains. That is calculated as;

Change in Product Portfolio= $\frac{238-82}{82}=190\% \Rightarrow 100\%$ **(IX.3)**

IX.2.2. New Product Ratio

Although the change in product portfolio is denoted as 100%, new product ratio is also be analyzed for 2009. If there were 82 new products and 82 previous products, product portfolio had increased 100%. However, only 82 of total 164 products, 50% of portfolio comprises of new products. When the product portfolio of 2009 is analyzed, 172 of the 238 number of product families were different than the ones in 2006.

New Product Ratio= $\frac{172}{238}=72.27\%$ **(IX.4)**

It means that 72.27% of the product portfolio comprises of the new products. Since the best case cannot exceed 100%, in case of changing the product portfolio at all, this score is moderately high. 72% indicates that the company has adopted most of its product portfolio due to the changes.

IX.2.3. Ratio of the Sales Amount of the New Products

Although there were 172 different types of products in 2009, as imposed by the model, the sales amounts of these new products should be compared with total sales amount. That is to indicate if the new products are marketable or not.

Sales Amount Ratio of New Product= $\frac{554581}{1308588}=42.38\%$ **(IX.5)**

It indicates that 172 new products make up the 42.38% of the amount of sales. Although the number of new products is much greater than the number of previous products, sales amount of new products are less than the previous ones. That is a good signal that, these new products are not so marketable. On the other side this may be caused by the reason that, these new products may be so brand new that, the customer demands may not been created yet. Hence this analysis should be carried on continuously for different periods.

IX.2.4. Ratio of the Sales Revenue of the New Products

In addition to previous analysis, the model requires that the value of the new products should be studied in order to indicate if the new products really create a value for the company. When the sales revenue of the new products is divided by the total value of the products in 2009, it is found out that;

$$\text{Sales Revenue Ratio of New Products} = \frac{2286324.175}{8058268.875} = 28.37\% \qquad \textbf{(IX.6)}$$

Similarly it points out that the 172 new products (72.27% of the product portfolio) only make up the 28.37% of the total value of the products. That means although the company produces lots of new products, these products do not add as much value to the total value of the product portfolio as expected.

After analyzing 4 indicators of the innovation as pointed out by the model, the overall technological innovation capability of the company can be calculated through taking the weighted average of each indicator. Table IX-9 summarizes the scores of the indicators and the relative weights, which are gathered through the questionnaire as explained in Chapter VII Note that, the overall Technological Innovation Capability (IC) is found as 62,14%. That can be interpreted as moderate successful for producing innovative products and updating its product portfolio due to the changes occur.

Table IX-9: Technological Innovation Capability

Innovativeness Indicators	**Weight**	**Innovativeness Score (%)**
Change in Product Portfolio	0.30	100.00
New Product Ratio	0.20	72.27
Sales Amount Ratio of New Product	0.25	42.38
Value Ratio of New Product	0.25	28.37
Innovation Capability (IC) (%)		**62.14**

IX.3. TECHNOLOGICAL ADAPTATION IN KAS FLEX

In order to understand the capability of following the technological changes, technological adaptation should also be studied. This may include the analysis of 3 elements as imposed by the model. They are Tool Effect, Human Effect, and Knowledge Effect.

IX.3.1. Tool Effect in KAS FLEX

To analyze the Tool Effect of the manufacturing process; Machine Replacement Rate, Automation Level, and Information Technologies Utilization Rate need to be examined.

IX.3.1.1. Machine Replacement Rate

When flex production process is analyzed, it is seen that tig welding process is implemented replacing induction welding in 2008 and a 4-handle welding machine is purchased in 2009. Total costs of these changes as provided by the company were 300,000 TL and 700,000TL for the respective years.

Machine replacement rate, which designates the average changes in machine investment in successive years of the analysis, is calculated by comparing the machine investments of two successive years according to the following formulation. For example, since there is no change for the investment of machinery in 2007 with respect to2006, machine replacement rate is set to zero for those periods.

$$\Delta MI = \frac{MI_n - MI_{n-1}}{MI_{n-1}} \qquad \textbf{(IX.7)}$$

MI_n: Machine Investment value for n^{th} year

MI_{n-1}: Machine Investment value for $n\text{-}1^{th}$ year

ΔMI: Change in Machine Investment Value

n : 2007, 2008, 2009

However there was an investment of 300,000TL on machinery in 2008. Although the change in machine investment in 2008 will be infinite compared to the investment value in 2007, the adjusted change in machinery investment for 2008 is assumed as 100%. Additionally, since the analysis period starts from 2006, change in machine investment for 2006 cannot be calculated and it is taken out of concern. Changes in machine investment for years 2007, 2008, and 2009 are summarized in Table IX-10 accompanying with the Machine Replacement Rate of the company, which is the average of 3 years.

Table IX-10: Machine Replacement Rate

Machine Replacement Rate	**2006**	**2007**	**2008**	**2009**
Machine Investment	0	0	300,000	700,000
ΔMI	Don't Exist	$= \frac{(0-0)}{0} = \infty$	$= \frac{(300000-0)}{0} = \infty$	$\frac{(700000-300000)}{300000}$
Adjusted ΔMI (%)	Don't Exist	0	100	100
Machine Replacement Rate (%)			$\frac{(0+100+100)}{3*100} = 66.67$	

Having 66.67% machine replacement capability makes the company to respond technological changes as following the changes and adapting machinery system according to new trends for manufacturing system.

IX.3.1.2. Level of Automation

Since the technological developments introduce the automated machinery systems in manufacturing systems, the level of automation is considered to be a good indicator of following the change in the respect of Tool Effect of Technological Adaptation. Therefore the value of automated machines is sought from the company records in KAS FLEX. However, none of the machines are fully or semi automated in the flex production process. Since all of the machines are changed in 2007 and 2008 the total value of the machines is equal to the machine investment value of 2008 and 2009, which is 100,000TL. Since the automation level can be found by dividing the value of automated machines over the value of all machines, it will definitely be zero for the process (see Table IX-11)

Table IX-11: Level of Automation

Automation Level	**2009**
Value of Fully Automated Machines	0
Value of Total Machines	100,000TL
Automation Level (%)	$\frac{0}{100000} = 0$

IX.3.1.3. Rate of IT Utilization

While analyzing the Tool Effect of Technological Adaptation, the interest should not only be given onto the machinery used, but also the information technologies utilized. Important IT systems are listed as; Database Management Systems, Infrastructure, Management Information Systems, Decision Support Systems, and Expert Systems. In the analysis of IT Utilization 6 different cases are defined by the model including;

Case 0 : No implementation at all

Case 1 : No implementation, but personalized employment

Case 2 : Partial implementation, partial employment

Case 3 : Partial implementation, full employment

Case 4 : Full implementation, partial employment

Case 5 : Full implementation, full employment

In the analysis of IT systems in the company, it was found out that the application of an ERP program provides a fully implementation and fully employment of database management system. By utilizing this ERP program, all functions of Management Information Systems can be performed. Although this program is fully implemented, some of the tasks cannot be performed due to partial employment of the infrastructure. For example, although the production cost of each unit can be calculated by the program, it does not work properly due to missing information about raw material or overhead cost which should be recorded by the employees. Beyond this, there is not any evidence of decision support systems which can analyzes the production system and prepares periodical reports to help decision process, at all. Moreover it is hard to state the existence of an expert system, which can attempt to provide an answer to a problem or clarify uncertainties where normally one or more human experts would need to be consulted. The relative importance weights for each system and the application of each system in the company is shaded and summarized in Table IX-12.

Table IX-12: Rate of IT Utilization in KAS FLEX

IT Utilization Rate	Weights	Case 0	Case 1	Case 2	Case 3	Case 4	Case 5
DMS	30	0	6	12	18	24	**30**
Infrastructure	25		5	10	15	**20**	25
MIS	20	0	4	8	12	16	**20**
DSS	15	**0**	3	6	9	12	15
Expert Systems	10	**0**	2	4	6	8	10
IT Utilization Rate (%)					$\frac{30+20+20+0+0}{100} = 70$		

After analyzing the 3 indicators, the capability of Tool Effect (TE) can be calculated by taking the weighted average of each indicator. Table IX-13 summarizes the scores of the indicators and the relative weights, note that overall Tool Effect Capability is found to be 48.00%. This means only 48% of the tools and machinery used are effectively adapted to new technologies with respect to stated factors. Hence the company is not so much capable to adapt new technologies in accordance with the tools utilized.

Table IX-13: Tool Effect Capability

Tool Effect Indicators	Weight	Capability of Indicators
Machine Replacement Rate	0.3	66.67
Automation Level	0.3	0.00
IT Utilization Rate	0.4	70.00
Tool Effect (TE) Capability (%)		**48.00**

IX.3.2. Human Effect in KAS FLEX

In order to adapt to new technologies, the resistance of the employees is one of the main concerns. The Human Effect on technological adaptation is therefore as much important as the Tool Effect. Just as a reminder, average experience of the workers, technological investment per worker, and the rotation ability of the workers are the indicators of Human Effect for Technological Adaptation.

IX.3.2.1. Average Worker Experience

In order to define the worker experience, the standard time to work in the related sector should be identified at first. A ratio of the working period of the worker over the standard available time gives the rate of experience of the worker.

According to some interview with the production manager and the foremen of the flex production process, the standard time to achieve the maximum experience for the workers in the process is determined as 3 months (as defined by the company). Since all of the workers have been working for more than 3 months, they have the maximum experience for the work they are employed. Therefore the average worker experience is stated to be 100%. Table IX-14, summarizes the standard working time for the maximum experience, working time of the workers and the average experience of the workers in the process analyzed.

Table IX-14: Average Worker Experience

Average Worker Experience	**Explanation**
Standard Working Time for Max. Experience	3 Months
Working Time of the Workers	All of them >3 Months
Average Worker Experience (%)	**100**

IX.3.2.2. Technological Investment per Worker

Investments in new technologies either decrease the standard unit production time or the required number of staff. Therefore analyzing the technological investment per worker investigates both the investment amount and the number of workers for technological adaptation.

The information about the amount of investment and the number of workers for each year is from company records. There was not any investment for 2006 and 2007. However investment of 30,000TL and 70,000TL occur in 2008 and 2009 respectively. The numbers of workers throughout 4-years analysis period are 7, 10, 22, and 36. Based on this information technological investment per worker for each year is calculated as given in Table IX-15.

Table IX-15: Technological Investment/Worker

Technological Investment/Worker	**2006**	**2007**	**2008**	**2009**
Investment Amount	0	0	30000	70000
# of Workers	7	10	22	36
Investment/Worker	0	0	=30000/22=1363.63	1944.440
Change in Investment/Worker	Not Concerned	0	=(1363.63-0)/0 = ∞	0.426
Adjusted Change in Investment/Worker (%)	Not Concerned	0	100	42.600
Average Change in Investment/Worker (%)			$\frac{0+1+0.426}{3} = 47.53\%$	

Although the technological investment per worker is an important indicator, the change in this indicator signals the capability to follow up and adapt to new technologies. Hence, the change in investment per worker is evaluated by comparing the values of the successive years. For example, change in investment per worker in 2007 with respect 2006 is zero. However the change in investment per worker in 2008 with respect to 2007 is infinite and it is adjusted as 100% to form a scale between 0 and 100. Similarly the change in investment per worker in 2009 with respect to 2008 is calculated as 42.6%. Since the analysis period starts from 2006, the change in investment per worker in 2006 is out of concern. Consequently the average change in investment per worker can be found as 47.53%. This indicates that, although the number of workers increase, the increase in technological investment is not enough to adapt the employees to new technologies.

