ORGANIZATIONAL MEMORY IN CONSTRUCTION COMPANIES: A CASE-BASED REASONING MODEL AS AN ORGANIZATIONAL LEARNING TOOL

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

BELİZ ÖZORHON

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
THE DEPARTMENT OF CIVIL ENGINEERING

APRIL 2004

Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

ORGANIZATIONAL MEMORY IN CONSTRUCTION COMPANIES: A CASE-BASED REASONING MODEL AS AN ORGANIZATIONAL LEARNING TOOL

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April 2004, 162 pages

Companies struggle against complex and dynamic conditions in order to survive in their business settings. Being in the knowledge era, learning has been accepted as one of the main sources of sustainable competitive advantage. Organizational learning (OL) is a set of activities to obtain organizational memory (OM) by acquiring, sharing, interpreting, integrating and institutionalizing knowledge. OM is exploited by the companies in strategic decision-making process, which makes OL a critical concept.

The major objective of this study is to explore how construction companies create OM and how they exploit this asset in strategic decision-making process. In this context, an interview study is conducted with eight large Turkish construction companies and OM perceptions of each company are presented as case studies. This survey revealed the strengths and weaknesses in terms of OL competence. One of the key outputs is that companies are successful at acquiring and storing knowledge but they are not familiar with decision support systems

(DSSs) that benefit from OM. Such systems enable OL by assisting decision makers in processing, assessing, integrating and organizing knowledge. To meet the requirements of the industry, a DSS is proposed to aid construction companies in international market entry decisions. This tool is generated under a software package by adopting case-based reasoning (CBR) as the problem solving approach, which finds solutions to new problems based on the past experiences. The model is developed by the acquisition of past real international project data as input information. The model produces two outputs that are indicators of attractiveness of a project and competitiveness of a company, which are the key decision criteria in international market entry problem.

Key Words: Organizational Learning, Organizational Memory, Decision Support Systems, Case-Based Reasoning, Turkish Construction Industry, Learning Organizations, Knowledge Management.

ÖZ

İNŞAAT ŞİRKETLERİNDE KURUMSAL BELLEK: KURUMSAL ÖĞRENME ARACI OLARAK BİR VAKA BAZLI ÇÖZÜMLEME MODELİ

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Nisan 2004, 162 sayfa

Şirketler içinde bulundukları iş piyasasında varlıklarına devam edebilmek için karmaşık ve değişken koşullara karşı direnmektedirler. Bilgi çağının bir getirisi olarak öğrenme, sürdürülebilir rekabet avantajının en önemli kaynaklarından biri sayılmaktadır. Kurumsal öğrenme (KÖ), bilginin edinimi, paylaşımı, yorumlanması, entegrasyonu ve kurumsallaştırılması yoluyla kurumsal belleğe (KB) ulaşmak için yapılan aktivitelerin tümüne denmektedir. KB şirketlerin stratejik kararlarını vermesinde kullanıldığından, KÖ kritik bir kavram haline gelmektedir.

Bu tezin asıl amaçlarından biri inşaat şirketlerinde KB'nin nasıl oluşturulduğunu ve stratejik karar verme aşamasında bu varlıktan nasıl faydalanıldığını ortaya çıkarmaktır. Bu bağlamda, sekiz büyük Türk inşaat şirketiyle görüşmeler yapılmış ve her bir şirketin KB hakkındaki görüşleri vaka analizleri şeklinde sunulmuştur.

Bu çalışma KÖ yeteneği açısından güçlü ve zayıf yönleri ortaya koymuştur. En önemli çıktılardan biri de, şirketlerin bilgiyi edinmede ve depolamada başarılı oldukları ancak KB'den faydalanan karar destek sistemlerini (KDS) fazla bilmedikleri hususudur. Bu tür sistemler, şirketlerde karar verme konumundaki kişilere bilgiyi işleme, değerlendirme, entegre etme ve düzenleme fonksiyonlarında yardım ederek KÖ'yü de olanaklı kılmaktadır. İnşaat endüstrisinin gereksinimlerini karşılamak adına, şirketlere uluslararası pazara girme konusunda fikir verecek bir KDS önerilmektedir. Bu sistem çözümleme tekniği olarak yeni problemlere eski deneyimlere dayanarak çözümler bulan vaka bazlı çözümleme tekniğini kullanan bir yazılım altında geliştirilmiştir. Oluşturulan model, geçmiş uluslararası projelerin gerçek verilerini girdi olarak kullanmaktadır. Model, uluslararası pazara girme konusunda anahtar karar kriterleri olan projenin çekiciliği ve şirketin rekabetçiliğini belirleyen iki çıktı üretmektedir.

Anahtar Sözcükler: Kurumsal Öğrenme, Kurumsal Bellek, Karar Destek Sistemleri, Vaka Bazlı Çözümleme, Türk İnşaat Sektörü, Öğrenen Organizasyonlar, Bilgi Yönetimi.

ACKNOWLEDGMENTS

I want to gratefully thank to Dr. İrem Dikmen and Dr. Talat Birgönül, without whom I would not be able to complete my thesis, for their unconditional guidance, support, patience and tolerance at each step of this study. Their unlimited assistance that made my research come into this stage should never be forgotten.

For the provision of good times throughout my life, my father Korkuthan Özorhon and my mother Hülya Özorhon, who have never left me alone, deserve special emphasis. I would like to express my appreciation to my family members for their endless love and efforts that encouraged me to realize my goals.

I wish to thank to all company members who have participated in the interview study and especially to Mesut Özden for his positive approach and considerable aids that have made this study reach its objectives.

I should thank to all my friends, who have believed in me in the way to achieve this study, for their sincere and continuous love.

Finally, I would like to thank to Alper, from whom I have always received spiritual and remarkable support and who made me feel strong all the time by sharing his unique friendship.

To

My Family

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AI	Artificial Intelligence
ANN	Artificial Neural Network
CBR	Case-Based Reasoning
DSS	Decision Support System
GNP	Gross National Product
IS	Information Systems
IT	Information Technology
JV	Joint Venture
OL	Organizational Learning
OM	Organizational Memory
TQM	Total Quality Management
US	United States
USD	United States Dollar

CHAPTER 1

INTRODUCTION

Learning is an inseparable component of human life; people intentionally or unintentionally learn in a continuous manner. Learning enhances the adaptability of humans to the environment and it increases their living conditions as well. Similar influences are valid for the organizations that can be regarded as entities having common objectives with people. Source of survival for organizations is accepted to be learning and organizations have become enforced to manage learning activities to stay competitive in their business settings.

Being aware of the value of knowledge in today's business environment, concepts related to learning are attractive not only for business members but also for researchers. For a long period of time, learning organizations have been studied and their learning styles have been explored. Following the developments in other industries recently, construction industry has also shown great effort in terms of improving learning skills. Construction companies carry out knowledge management activities to acquire, store, share and utilize knowledge to increase the efficiency of their operations as well as the effectiveness of their organization. There have been several researches on the learning styles and mechanisms employed in the construction industry. Although how construction firms learn is apparent, to what extent they make use of their knowledge accumulation remains unsolved.

Organizations learn through their employees and finally obtain a corporate asset namely, the organizational memory (OM), by the integration of knowledge to the organizational activities. One of the major concerns of this thesis is to investigate how construction companies create their memories and to explore how they make use of these assets in the strategic decision-making process. To achieve these goals, an interview study is conducted with eight large Turkish construction companies and the results of the study are presented as case studies.

In order to discuss the role of OM in construction companies, essential concepts related to organizational learning (OL) should be explained. The following chapter gives definitions on OL and learning organizations; it mentions the dimensions of a learning organization and highlights the importance of OL for construction companies.

Having defined the OL principles, role of OM in the construction industry is modeled in the third chapter of the thesis. Based on the OL framework developed for construction companies, knowledge acquisition mechanisms are examined in a different perspective; role of OM in strategic decision-making is emphasized; knowledge management activities are reviewed and OL barriers are listed. The interviews are carried out to reveal the perceptions of construction companies about the issues covered in this chapter. The company representatives are asked to respond to the questions related to OM on behalf of their organizations.

The research findings are presented as case studies, which would best demonstrate the outcomes of the survey. Since a limited number of companies are involved in this study, it would not be proper to generalize the answers of eight companies as if they were common to all other firms in the construction industry. Chapter four identifies company specific assumptions and behaviors on OL and also determines a general trend about each topic of the framework discussed in the previous chapter. Common to all companies was the inability to exploit from the OM. As far as the facts and requirements of the companies are

concerned, the direction of the study has diverted toward the development of a decision support tool to aid construction companies in strategic decision-making.

Considering the results of the survey, existence of a DSS for international market entry was found to be very beneficial for the companies. Since none of them had a DSS used for this aim, development of a program to help companies make decisions about international projects would be appropriate. In the fifth chapter, to meet the needs of the industry, a decision support system (DSS) is developed by adopting case-based reasoning (CBR) as the problem solving approach. The key point in preferring CBR was its suitability to construction problems that are solved through past experiences, which is also the main principle of this technique. Using a software package, the attractiveness value of an international project and the competitiveness value of a company for that project, which are the indicators of deciding to enter an international market, are predicted through this model. Chapter five discusses how problems are solved by CBR, which problems CBR can be applied and it gives examples from the construction management field. The development of the DSS is then explained and an illustrative example is presented. Finally the benefits and shortcomings of the system are discussed.

In addition to the main text, this thesis also includes four appendices. In Appendix A, a sample of the interview related to the research study can be found. Some details of the analysis results of the DSS generated for international market entry are presented in the other three appendices; Appendix B presents the testing cases used for the system; Appendix C shows the evaluation form for the quantification of importance weights of the features and Appendix D has the properties of similarity definitions used to construct the model.

CHAPTER 2

ORGANIZATIONAL LEARNING

Organizations, just like the humans, struggle for survival in their business settings. Due to the changes such as technological advances, growing and changing customer demands, competitive forces, changes in the labor force and environmental and political concerns, it has become much more important for the organizations to be able to quickly respond and adapt to this dynamic environment (Bhatt and Zaveri, 2002). In order to survive and stay competitive, firms nourish new ideas, process better ways of doing things, develop new products and technologies, and accomplish all those tasks to grow and become better at what they currently do (Malone, 2002).

Being in the knowledge era entails companies to emphasize cooperation, collaboration, autonomy, being proactive, long-term thinking and learning when they are making strategic planning (Preskill and Torres, 1999). Consistent with their ongoing strategies, what the organizations try to do is to employ new ways to become competitive in their markets. As Senge (1990a) remarks: “The rate at which organizations learn may become the only sustainable source of competitive advantage”. Competitive advantage requires an organization to be adaptable to changes in demand, able to analyze the environment, flexible enough to respond to changes and assess its capability relative to demand. To achieve these goals bring out the necessity of learning organizations. Companies are urged to become “learning organizations” to develop their learning capability for survival and maintaining competitiveness (Hong, 1999).

The objective of this chapter is mainly to examine the basic ideas related to both organizational learning (OL) and the learning organization in the literature. Then, steps of building the learning organization will be discussed in a systems-linked model. In this model the learning organization has five subsystems namely; learning, organization, people, knowledge and technology. These subsystems will be mentioned in detail in the following sections. Finally, the role of OL in construction will be highlighted and some industry specific examples will be explored.

2.1. Definitions on Organizational Learning and Learning Organization

The concept of OL has taken its prominence in the past several decades as a way to achieve competitive advantage. There are several definitions for OL and the learning organization, regarding the components constituting the learning process; these may be the human dimension, the environment, the knowledge concept or the organization's identity.

One of the earliest definitions is given by Argyris (1977) who defines OL as the process of "detection and correction of errors". As Huber (1991) states, learning occurs in an organization if its potential behaviors is changed through its processing of information. With a broader perspective, Dodgson (1993) explains OL as "the way firms build, supplement, and organize knowledge and routines around their activities and within their cultures and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces". OL may also be defined as encouraging a learning culture within an organization such that employees at all levels, individually and collectively, continually increase their capacity to improve their level of performance (Kululanga et al., 2001).

In the light of these definitions, OL can be summarized as the set of actions to acquire, share and interpret knowledge among the members whose main

objective is to increase company performance through improved quality of decision-making in the organization.

Although the concept of learning organization can be explained through the definitions given for OL, there are several perceptions on what a learning organization is. So, different perspectives will be presented for this term that has become popular due to the company goals of elevating organizational efficiency and flexibility to be more adaptable to changes in the environment.

Garvin (1993) views a learning organization as an organization skilled at creating, acquiring and transferring knowledge and modifying its behavior to reflect new knowledge and insights. Senge (1990a), on the other hand, adopts a broader approach to define the learning organization. He describes it as a place where people continually expand their capacity to create results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free and where people are continually "learning how to learn".

Change over time arises not only in the environment but also in the organization's interpretation of its environment (Huemer and Ostergern, 2000). The major aim of a company has to increase the "absorptive capacity" which means its ability to recognize the value of new knowledge, assimilate it with existing knowledge and apply it to commercial ends so as to reach the goals of a learning organization (Cohen and Levinthal, 1990 cited in Bresnen et al., 2003).

2.2. Dimensions of a Learning Organization

Learning organization is a multidimensional notion that has to be investigated from different approaches. The factors that construct the learning organization should be analyzed one by one in order create a unified picture about how a learning organization is built and what a learning organization can do. The most important point is the existence of a knowledge management infrastructure within the organization whose mandate is to identify, analyze, manage, maintain and disseminate knowledge to appropriate individuals within the organization

and externally to others (Liebowitz et al., 1999). This can only be achieved through the proper combination of relevant systems and skills that are influential in the learning process of an organization. In his classic *The Fifth Discipline*, Peter Senge (1990a) identified five learning disciplines or skills that would facilitate the transition of a company to a learning organization. The skills or disciplines of systems thinking, mental model, personal mastery, team learning and shared vision are necessary to maximize OL. They are indispensable partners for building, maintaining and sustaining learning and productivity in the learning organization.

Marquardt (1996) proposed a systems-linked learning organization model, which is made up of five closely interrelated subsystems that interface and support one another. The core subsystem of the learning organization is learning and this dimension permeates the other four subsystems. Each of the other subsystems namely; organization, people, knowledge and technology are necessary to enhance and augment the quality and impact of the learning. Building the learning organization will be discussed by analyzing these subsystems.

2.2.1. Learning in the Organization

Being the core of the model, the learning dimension will be covered in detail. The learning subsystem refers to levels of learning and types of learning that are crucial for OL and critical for OL skills.

2.2.1.1. Levels of Learning

Strategic management of OL requires the intuiting, interpreting, integrating and institutionalizing of knowledge flows (Crossan and Bontis, 1998), which take place at individual, group and organization levels respectively. Jeffries et al. (2003) develop a similar perspective by defining the levels of OL as three phases beginning at the individual level by interpreting and reflection, maturing at group level by integration and conceptualization and finally reaching the organization level by institutionalizing and experimentation.

Individual learning is the foundation for the existence of organization's learning and it should be enhanced to lead to more effective OL. Individuals learn by detecting and correcting their errors (Argyris, 1977) and they learn when they produce effective actions from errors. Espejo (1996) states that as we learn, we develop the necessary practices and skills to make effective decisions.

Group/team learning is an inseparable step of OL since teams provide new approaches to the learning process, cause fundamental organizational changes by functioning as a bridge between the individuals and the organization (Marquardt, 1996). Groups learn from their own experiences and past histories and transform knowledge among themselves and the organization.