IX.3.2.3. Rotation Ability

Although Average Worker Experience, which is the first indicator of Human Effect, is important to adapt to new technologies, it is not sufficiently enough. Rotation ability of the workers should be analyzed to find out the percentage value of the workers who can be employed on different work centers. If any change occurs in any of the work centers, the number of workers who can substitute the worker on the related work center will denote the flexibility of the whole system due to the changes occur.

Based on the interview with the production manager and the foremen and analyzing the company records, 27 of 36 workers are rotated in different times and are capable of working on different work centers. Only 9 of the workers cannot work any other work center except the makaron work center. Therefore the average rotation ability is calculated as 75% and given in Table IX-16.

Table IX-16: Rotation Ability

Rotation Ability	**Values**
# of Workers	36
# of Workers who can perform different work centers	27
Average Rotation Ability (%)	(27/30*100)= 75

After analyzing the 3 indicators, the capability of Human Effect (HE) can be calculated by taking the weighted average of each indicator. Table IX-17 summarizes the scores of the indicators and the relative weights as defined through expert view. The Human Effect Capability is eventually found as 82.01% indicating high degree of flexibility in utilizing employees due to changes.

Table IX-17: Human Effect Complying with the Change

Human Effect Indicators	**Weight**	**Capability of Indicators**
Average Worker Experience	0.5	100.00
Change in Technological Investment/Worker	0.2	47.53
Rotation Ability	0.3	75.00
Human Effect (HE) Capability (%)		**82.01**

IX.3.3. Knowledge Effect in KAS FLEX

Knowledge, which is the intellectual capital of the companies, plays an important role in adapting to the new technologies. Therefore the Knowledge Effect capability of the analyzed company is an important sign for Technological Adaptation. Training hour per Worker, Response Generation Rate, and Enterprise Knowledge Index are the indicators for this.

IX.3.3.1. Training Hour /Worker

Training the workers for the new technologies is definitely an important activity for technological adaptation. Therefore total training hour is divided by the total number of workers for each year to find out the training hour per worker as 0, 7, 10, and 0 for each year. However, the change in Training Hour per worker is more important to designate the capability to follow up the change in new technologies. Hence the change in this value is calculated by comparing the training hour per worker value with the value of preceding year.

For example; training hour per worker is 7 hours in 2007. Since the same indicator is zero for 2006, the change for training hour per worker in 2007 occurs to be infinite and adjusted as 100% to form a scale between 0 and 100. Since there is not any training activity in 2009, the change in training hour per worker for 2009 with respect to 2008 will be negative and adjusted to zero. Number of workers and total training hours for each year are given in Table IX-18 accompanying with the percentage change in training hour per worker.

Table IX-18: Training Hour/Worker

Training Hour/Worker	**2006**	**2007**	**2008**	**2009**
# of Workers	7	10	22	36
Total Training Hour	0	70	220	0
Training Hour/Worker	0	7	10	0
Change in Training Hour/Worker	Not Concern	∞	$\frac{(10-7)}{7}=0.43$	$\frac{(0-10)}{10}=-1$
Adjusted Change in Training Hour/Worker	Not Concern	1	0.43	0
Average Change in Training Hour/Worker			$\frac{(1+0.43+0)}{3}=47.62\%$	

IX.3.3.2. Rate of Response Generation

In the adaptation phase of a new technology, every worker may not have the whole knowledge. Therefore in case of a problem, every worker should know how and from whom he can achieve the required knowledge. Therefore a manual, which is prescribed in the model development part, on which the information flow is recorded on a timely basis, should be prepared to analyze the response generation rate.

However for the company analyzed, this manual is unnecessary since the operations are simple and foremen and the production manager are always ready to answer all of the problems which may occur. Consequently rate of response generation is assumed to be 100%, representing the fully success of achieving the required information on time. This part of the model is useless and omitted for the company analyzed.

IX.3.3.3. Enterprise Knowledge Index

As stated earlier, a questionnaire is set up for measuring the enterprise knowledge index. Enterprise knowledge index of the company is assessed by the interview of the general manager and the production engineer. To eliminate the bias of the manager, the results are checked and validated through the analysis of knowledge management system. Respondent values range from 1 to the number sub-factors constructs for each factor. That is, for the Knowledge Creation factor; 1 represents the case of “totally disagree” and 7 represents the case of “totally agree”. The questionnaire with the responses for each construct of the factor is given in Table IX-19.

Table IX-19: Enterprise Knowledge Index Questionnaire

Factor	Sub-Factor	Items	Respondent
Knowledge Creation	Tasks Understanding	I often use an electronic bulletin board to analyze tasks.	5
		My predecessor introduced me to my tasks.	1
		I fully understand the core knowledge necessary for my tasks.	7
	Information Understanding	I obtain useful info. And suggestions from brainstorming	7
		I am ready to accept to new knowledge and apply it to my tasks when necessary	5
		I understand computer programs needed to perform the tasks and use well.	7
		I search info. for tasks from various knowledge sources administrated by organization	7
Knowledge Accumulation	Database Utilization	We refer to corporate database before processing tasks	5
		We search through customer and task related databases to obtain knowledge necessary for the tasks.	5
	Systematic Mang. of Task Knowledge	We try to store expertise on new tasks design and development	7
		We try to store legal guidelines and policies related to tasks	7
		We are able to systematically administer knowledge necessary for the tasks and store it for further usage	7
	Individual capacity for Accumulation	We document such knowledge needed for the task	7
		We summarize education results and store them	1
Knowledge Sharing	Core Knowledge Sharing	We share information and knowledge necessary for the tasks	2
		We improve task efficiency by sharing information and knowledge.	2
	Knowledge Sharing	We promote sharing of information and knowledge with other teams	2
		We developed information systems like intranet and electronic bulletin boards to share information and knowledge	4
Knowledge Utilization	Degree of Knowledge Utilization	Teamwork is promoted by utilizing organization-wide information and knowledge	2
		Electronic data interface is extensively used to facilitate processing tasks	6
		Work flow diagrams are required and used in performing tasks	3
	Knowledge Utilization Culture	There exists a culture encouraging knowledge sharing	2
		There exist incentive and benefit policies for new idea suggestions through utilizing existing knowledge	6
		There exist research and education programs	1
Knowledge Internalization	Capability to Internalize Task Related Knowledge	I have a unique mastery of the tasks	9
		I can learn what is necessary for new tasks	9
		I can use the internet to obtain knowledge for the tasks	9
		I can refer to best practices and apply them to my tasks	9
	Education Opportunity	Employees are given educational opportunities to improve adaptability to new tasks	1
		University administrated education is offered to enhance employees' ability to perform the tasks	1
	Level of Organization Learning	Professional knowledge such as customer knowledge and demand forecasting is managed systematically	8
		Organization-wide standards for information resources are built	9
		Organization-wide knowledge and information are updated regularly and maintained well.	9

Depending on the information provided as in Table IX.19, percentage values for each factor and the average value for the enterprise index of the company is given in Table IX-20. For example the success of knowledge creation factor is calculated by averaging the scores of each item as shown;

$$\text{Success in Knowledge Creation} = \frac{5+1+7+7+5+7+7}{7*7} = 0.7959 = 79.59\% \qquad \textbf{(IX.8)}$$

Table IX-20: Enterprise Knowledge Index for the company

Enterprise Knowledge Factors	Value
Knowledge Creation (%)	79.59
Knowledge Accumulation (%:)	79.59
Knowledge Sharing (%)	62.50
Knowledge Utilization (%)	55.56
Knowledge Internalization (%)	79.01
Enterprise Knowledge Index (%)	**71.25**

After analyzing the 3 indicators, the capability of responding to the change through Knowledge can be measured by taking the weighted average of each indicator. Table IX-21 summarizes the scores of the indicators and the relative weights. The Knowledge Effect (KE) Capability of the company is found as 72.79%. This means, to adapt to new technologies the company is only about 73% successful in accordance to the knowledge factor of the technologies. Although it seems a good score, the importance of knowledge effect is so much important to adapt to new technologies that, the company should try to increase this score by focusing on the mentioned factors.

Table IX-21: Knowledge Effect Capability

Knowledge Effect Indicators	**Weight**	**Capability of Indicators**
Change in Training Hour/Worker	0.3	47.62
Response Generation Rate	0.3	100.00
Enterprise Knowledge Index	0.4	71.25
Knowledge Effect (KE) Capability (%)		**72.79**

IX.4. TECHNOLOGICAL CHANGE CAPABILITY

Since the 3 effects of Technological Adaptation are studied, the capability to adapt the technology is calculated by taking the weighted average of each effect. Table IX-22 summarizes the scores of each effect on technology adaptation with relative weights. As shown, the overall Technological Adaptation Capability of the company is found as 68.12%. This score signifies moderate success to adapt to new technologies with respect to related factors. Moreover, the company should pay more attention to the machinery and equipments used in order to adapt to changes.

Table IX-22: Technological Adaptation Capability

Technological Adaptation Effects	**Weight**	**Capability of Effects**
Tool Effect	0.3	48.00
Human Effect	0.3	82.01
Knowledge Effect	0.4	72.79
Technological Adaptation Capability (%)		**68.12**

To sum up the analysis on measuring the Technological Change in KAS FLEX, three factors to follow and manage the change namely, forecasting innovation, and adaptation capabilities are studied and respective values are listed in Table IX-23. Based on the expert view weight assignments, overall capability to manage the technological change is found as 60.78%

Table IX-23: Technological Change Capability

Technological Change Capability	**Weight**	**Capabilities (%)**
Forecasting Capability (FC)	0.29	49.62
Innovation Capability (IC)	0.33	62.14
Adaptation Capability (AC)	0.38	68.12
Technological Change (TC) Capability (%)		**60.78**

Although the adaptation capability is successful about 70%, forecasting capability is under 50%. Hence, it may be interfered that, the company does not make any researches about the new technologies and their revenues. However, they are capable of adapting these technologies. To achieve the utmost case, it is better to analyze the technologies before investment and be aware of their returns through successful forecasting activities. In the second step, they can produce more innovative products, which will add value to the total revenue of the sales. Since, 62% capability for innovative activities is not satisfying in case of rapid changing market structure and customer demands. As the last step, the adaptation phase should be enhanced by utilizing more recent machinery and equipments and some sort of training about the employees about the new technologies.

X. PROCESS CHANGE IN KAS FLEX

In order to analyze how the technological changes are implemented to the production process and investigate the effect of these changes, the Process Change analysis included the analysis of changes in “Average Worker Utilization”, “Total Bottleneck Ratio”, “Unit Production Time”, and “Unit Production Cost”. In order to measure the capability to follow the process changes some information as provided in Table X-1 is required.

Table X-1: General information for both 2006 and 2009

Information	2006	2009
Total # of Products	268321	1308588
Total # of Working Days	230	230
Total # of Workers	7	28
# of Shifts	1	2
Total Production Cost (TL)	700000	175000

Depending on this information, average daily productions are calculated by dividing the total number of products over the total number of working days and found as 1166 and 5690 for 2006 and 2009 respectively. However only 50% of the products are desired to be coated with a yellow rubber called “Makaron”, that is, daily production amount of “Makaron” is 583 for 2006 and 2845 for 2009. Additionally, in each shift, there is a working time of 9 hours except the “Testing” work center. It works only 8 hours because of the preparation of the testing equipments. In order to perform the process analysis, Table X-2 provides additional information about the process for 2006 and 2009.

As it is noticed that, standard time for welding machine is decreased from 40.50 to 21.38 seconds depending on the change from induction welding system to tig welding system. Similarly, standard time for Makaron work center decreased from 43.33 to 15 seconds based on the installation of new machinery

Table X-2: Process analysis for 2006 and 2009

Work Center	# of Machines		# of Workers in Day Shift		# of Workers in Night Shift		Standard Time (in seconds)		Daily Product	
	2006	2009	2006	2009	2006	2009	2006	2009	2006	2009
Cutting	1	1	1	1	0	1	3.5	3.5	1166	5690
Grinding	1	1	1	1	0	1	5	5	1166	5690
Welding	3	6	1	4	0	4	**40.50**	**21.38**	1166	5690
Testing	2	2	1	2	0	2	10	10	1166	5690
Makaron	1	1	2	2	0	1	**43.33**	**15**	583	2845
Packaging	1	1	1	5	0	4	23	23	1166	5690

Since there were two shifts in 2009, total number of workers is allocated as shown in Table X-2 the standard times for each work center are calculated by assigning allowance factors for each operation. Based on given information process change analysis is carried out through 4 indicators namely; Average Worker Utilization, Total Bottleneck Ratio, Unit Production Time, and Unit Production Cost. The results of this analysis are provided below.

X.1. CHANGE IN AVERAGE WORKER UTILIZATION

To measure the change in Average Worker Utilization, utilization rate for 2009 is compared to that of 2006. Basically utilization rate is calculated by dividing the required labor hour over the available labor hour. Required Labor hour and Available Labor hour can be calculated for each work center as shown in following equations. Table X-3 summarizes the worker utilization for each work center.

$$\text{Required Labor Hour} = \frac{\text{Standard Time (min.)} * \text{Daily Production}}{60} \quad \textbf{(X.1)}$$

$$\text{Available Labor Hour} = \text{\# of Workers} * \text{Working Hour/Day} \quad \textbf{(X.2)}$$

$$\text{Utilization} = \frac{\text{RequiredLaborHour}}{\text{AvailableLaborHour}} \quad \textbf{(X.3)}$$

Table X-3: Worker utilization for 2006

Work Center	# of Workers	Standard Time (sec.)	Daily Product (unit)	Required Labor Hour	Available Labor Hour	Utilization
Cutting	1	3.50	1166	1.13	9	0.13
Grinding	1	5.00	1166	1.62	9	0.18
Welding	1	40.50	1166	6.92	9	1.00
Testing	1	10.00	1166	3.24	8	0.40
Makaron	2	43.33	583	7.02	9*2=18	0.39
Packaging	1	23.00	1166	7.45	9	0.83
Average Worker Utilization (%)						**47.00**

To calculate the worker utilization in Cutting work center, required labor hour is found by multiplying the standard time with amount of daily production as shown;

$$\text{Required Labor Hour} = \frac{3.5\,\text{sec/unit} * 1166\,\text{unit}}{3600\,\text{sec/unit}} = 1.13 \qquad \textbf{(X.4)}$$

Since only one worker –working 9 hours a day- is allocated to the cutting work center, the respective utilization is calculated by;

$$\text{Utilization} = \frac{1.13}{9} = 0.13 \qquad \textbf{(X.5)}$$

Worker utilizations for the other work centers are calculated in same manner. However, the available labor hour for Testing work center is only 8 hours for the preparation operations. Available labor hour for Makaron work center is 18 hours as 2 workers are working in this center.

Average worker utilization (AWU) is calculated in the same manner by multiplying utilization of each work center with the number of workers assigned and dividing by the total number of workers. For 2006;

$$AWU = \frac{1*0.13 + 1*0.18 + 1*1 + 1*0.41 + 2*0.39 + 1*0.83}{7} = 47\% \qquad \textbf{(X.6)}$$

Worker utilization for 2009 is calculated in similar manner. However, daily product number has changed. In addition, available labor hour is the total available labor hours of both day and night shifts. Depending on the given information in Table X-4, utilization of each worker is found and the average worker utilization is calculated as 0.45.

Table X-4: Worker utilization for 2009

Work Center	# of Workers in Day Shift	# of Workers in Night Shift	Standard Time	Daily Product (unit)	Required Labor Hour	Available Labor Hour	Utilization
Cutting	1	1	3.50	5690	5.53	18	0.31
Grinding	1	1	5.00	5690	7.90	18	0.44
Welding	4	4	21.38	5690	33.79	72	0.47
Testing	2	2	10.00	5690	15.81	32	0.49
Makaron	2	1	15.00	2845	11.85	27	0.44
Packaging	5	4	23.00	5690	36.35	81	0.45
Average Worker Utilization (%)							**45.00**

The change in average worker utilization is the comparison of the value for 2009 to that of 2006. It is calculated as;

$$\Delta\text{AWU}= \Delta AWU = \frac{45-47}{47} = -0.05$$

(X.7)

Where,

ΔAWU: Change in Average Worker Utilization

The negative result in percentage change of worker utilization designates the decrease in the average utilization. Depending on the decrease of standard times of two work centers, the increase in total production amount is less than total available time of labor hour. Although the number of products per day has increased from 1166 to 5690, number of workers and shifts has increased. In other words, the increase in the number of workers and number of shifts has not yielded as much increase in the total production amount. These factors lead to a decrease in average worker utilization. Hence the change in average worker utilization is assumed to be zero.

X.2. CHANGE IN TOTAL BOTTLENECK RATIO

Similar to worker utilization, bottleneck of each work center plays an important role for the efficiency of the processes indicating how capable the company is to change the process.

Bottleneck of each work center is the difference of its standard time with the previous one. If the standard time of the latter is greater than the previous one, there will be a bottleneck time. However this difference is just for a single unit. If this unit bottleneck time is multiplied with the number of products then the total bottleneck of the work center is defined. When the total bottleneck time of the work center is divided by the total capacity – which is the total working hours of the work center-, bottleneck ratio of the related work center is calculated. The methodology is clarified by explanation of the Bottleneck Ratio of the Cutting and Grinding work centers for 2006.

Unit bottleneck time for Cutting work center is definitely be zero, since it is the first work center. Since the standard time of Grinding work center is greater than the

Cutting work center, the difference release the unit bottleneck time of Grinding machine.

Unit Bottleneck Time =5-3.5=1.5sec. **(X.8)**

Total bottleneck time of Grinding machine is the multiplication of unit bottleneck time with the number of products in a day.

Total Bottleneck Time= 1.5 * 1166 = 1749sec. **(X.9)**

Since there is only 1 machine working 9-hour shift for Grinding machine, its capacity is equal to 9 hours or 32400sec.

Capacity=9 hour*1*3600=32400sec **(X.10)**

Bottleneck ratio is the division of total bottleneck time over total capacity.

$$\text{Bottleneck Ratio}=\frac{1749}{32400}=0.05 \quad \textbf{(X.11)}$$

That is, in 1749 seconds of total 32400 seconds working time, or 5% of its available capacity, it is full of products waiting to be operated by the Grinding machine. Similar calculations are performed and bottleneck ratios are calculated for the other work centers as presented in Table X-5.

Table X-5: Bottleneck Ratios for 2006

Work Center	Capacity (sec)	Standard Time (sec)	Unit Bottleneck Time (sec)	Total Bottleneck Time (sec)	Bottleneck Ratio
Cutting	32400	3.50	0.00	0	0.00
Grinding	32400	5.00	1.50	1749	0.05
Welding	32400	40.50	35.50	41393	1.28 → 1
Testing	28800	10.00	0.00	0	0.00
Makaron	32400	43.33	33.33	19431.39	0.60
Packaging	32400	23.00	0.00	0	0.00

Since the testing work center only works 8 hour a day because of the set up operations, its capacity is calculated using 8 hours of standard time. As it is noticed that bottleneck ratio of Welding work center becomes a value greater than 1, which is impossible due to the fact that total working capacity of the work center is much less than the bottleneck time. That is because of the unbalanced standard times of

Welding and Grinding work centers. Therefore bottleneck ratio of Welding is adjusted to 1, to represent 100% bottleneck time in its capacity.

As a summary for bottleneck analysis in 2006; there occur bottlenecks for Grinding, Welding, and Makaron work center with 5%, 100% and 60% respectively. Summation of these bottleneck ratios signals the overall success of the process in 2006.

$$\sum \text{Bottleneck Ratios} = 0+0.05+1+0+0.6+0 = 1.65 \quad \textbf{(X.12)}$$

Similar calculations are performed for 2009 and summarize the bottleneck ratios of each work center are given in Table X-6.

Table X-6: Bottleneck Ratios for 2009

Work Center	Capacity (sec)	Standard Time (sec)	Unit Bottleneck Time (sec)	Total Bottleneck Time (sec)	Bottleneck Ratio
Cutting	64800	3.50	0.00	0.00	0.00
Grinding	64800	5.00	1.50	8535.00	0.13
Welding	259200	21.38	16.38	93202.20	0.36
Testing	129600	10.00	0.00	0.00	0.00
Makaron	97200	15.00	5.00	14225.00	0.15
Packaging	291600	23.00	8.00	45520.00	0.16

The standard times of Welding and Makaron work centers have decreased and the total capacity of every work center have increased due to 2 shifts and number of machines.

When Table X-5 and Table X-6 are compared, bottleneck ratio of Grinding work center increased due to increase of the number of products. Bottleneck ratio of Welding work center has dramatically decreased form 100% to 36% due to the process change of tig welding instead of induction welding in the welding technology. Similarly bottleneck ratio for Makaron work center has diminished from 60% to 15% depending on the change in standard time. On the other side, since the standard time of Makaron has decreased, there occurs a bottleneck in front of the Packaging work center with a ratio of 16%. It is better to analyze the success of the process change with respect to total bottleneck ratio of the system instead of dealing with individual work centers. Therefore, total bottleneck ratio of the system in 2009 is defined as the;

$$\sum \text{Bottleneck Ratios} = 0+0.13 + 0.36 + 0 + 0.15 + 0.16 = 0.79 \quad \textbf{(X.13)}$$

Depending on the total bottleneck ratios of 2006 and 2009, percentage change of them points out the capability of the process change with respect to bottleneck factor.

$$\Delta TBR = \left| \frac{0.79 - 1.65}{1.65} \right| = 52.03\% \quad \textbf{(X.14)}$$

Where,

ΔTBR: Change in Total Bottleneck ratio

The result of 52% decrease in total bottleneck ratio signifies the manufacturing system is eliminated from the bottlenecks as 52%, which is a great deal of success to prevent work in process items in the shop floor.

X.3. CHANGE IN UNIT PRODUCTION TIME

Unit production time of the manufacturing system is as important as the utilization and the bottleneck of the system. Therefore, the change in the unit production time due to the process change is a good indicator of the capability of following the process change. Unit production time in 2009 is compared to the value of 2006 in order to analyze this change in KAS FLEX.

Basically unit production time is the summation of standard times of each work center. Hence the unit production times are equal to 125.33 and 77.88 seconds in 2006 and 2009 respectively. Table X-7 summarizes the standard times and unit production times for 2006 and 2009 and reveals the change in unit production time. Percentage change in unit production time is calculated as;

$$\Delta UPT = \left| \frac{77.88 - 125.33}{125.33} \right| = 37.86\% \quad \textbf{(X.15)}$$

Where,

ΔUPT: Change in Unit Production Time

Depending on the technological changes especially for Welding machine, the unit production time has decreased by 37.86 %.