Organization learning requires the crucial step of the transformation of individual learning into OL. The process necessitates four main events defined by Crossan et al.'s (1999) framework including intuiting, the preconscious recognition of the possibilities inherent in a personal experience; interpreting, the explanation of an idea to oneself and to others; integrating, the developing of a shared understanding and coordinated action among individuals and institutionalizing, the process of ensuring that actions are made routine (cited in Robey et al., 2000).

2.2.1.2. Types of Learning

Argyris and Schon (1978) focus on reflective processes or methods of learning for the individual and the connection between individual learning and OL and describe three types of OL (cited in Love et al., 2000).

Single-loop learning involves an organization to respond to changes in its environment by detecting errors and correcting them, but maintaining its existing organizational norms. Present policies and goals are preserved in this level of learning that does not result in any reflection or inquiry. Singe loop learning has also been referred to adaptive learning by Senge (1990b).

Double-loop learning, on the other hand, involves the revision of organizational culture, assumptions, guidelines, objectives, strategies and structure of an organization. Double-loop learning is also called generative learning by Senge (1990b) that is a process of creative renewal and rediscovery of an organization to remain competitive.

This type of learning leads to the development of creativity in the problem-solving process, which Argyris and Schon (1978) refer to as *deutro-learning*, that is, learning about learning (cited in Love et al., 2000). Double-loop and deutro learning are concerned with the why and how to redefine the organization to adapt and survive in dynamic environments while single-loop learning is concerned with problem solving without questioning underlying assumptions and core beliefs (Bhatt and Zaveri, 2002).

It can be concluded that, many construction organizations may have difficulty with double-loop or deutro-learning, as these type of learning require them to break away from existing norms and value systems. Construction companies should also be more careful in sharing, interpreting and institutionalizing individual knowledge in order to obtain a corporate asset for the employees.

2.2.2. Organizational Transformation

Organization is the structure in which the individuals, groups and the organization itself learn. As Huber (1991) states, organizations whose structures, processes and technologies are not well suited to deal with the increasing environmental complexity and knowledge are unlikely to survive. Around the shared vision and culture, organization should develop new strategies and structures so as to become a learning organization (Marquardt, 1996). Under the organization subsystem, vision, culture, structure and strategy components are discussed to stress the importance of organizational transformation for learning at the organization level.

2.2.2.1. Vision

The vision of the organization is represented by the commitment for a certain goal, direction or hope for the future of the organization. According to Marquardt (1996), the first and the most important step in becoming a learning organization is to build a solid foundation of shared vision about learning. Above all, what is needed is to share an understanding of the organization's identity, which means more than sharing a common view of its mission. It provides not only a common direction for individual's actions but also an orientation for their necessary interactions (Espejo et al., 1996).

2.2.2.2. Culture

Walsh and Ungson (1991) define culture as the conscious and unconscious patterns of assumptions, values, and beliefs shared by a collective (cited in Berthon et al., 2001). Culture acts as a kind of knowledge filter; it specifies what information is of value, influences the interpretation of information and coordinates collective action taking (Weick, 1994 cited in Berthon et al., 2001).

According to Schein (1985), organizational culture is regarded as a pattern of basic assumptions invented, discovered and developed by a given group as it learns to cope with the problems of external adaptation and internal integration that has worked well enough to be considered valid and taught to new members as the correct way to perceive, think and feel in relation to those problems (cited in Jeffries et al., 2003).

In principle, available knowledge will only be acknowledged by an organization when it does not conflict with its organizational paradigm (Lehner and Maier, 2000). Organizational culture determines the quality and quantity of learning in an organization in addition to its influence on decision-making since it involves assumptions, adaptations, perception and learning (Jeffries et al., 2003). Development of a culture that entails OL does not come by chance; it is rather a result of deliberate actions to be undertaken by an organization to relevant

knowledge and other stimuli from its internal and external business environments (Kululanga et al., 2002). Robbins et al. (1994) state that there are ten primary characteristics to capture the essence of organizational culture namely; member identity, group emphasis, people focus, unit integration, control, risk tolerance, reward criteria, conflict tolerance, means-ends orientation and open-system focus (cited in Jeffries et al., 2003).

2.2.2.3. Structure

The key characteristic of the structure of the organization is that, it links the various elements of the organization through the transformation of information. The design and structure of organizations should be perceived as an important task as it confines and regulates the interaction between people (Hong, 1999). According to Liebowitz and Megbolugbe (2003), organizational facilitation assesses the complexity of the knowledge management infrastructure and knowledge sharing capability within the organization. As emphasized by Salaman and Butler (1994), the organizational structures surrounding a project appear to centrally influence a project's tendency to perform learning activities and to contribute to the knowledge of the permanent organization (cited in Kasvi et al., 2003). Hong (1999) believes the optimal structure should adapt the complexity and dynamism of the external environment.

2.2.2.4. Strategy

Identification, capture and transfer of knowledge within the firm are expected to be in alignment with the organization's strategic objectives. Strategy influences learning by providing a boundary to decision-making and a context for the perception and interpretation of the environment. As managers make decisions to provide strategic value, they should be good at creation of innovative ideas, improvement of business processes and making better decisions (Malone, 2002) by the utilization of knowledge to realize their ongoing strategies.

2.2.3. People Dimension of Learning

The people subsystem is one of the most important dimensions of the learning organization since people are the masters who can take data and transform it into valuable knowledge for personal and organizational use. According to Argyris and Schon (1978), individuals are the "agents" for learning in organizations (cited in Hong, 1999). Learning takes place as knowledge is created and captured and the knowledge is applied and embedded within individual and organizational processes (Liebowitz and Megbolugbe, 2003). Lehner and Maier (2000) believe that the probability of acceptance of new knowledge largely depends on the knowledge or opinions of those employees in positions of power, which emphasizes the human dimension of learning.

Since individuals form the bulk of the organization, necessary forms and processes should be set up to enable and enhance learning in the organization. Managers must provide structured learning processes for individuals and groups so that newly acquired knowledge can be integrated into daily activities. Establishment of communities of practice, that are defined as a small group of people working together over a period of time who perform the same tasks or collaborate on a shared task (Brown and Gray, 1995 cited in Malone, 2002) may be a proper way to promote learning among employees. In communities of practice, constructing meaning through combined efforts provides organizational members with identity and cohesiveness which grants the basis for effective learning (Bresnen et al, 2003).

2.2.4. Knowledge Management in the Organization

A knowledge management system, the aim of which is to support OL and organizational effectiveness, is a dynamic system comprising of functions to identify, acquire, maintain, search, retrieve and distribute knowledge (Lehner and Maier, 2000). Before discussing the necessary activities for knowledge management, distinctions between the meanings of data, information and knowledge should be searched.

Data can be defined as the simple observations of states of the world. *Information* is viewed as organized facts and data to describe a particular situation or conditions and *knowledge* consists of truths, beliefs, perspectives, concepts, judgments, expectations, methodologies and know-how and it exists in different forms (Egbu and Botterill, 2002). Information can be said to emerge when isolated facts are put into a context and combined within a structure. When information is given meaning by being interpreted, information becomes true knowledge.

Knowledge may be present in two types being *tacit* (informal or soft) and *explicit* (formal or hard). The tacit knowledge is composed of competences, values and norms whereas the explicit knowledge can be found in forms of specifications, instructions and definitions. The informal knowledge that is hard to capture and keep includes ideas, facts, assumptions, meanings, questions, decisions, guesses, stories, and points of view (Conklin, 2001). Hong (1999) argues that knowledge is perceived to be hard and transferable in the case of scientific, technical and commercial information; it can easily be codified, documented, and transferred to other people. But it should be noted that organizations need to pay greater attention to managing tacit knowledge, judgment and intuitive abilities since soft knowledge has recently been accepted as a possible source of competitive advantage.

Organizations are perceived to have information processing capacity to acquire, interpret, distribute, and store information throughout the organization (Huber, 1991). The discussion on knowledge management process will uncover four activities as knowledge acquisition, information distribution, information interpretation and organizational memory.

2.2.4.1. Knowledge Acquisition

The OL cycle starts with the collection of information, both from internal and external sources (Dixon, 1994 cited in Hong, 1999). Acquisition of declarative knowledge or facts and information is achieved by monitoring the environment

and using information systems to store, manage, and retrieve information. According to Ingram and Baum (1997), organizations can learn from two sources of experience to improve performance, namely their own and industry experiences (cited in Hong, 1999). As one can easily determine, the organization itself is not the only place where information can be gathered. Walsh and Ungson (1991) mention the existence of external archives (cited in Lehner and Maier, 2000); the additional sources such as government agencies, advertising agencies, societies, accounting offices, news agencies and the media, etc. where companies acquire knowledge. It can be concluded that there are three knowledge acquisition sources as company's own experiences, other companies' experiences and the external resources.

2.2.4.2. Information Distribution

Information distribution refers to the process by which an organization shares information among its units and members, thereby promoting learning and producing new knowledge or understanding. Information distribution determines both the occurrence and breadth of OL (Huber, 1991). In addition to traditional forms of information distribution such as sharing stories to capture and distribute tacit knowledge, computer-mediated communication systems such as document delivery systems and networks such as intranets can facilitate the sharing of information among the organization members.

2.2.4.3. Information Interpretation

Interpretation is defined by March (1998) as the process of translating the events, developing models for comprehending, giving meaning and assembling conceptual schemes (cited in Hong, 1999). Huber (1991) states that individuals and groups have prior belief structures that shape their interpretation of information and thus the formation of meaning. A decision support system can support not only the storage and retrieval of information going into the decision-making process but also can be regarded as a tool to promote learning and awareness among individuals and groups.

2.2.4.4. Organizational Memory

Organizational memory (OM) has been defined as the means by which organizations store knowledge for future use (Huber, 1991). A similar definition is given by Stein and Zwass (1995) who define OM as the means by which knowledge from the past is brought to bear on present activities thus resulting in increased levels of effectiveness for the organization. Although organizations do not have brains, they have intentionally or unintentionally constructed memories. OM becomes a corporate asset by capturing, organizing, disseminating, and reusing the knowledge created by its employees (Conklin, 2001).

Walsh and Ungson (1991) developed the structure of organizational memory as acquisition, retention, and retrieval and postulated the existence of five storage bins that compose the structure of memory within organizations and one source outside of the organization being individuals, culture, transformations, structures, ecology and external archives (cited in Ji and Salvendy, 2001). An alternative approach is developed by Cross and Baird (2000) who identify the components of OM as individual memory, personal relationships, databases, work processes and support systems, product and services.

A number of authors like Argyris and Schon (1978) have stressed how OM development can produce habitual decisions and actions, which emphasize short-term operational efficiency over long-term strategic effectiveness (cited in Berthon et al., 2001). Lehner and Maier (2000) also stress the function of OM in connecting past and present decision-making situations.

OM is a general term implying that knowledge may be stored in a variety of repositories, both human and artifact (Robey et al cited in Walsh and Ungson, 1991). It is known that decision makers do not only store and retrieve hard data but they make use of the soft information in the form of tacit know-how and expertise. Obviously, it is a difficult task to ask company members to share such information since they may not desire to give up valuable information for fear of losing their individual competitive edge. Then an inevitable solution arises:

establishing information systems to store and retrieve such collective knowledge in order to preserve tacit knowledge and further promote OL. At this point, the necessity of technological means comes out.

2.2.5. Technological Power for OL

Technology should be regarded as a medium for the accumulation of a corporate memory of shared stories, discourses, routines and so on (Broendsted and Elkjaer, 2001). The influence of technology on both OL and OM will be discussed in the following sections by mentioning the information technology tools that support learning in the organizations, importance of information systems to construct corporate memories and role of decision support systems in enabling learning and relation with OM. It should be remembered that although explained under different headings, these concepts are interrelated and they have several common points.

2.2.5.1. Information Technology

Information technology (IT) can be an important ingredient in the design of learning organizations by providing an infrastructure for storing, accessing and revising some of the elements of OM (Robey et al., 2000). IT is the general term that specifies computer-based tools used to gather, code, process, store, transfer and apply data between machines, people and organizations. Information systems (IS) can indirectly influence OL by affecting contextual factors such as structure and environment, which, in turn, influence learning. Although, Huber (1991) explicitly specifies the role of IS in the learning organization as primarily serving OM, IS can also serve knowledge acquisition, information distribution and information interpretation as well. For example, technologies such as data warehousing, expert systems and intranet/internet systems, which comprise valuable components of OM (Stein and Zwass, 1995) can facilitate the processes of knowledge acquisition, information distribution and information interpretation. Intranet can be defined as any private network supporting the Internet application and file transfer protocol (Ji and Salvendy, 2001).

Knowledge-handling technologies including hypertext and hypermedia technologies, expert systems and case-based reasoning systems enhance OM and OL by enabling individuals to enrich representations of their understanding, reflect upon those representations, transfer these to others and use them to notify action (Robey et al., 2000).

2.2.5.2. Organizational Memory Information Systems

Steps of information processing include data processing, data base administration, data management, information management and OM management (Lehner and Maier, 2000). So as to support and integrate OL systematically, a form of an information infrastructure namely an organizational memory information system (OMIS) should be implemented (Ji and Salvendy, 2001). An OMIS can be realized by the application of different types of information technologies such as databases, knowledge bases, social networks, electronic bulletin boards and intranet that together form the OMIS infrastructure.

The development of OM systems is substantially more complicated than the development of conventional IS since the existing models and planning methods should be developed further and a relationship to management applications must also be developed because OM has a strategic role in decision-making (Lehner and Maier, 2000). Moreover, being an effective organization requires maintaining values, attitudes and norms that contribute to corporate cohesion, which should also take part in the OM.

An OMIS can help a user's routine decision-making process because when a user is to make a decision, he or she refers to his or her personal memory and OM, in which organizational knowledge is stored, including past organization experience that will be helpful in giving strategic decisions (Ji and Salvendy, 2001).

2.2.5.3. Decision Support Systems

It is a commonly accepted fact that learning is closely linked to experience. Additionally, information is the most important prerequisite for decision-making (Lehner and Maier, 2000). Then, past experience with the use of IT tools can improve future implementation if organizations consciously reflect and learn from it (Robey et al., 2000).

A decision support system (DSS) can assist a decision maker in processing, assessing, categorizing and organizing information in a useful fashion that can be easily retrieved in different forms. A DSS is a computer program that accepts inputs of a large number of facts and methods to convert them into meaningful outputs that can facilitate and enhance decision-making abilities. A DSS can facilitate problem recognition, model building, assist in collecting, integrating, organizing and presenting the relevant knowledge, select an appropriate problem solving strategy, evaluate the different solutions and choose the best solution (Bhatt and Zaveri, 2002). It is obvious that all these activities can promote OL, making it a more efficient, effective and a satisfying process. DSSs enable OL by the provision of some attributes such as efficient access of data, experimentation with variables, generation of alternate models, trend analysis, explanatory and confirmatory models, simulation, justification of solutions, exploration and exploitation of knowledge and idea generation (Bhatt and Zaveri, 2002). These functions can only be achieved through the computer programs that apply some problem-solving approaches. One main field that involves computer algorithms to solve problems is the Artificial Intelligence (AI).