Table X-7: Unit Production Times for 2006 and 2009

Year	Cutting (sec.)	Grinding (sec.)	Welding (sec.)	Testing (sec.)	Makaron (sec.)	Packaging (sec.)	Unit Production Time (sec.)
2006	3.50	5.00	40.50	10.00	43.33	23.00	125.33
2009	3.50	5.00	21.38	10.00	15.00	23.00	77.88
Change in Unit Production Time %							**37.86**

X.4. CHANGE IN UNIT COST

As, the average change in unit production cost is another important indicator of the successful process change, to measure this indicator in KAS FLEX, total production cost is divided by total production amount for 2006 and 2009 . The comparison between these two years will signal the performance of the process change with respect to the unit cost.

$$\text{Unit Cost in 2006} = \frac{700000}{268321} = 2.61 \qquad \textbf{(X.16)}$$

$$\text{Unit Cost in 2009} = \frac{175000}{1308588} = 0.13 \qquad \textbf{(X.17)}$$

$$\Delta UPC = \left| \frac{0.13 - 2.61}{2.61} \right| = 95.01\% \qquad \textbf{(X.18)}$$

Where,

ΔUPC: Change in Unit Production Cost

Table X-8 summarizes the total number of products and total cost for 2006 and 2009, and reveals the percentage change in unit cost.

Table X-8: Cost of products fro 2006 and 2009

Year	# of Product	Total Production Cost	Unit Cost
2006	268321	700000	2.61
2009	1308588	175000	0.13
Change in Unit Cost %			**95.01**

95% of change in unit cost is remarkable. That is because of two important factors. The company has achieved the success of decreasing total production cost while increasing the number of products. Depending on the cost and number of products information gathered from the company, 95% success in unit cost change is noteworthy.

X.5. PROCESS CHANGE CAPABILITY

4 indicators of the Process Change, namely; Average Worker Utilization, Total Bottleneck Ratio, Unit Production Time, and Unit Cost are analyzed in KAS for the years 2006 and 2009. Table X-9 summarizes the changes in each indicator and the relative weights, which are gathered through the questionnaire as explained in Chapter VII. The capability for the process change is found as 47.95%, by taking the weighted average of the change for each indicator. Note that this is a good indication of incapability for the process change with these 4 respects. Although the unit production cost has notably decreased, average worker utilization has not changed at all. Moreover, it has decreased from 47% to 45%. Hence, in order to manage the change in process, average worker utilization is obligatory to be increased either decreasing number of shifts or increasing the production amount.

Table X-9: Process Change Analysis in KAS FLEX

Process Change Indicators	**2006**	**2009**	**Change**	**Weight**
Average Worker Utilization (AWU)	47%	45%	0%	0.26
Total Bottleneck Ratio (TBR)	1.65	0.79	52.03%	0.24
Unit Production Time (UPT)	125.33	77.88	37.86%	0.21
Unit Production Cost (UPC)	2.61	0.13	94.87%	0.29
Process Change (PC) Capability %				**47.95**

XI. CUSTOMER CHANGE

KAS FLEX has only a single customer called KASPA, which is responsible for all marketing operations of Kayalar Plastik San. Tic. A.Ş. (KAYALAR GRUP). All of the customer orders are received by KASPA, and respective order (request) is made to KAS FLEX. Flex production facility has therefore no effects on the customer portfolio. In other words, they basically concentrate on the manufacturing activities not on marketing in any case.

Although the overall change management model proposed in this thesis, includes the customer oriented change, this is not encountered here in this implementation due to the fact that KAS FLEX Production facility do not have a variety of customers and has to obey the order of KASPA. The company does not have the chance of getting new customers, or growing the customer sales Hence the model components "Get Ratio", "Keep Ratio", and "Growth Ratio" which are the three important components of the customer change management model as proposed are not measured. Since the main focus of the study is on Flex Production facility, customer oriented change may be the subject of another study dealing with the marketing capability of KASPA.

XII. MANAGERIAL CHANGE IN KAS FLEX

In order to measure the capability of following managerial change 5 functions of management theory are considered in developing the model. As stated earlier in Chapter V, each function is characterized by 5 levels of implementation indicating the degree of managing respective change attributes. To determine implementation levels of management function, a question list is prepared to be analyzed through the general manager and the production manager of the company in question. Moreover, this question list and respective levels is validated through the system analysis to prevent the bias of the general manager. According to this analysis of the questionnaire, which includes 30 questions in total, levels of management function are determined as well as the respective scores for each function

Based on this, weighted averages of each function are calculated in order to measure the overall capability of following managerial change. Note that, the functions mentioned above includes; Planning, Organizing, Leading, Controlling, and Coordinating. Following sections explain respective analysis.

XII.1. PLANNING IN KAS FLEX

As the model imposes, Planning is considered to be one of the functions triggering the change in management. The capability to follow the change in this is analyzed through a questionnaire aimed at finding out which methodology (*Rules*, *Procedures*, *Planned Processes*, *Programs*, and *Rolling Plans)* is implemented in KAS FLEX. Since the model provides a score for each methodology mainly 1 for "*Rules"* to 16 for "*Rolling Plans",* the company planning process is examined to find out the respective implementation score.

Note that the questionnaire included 30 questions in total, 5 of them are related to Planning only, which is given in Table XII-1. These questions are set up in order to highlight the capability of company to implement methodologies as defined by the model. The company received a score of 17.4 out of possible 31. This indicates capability of implementing and following the change in planning methodologies represented as the score of Planning Function (PF) will be equal to

$$PF = \left(\frac{17.4}{31} \right) = 56.13\% \qquad \textbf{(XII.1)}$$

Table XII-1 reveals methodologies with respective questions as well as the scores the company received.

Table XII-1: Questionnaire for Planning Function

METHOD	QUESTIONS	EXPLANATION	SCORES
RULES (score=1)	Is there a set of rules (written or unwritten) that is mostly dependent on management perspective?	Responsibilities for each worker and the production amount for each day are certain.	1
PROCEDURES (score=2)	Are the procedures of the rules defined to implement the rules?	Procedures of the tasks are known by the workers	2
PLANNED PROCESSES (score=4)	Is the process management followed during the planning function?	Each process has a leader and the objective	4
PROGRAMS (score=8)	Does the production planning function cooperate with other enterprise plans?	If the orders exceed capacity, marketing department is informed.	4
ROLLING PLANS (score=16)	Can the online changes be adapted without running the whole planning system?	40% success	6.4
TOTAL			17.4

As indicated in Table XII-1, the company is only able to implement Rules, Procedures, and clearly defined its own planning processes. It is capable of transferring the planning activities from Rules to Procedures, from Procedures to Processes.

However there is no evidence in creating integrated production plans fully aligned with other respective enterprise plans such as aggregate plan, forecasting plans or capacity planning. Although production plans are developed according to order from marketing department and master plan developed through yearly targeted amount of production, the other departments had no information regarding the planning capability and respective facilities of the company. Due to this fact only 50% of the methodology called “Programs” is considered to be applicable.

Similar to this analysis the planning department was facing difficulty in creating Rolling Plans which is aligned with overall enterprise plans. The production plans were easily updated without considering the consequences in other plans. Since there was some capability to quick response in the changes of the production system including the orders only 40% of respective score is given. As the model indicates there are 3 aspects of Rolling Plans; changing the plans due to sudden changes in production systems (40%), unexpected requests from other departments (40%), implementing integrated bidirectional change mechanism (20%). Only the first option of these aspects is implementable in the company.

XII.2. ORGANIZING IN KAS FLEX

Organizing is considered to be another important function triggering the change in management. The capability to follow the change in this, is analyzed through a questionnaire aimed at finding out which organization type (*Product*, *Functional*, *Process*, *Customer*, and *Territory Based)* is valid for the company in question. Since the model provides similar scores for each type (mainly from 1 for *Product Based Type* to 16 for *Territory Based Type),* the organization of the company is examined to find out the respective score.

5 of the questions related with Organization type, are set up in order to highlight the capability of company to implement the changes in organizational structure as defined by the model. The company received a score of 3 out of possible 31as shown in Table XII-2. This indicates capability of implementing and following the change in Organization types, represented as the score of Organizing Function (OF) will be equal to

$$\mathrm{OF} = \left(\frac{3}{31}\right) = 9.68\% \qquad \textbf{(XII.2)}$$

Using this, it can be concluded that the organizational structure of the company is still functional based. That means the evolutions in the organizational aspect cannot be followed as well.

Table XII-2 reveals methodologies with respective questions as well as the scores the company received.

Table XII-2: Questionnaire for Organizing Function

METHOD	QUESTIONS	EXPLANATION	SCORES
PRODUCT BASED (1)	Is the organizational structure is based on the products?	Hose production at the second floor and flex production at the first floor	1
FUNCTIONAL BASED (2)	Is the organizational structure is based on departments responsible for different professions?	There are departments for Hose and Flex productions	2
PROCESS BASED (4)	Is the organizational structure is based on the processes of the activities and related performances?	Process performances are not determined	0
CUSTOMER BASED (8)	Is the organizational structure is based on customer expectations and related performances?	Only one customer -KASPA-	0
TERRITORY BASED (16)	Are there any distribute units to exploit competitive market?	One location for all activities	0
TOTAL			3

As indicated in Table XII-2, the company is only able to implement Product and Functional based organization types. The manufacturing facility basically produces two main products, hoses and flex. Hose production is totally performed by automated machines and located at the second floor of the facility and feeds the flex production at the first floor. Therefore, the facility can be stated to be organized due to the "*Product*" type. Since it is the primitive organization type, it only provides 1 point to measure the capability to follow the change in Organizing function. Since the two main product types, are located on different departments, there is also a "*Functional*" type implemented.

In order to have a process based organization type, each of the manufacturing processes should be defined clearly and performance metrics should be set out. However, performance metrics are not defined and cannot be controlled over time as the organization is not "*Process*" based at all

Furthermore, as explained before KASPA, which is another company within the group of Kayalar Plastik San. Tic. AŞ, is the sole customer of flex production. It has not much of a customer effect on KAS FLEX. Consequently the organization type cannot be considered "*Customer*" based. Additionally, since all of the operations to produce flex are performed in one location, it is hard to mention about the "*Territory*" based organizational structures in the company.

XII.3. LEADING IN KAS FLEX

Leading is also an important function triggering the change in management. The capability to follow the change in this, is analyzed through 5 questions aimed at finding out which Leading behavior (*Dictative*, *Structural*, *Supportive*, *Participatory*, and *Referent)* exists in KAS FLEX as shown in TableXII-3. Since the model provides a score for each type mainly from 1 for *Dictative* to 16 for *Referent,* the leading behavior of the manager is examined to find out the respective score.

5 of the questions related with Leading behavior, are set up in order to highlight the capability of company to implement the changes in leadership as defined by the model. The company received a score of 27 out of possible 31. This indicates capability of implementing and following the change in leading behavior, represented as the score of Leading Function (LF) will be equal to;

$$\text{LF} = \left(\frac{27}{31}\right) = 87.10\% \qquad \textbf{(XII.3)}$$

Unlike the organizational change, the company can be considered successful in managing the leadership changes.

Following Table XII-3 reveals methodologies with respective questions as well as the scores the company received.