AI domain involves the problem-solving techniques that imitate human reasoning and tries to make computers behave like humans in the lack of experts. These approaches can be used in developing DSSs. Some important techniques in this field are Case-Based Reasoning (CBR), Artificial Neural Networks (ANNs), Rule-Based Expert Systems and Model-Based Expert Systems. The

most powerful of these methods seems to be CBR due to its more flexible and comprehensible structure.

CBR is problem-solving approach that relies on past solutions to problems, to modify and assess existing solutions and to explain anomalous situations (Kolodner, 1991). CBR is "the process of solving new problems by adapting solutions that were used to solve old problems" (Riesbeck and Schank, 1989). Indeed, CBR uses the principles of human reasoning as it learns from the past situations. With this feature, CBR can be applied for problems that can be solved through previous experiences. The application domain of CBR ranges from planning and design to speech recognition and diagnosis. CBR has been applied to a full spectrum of AI tasks, such as classification, interpretation, scheduling, planning, design, diagnosis, explanation, dispute mediation, argumentation, projection of effects and execution monitoring (Leake, 1996).

ANN is a technique that focuses on designing and implementing computer systems with architectures and processing capabilities based on the capabilities of the human brain (Bhatt and Zaveri, 2002). The essence of Rule-Based Expert Systems is a knowledge base consisting of expert knowledge and the structure based on if-then rules. Model-Based Systems require an explicit domain model to solve the problems, so they can be applied to problems where accurate models are available.

The details of these approaches are given in Chapter 5, which deals with a DSS generated by using CBR technique.

2.3. Organizational Learning in Construction Industry

All companies share common goals such as increasing their performance and profitability to survive in the competitive environment. According to Kim (1993), OL is concerned with increasing an organization's capacity to take effective action. Then, construction companies should adopt learning notion a prominent feature of their activities that should be deeply imbedded in their

routines to increase their ability to innovate and ensure continuous improvement (Kululanga et al., 1999). The construction industry has some features that make it different from the other industries. The outputs of construction works are unique projects that involve the integration of different subsystems and components by a range of participants such as clients, advisors and subcontractors who come together for a temporary cooperation (Barlow, 2000). Having a project-based nature, characterized as short-term and task-oriented, construction industry does not allow a culture for continuous learning. For this reason, construction companies should be more careful in developing and measuring OL so as to benefit from OL principles (Kululanga et al., 2001).

A learning organization in construction should be skilled at five main activities as Garvin (1993) suggests: systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others and transferring knowledge quickly and efficiently throughout the organization (cited in Love et al., 2000). Indeed these activities correspond to some knowledge acquisition and sharing mechanisms and interpretation and utilization of knowledge in company practices. Systematic problem solving may be regarded as equivalent to standardization of procedures, which may be achieved through the total quality management (TQM) principles. Innovation may be a good example for experimentation with new approaches. As Holt et al. (2000) state, construction companies should stop employing yesterday's business philosophies in order to remain in business tomorrow. Learning from the past history of the company and experiences and best practices of others contribute to two main sources for knowledge utilization. A construction company learns from its internal resources as well as from the other organizations through partnerships and benchmarking. Finally, construction companies should not only learn from its own experiences and the other companies' experiences and code them but they should also be skillful at deciding which lessons to apply and when (Kululanga et al., 2002) to achieve success.

The following sections explain how these essential activities are carried out by the construction companies and how competitive advantage can be created through these learning practices. Firstly, creation of corporate memories through project learning, other companies' experiences and external resources will be discussed then; examples for the enablers of OL will be given which is followed by the knowledge sharing methods. Finally the importance of exploitation of knowledge for construction companies will be explored.

2.3.1. How Construction Companies Learn

As Nevis et al. (1995) state learning is concerned about the production and delivery of goods and services. The major idea here is that organizations learn as they produce. Since in construction works, the unit of production or service is the project then, the most important source of learning is the project-related activities that constitute own experiences of companies. Project knowledge includes the technical knowledge concerning the product, its parts and technologies, procedural knowledge concerning producing and using of the product and organizational knowledge concerning communication and collaboration between the work teams (Kasvi et al., 2003). There are two basic strategies for managing knowledge (Hansen et al., 1999), one of which is the codification strategy that is based on codifying the knowledge and storing it in artifacts and databases where it can be accessed. The other is the personalization strategy in which knowledge is tied to people developing it and it is shared by personal interaction.

As projects differ substantially from one another and significant discontinuities are encountered in flows of personnel, materials and information; it becomes difficult to develop routines to maximize the knowledge flow and the capture of learning from one project to the next (DeFillippi and Paradox, 1998 cited in Bresnen et al., 2003). Therefore construction companies are responsible for documenting the existing knowledge and know-how in the company, making it accessible for new employees and for protecting it when employees leave the

company. Unfortunately, for most construction companies there is a problem in the systematic integration of knowledge and experiences gathered in different projects into the organizational knowledge base (Schindler and Eppler, 2003). These systems often allow an organization to apply its collective intelligence to any problem, regardless of time or geographic location. From a long-term perspective, with the provision discipline, motivation, debriefing skills and know-how about adequate documentation formats (Schindler and Eppler, 2003); it is assumed that project learning leads to a sustainable competitive advantage. Related documentation techniques will be explained in detail in the following chapter.

The main learning mechanisms employed by construction contractors are identified by (Kululanga et al., 1999) through a literature survey and an interview study. These mechanisms are based on collaborative arrangements such as partnering, alliancing and joint-venturing; noncollaborative arrangements such as acquisitions and mergers; networks such as intercompany networks based on the value chain; methods such as reviews of successes and failures and benchmarking in addition to individual employee learning through staff training by company and internal and external seminars.

Love et al. (2000) argue that lean production, concurrent engineering, benchmarking, partnering and supply-chain management can be effectively implemented when construction companies have learning foundations. This idea emphasizes the cyclic nature of OL; through some mechanisms companies enhance their learning potential as well as their potential creates opportunities to apply some techniques successfully. Benchmarking is a popular means of learning the best practices used by other companies, including the competitors (Mann, Samson and Dow, 1998 cited in Robey et al., 2000). On the other hand, partnering, with its emphasis on communications, risk and reward sharing and the development of trust between organizations, promotes a culture within which technical and process innovation could flourish in addition to OL within its members (Barlow, 2000). Cooperative strategic alliances encourage partners to

commit resources to the relationship. By the help of alliances, companies learn from each other, compensate their lacks and become competitive in the market. In short, all these mechanisms facilitate learning of construction companies from other companies' experiences besides the techniques adopted to improve the business processes such as quality management practices and innovation, which enable companies to increase their OL competence through their own experiences.

2.3.2. Enablers of Organizational Learning

The TQM philosophy, which has the major goal of continuous improvement, can be regarded as a framework for organizations to develop a shared and even synergistic understanding of information, experiences and objectives of all individuals within the organization so that change can be consciously and proactively managed. Hill (1996) argues that continuous improvement and learning are complementary concepts such that learning is the most compelling reason for establishing systems that lead to continuous improvement in an organization. According to Love et al. (2000), ideas of continuous learning allied to concepts such as empowerment and partnership, which are components of TQM, also involve that a change in behavior and culture is necessary if construction organizations are to become learning organizations. So, the TQM approach, which has matured in the manufacturing industry, can help construction companies in terms of increasing their OL ability. Love and Li (2000) describe the experiences of a contracting organization that realized a reduction in the rework it experienced in projects from 5 % to less than 1 % of contract value through effectively implementing a quality assurance system in conjunction with continuous improvement practices. These kinds of experiences may be useful for increasing the knowledge potential of companies and help them enhance their business processes.

Vakola and Rezgui (2000) focus how adequate OL and innovation can make contribution to the enhancement, development and improvement of professional

expertise in the construction domain. OL and innovation are considered intangible resources since they are very difficult to possess and imitate. Companies are trying to use OL and innovation in order to solve existing problems as well as to continuously improve themselves to increase their adaptability to the changing conditions because these make them obtain a competitive edge over the competitors.

2.3.3. Strategic Role of Organizational Learning for Construction Companies

A successful culture of OL can influence performance, long-term effectiveness and survival of an organization (Kululanga et al., 2001). In order to achieve these goals, companies should seek ways for improving and measuring their OL capabilities. The framework of Kululanga et al. (2001) measures OL as one of the strategies for improving construction business processes in which ten dimensions for learning and eight factors for promotion of organizational generative learning are unveiled. Different mechanisms by which learning can occur at both individual and organizational level are defined by the learning dimensions. There are some parameters that increases performance of companies which can also be the described as catalysts that promote OL.

Another important issue is the utilization of external learning resources besides learning from the own past experiences and experiences and best practices of other companies. Cohen and Levinthal (1990) underline the role of absorptive capacity of an organization that is the ability of searching, encoding, distributing, and interpreting the external information (cited in Hong, 1999).

Companies should pay more attention to sharing, interpretation and utilization of knowledge to integrate this asset in their daily activities to make better decisions. According to the results of a survey, the most frequently used techniques and technologies for knowledge sharing among employees in construction organizations are the telephone, Internet/intranet/e-mail and documents and reports. These are closely followed by face-to-face meetings and interaction with

the supply chain (Egbu and Botterill, 2002). It has been argued that a corporate intranet, which is an efficient tool for the storage and flow of explicit knowledge, can improve company decision-making and lead to greater innovation (Bennett and Gabriel, 1999 cited in Egbu and Botterill, 2002).

In order to enhance decision-making, DSSs are widely utilized. These systems involve collection and storage of past knowledge to exploit for future decisions. Since DSSs require collection of data, storage of information in databases and utilization of knowledge in the decision-making stage, they are assumed to increase the OL in a company. DSSs can be beneficial for solving construction management problems and enhance learning in construction companies.

A review in literature in the construction management domain uncovers some DSSs to assist construction companies in monitoring and controlling the implementation of geotechnical construction (Cheng et al., 2001 cited in Shen, 2003) and selecting proper subcontractors among various combinations of on-list subcontractors by considering the trade-offs between risk and profit (Tserng and Lin, 2002 cited in Shen, 2003). In addition to these, Shen (2003) presented a computer-aided DSS to assist both project clients in identifying proper contractors at the prequalification stage and the contractors in adopting proper measures to improve its competitiveness. Shen (2003) argues that with the provision of this information, clients have a direct and comprehensive picture of the competitiveness of all bidders, which enables proper decision-making in identifying which contractors should be invited to participate in the final bidding.

In fact, there are not many examples exploring the role of corporate knowledge namely; the OM, in decision-making process. Although companies create intentionally or unintentionally a shared asset as a result of learning practices including knowledge acquisition through own experiences, other companies' experiences and external resources; storage of collected information either in databases by codification or in individuals' mind as tacit knowledge and knowledge sharing among employees through intranets and other technological

tools, the advantage of possessing such a value should be revealed in the quality of the strategic decisions made in the company. In order to highlight how construction companies create their OMs and how they make use of this corporate asset, a research study is carried out including interviews with the leading construction companies in Turkey.

The content of the interview and concepts related to this study is given in the next chapter that is followed by another chapter in which research findings are presented as case studies to be much more explanatory.

CHAPTER 3

RESEARCH METHODOLOGY

OL, which has been accepted as an important source of sustainable competitive advantage both for construction companies and the firms in other industries, is becoming an arising value recently. This attracting concept has several aspects to be discussed such as how learning at the organization level takes place, which sources should be utilized, what are the requirements to become a learning organization, what kind of outputs can be derived as a result of OL, what are the advantages of being a learning company, what are the barriers preventing to learn as an organization or most importantly why should companies learn.

Robey et al. (2000) define OL as an intentional and unintentional organizational process, which enables the acquisition of, access to and revision of OM and finally guides to organizational action. Assuming the logic behind this definition, an OL framework is formed. Figure 3.1 illustrates the components of this cyclic learning process where OM is created through acquiring knowledge from three main sources and then utilized to give strategic decisions and by the revision of new ideas learning becomes a continuous activity.

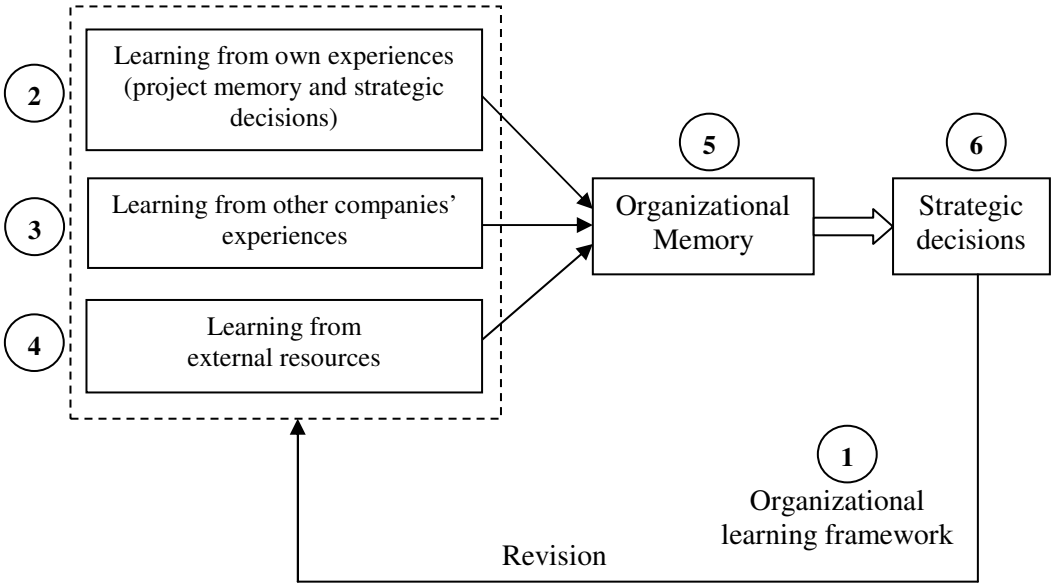

Figure 3.1. OL framework

The main idea behind this framework is that construction companies not only learn from their own experiences but also from other companies' experiences and external sources. As mentioned in the previous chapter, although some researchers identify two sources of knowledge as own experiences and industry experiences (Ingram and Baum, 1997 cited in Hong, 1999), external archives as referred by Walsh and Ungson (1991 cited in Lehner and Maier, 2000) contribute to the learning sources that are named as external sources in this study.

In general, the term memory may be explained as a system capable of storing things perceived or experienced and then retrieving them at a later point in time. OM is created by the interpretation of acquired knowledge within the organization, integration of this knowledge to daily activities and institutionalizing it to obtain a corporate asset. This valuable asset is utilized when companies are to make strategic decisions. The output of strategic decisions is new insights and ideas that can be converted to knowledge that can

be a component of the OM. These new ideas take part in this framework by revision and processing like other acquired knowledge.

In the context of this research study, the main objective is to find out how construction companies create their OM and how they exploit this corporate asset in the strategic decision-making process. Construction companies consciously or unconsciously transfer some of the employees' individual learning into OL and they obtain a common understanding of perceiving the problems and they begin to behave in the same manner. They make decisions based on a shared asset namely the OM. In order to reveal the facts of the construction industry in terms of OM, an interview study is carried out with large Turkish construction companies. The following paragraphs discuss the administration and content of the interviews in detail.

3.1. Administration of Interviews

This research consists of a set of face-to-face interviews carried out in the companies with the respondents at the managerial level. Each interview took about 1 ½ hour. There are eight large construction companies participated in this study, all of which are the members of the Turkish Contractors Association (TCA). In accordance with the general OL framework, the interview has been established covering each topic with several questions. After presenting the main idea behind the preparation of this framework to the managers and giving basic definitions on OL and OM, the aim of the research is explained and the company representatives are requested to state their ideas on the subjects and explain the company behaviors towards the creation and utilization of OM.