Table XII-3: Questionnaire for Leading Function

METHOD	QUESTIONS	EXPLANATION	SCORES
DICTATIVE (1)	Are the required rules predefined and written by the manager?	Manager defines the rules and procedures	1
STRUCTURAL (2)	Is the leading authority and responsibility shared by the subordinates?	Manager does not interfere in the subordinates' tasks.	2
SUPPORTIVE (4)	Is the leader supportive to subordinates?	Subordinates have to solve the problems related to their own responsibilities.	0
PARTICIPATORY (8)	Does the leader consult with subordinates in a participative behavior?	Suggestions from subordinates are evaluated and promising ones are implemented	8
REFERENT (16)	Does the leader use knowledge and experience for the benefit of the enterprise outside the company?	Co-operates with supplier to achieve better quality and less cost raw material	16
TOTAL			27

As indicated in Table XII-3, the manager has Dictative, Structural, Participatory, and a Referent leadership manner. Since the general manager defines the rules and procedure for all tasks legitimately, there exists a *Dictative* manner in leading function. Additionally, although the general manager is the only authority, he does not interfere the subordinate's tasks. If there is a problem in any part of production, it is in the responsibility of the foreman or the production manager. That is to say that, there is an indication of *Structural* leading type in the manufacturing system.

On the other side, since the authority and responsibility is shared within the subordinates, the general manager expects the problems to be solved by their responsible staff. If the problem cannot be sorted out, the general manager deals with the problem. However, it is not a kind of supporting manner for leadership activities. Hence it is hard to mention about *Supportive* manner of the manager.

According to the interview performed with the general manager and some of the subordinates separately, it is understood that the general manager listens to different suggestions from various sources and implement the promising ones to increase the productivity of the system. The suggestions from the subordinates are evaluated and implemented according to their promising benefits. Since all the employees have the chance to say a word about the manufacturing, participation is stated to be organizational-wide. Therefore the manager is easily stated to be having a *Participatory* leading manner.

Additionally, having a participatory leading manner, the manager has the referent power as co-operating with the suppliers to achieve better quality and less cost raw materials. Depending on his own endeavor with suppliers, the raw material cost of the enterprise diminished significantly. Therefore the manager stands for a *Referent* leading manner denoting to use of his knowledge for the benefit of the enterprise outside the company.

XII.4. CONTROLLING IN KAS FLEX

Controlling is one of the most important functions triggering the change in management. Therefore, it is analyzed in two parts dealing with controlling methods, and controlling tools.

XII.4.1. Controlling Methods

The capability to follow the change in controlling methods, is analyzed through a questionnaire aimed at finding out which methods (*Upon Requests*, *Scheduled*, *Adaptive-Flexible*, *Continuous-Self*, and *Integrated* controls*)* are executed in KAS FLEX. 5 of the questions related with Controlling Methods, are set up in order to highlight the capability of company to implement the changes in the methods for controlling the production as defined by the model. The company received a score of 15 out of possible 31. This indicates capability of implementing and following the change in controlling methods will be equal to;

$$\text{Controlling Methods} = \left(\frac{15}{31}\right) = 48.39\% \qquad \textbf{(XII.4)}$$

This is to say that the methods to control the manufacturing system follow the trends in the evolution of controlling techniques just around the mid-level.

Table XII-4 indicates methodologies with respective questions as well as the scores the company received. As indicated, the manufacturing controls are performed by upon requests, or in periodical schedules. Additionally the controlling system is adaptive and flexible depending on the continuous self controlling mechanism of the employees.

Table XII-4: Questionnaire for Controlling Methods

METHOD	**QUESTIONS**	**EXPLANATION**	**SCORES**
UPON REQUESTS (1)	Is the control function performed by upon request?	Raw material inventory is checked upon request of new orders	1
SCHEDULED CONTROL (2)	Is the control function scheduled?	All materials are checked by daily, weekly, and yearly controls	2
ADAPTIVE-FLEXIBLE CONTROL (4)	Can the control system be updated depending on the recent conditions?	Controlling system can be updated due to new products by utilizing ERP	4
CONTINUOUS SELF CONTROL (8)	Is the control function performed by each employee continuously within the enterprise?	Each worker is responsible to inform foremen about the stocks continuously	8
INTEGRATED CONTROL (16)	Is the control function integrated with other functions within the enterprise?	The relation between inventory control and purchasing is not computer integrated.	0
TOTAL			15

Since the raw material inventory is checked upon request of new orders, *Upon Request*, which is the simplest controlling method, is definitely implemented. Additionally, checking all materials on daily, weekly, and yearly periods represents a *Scheduled* Control. Moreover there is an *Adaptive* and *Flexible* controlling system which can modify itself due to the changes of product portfolio and the bill of material of the products of new products utilizing existing ERP system. Furthermore, since each worker is responsible to inform foremen about the stocks constantly, there exists a *Continuous* and *Self* controlling method. However there is no evidence of *Integrated* controlling system, because the relation between inventory control and purchasing is not yet integrated within the IT system

XII.4.2. Controlling Tools

In the second part of the analysis of Controlling Function, the tools that are used for controlling, (*Individual*, *Budget*, *Project*, *Performance Based*, and *Computerized* controls), are analyzed. Similarly, each of these tools has the importance degree as 1, 2, 4, 8, and 16 respectively, denoting the up to date controlling tools. Hence, existence of each of these methodologies is searched in the questionnaire and denotes the capability to follow the change in controlling tools.

5 of the questions related with Controlling Tools, are set up in order to highlight the capability of company to implement the changes in the tools for controlling the production as defined by the model. The company received a score of 27 out of possible 31. This indicates capability of implementing and following the change in controlling tools will be equal to;

$$\text{Controlling Tools} = \left(\frac{27}{31}\right) = 87.10\% \qquad \textbf{(XII.5)}$$

Similar to leadership, this also indicates that the control tools are regularly updated and recent tools are utilized. The tendency to improve the tools seems to be impressive as well. The rational behind this scoring is explained below.

Table XII-5 provides information on control tools with respective questions as well as the scores the company received. As indicated, the manufacturing controls are performed through individual controls of the employees, on a budget based. Additionally performance metrics are set and according to these metrics performance of the employees are evaluated and recorded within IT system of the company.

Table XII-5: Questionnaire for Controlling Tools

METHOD	QUESTIONS	EXPLANATION	SCORES
INDIVIDUAL (1)	Are the control elements defined individually?	Each employee is responsible for own tasks and products	1
BUDGET (2)	Are the control elements based on budget control?	There are yearly budget objectives	2
PROJECT (4)	Are the control elements based on projects control?	Lack of projects and project control	0
PERFORMANCE BASED (8)	Are the control elements based on the performances?	There are daily target values for each machine and worker to be achieved	8
COMPUTERIZED CONTROL (16)	Are the control elements computerized?	Results of controls are recorded on computer and reported to manager	16
TOTAL			27

Since each employee is responsible for own tasks and products or raw materials, *Individual Control*, which is the simplest controlling tool, is definitely implemented. Additionally, controlling the manufacturing system on yearly budget objectives represents a *Budget Control*. However there are not any projects and *Project Control* at all. But, there is a *Performance Based* controlling tool due to predefined daily target values for each machine and worker. Furthermore, since all the results of controls are recorded on the computer and reported to the manager, there exists a *Computer Based* controlling tool.

XII.5. COORDINATING FUNCTION IN KAS FLEX

The capability to follow the change in coordinating function is analyzed due to a questionnaire aimed to find out which methodology is implemented. *Directive, Departmental, Electronical, Virtual,* and *Automated* coordination types have been defined with importance degrees of 1, 2, 4, 8, and 16, respectively.

5 of the questions related with Coordination types, are set up in order to highlight the capability of company to implement the changes in coordination as defined by the model. The company received a score of 7 out of possible 31. This indicates capability of implementing and following the change in coordination methods, represented as the score of Coordinating Function (CoorF) will be equal to;

$$\text{CoorF} = \left(\frac{7}{31}\right) = 22.58\% \qquad \textbf{(XII.6)}$$

Unlike the control and leadership, the company seems to have some problems in following the changes in coordinating attitudes. Table XII-6 shows different coordination types with respective questions as well as the scores the company received. Note that the coordination within the company is performed through Directive channels set by the management, and departments are heavily utilizing the electronically communication channels

Table XII-6: Questionnaire for Coordinating Function

METHOD	QUESTIONS	EXPLANATION	SCORES
DIRECTIVE (1)	Is coordination sustained by the manager?	Manager defines the coordinating channels	1
DEPARTMENTAL (2)	Is coordination sustained through the division of labor?	Workers inform the foremen, foremen informs the production manager and production manager informs the general manager	2
ELECTRONICAL (4)	Is coordination sustained through knowledge automation systems (ERP, MIS)?	Authorized employee achieves the related and required information through ERP program.	4
VIRTUAL (8)	Is coordination sustained through virtual meetings (Net Meeting)?	Meetings have to be performed physically.	0
AUTOMATED (16)	Is coordination sustained through unmanned systems (Artificial Intelligence)?	Although Harmony has the capability to open an order for raw material automatically, it is not utilized.	0
TOTAL			7

Since general manager defines the coordinating channels, *Directive*, which is the simplest coordinating method, is definitely implemented. Additionally, the existence of the information chain from workers to general manager represents a *Departmental* coordination. Moreover *Electronical* information through ERP program sustains the attainment of required information by authorized employees. However *Virtual* coordination does not exist since the meetings have to be performed physically. Also, there is a lack of *Automated* coordination, which refers to setting an order for raw material in case of out of stock automatically by utilizing some advanced applications such as Artificial Intelligence.

XII.6. MANAGERIAL CHANGE CAPABILITY

In order to define the degree of following managerial changes in KAS FLEX, the following methodology is implemented. A weighted score for each function prone to change is calculated using respective weight values defined by the model. Table XII-7 summarizes the degree of each function and the relative weights, and the result of capability to follow managerial change.

Table XII-7: Managerial Change Analysis

Management Functions	**Degree**	**Weight**
Planning	56.13%	0.25
Organizing	9.68%	0.17
Leading	87.10%	0.22
Control Methods	48.39%	0.09
Control Tools	87.10%	0.12
Coordinating	22.58%	0.15
Capability to Follow Managerial Change %		**53.03%**

Note that, the company was able to follow managerial change with the rate of 53.03% of success based on the requirements set out by the model. Table XII-7 points out several facts;

- ✓ Company is very efficient in implementing leadership functions as evolved. This clearly created a flexible decision making mechanism. It would definitely sort out procedural problems.
- ✓ Additionally, high result for the controlling methods implies the successful controlling techniques aligned with up to date approaches.
- ✓ However, the organization of the company cannot fulfill the requirement of the changes in concern. The organizational structure is departmental and based on the products. It is hard to observe process oriented units which focus on the customers' desires and requirements. Additionally, since there is a lack of territory based structure, it loses the chance of utilizing some opportunities of

different locations such as low employee wage, better transportation utilities, or innovative R&D activities.

- ✓ However the overall score of 53.03% is not adequate to follow the change in managerial function; the company cannot be mentioned as out of date with respect to changes in managerial aspects. The company takes higher degrees for Planning and Leading, which are the most two important management functions according to the survey. On the other side, the company should focus on its organizational structure which is the third important function, in order to increase its degree of capability to manage the change from 9.68% to upper levels.

XIII. ENVIRONMENTAL CHANGE IN KAS FLEX

In order to measure the capability of following the environmental changes, 4 aspects (as imposed by the model) of the company are investigated. These aspects are cited as; Comply with Legislations, Comply with Standards, Organizational Structure, and Voluntary Activities of the company.

XIII.1. COMPLY WITH LEGISLATIONS IN KAS FLEX

As mentioned in the model development part, compliance to the legislations is an indispensable necessity for every manufacturing company. Therefore the compliance rate of the company in question is analyzed at first. The methodology to measure this rate is carried out by examining the existence of 4 indicators from 2006 to 2009. These factors are nominated as; *Shutdown Penalty*, *Product Withdrawal*, *Pecuniary Penalty*, and *Reprehension Fine*.