3.2. Content of the Interview

The respondents are given a Table of Contents on which the subject headings are listed. A sample of the interview can be found in Appendix A. The interview has eight topics and each is examined in below paragraphs.

3.2.1. General Information About the Company

Respondents are asked to state for how many years they have been in the construction sector, the total turnover of domestic and overseas jobs undertaken so far, the annual turnovers of the company for domestic and overseas projects for the last 5 years, how frequently they form Joint Ventures (JV) with domestic and foreign partners and the other industries related/unrelated to construction that they have been working actively. The main goal of asking the company information was to generate a profile of the respondent companies whose ideas were asked about the research topic. It may be considered that as organizations age and grow in size they may become more passive in learning due to their developed memories. Moreover, companies that form partnerships are assumed to learn more than the others. Sector facts on all these points about their influence on OL are revealed in the research findings chapter.

3.2.2. Learning From Own Experiences of the Company

Since the unit of work performed in the construction industry is project, companies mainly learn from the projects they have undertaken or projects that are planned to be undertaken or parties involved in these projects. Learning from own experiences may be considered as the most frequently referred source in the OL process as individuals have the chance to experience different conditions, correct their mistakes, encounter several problems and observe the methods of different people and obtain perspectives of others when they have an active role in a project.

Learning from own experiences of the company is converted to OM through two groups; being the project memory and knowledge gained through strategic decisions. These two branches are improved and strengthened as more projects are done and more strategic decisions are made. Finally the accumulated knowledge forms an important component of the OM. Under this dominant learning source heading, there are 3 main areas to be highlighted. The first one is about types of information that companies store as the project information and

strategic information. Project information refers to the data related to previously undertaken projects (about the method of work, parties involved in the project and market) and strategic information includes records on potential projects, markets or company performance (rival company information and environmental scanning about the market). The managers are also asked how they store the collected data namely in computer or in individuals' minds. The second question was related to the data collection and documentation methods employed by the companies. The respondents were allowed to state the mechanism they adopt and they were offered 6 additional documentation methods to state their ideas about. These methods can be grouped into two for the creation of project memory and for the documentation of the results of strategic decisions.

3.2.2.1. Learning Mechanisms for Project Memory

The concept of project memory originates from the concept of OM that is used to define the knowledge present in an organization and the processes by which this knowledge is managed (Kasvi et al cited in Walsh and Ungson, 1991). Documentation-based methods focus on representation of the experiences and the storage of contents within the organization and in order to create the organization's project memory. Schindler and Eppler (2003) offer 4 documentation-based methods that are explained in detail as follows:

- *Project evaluation* is the process of documentation of project experiences during or at the end of the project.

- *Micro articles* can be defined as a method to store experiences of people after completion of a project involving the cause-effect relations and solutions to problems and keywords related to the topic. This knowledge is then transferred into databases and shared through the intranets.

- *Learning histories* cover the chronological progress, actions taken and results of the decisions in a 20 to 100-page report written by one person by making references to other project members' experiences. This concept was first

developed in the US at the MIT Center for OL and the process entails project debrief interviews with participants and a qualitative data analysis of their project experiences leading to process improvement on the basis of the lessons learnt (Jeffries et al., 2003).

- *Formation of case bases using computer programs* means that experiences of each employee participated in a project are collected in the same system. Formation of case bases related to project's critical success factors, results or productivity and performance values are the examples of this method.

3.2.2.2. Methods to Store the Consequences of Strategic Decisions

Decision-making can be of a long-term strategic nature, such as analyzing event patterns over several years to prevent or reduce the rate of occurrence of a particular event or it may be short-term and tactical in nature, such as reviewing and changing the time schedule for a particular part of a project (Chua et al., 2002). Process-based methods stress the relevant steps and their sequence in course of a project's time line (Schindler and Eppler, 2003). Related to the research questions there are two types of process-based methods defined by Schindler and Eppler (2003) as;

- *Post-project appraisal* is a documentation method performed by external post-project appraisal unit two years after project completion that covers all project information (market, project parties, etc.) and results of strategic decisions to learn from mistakes and transfer knowledge.

- *After action review* is a collection and storage mechanism performed after each decision stage that covers the answers to questions like "what was supposed to happen", "what actually happened", "why were there differences" and "what can you learn from this experience".

3.2.3. Learning From the Experiences of Other Companies

Although learning from own experiences is regarded as the major source of the OM, other companies' experiences have an intense influence on the organization since different people, their styles, cultural aspects, their shared values and common perceptions teach many new ideas and help them gain different perspectives. In this respect, the company managers are asked if they believe the other companies' experiences may be learning sources for them, how they increase their learning potential from this source and how they collect, store and share knowledge acquired through this means. The interview contains questions concerning the competitors, benchmarking opportunities, foreign companies, JV partners and companies that function out of the construction sector.

3.2.4. Learning From External Sources

Knowledge domains exist both internal and external to the organization. Each structure within an organization ultimately draws knowledge, either directly or indirectly, from the various knowledge domains. The last resource contributing to OL of a company in the way to construct its memory is the external learning sources. These sources are the ones, which are unrelated to the projects that construction companies perform, or the parties they cooperate with or the companies operating in (out of) the construction industry. The company managers are given a list of the external resources to learn from; such as universities, advisor companies, governmental or foreign bodies that are not clients, etc. The respondents are asked to tell whether they utilize these sources or not and how they store this information and avoid losing it. This knowledge may be gathered in a computer-based environment and shared among other people through the intranet or it may remain in the individuals' minds and it does only have the opportunity to be shared among other people through informal meetings.

3.2.5. Organizational Memory

Hansen et al. (1999) described two basic strategies for knowledge management being personalization and codification. Codification is about capturing and archiving knowledge whereas personalization strategy focuses on facilitating interpersonal communications, improving retention or possibly improving the organization's ability to locate and hire people with specialized knowledge. An organization's memory resides in the minds of its employees and besides it is stored in repositories such as computer databases (Cross and Baird, 2000). While individual knowledge is an important part of OM it is always at risk of being lost. Employee turnover endangers OM since people take what they know with them. So, the transferability of knowledge is shaped by the degree to which it can be codified (structured according to a set of easily communicated rule) (Barlow, 2000).

As mentioned before, construction companies can forge their OM by means of 3 main sources. The knowledge acquired through these sources is captured within the company in two types being explicit (codified) and tacit. Explicit knowledge can be accessed by company members easily since it becomes a corporate asset by being stored in a computer-based environment. The tacit knowledge is hidden in the beliefs, perceptions, norms and actions of individuals and requires to be transferred to explicit knowledge in order to be beneficial for the whole company.

This topic consists of questions regarding the contribution of the learning sources to the company's memory and the percent distribution of knowledge types according to how they are accumulated in the company.

3.2.6. Exploitation of Organizational Memory in Strategic Decision-Making

Fiol and Lyles (1985) state that learning includes the development of insights, associations and conclusions about the effectiveness of past actions and their influence on future actions (cited in Love, 1999). OM enables organizations to

quickly respond to crisis and make efficient and effective adjustment to the conflicting requirements of the environments.

Similar to other companies in other industries, construction companies have also the common goals to take jobs and make profit. Since the central objective is to earn money through the projects, construction companies concern the profitability of any decision to be made. Strategic problems deal with the determination of an organization's purpose, goals, and direction, the fit or alignment between the organization and its environment and the organization as a whole (Berthon et al., 2001). Due to the unique nature of each construction process, inherent uncertainties and incomplete scope definition, it is almost impossible to have all the needed information at the time of decision-making and mostly decision problems are solved by expert judgment (Ahmad, 1990). The strategic decisions such as entering international markets, entering new markets related/unrelated to construction sector, selection of JV partners, preparation of bids, restructuring of the company or making new investment are all twofold having outputs as profit or nonprofit. So, companies should be aware of the fact that strategic decision-making process necessitates furthest attention. At this point, DSSs assist decision makers in combining analytical methods with subjective knowledge of experts. This allows users to incorporate the knowledge, expertise and judgment to explicit decision-making process, which converts data to information (Ahmad, 1990).

What is proposed in this study is that OM is a precious asset that must be built and exploited in order to give more trustworthy decisions at the corporate level and enhancing the codified component of the memory will bring more benefit to aid strategic decision-making with DSSs. This section of the interview covers questions on the importance of possessing codified knowledge to make decisions, how frequently the company refers to its codified knowledge when it is making strategic decisions, how useful would be the existence of a computer program (DSS) to assist the company's decisions, which they should answer in a 1-5 Likert scale and whether they have been using a DSS in the company or not.

3.2.7. Evaluation of the Company in Terms of Organizational Learning Competence

A company is considered to have high organizational competence if it is good at acquiring, storing and sharing mechanisms to construct its memory and manage utilizing this asset in strategic decision-making process and explore new insights from the outcomes of these decisions. Besides acquiring knowledge it is more important to distribute it among the employees. For example an employee may deposit information into a database to be used elsewhere in the organization when needed and this information can be shared via internal networks such as an intranet designed to facilitate communication within the organization. In addition to this, OM needs to be continuously updated and refreshed since the validity and value of information may change rapidly.

In this standpoint, the companies are asked to state how important they perceive the knowledge management activities and how successfully they implement these functions. Besides, they are required to evaluate themselves in terms of OL competence in a 1-5 Likert scale. The importance of knowledge activities and their success levels are also answered in a 1-5 scale where 1 contributes to “very low”, 2 is equivalent to “low”, 3 means “medium”, 4 is “high” and 5 shows “very high”.

3.2.8. Organizational Learning Barriers

The aim of this part is to reveal the facts about the factors preventing individual knowledge to become a corporate asset. Although OL is accepted to be necessary and critical concept for the survival of the companies, due to some reasons, OM creation is not at the desired level in most firms.

In literature some authors mention the existence of some enablers and barriers to capture and diffuse knowledge. According to Bresnen et al. (2003) organizational structure effects, cultural context and the climate for change, skills and capabilities, communications, networks and information flows, technological

mechanisms and objectives are the influential parameters for OL. Another implication of the difficulty of embedding knowledge is that success depends considerably upon interpersonal and societal facets rather than technological or procedural mechanisms (Hansen et al, 1999).

To find out the dominant barriers to OL, the company managers are asked to list why they are not fully performing the requirements of OL and the causes of deficiencies to structure the OM. The respondents are inquired to state whether the listed factors are the key players disabling the learning activities and how important these parameters are for the OL competence. Some of the listed barriers were the cultural factors, unsupportive nature of the industry, lack of resources and lack of consciousness.

What should be derived in the light of this interview study is a general view about the perceptions of construction companies on OL and OM topics, the mechanisms employed to create their memories and how they make use of this asset in decision-making stage. In the context of this survey, major resources and methods of knowledge acquisition and storage are investigated, managers' ideas on the benefits brought by the exploitation of OM are questioned and barriers to OL are tried to be identified.

Findings of the interviews are presented in the following chapter as case studies of 8 companies reflecting the general opinions on the research topics.

CHAPTER 4

RESEARCH FINDINGS

In this chapter, answers of the respondent companies are evaluated. Results of the interviews are presented as case studies since it would be misleading to generalize some perceptions and applications about OM due to the characteristics, visions, cultures and opportunities of each company.

4.1. General Information About the Companies

The following paragraphs will give the profiles of the firms for which some trends, ideas and surprising or attracting points are identified as an objective of this research study. As indicated in Table 4.1, the age of the respondent companies range between 22 and 45 and titles of the interviewees are also given on the table.

Table 4.1. Respondent companies involved in the interviews

Company	Age	Title of the interviewee
A	43	Project manager
B	45	Assistant general manager
C	27	Business development manager
D	35	Architect: Bid preparation department
E	36	Business development manager
F	36	Business development manager
G	22	Deputy general manager
H	35	Business development manager

Company A, which has been active in construction sector for 43 years, has gained a considerable experience and reputation not only in construction business but also in other sectors such as tourism, energy and international commerce. Company's domestic and overseas turnovers realized so far are stated as 2.24 billion USD and 1.39 billion USD respectively. Considering the turnovers of the undertaken jobs, Company A has worked with domestic partners usually and with foreign partners sometimes. For over 20 years, the company has participated in major Build-Operate-Transfer projects in Turkey as a business developer and investor. The company is certified by ISO 9001 Quality, ISO 14001 Environmental Protection and OHSAS 18001 Occupational Health and Safety Management system Standards. Being one of the most successful construction companies in Turkey, Company A was considered to have a positive climate about learning practices and their project manager participated in the interview to give detailed information.

Company B, as the oldest among eight organizations, was founded as a partnership in 1958 by three entrepreneurs and for 45 years has an objective for its name to be perceived as identical as quality and trust in its Clients' opinion. Following the accelerated infrastructural investments in Turkey, the company is today a holding with more than 15 affiliates and 5000 employees. The company has vast experience in the turnkey projects in a wide variety of fields from tunnels to thermal power plants, rail transportation systems, dams, pipelines, ports, highways and natural gas. During its life of 45 years, Company B has extended its activities from construction to energy, tourism and insurance. Having performed only domestic projects of a total turnover of 2.45 billion USD the firm has realized an annual average turnover of 110 million USD in the last 5 years. It should be noted that the company has formed partnerships with the both domestic and foreign partners usually as the turnovers are concerned. Regarding the most important component of success of a project as the human influence, Company B has the mission to increase the quality of human life by uniting the devoted efforts of its experienced personnel, to recreate the nature by reflecting

the effect of every suitable technological development and innovation on its know-how and to present the outcome to the service of humanity. The firm has been certified by ISO 9001 as an indicator of the quality standards of the company's management system. To share the company's attitude toward OL concept and answer the related questions, the Assistant General Manager has been involved in the interview study.

Company C, which was established in 1976 holds a strong position in Turkish construction market with its experience in mainly installation projects of plants and steel constructions in addition to recent works such as dams, irrigation plants, highways, pipelines and turnkey factory projects. The total turnover of domestic projects has reached 1.6 billion USD. The international projects are not dominant as it can be observed in the annual average turnover value being only 17 million USD. The company's most powerful assets can be considered as its qualified workforce, national and international partnerships, and exploitation of technological and managerial opportunities. Being also active in tourism and energy sectors, Company C has high contributions to Turkish economy and with its 5000 employees is in line with the latest developments. The firm is certified by ISO 9001 and OHSAS 18001 and is very neat about the requirements and procedures of these quality standards. The Business Development Manager has explained the perceptions of his company on OM.

Company D beginning from its establishment in 1969, has gained a reputable position in the mass housing market by the realization of over 50 000 residences. Besides the construction of exclusive building the group companies are responsible for planning, design, construction and at the same time manufacturing the building components. Looking at the realized turnovers, the firm is the last among the other seven companies. It has performed at total of 200 million USD worth domestic projects and 100 million USD overseas projects so far. Company D has extended its scope of services by making investments in tourism, shopping centers and health sector. The firm draws strength from its past successes and aims to sustain its competitiveness both in domestic and

international markets. The management system is certified by ISO 9001, ISO 14001 and OHSAS 18001. In company D, an architect of the bid preparation department has answered the interview questions and explained the procedures and standpoint of his company.

Company E has become a holding organization by a continuous growth since its establishment in 1967. The firm has undertaken civil engineering jobs in several fields such as housing projects, military, industrial and housing projects both in Turkey and overseas. The firm covers all phases of a project including feasibility and environmental studies, planning and preliminary design, procurement and construction. The construction projects has reached a total amount of 1.25 billion UDS in domestic jobs and 800 million USD for overseas works that contribute to annual average turnover value of 100 million USD of which the domestic projects have 80 % contribution. Apart from construction business, the firm has extended its field of interest to other sectors such as machinery manufacturing, tourism, marketing, insurance, energy, shoe production and electronics. The management system of the firm is certified by ISO 9001, ISO 14001 and OHSAS 18001 which bring standards to daily activities and additional requirements for both processing and documentation of the projects. Being fully aware of the competitive edge provided by a vision to enhance learning competence, the Business Development Manager tried to express the learning environment within the company and their efforts to apply new systems.

Company F was established 36 years ago and has accomplished major projects in domestic and overseas markets. The firm has benefited from the alliances formed with local and international organizations in terms of collaborative working and entering new foreign markets. The company facts reveal that it has worked with national and international partners frequently. The group companies have shown great effort against the difficulties of the local market conditions during the recession periods and tried to exploit business opportunities in foreign markets. The turnover of 860 million USD for the domestic projects is followed by an amount of 430 million USD for international projects. In addition to construction

being the core activity area, the other companies are active in fields such a tourism, food, defense, energy and health. The main principle of Company F is to produce the products and services at high quality standards with unconditional customer satisfaction objective and more economically than its competitors. A new perspective is acquired through the certification by ISO 9001, ISO 14001 and OHSAS 18001 and this led the company much more systematize its processes. The Business Development Manager of the company has shared his ideas on the OL framework and answered the related questions.

Company G is the youngest firm among the others. It is incorporated as a private entity under its own law subject to Turkish civil and commercial codes. The company provides its members with social benefits such as loans and retirement income systems. Being active in the construction sector for 22 years, Company G is in the way to become one of the strongest construction companies in the domestic market jobs undertaken for the Armed Forces Pension Fund. The turnover values realized so far for domestic and recently started overseas projects are observed as 481 million USD and 26.3 million USD respectively. The domestic jobs are never performed with partners whereas for the international projects partnerships were established sometimes. The group companies are also operating in several sectors such as finance, automotive, cement production and food-chemicals. ISO 9001 and OHSAS 18001 have certified the quality management system of the company. Following the structuring of the company, in the last two years there are considerable improvements both in the way of perceiving the environment and also the way of performing the jobs. The views of Company G are obtained by talking to its Deputy General Manager.

Company H, which has been in the construction sector for 35 years, has been known for creating resources for a university. The firm's major aim is to achieve customer satisfaction through continuous improvement. Regarding its employees as the most important resources, the company tries to increase employee productivity to ensure quality by considering competition, efficiency and profitability. Company G, as an endowment of the university, undertakes turnkey

projects in Turkey and overseas by using latest technology and covers all project stages from design to construction and operation. The firm's domestic turnover has reached 1.2 billion USD while its overseas amount is realized as 800 million USD. Considering the last 5 years the annual average turnover of the company in domestic markets is observed as 400 million USD, on the other hand the international projects provide an average of 200 million USD turnover annually. During the project lives, the firm works with national and international partners sometimes. Apart from construction business, Company G also diversified its interest field by producing construction materials and furniture, investing in tourism, security and software sectors. Since the company concerns competitiveness and continuous improvement as significant parameters for sustainable success, it offers a learning environment within the organization. In Company G, the Business Development Manager has responded to the interview questions.

4.2. Learning From Own Experiences of the Company

As construction companies mainly learn from the projects they undertake, learning from own experiences should be examined in more detail compared to other learning sources. The following paragraphs explore how the respondent companies learn from their experiences, which methods they adopt to collect and store necessary information. There are two headings one of which mentions what kind of knowledge is acquired through own experiences and the other discusses the knowledge collection and storage mechanisms.

4.2.1. Knowledge Acquired Through Company's Own Experiences

As previously mentioned, the most frequently utilized learning source of construction companies are their own experiences consisting of the project memory created during and after the realization of a project and the strategic information acquired through the decisions made for future projects or the markets that are planned to be entered. In this section the companies are asked to

tell which kind of data they collect after project completion and how they store them in order not to lose.

It is observed that all companies are aware of the fact that storage of previous project information and the results of strategic decisions will be helpful for the forthcoming projects. As far as the competitive construction environment is concerned, each company should follow both its internal processes and also scan the exterior environment for potential projects and markets. Firms are obliged to collect and store project information as a requirement of ISO 9001 Standards. The quality management systems are forced to document some specified data for a certain period of time. What is common for all companies is the preparation of prequalification files, tender files and project progress reports on daily, weekly and monthly basis.

Company A, as all the others, collects all kinds of information related to the project memory as a requirement of ISO 9001. They store information related to parties involved in a project (client and subcontractor) in computer-based environment since they think these are valuable for the future projects. On the other hand information regarding the performance of the job such as productivity data (man-hours), methods applied for that project and unit costs may be found either as hard or soft copy. Similarly, the information on market where the project was undertaken such as the construction demand, country risk level or success criteria for that market are kept in partially computer-based environment. In addition to project information, strategic information related to market scanning and company performance according to the success criteria are found in the archives of the company in computer-based environment whereas search results of competitor companies are deposited in individuals' minds.

Company B collects each necessary data and store both project and strategic information in computer-based environment as a must of their quality management principles. There is one important point to be noted that since they subcontract all their jobs, the related data are collected and stored by the

subcontractors. Only the client information and company performance according to the success criteria in a specific market remain as individual learning. They report the daily progress of the projects and monthly activity reports are prepared for both themselves and the clients.

The respondent of the firm expresses his view on data collection and information storage as *"…I have always been against collection of project data since each project is unique and we do not need the previous information to perform a new job"*, he believes that technical information should not be stored because its costs are higher than the benefits. He continues as *"…now we have used the past data about Project X for Project Y but we could have done the job without referring to these information"*. As obvious, although the managers oppose the creation of project memory, it is a necessary asset for a company to perform its future projects. Company B has adopted an attitude to store strategic information in the database, as they believe these are valuable signs and create competitiveness for taking jobs. They have a subsidiary company abroad undertaking the international projects, which have the environmental scanning results, information on material costs, local companies, host country's political view and country's economic profile.

Company C, where OL practices are tried to be adopted, is very careful about the collection and documentation of project and strategic information for project progress follow-up and determination of new markets for potential projects. This firm is experienced in preparation of prequalification and tender files as a necessity to take part in awards. The project related information is kept in computer environment as a requirement of ISO 9001. The Business Development Manager tells that especially for the projects undertaken abroad, by the help and compulsion of the JV partners they have set systematic documentation and the central office is informed about the project progress via e-mails including excel files prepared by the site engineers. The information flow provides the managers at the office learn about the project and take an action when necessary. There is a detailed analysis of the environment before deciding

to enter an international market. The documents about a foreign market generally include the host country's political view, cultural relations between the countries, previous experiences of other Turkish firms in that market, host country's economic profile, tax laws and construction demand. Outcomes of strategic investigations for potential projects and markets are stored in the database of the company to be benefited by the upper level managers to make decisions in the future. The respondent stresses an interesting point about decision-making for a new project as *"…sometimes all data may tell you to take that job, everything may be positive about that project but when you meet the client face-to-face, your intuition says: you cannot work with this person or in spite of all negative indicators about a project, it may seem to be so attractive for you that you may decide to bid for that project"*.

Company D as one of the principal companies in mass housing sector, is known for the innovative framework applications. Since the firm is the leader in its market, it tries to follow the recent developments in global markets and control the other Turkish competitors at the same time feeling responsible for proper application of the new technique offered by them. The organization finds it very important to collect and store project related information, as these are so useful for determining bid prices of similar projects. The architect who participated to the interview as respondent from Company D points to the obligations brought by ISO 9001 standards, he says that *"…thanks to ISO standards, our documentation system has become much more improved"* which emphasizes the importance of being certified by Quality Standards. In the company, project related information is stored in the databases except the market related features that are found partially computer-based. Since contracts are awarded according to the lowest bid, all firms are seeking ways to decrease the bid mark-ups to take jobs. Managers of Company D believe that in order to give lower prices than rival companies, they should not only keep record of their data but also the other companies should be followed. When searching new opportunities in new markets, the company makes an environmental scanning and evaluates its

performance, then stores this information in the database. In potential markets competitors are also analyzed and related documents can be found either as hard or soft copies.

Company E pays attention to information flow about the ongoing projects and exploits the advantages offered by technological tools. The firm follows overseas turnkey projects on Primavera Project Planner to see the progress of the job and the financial situation. In Turkey only the financial progress of the projects is followed. After project completion the documents associated with the performance of the job may be found in paper-based or computer-based environment. Market information remains as individual experience but information on parties involved in the project is strictly transferred to computer. The Business Development Manager notes that when they worked in a project with an international JV partner, they have exploited from their experience in terms of documentation methods and analysis of previously stored information. At the end of each award a list including the winner, order of other bidders and the bid price is obtained. This report is transmitted to the general manager, business development manager and an analysis is carried out to find the advantages of the winning company (tax advantage, cheap workmanship or sacrifice from the profit) and they question the ways to decrease the bid markup for the next similar job. These may be present on paper or become a part of personal experience only. They have a program, for the access of business development department only, in the hardware where updated information is accumulated continuously about the potential projects including host country information, their laws and regulations and economic situation. As a common view of all organizations, the strategic information is not accessible to everyone since it is assumed to be confidential, only the business development and general management can see the records.

Company F is one of the most successful companies in terms of data collection, project follow-up, strategic search and documentation of this information. Like all other companies, the firm prepares prequalification and tender files and is

very careful about the planning and control of process flows as stated in ISO Standards. Other than the market-related information all kind of data that may constitute the project memory is deposited in the databases of the company. The market information is also strictly documented but this is stored partially in computer-based environment. The Business Development Manager of the company is frequently abroad and makes environmental scanning for new markets and projects. Host country's political view, cultural relations, previous experiences of other Turkish firms, country's economic profile, tax laws, construction demand and potential projects are investigated. The country reports also cover information on potential rivals and subcontractors. The similar projects performed by competitors, the experienced employees of that competitor are analyzed; success criteria are tried to be explored. The company seriously focuses on the subcontractors, which may be beneficial also for their subsidiaries. As long as the significance of strategic surveys in overseas markets is concerned, the related documents are reported to the Board of Directors to be evaluated and stored partially in computers and partially on paper for future reference. The respondent believes that there are more important parameters for bidding for a job other than concrete indicators. He tells that *"…the company owner may invest in the project just because of his own wish or he may offer a bid price of 3 for a job that certainly costs more than 5"*.

Company G has some surprising answers about the creation of OM since restructuring of the organization is a current issue. Until the last two years, no project information was kept in the archives of the firm because they have performed all their jobs on a cost plus fixed fee basis. They have not encountered any problems as there was a profit for each project. For the last 1 year, the firm has been taking jobs with different contract types and it has become mandatory to take records of the projects performed on a monthly basis as stated by the quality management principles. These records are useful for tender preparation for future projects. Unfortunately, the company has not achieved to store project information fully in computer environment. Market information are tried to be

kept in computer but the performance indicators and information on parties involved in projects remain as individual learning. The Deputy General Manager states that they are in the right way and will systematize the documentation business in a short period of time. They have an intense intention to employ mechanisms to store project and strategic information but they have not got such a system. Before entering a new market, they analyze both the host country's parameters and the project specific characteristics. It is assumed as an integral part of the quality system of the company.

Company H, which performs all sub processes related to an ongoing project, charges its own team for knowledge creation involving data collection, information storage in databases and knowledge sharing among other employees by exploitation of IS. The firm's project memory is formed partially in computer environment as they think that not every type of information can be transferred to computers by codification. They try to document all project related information either on paper or they store in the databases. The project completion report, which contains technical and financial information, is prepared by the project team and is given only to related people since some information is confidential. They have a subcontractor database where information belonging to all subcontractors they have cooperated. The strategic information is collected neatly and stored similarly as in case of project information.

4.2.2. Knowledge Collection and Storage Mechanisms

As previously mentioned, there are six mechanisms to store the experiences of a construction company that are composed of four documentation-based and two process-based methods. When the overall frequency of utilization of these mechanisms is sought, it is seen that firms mostly performs Project Evaluation among the other five methods. It is also observed that none of the respondents have Learning Histories and Case Bases in their databases. Since these methods are assumed to be more theoretical and difficult to implement in construction

industry, the results were expected. What is more interesting is that Companies B, C, G and H do not employ any of these methods, which corresponds to half of the respondents. Micro Articles are prepared only in one firm and Post Project Appraisal is a method only present again in one company. The frequency of accomplishing After Action Reviews is two out of eight companies as it was a probable result. These consequences can also be found on Table 4.2. The following paragraphs give details about the procedures and methods adopted by each company.

Table 4.2. Utilization frequencies of knowledge collection and storage mechanisms

	Method	**Utilization frequency**
Documentation-based methods	Project Evaluation	4
	Micro articles	1
	Learning histories	-
	Formation of case bases	-
Process-based methods	Post project appraisal	1
	After action review	2

Company A is among the respondents that carry out Project Evaluation by its engineers who were active in a project. The reports are prepared by the project manager and the project team and the output is a document of about 100 pages covering the whole project information (man-hours, methods used, cost analyses, etc.). The reports are kept as both soft and hard copies in the archives and database. With some of the features, this method has some similarities with Learning Histories also. The firm does not find it necessary to analyze a project that was completed 2 years ago so Post Project Appraisal is not implemented. The project managers tells that *"…we really do not have the opportunity to go back 2 or 3 years, instead reports are prepared when necessary, this may be a month after the project completion or even 5 years later"*. As understood from the rest of the conversation, Micro Articles, Formation of Case Bases and After Action Review are not among the mechanisms applied by Company A.

Company B illustrates the most remarkable case within the eight organizations. Despite the likely view about learning competence due to its success and corporate atmosphere, it is upsetting to observe that a knowledge management vision could not be built in such a large firm. The reason for this is explained by the Assistant General Manager of the company as undertaking the projects through the subcontractors. So, the work experience is obtained by the subcontractors, the documentations are under their responsibilities and Company B does not accept evaluation or assessment of past projects as necessary activities. In short, none of the document or process-based methods is adopted in the firm as knowledge storage mechanisms. It can be stated that none of the suggested storage mechanisms is implemented in Company C, but there are similar applications. Analysis and evaluations of previously undertaken projects are done when it is decided to be necessary to take an action. The prepared reports for projects may not be as long as 100 pages like in case of Learning Histories but shorter documents are always found in the archives. There exists no method to prepare documents as systematic as Micro Articles; Formation of Case Bases in computer environment is not either a familiar approach for Company C. They think that they do not have enough opportunity to go back years before and spend time to assess a past project. They cannot also review the actions taken in a project to learn lessons and transfer this knowledge to other employees in the organization.