Based on the information obtained from company records KAS FLEX did not and has not received any Shutdown Penalty in the analysis time period between 2006 and 2009 indicating full compliancy with the respective legislations.

Similar to Shutdown Penalty, None of the products of the company was and is withdrawn between 2006 and 2009. Based on this fact, the company is considered to be successful in producing environmentally safe products.

As the third indicator of compliance with legislation, the company has not received any financial punishment in 2006 up to 2009; it is another good indicator of following the environmental change by KAS FLEX.

The fourth indicator inspects whether there is a “Reprehension Fine” due to any violation to laws or legislations. Likely to others, it is also found out that there was not any reprehension fine paid due to unsafe production environment or destroying the health of the environment. This fact leads to another indicator of following the environmental change with respect to legislations.

To sum up this section, the company has not been shutdown by local government or ministry of Environment and Forestry in the analysis period. Any of its products have not been withdrawn for the reason of hazardous products for environment. Additionally, the company analyzed has not taken any pecuniary and reprehension fine in the period. These four indicators are the evidence of 100% success compliance with legislation. Since the basic assumption requires that the legislation and laws are updated due to contemporary environmental changes, the company is stated to be capable to follow the environmental change regarding to the "Complying with Legislation".

XIII.2. PROPERNESS TO STANDARDS IN KAS FLEX

Even if the companies obey the legislation and respective regulations, at all, every manufacturing company should prove that they obey international standards to sustain their business in the competitive market. ISO 9001 and its derivatives are commonly accepted for the quality of the products and processes. However, there exist some standards in the focus of environmental protection. The series of ISO 14000 especially, ISO 14001 individually, are widely approved by environmental authorities. Basically ISO 14001 aims to set some standards on the manufacturing processes regarding the environmental issues. Therefore obtaining ISO 14001 certificate reveals an indicator of compliance to international standards. However obtaining it at once is not sufficiently enough for 100% success for obeying the standards. The company has to maintain the standards for every auditing period and update their implementations in accordance with standards when they evolve.

KAS FLEX does not have ISO 14001 or one of its derivatives. Although they have other certificates for quality assurance and quality management for example ISO 9001:2000 and other Turkish Standards for their products, they do not have any certificate focusing on the environmental issues. They would like to obtain this certificate at the closest convenient time. Consequently since the company does not have any certificate focusing on environment, the company is stated to possess 0% of success in following the changes in standards for the sake of environmental protection

XIII.3. THE ENVIRONMENTAL ORGANIZATION IN KAS FLEX

In a wide perspective, following the environmental change is not only an issue to be performed by paperwork to supply the compliance with legislation and standards but also the organizational structure of the company to be regulated to analyze the changes in environment. Regulation of the organizational structure of the company is checked through investigating some of the important activities to be performed. Therefore a questionnaire as explained in Chapter VI is presented to the manager to fill out the frequency of the activities performed. To prevent the bias of the manager, manufacturing system is also analyzed for the existence of related environmental activities. This questionnaire investigates the existence of 5 important activities and shown in Table XIII-1, as well as the responses of the general manager in bold and shaded.

Table XIII-1: Questionnaire for the Structure of Environmental Organization

Environmental Activities	**Situation**				
Is there an organizational unit responsible to follow the environmental changes?	YES (1)		**NO (0)**		
Are the Environmental Effect Evaluation Reports prepared?	ALWAYS (1)	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	**NEVER (0)**
Is the enterprise policy determined regarding environmental changes?	ALWAYS (1)	USUALLY (0.75)	**SOMETIMES (0.5)**	RARELY (0.25)	NEVER (0)
Are the future investment decisions determined regarding environmental changes?	ALWAYS (1)	**USUALLY (0.75)**	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)
Is the maintenance of treatment facilities performed regularly?	**ALWAYS (1)**	USUALLY (0.75)	SOMETIMES (0.5)	RARELY (0.25)	NEVER (0)
Degree of Organizational Structure (OS)					=45%

At first, presence of an organizational unit, which is responsible to follow the changes in environment, is crucially important. According to these changes preparing reports and determining future strategies provide successful forecasts for future. However in KAS FLEX there is not a unit responsible for that. Only the general manager is in charge.

Environmental effect evaluation reports are formal prerequisite reports to attain ISO 14001. With similar reason for the failure of achieving ISO 14001 certificate, these reports are unlikely to be prepared. Although the official environmental effect evaluation report is not prepared, there are some activities to foresight the environmental changes by the manager. For example the prices of iron and copper, which are the important raw materials for production, are followed closely. Although the price fluctuations are not totally dependent on the environmental changes, following an environmental oriented change is a good sign, while determining the enterprise policy. Since the following the price change is semi-interested in environmental change, the enterprise policy is stated to be determined regarding the environmental changes as 50%.

Additionally the future investment plans of the company should be arranged due to environmental changes in order to have the full capability to follow the change. In this respect, KAS FLEX focus on alternative products in case of depletion of natural gas, which is the main reason for their existence in gas flex market. However not all of the future investment decisions consider the environmental change, 75% of rate for this activity is assumed to be sustained.

As the last, maintenance of the water and solid treatment facilities is also important and checked periodically. In fact this is a legal obligation and it is performed periodically, which leads to 100% rate for this activity.

To sum up this section, the importance of an organizational unit responsible for the listed activities is explained. To calculate the degree of Organizational Structure (OS) aspect of the company regarding the environmental changes, the performance rates of each of these activities are averaged. .

$$OS = \frac{0 + 0 + 0.5 + 0.75 + 1}{5} = 45\% \qquad \textbf{(XIII.1)}$$

45% for the degree of Organizational structure denotes that there is a lack of some concepts to follow the environmental change within the enterprise organizational structure.

XIII.4. VOLUNTARY ACTIVITIES

Even if a manufacturing company totally complies with the laws and legislations and has attained international certificates for environmental protection, these are not considered to be sufficient enough to demonstrate the capability to follow the environmental changes as fully effective as possible. The proposed model also requires some voluntary activities to track the changes. Although some activities are not obligatorily enforced by the laws or standards, performing them can provide some intellectual knowledge about the environment and respective changes. Therefore a questionnaire is presented to the general manager and the production manager to fill out the frequency of the important voluntary activities performed. In order to prevent the bias of the respondents, the manufacturing system is analyzed for the existence of voluntary activities. This questionnaire investigates the existence of 5 important activities and shown in Table XIII-2, as well as the responses of the general manager in bold and shaded.

Table XIII-2: Voluntary Activities for Environment Protection

Voluntary Activities	Situation		
Does the company have any voluntary activity to produce environmental friendly products?	**YES (1)**	PARTIALLY (0.5)	NO (0)
Does the company have any voluntary activity to possess environmental friendly processes?	**YES (1)**	PARTIALLY (0.5)	NO (0)
Has the company published any literature with the aim of increasing environmental conscious in press?	YES (1)	PARTIALLY (0.5)	**NO (0)**
Has the company organized any conferences or seminars with the aim of increasing environmental conscious in periodically?	YES (1)	**PARTIALLY (0.5)**	NO (0)
Has the company supported any of the environment protection organizations financially or structural?	YES (1)	PARTIALLY (0.5)	**NO (0)**
Degree of Voluntary Activities (VA)	=50%		

At first, the general manager and the production manager is queried about the environmental friendliness of the products. Since all of the scrap material and the returned products for any reason, can be recycled through melting and casting again, production activities are stated to be fully designed to manufacture environmental friendly products and are assumed as 100% success for this voluntary activity.

Additionally, all of water waste including production and human wastes are discharged through the water treatment facility. This fact leads to an inference of the company to be assumed to perform environmental friendly processes and also receives 100% success in scoring.

However there is no publication with the aim of increasing environmental conscious in their business. That is, the company is totally reluctant to pay time and money resulting a 0% success for this activity at all.

Organizing conferences or seminars may provide vital information sharing between the companies and universities about the environmental change. By utilizing this, the company can follow the environmental change easily. KAS FLEX organized a 2000-people seminar about the topic of hazardous effects of gas consumption in cooperation with İGDAŞ (İstanbul Gas Distribution Network A.Ş) and BOSCH. Since it is only one example for this activity and KAS FLEX is only one of the organizators, the performance of this activity is degreed as 50% representing partial implementation. To achieve 100% for this activity, there should be scheduled panels or seminars organized by the company periodically.

On the other side, supporting to environmental protection organization provides not only information sharing but also to sustain an environmental friendly company in the customers' perspectives. However, there is not any support to any environmental organization by KAS FLEX resulting 0% success for this activity.

XIII.5. ENVIRONMENTAL CHANGE CAPABILITY

In order to define the degree of following environmental changes in KAS FLEX, the following methodology is implemented. Weighted success rates for Compliance with the regulations respective legislations, Standards, Organizational Structure, and Voluntary Activities is calculated using predefined weight values. The compulsory condition is stated to be compliance with legislations. The weighted averages of three aspects are multiplied with the compliance with legislations in order to find out the percentage capability to follow Environmental Change (EC).

$$EC = CL * \frac{(W_{PS} * PS + W_{OS} * OS + W_{VA} * VA)}{W_{PS} + W_{OS} + W_{VA} +} \quad \textbf{(XIII.2)}$$

Where;

CL: Compliance with Legislation Rate — W_{CL}: Weight for CL

PS: Properness to Standards Rate — W_{PS}: Weight for PS

OS: Organizational Structure Rate — W_{OS}: Weight for OS

VA: Voluntary Activities Rate — W_{VA}: Weight for VA

Table XIII-3 summarizes the rates of each aspect and the relative weights, as well as the result of capability of the company to follow environmental change.

Table XIII-3: Environmental Managerial Change Analysis

Environmental Change Aspects	**Degree**	**Weight**
Comply with Legislations	100%	Compulsory
Properness to Standards	0%	0.42
Organizational Structure	45%	0.37
Voluntary Activities	50%	0.21
Capability to follow Environmental Change %		**27.15%**

Table XIII-3 also highlights several deductions for the company of the environmental change analysis. They are;

- 27.15% of success for the capability to follow the managerial changes represents a very low value for this aim. Consequently, the company can be considered as being incapable of following the change. However, this will bear some failure risks in the future, in case of a significant environmental change.
- Although the company totally obeys the laws and legislations, it does not comply with the international standards.
- The structure of the company is semi-organized due to following the change. They have to pay more attention for their organizational structure for this aim.
- Although there are some evidences about the voluntary environmental activities, they have to improve the success rate and frequency of the applications.

XIV. CHANGE MANAGEMENT CAPABILITY OF KAS FLEX

In order to asses the overall capability of KAS FLEX to manage the change focusing its attention on manufacturing each component of the model is measured using the proposed methodologies. Table XIV-1 indicates the overall result of this analysis together with respective weights of each component.

Table XIV-1: Overall capability of KAS FLEX to manage the change

Model Components	**Scores**	**Weights**
Technological Change (TC)	60.79	0.28
Process Based Change (PC)	48.79	0.21
Customer Oriented Change (CC)	0.00	0.23
Managerial Change (MC)	48.65	0.17
Environmental Change (EC)	28.00	0.11
CHANGE MANAGEMENT CAPABILITY		**50.15%**

An interesting change is done to the model regarding customer oriented changes. As each of these weights was gathered through the survey, customer oriented was the second important factor with 23.66% of relative importance. Since KAS FLEX has nothing to do with its customers and does not have active customer orientation due to the organizational structure of KAYALAR GRUP in which the company has to obey the business rules and the structure set forward. Hence the overall model should measure the change management capability of the company over 4 components except the "Customer Oriented Change".