Company D, where the positive influence of the obligations brought by ISO Standards is clearly observed, exploits the advantages of databases and intranets to store and share all kind of project data, news and progress of ongoing works. Monthly progress of a project is reported to the central office covering information on materials, economic events and the agreements. In addition, if needed the central office may ask for the site book for a specific job. For each job, feasibility reports are prepared and evaluation of the past experiences in terms of costs and performance is done by the participation of both technical office and research and consulting group. In this respect this activity may be

assumed to be Project Evaluation. As a very cautious organization about the storage and sharing of information, the company has a system created under ORACLE for integration of accounting and construction and there is a recent development about utilization of a new software package which serves all employees to save and share project information. The firm does not produce long reports like Learning Histories; instead shorter documents including construction, mechanical and instrumentation progress are prepared. Company D shares the same idea with Company A on Post Project Appraisal and does not believe in the necessity to go back to 2 years before to evaluate a project. The respondent of the company says that when needed there has to be reassessment about past projects.

Company E stresses on the importance of experiences gained through the JV partners. According to what the Business Development Manager of the organization has told, when they had worked with a foreign company there had been a study for Post Project Evaluation. He says that *"…we have lots to learn from the foreign companies, they are far ahead of us in some aspects"*. Although the company does not prepare Learning Histories of 20-100 pages, during and after completion of projects they document the progresses regularly. It should also be noted that the other methods are not employed in the company but the respondent confesses this by saying *"…unfortunately"*.

Company F should be considered as the most willing and successful one among the others in terms of information flow within the organization. The firm utilizes three out of six proposed mechanisms to store knowledge. Learning Histories, Case Bases and Post Project Appraisal are not the methods adopted by the company. Project Evaluation is carried out by the engineers who were active in that project, the reports are based on the requirements, drawings, geological test results of the client and consultant, additionally the extra works required from the contractor can also be found on the both soft and hard copy documents. Micro Articles involve information about the performance of the subcontractors, partners, material suppliers and content of the project and these are about 1 page

and stored in the computer. Since Learning Histories are complicated and long for them, shorter reports are preferred. In the company, project files are prepared but not stored in computers in the form of Case Bases since access is not desired for security reasons (success and failures are not desired to be known by everyone). After the project completion, key personnel (managers, quality control, safety engineers, site engineers) prepare a report on the methodology of the project (in terms of profitability, productivity, duration), then this report is distributed to other groups and discussed and if necessary it is reviewed to get prepared for the next project and to prepare bids. In this respect this is similar to Post Project Appraisal but not completely. Instead reports are prepared following a shorter period after project completion and they involve information about the cooperated parties, methods and costs of the projects. After Action Reviews are performed and reported by the tender group and design group, if there are some mistakes during the projects, causes of them are investigated. The firm has a very advanced network but access is allowed to only authorized people.

Company G, in spite of the fact that there exists no documentation mechanism, pays attention to sharing of information. Outlook is a network system from which only authorized people can benefit (general manager, deputy general manager, tendering manager, business development manager, etc.). Under the task item, there are folders, which include files for each country and the projects that are being interested in those countries. The sub files contain project risk analysis (for each project there is an attractiveness score which should be higher than 50), project information sheet, progresses of the project (even the phone calls are recorded), reports including the travels to the related countries). Each employee has to report his experiences about that job and this is shared through upper level managers via intranet.

Company H is one of the four companies that do not implement the proposed documentation-based and process-based methods. In this organization, project completion report is given only to related people since some information is confidential. The report contains financial and technical information. This is not

frequently overviewed but the necessary information is searched when needed. There is intranet that includes quality system information, news about the company and phonebook. The documentation center has a search engine but the project completion report cannot be accessed from this center by the employees.

4.3. Learning From Other Companies' Experiences

Construction companies do not only learn from the projects they have undertaken. Certainly, there are many important lessons to be captured from the other companies. This learning group is assumed to consist of the competitor firms in the market, the foreign construction companies that may be taken as models, the JV partners and the firms that operate in sectors other than construction industry. When the overall picture is taken into account, it can be stated that construction companies always follow the experiences of their competitors and they attempt to learn from the JV partners when they cooperate in a project. Learning does not take place in a very systematic way; benchmarking is not a familiar notion for them. Instead, the companies' major aim is to compensate for their lacks when they need expertise in a specific job. Collaboration for learning generally occurs when construction companies needs another party else to perform a piece of the project.

Company A seriously follows the bid prices offered by their competitors from the awards. The Official Gazette and some weekly magazines that announce the investment projects are the main sources referred to learn about the market news. They do not employ a specific method to learn from the competitors other than their performance in the awards. They try to catch the global developments in the construction industry from the international periodicals where they find news about the foreign companies' experiences. The project manager of Company A notes that foreign JV partners are real learning sources in terms of methodology, quality control, health and safety issues. Unfortunately the knowledge transfer between domestic partners remains as discussions. Out of sector companies are not regarded as sources to capture knowledge by this firm. The knowledge

acquired through these sources are transferred to related departments and not shared among all employees.

Similar to other respondents, Company B also tracks the competitors' experiences in the awards. They do not utilize any source to learn about the bids because the Assistant General Manager says, *"…these are known to everyone, no need to follow any other source"*. The company does not have any idea about benchmarking either. As the overall attitude of the company is analyzed, it is observed that there is not a positive climate or intention to learn from other companies. They believe it is unnecessary to follow foreign companies or the firms in other sectors, since they perform each job by subcontracting. It should be stated that the answers of the respondent were expected because they do not have a culture that allows the creation of a learning environment as it is clearly understood from the manager's first words in the interview *"…there exists no OM in the construction firms"*.

Being an enthusiastic organization to learn, Company C has efforts to increase its learning potential and utilizes each and every source available to her. They learn about the competitors through the authority, web pages and TCA publications. They learn from the competitors' experiences through employees of those firms and going directly to their construction sites. Company C is among two firms that adopt benchmarking to compare construction processes with other companies. They also follow the foreign companies via Internet. They gain different perspectives with the help of JV partners; as the Business Development Manager underlines *"…they are knowledge agents through whom we learn about construction methods, market information and relations with other parties"*. Since the company has investments in tourism sectors, they believe that the company has learnt about marketing from the tourism industry. Although knowledge acquisition and utilization is satisfactory in the firm, they are very good at sharing knowledge between other employees. What is learnt is transferred to related departments and is integrated to the activities through these channels.

Considering the competitive environment each firm has to keep track of the performances of their competitors. Company D also learns the unit prices offered by their rivals from the Official Gazette and the journals. As their architect says, *"…the subcontractors give limited information about other companies and their products are clear clues for their working styles"*. Although they do not benchmark from others, they follow each company in their market segment, as they believe they are responsible for the proper application of methods first adopted by them in Turkey. They widely use the Internet to follow the potential rivals for international projects and to establish relations in commercial aspect. As the respondent tells *"…the JV partners experienced in others sectors like tourism sometimes create new investment areas for them, they may continue to cooperate in other markets with the same partner"*. Company D investigates the knowledge sources in other sectors to learn about the material properties and customer profiles since their main objective is to satisfy their customers with their end products and services. This firm should be appreciated for its efforts to implement information systems to store, share and utilize knowledge in order to integrate all the processes carried out in the organization. The respondent of the firm believes that this is a consequence of ISO Standards that require strict improvements in terms of documentation business.

Company E is also curious about its rivals and the Business Development Manager confesses that to a certain extent they learn about the competitors from the authority illegally. They do not follow any publication for learning from the competitors; they do not need to benchmark either because they generally have expertise for the projects for which the requirements are specified in contract files. In case of a lack of experience for certain jobs, they look for partners to join their forces. The partners may be found through the investigations on the Internet or from the previously worked partners. According to Company E, JV partners are the mostly utilized knowledge sources for bid preparation and in construction phase of the job. The respondent says that *"…partnerships arise from necessities; we try to compensate our weaknesses by their experiences"*.

Company E does not consider the companies out of construction sector to be parties to transfer knowledge from.

Company F is the most fascinating organization for its ambition to acquire knowledge and to integrate the knowledge acquired through several sources to its core activities. Being fully aware of the competing forces in construction industry, the company scans the environment carefully, makes comparisons in a number of aspects and takes actions accordingly. As far as the role of competitors are concerned, Company F tries to learn about the technical and financial capabilities, human resources, project experience and current movements of its rivals from the suppliers, subcontractors and clients of those firms in addition to the visits on-site. Benchmarking is also used to compare the methodologies, technical and economic capabilities and relations of competitors with clients or consultants. Foreign companies are only followed if they are potential rivals for international projects. Their information is obtained through the subcontractors, embassies and the Turkish Treasury. The existing or potential JV partners are continuously tracked; ideas about their relations or their methods of work in a project guide the company for partner selection for future projects. Company F also learns from the other sectors. The marketing strategies of the tourism sector are beneficial for the firm. Besides, they are informed about the construction demand and economic situations of countries or relations with neighbors by the marketing and finance companies respectively. The Business Development Manager of the company emphasizes the acquired knowledge is captured by means of documentation, storing in databases, sharing among other employees through meetings and the intranet. It should be noted that knowledge is exploited in the strategic decision-making stage.

Company G, as a result of restructuring in the last two years, shows solid improvements and has potential to find solutions to effectively utilize knowledge. The Deputy General Manager has expressed his ideas very clearly on what is done in his company in practice and what should be done to increase the efficiency of operations. Authority and employees of competitors constitute the

origins to learn about the other companies. There is an important point to be highlighted as the respondent suggests *"…knowledge should be categorized according to the project types and stored in a database and by this way bid prices can be computed"*, he continues as *"…unfortunately, we do not have such a system*". The respondent does not believe in the possibility of implementation of techniques adopted by foreign companies, as their technical and economic circumstances are completely different from ours. The firm does not benchmark from the other companies and they are not able to learn from the JV partners. The other industry members are utilized when their expertise is needed. There is a pleasing feature of Company G: although they have not an infrastructure to manage knowledge, they have the desire to learn and take more effective steps to build a learning organization.

According to Company H, knowledge is acquired from any source when particular information is required. The competitors are perceived to be key players; the bid prices they offer, subcontractors and banks they work together are seriously followed. The firm does not have a strict method to gain knowledge from its rivals, the awards are obvious sources for them but benchmarking is nor a mechanism they are familiar with. The foreign companies for whom they carry out subcontracting are followed via the Internet. As a common view of all respondents, JV partners mean a lot for construction companies. Synergy is created when two or more firms come together and performs the fragments of a project for which they have strength. The Business Development Manager expresses his thoughts as *"…partnerships are formed to compensate the weaknesses of two firms… we try to learn from the core competences of our partners, we pay attention to catch the details"*. Company H benefits from the experiences of other sectors where they have to perform a new job that is out of their scope of expertise. The firm partially stores and shares knowledge within related departments, this is explained as a security measure by the respondent.

4.4. Learning From the External Resources

Table 4.3 illustrates the utilization frequencies of proposed external learning sources and how the acquired knowledge is stored within the organizations by indicating the number of companies. What is immediately observed is that the respondent companies learn from external sources at a high rate. Most frequently referred ones are the management supervisors, universities, associations and foreign organizations that are not clients. Least used external source comes out to be organizations like Chamber of Civil Engineers, etc. Generally the acquired knowledge is partially stored in a computer-based environment; fully codification of knowledge in computer occurs only in Company E. Other external sources indicated by the respondents are the equivalents of the above in foreign countries, periodicals, Official Gazette, the Internet and even the television.

Table 4.3. Exploitation of the external learning sources

External learning Sources	Utilization frequency	Storage		
		Computer based	Partially computer based	Individual based
Universities	7		7	
Educational supervisor companies	6		6	
Management supervisor companies	8		8	
Governmental bodies that are related with the construction sector (other than the clients)	6		6	
Other foreign organizations that are not clients (World Bank, etc.)	7	1	6	
Organizations like Chamber of Civil Engineers etc.	5		5	
Associations (Association of Turkish Contractors, etc.)	7	1	5	1

Company A learns almost from each proposed external source except the foreign organizations that are not clients and organizations like Chamber of Civil

Engineers, etc. They follow the foreign exchange currency and escalation values from the governmental bodies such as State Institute of Statistics. The knowledge gained through the external sources is partially transferred to databases and some remain in the minds of individuals.

Company B refers to all external sources except organizations like Chamber of Civil Engineers, etc. They benefit from the universities in terms of expertise for preparation of formal reports; management supervisors are exploited in cases of dispute resolution; cost indices are learnt from governmental bodies and foreign organizations are followed especially to be informed about World Bank supported projects. Company B considers the lawyers important in terms of legal and financial problems. Trade unions and State Planning Organization are continuously followed sources for this company. Some of the knowledge is documented and some cannot go through further than the heads of employees.

Company C as the majority of the interview sample tries to exploit the external knowledge sources as much as possible. Educational supervisor companies assist them for the issues such as environmental regulations, health and safety considerations and quality management. They are informed about the contract documents and legal judgments about Turkey and Turkish construction companies for participation in international projects through the foreign organizations such as World Bank and the European Union. Company C stores the knowledge partially in computer-based environment in order to be utilized for future reference.

All the proposed external learning sources in addition to the equivalents of these in foreign countries are considerable for Company D. The architect of this firm stresses the key role of technical, legal and financial consultants that provide information about the foreign companies that are considered to be potential JV partners for overseas projects. The respondent states also that by this way previously search information about those parties is confirmed. They also follow international magazines to catch up with the changes in the global markets.

Knowledge is not fully transferred to computer environment since not all knowledge can be codified.

Company E almost does not utilize half of the proposed external knowledge sources. Among the frequently used are universities, management supervisor companies, associations and foreign organizations other than the clients. The Business Development Manager tells that they attend to the seminars arranged by university members and the employees share their experiences with others in the company. Magazines and the Official Gazette are the other external sources that are utilized by the members of this organization. Apart from the suggested sources, they are a member of Foreign Economic Relations Board, which informs the company periodically about the international project opportunities. Information acquired through the foreign agents is stored in databases whereas others are partially found in computer-based environment.

Company F has a wide range of external knowledge acquisition sources. They use the complete list of the recommended sources in addition to the technical and administrative consultants, foreign organizations such as banks or sponsor companies, national organizations such as the Chamber of Commerce and Chamber of Industry. They are informed about currency rates, escalation values and other economic facts from these organizations. Knowledge is partially stored in databases and communicated through related personnel.

Company G learns from the management supervisors, foreign organizations and national associations in the recommended list of external sources. The company members mainly utilize the periodicals, television, newspapers and Official Gazette to gather information about the construction industry. They follow the latest events from the periodicals like MEED (Middle East Economic Digest), International Construction, Pipeline, and International Water. The Deputy General Manager does not believe in the benefits of external sources for construction companies. The following words may be attractive for his attitude: *"…there is nothing I can learn from the universities, they should learn from*

me…in construction the most important thing is the experience and I have got it". As it is expected, the limited knowledge gained from the external sources is either partially stored or cannot be more than individual learning.

Company H completely assumes the suggested list of external sources as knowledge acquisition sources as most of the respondents. What they put forward additionally is the Internet and pressed documents where all kind of developments can be followed easily. Company H cannot completely store the knowledge in the databases but try to transfer each possible component to a codified format.

4.5. Organizational Memory

As explained in the previous chapter, there are three main knowledge sources that compose the OM of the construction companies. The acquired knowledge exists in either codified format or remains as tacit knowledge.

The overall appearance obtained through the respondents' answers reveals that companies mostly learn from their own experiences when the percent contributions of these three sources are concerned. This is followed by other companies' experiences and external sources. It is observed that companies' own experiences constitute the 20 % of the organization memory as the minimum share and 90 % at maximum rate. The minimum contributions of other companies' experiences and external sources come out to be 5 %. The maximum ratings of these sources are 50 % and 30 % respectively.