Based on these scores and weights, overall capability to manage the change for the company in question is calculated and found as 50.15% as;

$$CMC = \frac{(W_{TC} * TC) + (W_{PC} * PC) + (W_{MC} * MC) + (W_{EC} * EC)}{W_{TC} + W_{PC} + W_{MC} + W_{EC}} \qquad \textbf{(XIV.1)}$$

$$= \frac{(0.28 * 60.79) + (0.21 * 48.79) + (0.17 * 48.65) + (0.11 * 28.00)}{(0.28 + 0.21 + 0.17 + 0.11)} = 50.15\%$$

Where;

CMC : Change Management Capability

W_{TC} : Weight for Technological Change

W_{PC} : Weight for Process Change

W_{MC} : Weight for Management Change

W_{EC} : Weight for Environmental Change

TC : Technological Change

PC : Process Change

MC : Management Change

EC : Environmental Change

Based on this analysis there may be some inferences about the capability of KAS FLEX to monitor and sustain the manufacturing changes. Some of those may include;

- ✓ The company is approximately 60% good at following the change in technological developments. However it is an evidence of to lag behind the technology in forthcoming periods unless the score is about 80%.
- ✓ The capability to follow the process change is only about 49%, which is an indicator of failing to adapt the new technologies into manufacturing processes. Although there are some process improvements for example welding method is transformed from induction to tig welding, these process improvements do not return as much as expected on the standard time of the manufacturing.
- ✓ The managerial change capability of about 49% similarly designates some out dated methods used for managerial functions. In order to follow the changes for management this score should be at least 60% or more.
- ✓ The worst case is for the environmental change part of the model. The company is capable of following the environmental change only 28%, which decreases the overall capability to manage the change. Although its relative weight is much less than the others, environmental change management should not be discarded.
- ✓ In order to mention about each component individually in more detail, the company should focus on the technological change management, which has the highest relative weight at first. Although it has the highest capability to manage the change with score of 60.79%, it is better for KAS FLEX to increase the forecasting capabilities of future technologies, to create more

innovative products, and to sustain well adaptation of new technologies into manufacturing system including tools, humans, as well as the knowledge concepts.

- ✓ When the process is analyzed, it has a score of fewer than 50% for the capability to manage the change. Although the unit cost of the production has diminished notably, average worker utilization has not increased. Hence to increase the process change capability, first thing to be performed is to increase the worker utilization.
- ✓ Similar to process change, the capability for managerial change is again fewer than 50%. Although the leading function seems to be appropriate for following the change, organizational structure of the company can be stated as out-dated according to the changing situations. Hence the most important thing is to update the structure of the company due to current conditions of the market.
- ✓ Capability for environmental change management is so low, since the company does not possess ISO 14001 or any other standards for the environmental protection. Although lacking of related standards does not affect the business so much for the time being, it is sure that they have to concentrate on this subject to sustain their competitive advantages in order to manage the environmental change in the future.

XV. CONCLUSION AND FURTHER STUDIES

XV.1. CONCLUSION

It is clear that there is change in every aspect of life and the change is the only constant for every organization. If the companies or individuals cannot follow the change they are forced to change. In the rapid changing structure of global economies, managing the change becomes more crucial than ever before. Hence the change management concept seems to be a wide area which has been started to be investigated recently and going to be analyzed by the academicians and practitioners in the future.

On the other hand, manufacturing systems, which highly depend on the technologies and processes, cannot keep away from the change. They are naturally affected by the changes occur around themselves. If the manufacturing company cannot accompany the changes in its products and processes, it is inevitable to shut down due to its out-dated products. Hence following and managing the change becomes one of the most important activities for an enterprise to survive in the competitive and rapid changing market structure. So a well organized change management model is required for the manufacturing systems.

Although there are various models to manage the change in the literature and the number of models is increasing day by day depending on its virgin research area, it is hard to encounter with a model which focuses on the manufacturing systems. Most of the promising and common change management models are researched in the literature and explained at first. However, their main focus is on the managerial aspect of the change. Most of the models concentrate on the sociological side of the change, which emphasizes on the resistance to change. Although overcoming the resistance is an important factor to manage the change, the manufacturing systems have their own characteristics of change to be managed. Hence the proposed change management model for manufacturing systems includes the analysis of these characteristics namely, Technological, Process Oriented, Customer Oriented, Managerial, and Environmental changes. Since the basic concept of the model depends on the logic that inapplicability of management unless measurement, the capability to manage each component is measured.

First important aspect of the change in production systems is the highly dependency on the Technological Changes. In order to manage the change, technological developments and trends should be well analyzed and forecasting about the future technologies should be performed at first. In the next step, according to promising forecast results, innovative products should be created to increase customer interest. In the last step of technological change, researches and development of new products should be embedded into the manufacturing system to sustain rapid production. This technological adaptation phase includes the adaptation of human, knowledge as well as the tools and equipments used. The capability to manage the technological changes is evaluated by weighted averages of the capabilities of these three aspects.

Second important component of the model concentrates on the Process Oriented Changes. When the technological changes are followed and managed, they need to be reflected in the manufacturing processes. It is senseless for a company to neglect the process oriented changes although performing technological changes. To measure the capability for the process oriented changes, the returns of technological changes on the process are evaluated through four aspects of the process. Average worker utilization, bottleneck time of the process, unit production time and unit production cost are defined to be respective aspects of the process, which are related to changes occur in the process. The changes in these aspects indicate the success rate of change and by the weighted averages of these success rates the capability to manage the process oriented change is evaluated.

Third component of the model deals with the Customer Oriented Changes. Since the customers are vital for the enterprises, the changes occur in their demands and requirements should not be discarded. Each manufacturing company has to increase the number of customers as well as keep the existing ones. Furthermore, the quantities and varieties of the products sold to the customers need to be expanded to sustain the market share. Therefore, the capability to manage the customer oriented change is evaluated through weighted average of the three ratios namely, Getting New Customers, Keeping Existing Ones, and Growing the Sales.

Fourth component of the model examines the capability of managerial changes. That is the change in managerial functions; Planning, Organizing, Leading, Controlling, and Coordinating are investigated. According to the evolution of the methods for these functions a score is assigned for each implementation method. Based on the score respect to relative method, in which level of the management function is denoted. By weighted average of scores for each function, capability to follow the managerial change is computed.

As the last, the Environmental Change is also important to be managed for a manufacturing system. In order to continue its activities, every enterprise must comply with legislations. In addition, attaining international standards for environmental protection issues and compliance with standards is vital for the competitiveness. Furthermore, organizing its company structure in order to follow and manage the environmental change is also required. Beyond this, performing voluntary activities for the environmental protection provides the company an environmental friendly customer perspective. Hence the capability to manage the environmental change is evaluated through respective success rates.

When the scores of each component are assessed, the overall capability of change management of a manufacturing system is evaluated through the relative weights, of which were gathered through a questionnaire performed by the academicians and industrial representatives expertise in the subject.

After completing the overall change management model, the validity and properness is checked during the implementation of the model for a manufacturing enterprise, which produces gas flex pipes named KAS FLEX. Through this implementation phase, it is noted that, KAS FLEX has nothing to do for the customer oriented changes; it does not have a variety of customers and has to obey the order of KASPA which is responsible for all marketing operations of Kayalar Plastik San. Tic. A.Ş. (KAYALAR GROUP). Hence the capability to manage the change for KAS FLEX is evaluated through other four components and found out to be at the middle level of success for this purpose.

As a conclusion of this study, the concept and importance of change management is explained comprehensively. Depending on the review of related change management models in the literature, the requirement for a model focusing on the manufacturing properties is stated. In order to fulfill this requirement a change management model, which focuses on the specific properties of manufacturing systems is proposed. Validity of the model is assessed through the implementation phase and the capability to manage the change for a manufacturing company is assessed. Naturally, this study can be assumed as a pioneer, for the concept of change management for manufacturing systems and some further studies need to be added on.

XV.2. FURTHER STUDIES

This study brings a different perspective for the subject of change management. Although it tries to encompass all related properties of manufacturing systems, there may be some other important areas to be included into the model. Since the basic aim is to set a baseline model for the change management of manufacturing systems, it is welcomed to be enhanced by additional components.

On the other side, although the methodology to measure the capability for the management of customer oriented changes is explained, in the implementation phase it is inapplicable to assess due to the structure of the company investigated. Hence this part is better to be implemented in KASPA, which responsible for the marketing operations of KAYALAR Group. However the main objective is to evaluate the change management capability of the manufacturing company it is left aside for a different analysis for the marketing company.

Moreover, the relative importance weights play an important role to assess the management capability. Since they are gathered through the survey of academicians and industrial representatives, they are open to be changed by different surveys. Although the survey is tried to span as much as possible, respondents of the survey may be increased in further steps. In addition to that, it could be another way to determine the related weights by some techniques of management science, for example analytical hierarchy policy decision making or by personal interviews to prevent misunderstanding the concepts and increasing the number of valid responds.

One of the further studies which could be implemented is to add a certain feedback mechanism to the model. This mechanism may highlight possible drawbacks and shortcomings and provide some recommendations and remedies for manufacturing units.

Furthermore, the proposed model can be enhanced by developing a computer program aimed to measure the change management capability periodically. Once the related required data is input to the program, it will be easy to measure the capability on successive years. In addition the incapable areas to manage the change and the suggestions to overcome these pitfalls can be seen via the utilization of the program.

In addition, an agent based change monitoring systems could be set up. Artificial intelligence technology allows creating fully automated monitoring systems. Several agents may be created to sustain possible changes in different aspect of manufacturing systems.

In summary, this study aims to develop a change management model for manufacturing systems. It is thought to be a well oriented and comprehensive model, which is proper and implantable to measure the capability of change management for manufacturing companies. It is mostly different from the ones in literature by focusing on the production systems. Hence, it is aimed to set a baseline to fulfill the requirement of a model to manage the change for manufacturing companies, it could be enhanced with different other perspectives in further studies.

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XVII. APPENDIX

ANKET

Sayın İlgili

Bu anket ile endüstri hayatında kaçınılmaz olan değişimlerin endüstriyel kurumlar tarafından izlenebilmesi ve uyum sağlanabilmesi amacı ile belirlenmiş olan faktörlerin etkinliklerinin belirlenmesi hedeflenmektedir. Bu kapsamda birçok farklı açıdan değişim ve değişimi tetikleyen unsurlar değerlendirilmek istenmektedir. Takdir edersiniz ki bu unsurların değişim üzerindeki etkileri farklı olacaktır. İçinde bulunduğunuz sektörün durumu, konu ile ilgili deneyim ve bilgilerinize dayanarak değişim unsurlarının oluşturacağı bu etkiyi önem derecesine göre ölçeklendirmenizi beklemekteyiz. Bu kapsamda lütfen sizin için hangi faktörün değişimi izlemede etkinliğini yapılan açıklamaları da dikkate alarak değerlendiriniz. Bu anket ile elde edilecek olan değerlendirmelerin sonuçları tamamen akademik bir çalışma amacı ile kullanılacaktır.

Bu anketi doldurmak için verdiğiniz kıymetli zamanınızdan dolayı teşekkür eder sonuçları sizinle paylaşacağımızı belirtmek isteriz.