There is an interesting picture about the percent shares of knowledge types in the composition of the OM. The respondents' ratings point out that the minimum and maximum shares of codified and tacit knowledge are equal. Due to the inconsistent ideas and attitudes between companies, codified and tacit knowledge may constitute 10 % of the corporate memory at the minimum and may have a share of 90 % as the maximum possible rate.

Table 4.4 summarizes the percent contributions of the proposed three knowledge sources in the formation of OMs and the composition of these memories in terms of knowledge types for each respondent company.

Table 4.4. OM profiles of the respondent companies

	Percent contribution to OM (%)							
Resources composing the OM	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Company's own experiences	90	90	60	55	60	60	20	60
Other companies' experiences	5	5	20	25	10	20	50	10
External resources	5	5	20	20	30	20	30	30
Knowledge types in the organization								
Codified knowledge	40	50	45	50	30	90	10	80
Tacit knowledge	60	50	55	50	70	10	90	20

As obvious from the percent contributions, Companies A and B almost learn only from their experiences; other two sources constitute only 10 % of their memories. Companies C, D, E, F and H give similar answers for the resource utilization; they learn from own experiences at most (around 60 %) but other companies' experiences and external resources have considerable contribution as much as 40 % totally. This results in fact what was expected from the research sample because construction industry is based on experience and companies learn as they undertake projects. It is clear that in a competitive environment, the firms should follow each other and try to exploit external parties to gather more information. This is a must to achieve main company objectives such as taking jobs and making profit. In short, these resources should be utilized by certain percents with the own experiences having the greatest share.

Company G is the extraordinary case among the others since the respondent of the firm told that the main learning source for them is the other companies' experiences, which constitutes 50 % of the OM. This is followed by the external

resources that have 30 % share whereas own experiences of the company has only 20 % contribution to the memory. This outcome may be interpreted by considering the previous contract types that the company has performed the projects with. It was mentioned previously that the company had undertaken cost plus fee agreements and there had been no need to collect and store project information. As far as the firm has not got any project memory till the previous year, it should not be surprising to encounter with the least contribution percent for own experiences among the other resources.

When the knowledge types are analyzed, there are some expected and surprising results. Half of the respondents namely Companies A, B, C and D state that nearly half or their memories is comprised of codified knowledge and the other half remains as tacit knowledge. If knowledge gained through the strategic decisions, other companies' experiences and external sources are considered, it is evident that not whole of the learning can be coded. Moreover, *"…experience gained through a project cannot be transferred to another engineer via paper; new employees cannot always show the same performance by reviewing the previous experiences of their pioneers"* says the Business Development Manager of Company E. The percentages may vary in accordance with the knowledge management perspectives and applications of each company. For example in Companies F and H, the codified portion of the memory is as much as 90 % and 80 % respectively. In contrary, for companies E and G these shares may go down to 30 % and 10 % respectively.

4.6. Exploitation of Organizational Memory in Strategic Decision-Making

The major goal of this thesis study is to explore how construction companies create their memories and how they make use of this asset in the strategic decision-making stage. OMs become meaningful if they are beneficial for the companies in terms of taking a new job and completing the projects with profit. As some companies think that the existence of a corporate memory will not provide them competitive edge, they do not attempt to increase their learning

potentials and implement new systems to exploit from their memories. Fortunately, Turkish construction companies are eager to find ways to enhance their learning capacities and they believe that they have sufficient resources to be allocated for knowledge management. Apart from knowledge acquisition from several sources with various mechanisms, companies have to share the individual learning within the organization and transfer it to a serviceable pattern. It is achieved through the integration of gained knowledge into daily activities and decisions of the company. By this opinion eight companies are asked whether they find it important to utilize codified knowledge and decision support systems in strategic decision-making and whether they have such applications.

Table 4.5 summarizes the scores for each question for this section. It should be noted that scores are given in 1-5 scale. Values in the first column indicate the average importance scores belonging to the importance of having a codified OM in making decisions about the corresponding cases. The second one has the average scores of how frequently the companies make use of their memories for making decisions about the suggested statements. The third column presents how important the companies think of the existence of DSSs to make strategic decisions, which is stated in a 1-5 scale.

It is observed from the scores that codified knowledge is much more important in case of bid preparation rather than the other situations. Since bid prices cannot be calculated without solid indicators and stored data in the files of the companies, this result was expected. Companies also need codified memory to make market entry decisions with the next highest rating. This is closely followed by making new investments. These two outcomes are also logical because in order to decide to enter a new market or make new investments, all companies desire to see historical data and wish to compare the current situation with the previous ones. It is not important for the companies to have codified knowledge to develop differentiation strategies. This strategic decision has the least score in this area. The respondents do not either find it important to refer to a codified memory when they are to restructure.

Table 4.5. Exploitation of OM by the respondent companies

Strategic decisions	Importance of codified memory	Utilization frequency of memory	Importance of DSS in decision making
International market entry	3.25	3.25	3.63
Market entry related/unrelated to construction	3.63	2.63	2.88
Bid/no bid	3.13	3.38	3.25
Selection of JV partner	3.13	2.75	3.25
Bid preparation (determining risk premium and bid price)	4.38	4.38	4.13
Developing differentiation strategy (marketing strategy, quality management)	2.88	3.25	3.13
Making new investments (IT, etc.)	3.50	2.63	3.50
Restructuring of the company (corporate changes to increase productivity)	3.00	2.75	3.13

When the applications in practice are searched, some similar answers are obtained. Companies make use of their memories mostly at the bid preparation stage. The next highest score is given for the bid/no bid decisions. The respondents do not overlook the existing memories to decide on bidding or not bidding. Astonishing scores are obtained about the utilization frequency of the memory for market entry and new investments decisions. Although it has a high weight for companies to have codified memories to decide about new market entries, it is seen that in fact they do not have the same behavior when it comes to make use of their memories. OMs are least utilized for deciding on market entry together with making new investments. These decisions are followed by the restructuring and selection of JV partners. This outcome is expected since companies do not consider the knowledge repositories to be effective to make decisions about these situations.

The research sample is also asked about their views on the assistance of DSSs to give strategic decisions. According to the scores, if there exists a computer

program to aid them in bid preparation, this would be very beneficial for them. As all companies uses some sort of mechanisms to offer bid prices, systematization of the process would help them in time and money saving. Companies also appreciate the benefits that would come from a DSS design to help them decide in international market entries. They do not regard a program as useful for new market entry decisions or for development of differentiation strategies and restructuring of the organization. These have the least scores in terms of importance of a DSS.

Besides the opinions on the significance of DSSs, their existence in the companies is also an indicator for utilization of IS to enhance the OL competence. With the help of IT tools, construction firms become more competent in their markets since their corporate asset namely the OM becomes meaningful and is utilized effectively by this means. The overall picture does not present a satisfactory situation because most of the strategic decisions are made by the upper level managers in companies without the assistance of a scientific indicator. Companies cannot be blamed for not using computer-based programs as the final decisions are in the mouths of the company owners. For example, the possibility of having a positive outcome for entering a new market may be very high despite all the indicators showing that a negative decision should be made. As a result, companies do not want to establish systems that will not be utilized or the outcomes of which will not be taken into consideration. Companies C, D, F, G and H have computer programs for bid preparation; Company G has for bid/no bid decisions. Company D gives all its strategic decisions by their own way of analyzing the related data, they do not use specific software packages but they are able to analyze the data in Excel. Companies A, B and E unfortunately do not utilize any DSS to aid them in strategic decision-making.

4.7. Evaluation of the Companies in Terms of Organizational Learning Competence

After getting answers to specific questions on the creation and utilization of OM in the large-scale construction companies, the respondents are asked to evaluate their companies in terms of overall OL competence. A company is assumed to have high OL competence if it is good at benefiting from knowledge acquisition sources, if it has knowledge storage mechanisms, if this knowledge is shared and interpreted by the company members, if the end product of these knowledge management activities, namely the OM can be effectively utilized in decision-making process and if the company can continuously review the knowledge warehouse.

Table 4.6 demonstrates the general view of the research sample on the importance of listed knowledge management activities and their success in achieving these processes. Knowledge sharing among the employees of the organization is the most important activity for the companies. Since the answers are given in 1-5 Scale, an average score obtained as 4.38 out of 5 may be regarded as quite high. Utilization of knowledge in decision-making and revision of knowledge take the next highest scores from the respondents having average scores of 4.13. It is surprising that knowledge storage is far less important relative to other activities; it has got only 3 as an average score.

Table 4.6. Evaluation of respondent companies in terms knowledge management activities

Knowledge management activity	Importance Score	Success Score
Knowledge acquisition	3.75	3.88
Knowledge storage	3.00	3.75
Knowledge sharing	4.38	3.75
Utilization of knowledge in decision-making	4.13	3.63
Revision of knowledge	4.13	3.88

The applications in practice reveal the fact that the most successful areas of construction companies are acquisition and revision of knowledge that have equal average scores as 3.88. These activities are closely followed by knowledge storage and sharing which have ratings as 3.75. It is seen that companies are not as good at knowledge sharing as they give importance to this activity. The same situation is observed for utilization of knowledge in decision-making. Although this process has the second highest importance ranking, it is the least successful activity of the companies. The average success score is very low (3.63) with respect to its importance score (4.13).

In the light of these assessments, the companies are requested to give ratings for their OL competences. The answers show that the sample's OL competence is "high"; half of the respondents have given 4 for their companies. Companies D, E, G and H find the knowledge management activities highly important and they perform these activities at a high success level. The minimum rating is given by Company B as 2 that corresponds to "low" level. Although the company tells that these activities are important for their companies, they cannot successfully manage knowledge. The maximum rate is obtained as 5, which means the Company F believes its OL competence is "very high". This result is consistent with the importance scores of the activities as all of them have "very high" ratings. Table 4.7 presents the ratings given by each company. Companies A and C are not as successful as the majority of the sample; their level is represented as "medium". The below discussions are detailed analysis of each company's OL perception and applications.

Table 4.7. OL competence values of respondent companies

Company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
OL Competence	3	2	3	4	4	5	4	4

Company A has a network within the company that has access to only authorized people. Knowledge sharing is the most important activity for them as it is observed from its importance rating being "high". The other knowledge

management activities got “medium” level of importance from this respondent. Although the company finds its success in knowledge acquisition as “low”, the rest of the processes are performed in a “medium” level. So the “medium” level for OL competence is an expected value for the company.

Company B as stated earlier, does not believe in the necessity of data collection and storage of project information. This attitude is reflected in the importance score given for the knowledge sharing activity as “low” in contrast to the “high” level of importance of the rest of the activities. There is a both parallelism and contradictions between the beliefs of the company and the applications in practice. Knowledge acquisition is found to be “highly” important and it is handled at a “high” success rate. This is observed for knowledge sharing too; the importance and success values are the same. For the utilization of knowledge in decision-making and revision of knowledge, the company cannot show the same success rate as much as it regards them important. As a result the OL competence of the firm comes out to be “low”.

Company C, having intentions to increase the learning capacity of its employees, tries to adopt a climate to provide more enhanced knowledge sharing among the members of the organization. There is an intranet in the firm where knowledge is stored but for the time being sharing is not at the desired level. These facts also evident from the importance score of “high” value and success score of “low” value. The respondent of the firm believes that knowledge acquisition has a significance degree of “very high” and he tells that they are “highly” successful at this process. They utilize their memories in decision-making at a “high” success rate; similarly the revision of knowledge is achieved at “high” level. The overall OL competence value is indicated by “medium” which is a fair assessment for this company.

Positive influences and restructuring movements are observed in company D due to the ISO Standards. There is a more systematic documentation business in the company for the last 5 years. Being aware of the key role of integrating all

company operations in achieving success, Company D has adopted systems where accounting, construction and administrative information are gathered in a center under ORACLE. There is also a newly acquired software package that allows information flow among all organization members. These knowledge management efforts are really delighting. As it is expected from such an organization, all knowledge management activities are handled at a "high" success rate. This value is of course the outcome of considering that knowledge is the core asset of any organization and should be managed seriously. Company D, due to its ambition and determined steps, is indeed far ahead of other firms in the research sample in terms of consciousness.

Company E is one of the organizations where the strategic aspect of knowledge is appreciated. Any information gained through any source is analyzed to take more effective steps for the upcoming projects. The upper level managers treat knowledge as a strategic source that can increase their competitiveness in the biddings. Business development and tendering department have a program on potential projects the information of which is continuously updated. There is a password requirement for intranet access. The company regards the most important knowledge management activity as the acquisition because nothing can be done without having the knowledge. Sharing also plays a major role besides the storage, utilization and revision of knowledge. The company evaluates its success for handling those activities at "high" level. Their OL competence is again rated as "high".

Company F presents the most outstanding case in the research study. Having a very advance network in the firm, each knowledge particle is tried to be captured and made used of by related departments. Experiences are considered to be past efforts that lead to more accurate actions in the future. Improvement in methodology, profitability and time schedule is reported and assessed by the groups to get ready for the future works. The reports prepared about the project progresses and parties involved in the projects or competitor information are strictly documented and are confidential. Company F has a great positive attitude

about improving the knowledge management activities that is also revealed in the importance scores given to each activity as “very high”. The OL competence of the company is evaluated as “very high” that corresponds to the highest rating in the research sample. Company F believes that it sufficiently realizes all knowledge management activities and rates its success as “very high” for all processes expect the success level of utilization of knowledge in strategic decision-making that is assessed as “high”. It should be noted that Company F really deserves to be appreciated for its structured mechanisms for knowledge management.

Company G is observed as a firm where a learning organization is flourishing. Due to the previously undertaken contract types, project memories could not be created and the company is trying to build a learning environment with its current efforts for the last 1 or 2 years. Company G seems to be able to improve the OL capacity in a short period of time. Underlining the existence of a considerable potential to manage knowledge in the their organization, the Deputy General Manager gives “high” scores for their success level and their OL competence. For them, sharing and revision of knowledge is of paramount importance. The least important activity for them is the storage of knowledge; they think that acquisition and utilization should have more weights.

Company H is not an extreme example over the other firms. As all of the companies, the firm thinks that all knowledge management activities are of “high” importance to gain a competitive edge in the construction industry. The Business Development Manager states that although corporate memories should not be overlooked in strategic decision-making process, there are other factors such as the individual desires of the company owners or the necessities to bid for a project, etc. Company H whose OL competence is rated as “high” performs each knowledge management activity with as “high” success level.

4.8. Organizational Learning Barriers

Although construction companies agree on the necessity to enhance OL in their organizations, there are some barriers that prevent them from reaching to desired levels. The respondents are asked to state the validity of the proposed barriers in their companies and the importance level of these factors for the construction sector in term of influencing the learning environments. Table 4.8 gives a general idea about which factors prevent companies from increasing their learning potential and it presents the average importance scores for the proposed OL barriers.