Batuhan Ayhan	Prof. Dr. Ercan Öztemel
Doktora öğrencisi	Tez Danışmanı

SORU 1: İmalat işletmelerinin değişimi izleyebilme yeteneklerinin ölçülebilmesi için yapılan araştırmada değişimin imalat sistemleri üzerinde 5 önemli etkiye sahip olduğu gözlemlenmiştir. Bunlar;

- **TEKNOLOJİK DEĞİŞİM:** Bununla imalat sistemlerinin gelişen teknolojik altyapıya uyum yeteneği kastedilmektedir.
- **SÜREÇ DEĞİŞİMİ:** Bununla imalat sistemlerinin teknolojik değişime bağlı olarak imalat süreçlerini yenileyebilme yeteneği kastedilmektedir.
- **MÜŞTERİ DEĞİŞİMİ:** Bununla imalat sistemlerinin en önemli var olma sebeplerinden bir olan müşterilerdeki ve müşteri taleplerindeki değişimi takip edebilme yeteneği kastedilmektedir.
- **YÖNETİMSEL DEĞİŞİM:** Bununla, imalat sistemlerinin günün şartlarına göre değişen yönetim tekniklerine uyum yeteneği kastedilmektedir.
- **ÇEVRESEL DEĞİŞİM:** Bununla imalat sistemlerinin çevresel değişim faktörlerine uyum yeteneği kastedilmektedir.

Bir imalat firmasının değişimlere ayak uydurması için bahsedilen bu 5 değişim unsurunu önem derecesine göre puanlamak durumunda kalsaydınız 100 puanı nasıl dağıtırdınız? Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Değişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu ise notlar kısmına ekleyip açıklayınız.

AÇIKLAMA: Örnek olarak; Teknolojik Değişim etkisinin 30 puan olması diğerlerine göre öneminin %30 olduğu anlamına gelmektedir. Bu doğrultuda aşağıda listelenen unsurların (ve varsa diğerlerinin) toplamı 100 olacak şekilde tabloyu doldurunuz.

Değişim Unsurları	**Önem Puanı (%)**
1. Teknolojik Değişim	
2. Süreç Değişimi	
3. Müşteri Değişimi	
4. Yönetimsel Değişim	
5. Çevresel Değişim	
Diğer	
TOPLAM	100
Notlar:	

SORU 2: İmalat sistemlerinde değişimi yönetebilmenin en önemli unsurlarından birisi ***Teknolojik Gelişmeleri*** yakından izleyebilmektir. Bu amaçla özellikle 3 alanda başarılı olmak önemli değerlendirilmektedir. Bunlar;

- **Teknolojik Tahmin Yeteneği:** Bununla teknolojik gelişmeleri doğru bir şekilde tahmin edebilme yeteneği kastedilmektedir.
- **Teknolojik Yenilikler Geliştirebilme Yeteneği:** Bununla; yapılan teknolojik tahminlere göre yenilikler yapabilmek ve yeni ürünler geliştirebilme yeteneği kastedilmektedir.
- **Teknolojik Adaptasyon Yeteneği:** Geliştirilen yeni sistemlerin ve teknolojilerin imalat sistemine adapte edebilme (uygulanabilme) yeteneği kastedilmektedir.

Bu tespitin doğru olduğunu varsayarak Teknolojik Değişime ayak uydurabilmesi için bahsedilen bu 3 teknolojik değişim unsurunu önem derecesine göre puanlamak durumunda kalsaydınız 100 puanı nasıl dağıtırdınız? Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Teknolojik Değişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu ise notlar kısmına ekleyip açıklayınız.

1. Teknolojik Değişim Unsurları	**Önem Puanı (%)**
1.1. Teknolojik Tahmin Yeteneği	
1.2. Teknolojik Yenilik Geliştirme	
1.3. Teknolojik Adaptasyon	
Diğer	
TOPLAM	100
Notlar:	

SORU 3: İmalat sistemlerinde değişimi yönetebilmenin en önemli unsurlarından bir diğeri ***Süreçlerdeki Gelişmeleri*** yakından izleyebilmektir. Bu amaçla aşağıdaki alanlara odaklanmak önemli görülmektedir. Bu doğrultuda değiştirilen imalat süreçlerinin aşağıda listelenen özelliklerinin değişimden önceki ve sonraki değerleri ile yapılacak olan bir kıyaslama süreç değişimin ne kadar başarılı olduğunu göstereceği düşünülmektedir. Bu özellikler;

- **Toplam Çevrim Zamanı:** İmalat sürecinde bir ürün üretilmesi için gereken toplam zaman (Cycle Time) kastedilmektedir.
- **Toplam Darboğaz Zamanı:** İmalat ortamında varsa darboğaz niteliğindeki makinelerin önünde bekleyen işlerin bekleme süreleri toplamı kastedilmektedir.
- **Ortalama İşçi Kullanım Oranı:** İmalat sürecinde bir ürün için gerekli olan işgücü zamanı kastedilmektedir.
- **Toplam Çevrim Maliyeti:** İmalat sürecinde bir ürün üretilmesi için gereken toplam maliyet (Cycle Cost) kastedilmektedir.

Bir imalat sisteminin Süreçlerdeki Gelişmelere ayak uydurabilmeleri için gerekli görülen bu temel unsurları önem derecesine göre sıralamak durumunda kalsaydınız 100 puanı nasıl dağıtırdınız? Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Süreç Değişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu notlar kısmına ekleyip açıklayınız.

2. Süreç Unsurları	**Önem Puanı (%)**
2.1. Toplam Çevrim Zamanı	
2.2. Toplam Darboğaz Zamanı	
2.3. Ortalama İşçi Kullanım Oranı	
2.4. Toplam Çevrim Maliyeti	
Diğer	
TOPLAM	100
Notlar:	

SORU 4: İmalat sitemlerinde değişimi yönetebilmenin bir diğer unsuru da müşteri beklentilerine en doğru şekilde cevap verebilmektir. Bu açıdan bir değerlendirme yapıldığında kurumun yeni müşteriler elde edebilmesi, mevcut müşteriyi koruyabilmesi ve mevcut müşterilere satış miktarını arttırabilmesi müşteri talebindeki değişimi izleyebilme göstergesi olarak belirlenmiştir. Bu unsurlar;

- **Yeni Müşteri Elde Etme Oranı:** İmalat şirketinin elde ettiği yeni müşterilerden kazandığı hâsılatın bir önceki döneme göre oranı kastedilmektedir.
- **Mevcut Müşteriyi Koruma Oranı:** İmalat şirketinin bir önceki dönem sahip olduğu müşterilerden elde ettiği hâsılatı koruma oranı kastedilmektedir.
- **Mevcut Müşteriye Satış Miktarını Arttırma Oranı:** İmalat şirketinin bir önceki dönem sahip olduğu müşterilere daha fazla mal satabilmesi kastedilmektedir.

Bir firmanın Müşteri Beklentilerindeki Değişimi yakından izleyebilme yeteneğini ölçmek için bahsedilen unsurları önem derecesine göre sıralamak durumunda kalsaydınız, 100 puanı nasıl dağıtırdınız? Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Müşteri Beklentilerindeki Değişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu notlar kısmına ekleyip açıklayınız.

3. Müşteri Beklentilerindeki Değişim Unsurları	**Önem Puanı (%)**
3.1. Yeni Müşteri Elde Etme Oranı	
3.2. Mevcut Müşteriyi Koruma Oranı	
3.3. Mevcut Müşteriye Satış Miktarını Arttırma Oranı	
Diğer	
TOPLAM	100
Notlar:	

SORU 5: İmalat sistemlerinde değişimi yönetebilmenin bir diğer unsuru da ***Yönetim Tekniklerindeki Gelişimi*** de yakından takip edebilmektir. Bu kapsamda aşağıdaki unsurların önemli olduğu belirlenmiştir.

- **Planlama:** İmalat hedeflerinin belirlenmesi ve bu hedeflere ulaşmak için yapılması gereken işlerin ve kullanılacak kaynakların tanımlanmasıdır.
- **Organizasyon:** İmalat amaçlarına ulaşmak için görev ve yetkilerin tanımlanması, kimlerin hangi işlerden sorumlu olduğunun net olarak tayin edilmesidir.
- **Liderlik:** İmalat amaçlarına ulaşmak için yöneticilerin çalışanlar üzerindeki otoritesi ve yetkinliğinin belirlenmesidir.
- **Kontrol:** İmalat hedeflerine ulaşmadaki yetkinliğinin izlenmesidir.
- **Koordinasyon:** İmalat hedeflerine ulaşmak için yapılan çalışmaların kurum içerisinde birbiriyle uyum içerisinde yürütülmesidir.

Bir firmanın Yönetim Tekniklerindeki gelişmeleri izleyebilme yeteneğini ölçmek için bu unsurları önem derecesine göre sıralamak durumunda kalsaydınız, 100 puanı nasıl dağıtırdınız? Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Yönetim Tekniklerindeki Gelişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu ise notlar kısmına ekleyip açıklayınız.

4. Yönetim Unsurları	**Önem Puanı (%)**
4.1. Planlama	
4.2. Organizasyon	
4.3. Liderlik	
4.4. Kontrol	
4.5. Koordinasyon	
Diğer	
TOPLAM	100
Notlar:	

SORU 6: İmalat sistemlerinde değişimi yönetebilmenin bir diğer unsuru da ***Çevresel Değişimi*** de yakından takip edebilmektir. Bu kapsamda aşağıdaki unsurların önemli olduğu belirlenmiştir.

- **Standartlara Uygunluk:** Uluslar arası kuruluşlar tarafından tanımlanmış olan kurallarca belirlenmiş Çevre Sertifikalarına sahip olmak ve bu sertifikaları koruyabilmek kastedilmektedir.
- **Çevre Unsurlarını Dikkate Alacak şekilde Organizasyonel Yapılanma:** Kurumsal yapı içerisinde çevresel değişimleri izleyebilecek bir birimin olması ve bu birim tarafından gerçekleştirilen faaliyetlerin kurum stratejisi üzerinde etkin olması kastedilmektedir.
- **Gönüllü Aktiviteler:** Yukarıdaki faktörlere ek olarak yapılabilecek gönüllü çevre koruma faaliyetleri ile (çevresel değişimin etkilerini incelemek üzere yayınlar yapmak, sempozyum ya da konferanslar düzenlemek gibi) çevresel değişimin daha etkin bir şekilde izlenmesi kastedilmektedir.

İmalat sistemlerinde çevresel değişimlerdeki etkinliği izleyebilmek için bahsedilen unsurları önem derecesine göre 100 puan üzerinden puanlamak durumunda kalsaydınız nasıl dağıtırdınız. Lütfen, toplamı 100 olacak şekilde aşağıdaki tabloyu doldurunuz. Çevresel Değişim unsuru olarak düşündüğünüz ama tabloda yer almayan bir unsur söz konusu ise notlar kısmına ekleyip açıklayınız.

5. Çevresel Değişim Unsurları	**Önem Derecesi (%)**
5.1. Standartlara Uygunluk	
5.2. Organizasyonel Yapılanma	
5.3. Gönüllü Aktiviteler	
Diğer	
TOPLAM	100
Notlar:	

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XVIII. BIOGRAPHY

M. Batuhan AYHAN was born in Konya in 02.10.1979. After completing high school education in Bursa Science High School, he attended Marmara University Faculty of Engineering Industrial Engineering Department in 1997. Posterior to license education, he achieved Master of Science Degree in Industrial Engineering Department of the Institute for Graduate Studies in Pure and Applied Sciences at Marmara University in 2004.

He worked as a Research Assistant from 2002 until 2009 in the Industrial Engineering Department of Marmara University. He has been an instructor in the same department till now. Some of his research areas include, Manufacturing Systems, Change Management, Production Planning, and Scheduling. He has been married since 2006 and has a daughter named Zeynep Ilgın.