Table 4.8. Validity and importance of OL barriers for respondent companies

Barriers to OL	**Validity frequency**	**Importance score**
Cultural barriers	2	2.5
Structure of the company	4	3.5
High employee turnover	5	3.75
Uniqueness of each project	1	2.38
Unsupportive nature of the industry	3	2.75
Not creating competitive advantage for taking jobs	2	2.75
Lack of resources	1	3.00
Lack of consciousness	3	3.75

The mostly encountered factor is the high employee turnover that is a common problem due to the project-based nature of the construction industry. Structure of an organization has certain influences on possessing an environment convenient for learning. The ability to acquire, store and share knowledge may be allowed or interrupted due to the deficiencies in information flow. As a result of the interview, structure of the company is the second most effective parameter to set barriers in front of the learning organizations. The research results also reveal that uniqueness of each project and lack of resources does not create a negative

effect on learning. Although these would be expected barriers for the companies, since the sample comprises of large-scale firms, their visions are bound to long term benefits rather than short term profitability and resources can be easily allocated if learning is the point of concern.

When the effectiveness of these factors is sought, the most important one comes out to be high employee turnover as it has the highest validity frequency among the sample. Lack of consciousness has the same score with high employee turnover. This is an important parameter for the construction companies because apart from the large firms OL is not a familiar concept and its competitive advantage creation feature is not accepted by a major portion of the sector. More interesting is about the least important factors. Large company representatives think that uniqueness of each project and cultural barriers would not stop learning of companies but the low possibility to standardize construction experiences, the difficulty of application of same procedures for each project decreases the necessity and ability to store and transfer knowledge between projects. Similarly, if the culture of a company does not provide its employees an attractive environment, nobody would like to make effort to share own experiences with others.

Company A accepts cultural barriers to be the most influential factor on learning. The main problem of this firm is stated as the insufficiency of solid applications in spite of the qualified work force. Company B thinks that the central problem effective for all construction companies and valid for themselves is the economic and political instability of the country. The respondent tells that these conditions do not permit the promotion of a learning culture in construction companies. According to Company C, since it requires serious amount of resource to establish systems that facilitate OL, lack of resources is the most effective barrier. The Business Development Manager of the company says that there should be a common belief in the organization about the necessity of learning and people should be technology-friendly. Also, he thinks that there are no leading people in the industry to tell the procedure to achieve OL process.

Companies D and E are the other striking cases since their only problem is the high employee turnover. According to the Business Development Manager of Company E, uniqueness of each project is a facilitator for learning; he thinks that this feature of projects creates advantage because as the diversity of the undertaken jobs increases, the knowledge range increases and learning becomes a continuous process. Company F states that OL does not create competitive advantage for taking jobs and structure of the company is very effective as a barrier to OL. The respondent of the company states that lack of time and not being able to catch up with recent development in technology negatively influences their learning competence. High employee turnover, lack of consciousness and previously adopted contract types are the factors that influence Company G's learning capability. Similarly these valid barriers are thought to be the most effective ones for the construction industry. There is only one company that does not take any barrier into consideration. According to Company H, none of the suggested factors can prevent them from learning and the importance of these factors is very low for the construction industry.

4.9. Conclusions and Recommendations

Important conclusions can be made from the answers of the respondent companies. The most significant point is that although some perceptions and attitudes are common to all companies, some may change due to the differences in cultures, strategies, structures, ages of companies and the markets they are in.

It is observed that all companies are good at the creation of project memory. Project information is shared among employees but strategic information is only accessible by the managerial level personnel. This situation is explained as a security measure by all respondents. Another common attitude is about the knowledge collection and storage mechanisms. Companies avoid preparing long and complex documents; instead they prefer short and explanatory reports. Most of them review the recently undertaken projects but do not find it necessary and cannot allocate time to assess projects completed long years ago.

The major component of learning from other companies is revealed to be the JV partners. Since partnerships are formed to compensate the weakness of one company with the strength of another, the leading company transfers its knowledge and experience to its partner. When the partner is a foreign company, then the quality and quantity of knowledge transferred increases.

Respondent companies agree on the utilization of external learning sources and state that to follow the developments in the construction markets external sources play a key role.

When the OM is overviewed, utilization frequencies and knowledge types composing the OM have some common points in addition to some extreme results. It is a fact that almost all respondent companies learn mainly from their own experiences; learning from other companies and external sources have less contribution to the OM compared to own experiences. Although the knowledge structure of OM is observed to be composed of tacit and explicit knowledge with equal proportions, one of these knowledge types come out to be dominant in some cases. This is probably due to the existence of a learning environment in the organization. In accordance with the continuing culture of learning, firms set their mechanisms to collect and store information, if such a culture is lacking then it is impossible to create codified memory.

Companies think that the role of OM in strategic decision-making is limited. Intuition and experience have more power to decide on taking a new job, entering a new market or making new investments. Firms do not rely much on their memories to make decisions unless that decision concerns some facts and historical information. All respondents agree on the importance and utilization of OM in case of situations that require mathematical parameters such as bid preparation. Companies do not utilize DSSs to aid them in decision-making in spite of the fact that they believe it would be beneficial to have such programs to help them. This contradiction arises due to the unfamiliarity with the DSSs and

more importantly because they make decisions based on their judgment, beliefs and experience.

When the knowledge management activities are considered, companies seem to be most successful at acquiring and revising knowledge. Knowledge sharing is the most important activity, which is followed by the utilization of knowledge in decision-making. But these activities are not performed as successful as they are regarded to be important. According to Berthon et al. (2001), as organizations age and grow in size, they become more passive in information search since their OM has developed to a certain extent. When the research sample is analyzed, the oldest company has the lowest OL competence score but this result cannot be generalized since some of the old companies have considerable efforts to increase their learning potential. In this respect, it should be noted that young firms may be eager to learn more to increase their OM but it does not mean that older organizations have given up learning. In contrast, older companies in Turkey, due to their experiences, have the chance to take more jobs and form partnerships with foreign companies, which has great influences on learning. Being good at managing knowledge perhaps is more related to the firm structure, culture and the vision of the organization that create a learning environment.

At this point, OL barriers are the key factors on the promotion of a learning environment. High employee turnover and structure of the company are the most important parameters affecting the level of OL. Companies do not consider uniqueness of each project and lack of resources as OL barriers.

The research results reveal the fact that knowledge acquisition is the most successful area in the knowledge management practices of the companies. Although the firms find utilization of knowledge in decision-making more important than acquisition of knowledge, it is observed as the companies' least successful activity. Then a contradictory situation arises. Indeed all companies desire to make use of the memory they have created but they are not able to develop right strategies or establish necessary systems to realize this goal.

Analysis of the successes and failures of finished projects and utilization of the existing data to examine patterns and trends for new projects seem to be impossible without some tools. Some companies analyze the collected data in Excel program in order to give some decisions. It is certain that companies starve for the existence of DSSs to aid them in strategic decision-making. Answers of the respondents demonstrate that especially for bid preparation and international market entry decisions, assistance of a computer program would be very precious. Since almost all construction companies handle the bid preparation process with software packages, there is a computer program requirement in the decision-making stage for international market entry when the answers of the managers are concerned.

In this thesis, as a solution to the lack and necessity of DSSs in the construction industry, a model is developed in order to assist construction companies in international market entry decisions. The model is built using a software package, which adopts the principles of case-based reasoning (CBR) approach to solve the problem. The following chapter explains the basics of CBR, its applications in construction management and presents the model as a decision support tool.

CHAPTER 5

A DECISION SUPPORT TOOL FOR INTERNATIONAL MARKET ENTRY

As far as the growing potential in the overseas markets in construction projects is concerned, it is becoming more and more important for the medium to large size Turkish construction companies to take their parts in international construction works. It is of paramount significance to follow right strategies when trying to give market entry decisions. At this point, the prior experiences of other companies that have performed international works or their own previous attempts resulting in success or failure may guide them in the way to take a new job abroad. Considering several variables included in an international construction work, it will be quite hard to evaluate the attractiveness of that specific job and the competitiveness of the related company.

In this thesis, this problem is solved though the implementation of a DSS that will help construction companies in making decisions for international market entry. Development of such a DSS will also be beneficial for the Turkish construction companies to meet their need in this area, which was revealed as a result of the interview study.

A DSS is an algorithmic computer program that accesses a database to locate the necessary data, utilizes mathematical and/or statistical models and produces the desired information at the user's terminal (Ahmad, 1990). Obviously, to establish a DSS, a problem solving approach should be selected.

Regarding the international market entry decision as a problem to solve, CBR is thought to be helpful to lead to clear solutions since it applies human reasoning when examining cases and uses past experiences to give decisions about future intentions. One of the main advantages of this problem solving approach is that the reasoning process can be easily followed and it is strengthened by the human interference at several steps.

Before examining the DSS, the details of the CBR approach will be given to demonstrate the suitability of this problem solving technique to the concerned problem.

5.1. Case-Based Reasoning

The objectives of increasing efficiency and surviving in business have become pushing forces for the organizations to seek ways to differentiate their processes. Companies are aware of the power of utilization of technology in their operations. Moreover, it is a must for them to take effective actions and make better decisions, which may be realized through a systematic approach. Recently, construction industry has begun to benefit from the technological aids and use knowledge-based systems to support their decision-making and problem solving process. The most promising techniques for developing knowledge-based systems are rule-based systems, case-based reasoning (CBR), model-based reasoning, artificial neural networks (ANNs) and genetic algorithms.

Among these methods, CBR has shown great potential for the situations requiring past experiences to solve current problems. A considerable number of prototype applications are being developed in areas including knowledge acquisition and refinement, legal reasoning, failure recovery, diagnosis, arbitration, design, general planning, help desks, teaching and learning. The pioneering work in CBR field is that of Schank (1982) on Dynamic Memory (cited in Aamodt and Plaza, 1994) and Kolodner (1983) and Rissland's (1983) work on legal reasoning (cited in Mantaras and Plaza, 1997). The Mediator

(Simpson, 1985 cited in Gupta, 1994) was one of the earliest case-based systems and it gives advice to resolve different kinds of disputes. Hypo (Ashley, 1991) is a popular CBR system in legal domain (cited in Gupta, 1994). Persuader (Sycara, 1988) is another example for case-based systems and it acts as a labor mediator to resolve conflicts and find compromises between union and management (cited in Aamodt and Plaza, 1994).

Systems that adopt CBR principles are best suited for domains that are experience-rich but knowledge poor (Chi et al., 1991 cited in Gupta, 1994). Since decision-making in construction is based on experience, CBR seems to be a better choice among the other techniques by its approach to solve new problems referring to the past similar cases. Generally construction companies make use of this technique in the areas of strategic planning, scheduling, integrated design and cost planning, dispute resolution and interpretation of construction law (Li, 1996).

5.2. Case-Based Reasoning as a Problem Solving Approach

Reasoning can be defined as a process that draws conclusions by sequencing generalized rules or situations. The principal knowledge source of CBR is not generalized rules but a memory of stored cases. In CBR, new solutions are generated not by chaining but by retrieving the most relevant cases from case library and adapting them to fit new situations (Leake, 1996).

CBR tasks are often divided into two classes as interpretive CBR and problem-solving CBR. Interpretive CBR uses prior cases as reference points for classifying or characterizing new situations; and problem-solving CBR uses prior cases to suggest solutions that might apply to new circumstances (Kolodner, 1993).

The interpretive CBR involves four steps being performing situation assessment (Kolodner, 1993) to determine which features of the current situation are really relevant; retrieving a relevant prior case or prior cases based on the results of

situation assessment; compares those cases to the new situation and finally saving the current situation and the interpretation as a new case for future reasoning (Leake, 1996). Legal problems and diagnosis concepts are the fields for which interpretive CBR processes are applied. On the other hand, in problem-solving CBR, the goal is to produce a solution to a new case based on the adaptation of solutions to past cases. Case-based design, planning, and explanation systems are the examples for this class since they require retrieving and adapting solutions of similar prior problems (Leake, 1996). Like interpretive CBR, problem-solving CBR involves situation assessment, case retrieval, and similarity assessment steps to find solutions for new problems. Since many problems have components of both types of CBR, most effective case-based reasoners use a combination of both methods (Mantaras and Plaza, 1997).

In short, CBR solves problems through a process that involves some basic steps as retrieving relevant cases from the case memory, selecting a set of best cases, deriving a solution, evaluating the solution and storing the newly solved case in the case memory (Mantaras and Plaza, 1997).

The goal of CBR is to use the computer to augment the analogical reasoning and memory of the domain expert by providing the expert with representative cases similar to the problem at hand (Kolodner, 1991 cited in Gupta, 1994). This statement points out the necessity of computers to apply CBR principles. In order to meet this requirement, several commercial companies offer shells for building CBR systems. CBR shells provide mechanisms to support case retrieval and allow users to interactively provide additional information as needed during retrieval besides; they provide sophisticated interfaces to facilitate creating and editing the case base (Leake, 1996).

The following paragraphs explain the processes involved to solve problems by using the CBR approach in detail.

5.2.1. How Case-Based Reasoning Solves Problems

Systems that adopt CBR to solve new situations have a common structure. They retrieve appropriate cases from memory; modify a retrieved case so that it will apply to the current problem; apply the transformed case and save the solution with its success or failure for future use (Luger, 2002). Similar to this view, Aamodt and Plaza (1994) describe CBR as a cyclic process comprising four steps:

- *Retrieve* the most similar case(s)
- *Reuse* the case(s) to attempt to solve the problem
- *Revise* the proposed solution if necessary and
- *Retain* the new solution as a part of a new case.

A new case that is to be solved is used to retrieve a case from the collection of previous cases that make up the case base. The retrieved case is combined with the new case and through reuse it is transferred into a solved case, which presents a proposed solution to the initial problem. Through the revise process this solution is tested for success. The solution is evaluated by and expert and it is repaired if failed. During retain, useful experience is retained for future reuse and the case base is updated by a new learned case or by modification of some existing cases (Aamodt and Plaza, 1994).

Leake (1996) states that the success of CBR depends on addressing issues in how to acquire, represent, index, and adapt existing cases. So, there are four major activities composing CBR being the acquisition of cases to form a case base, indexing the cases, retrieval of similar cases and adaptation to find a proper solution for the current problem.

5.2.1.1. Acquisition of Cases

A case can be defined as a conceptualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of the reasoner (Kolodner, 1993). It is a set of features, attributes and relations of a given situation and its associated outcomes. Case acquisition is an important aspect in designing efficient CBR systems. Cases in the case memory are designed to capture the knowledge and experience of domain experts (Gupta, 1994).

Cases are collected in a database which is composed of cases with each case including; a set of problems, characteristics that distinguish this set from others that warrant a different response, possible actions that were particularly helpful or harmful in such situations, indicators that suggest what type of response to expect and connections to other cases that reflect next steps or alternate steps depending on the responses observed (Kolodner, 1993). Since the case base reflects the conceptual view of the cases and it supports efficient search and retrieval methods, it should be organized in a manageable structure, which determines the scope of intelligence of the system and its breadth and depth of expertise (Gupta, 1994).

5.2.1.2. Indexing

One of the main concerns of CBR is to ensure that the right cases can be recalled at the right times. This is known as the indexing problem in CBR, which has two aspects. One is the vocabulary problem that requires assigning suitable labels or descriptors to the case so that it can be easily referenced in the case library during retrieval (Chua et al., 2001). Indices should address the purposes the case will be used for; they should be abstract enough to allow for broadening the future use of the case base and concrete enough to be recognized in future. However, despite the success of many automated methods, Kolodner (1993) believes that people tend to do better at choosing indices than algorithms, and therefore for practical applications indices should be chosen by hand.

A CBR system uses a set of indices to search for and retrieve cases similar to the current problem. There are three main approaches in indexing cases namely nearest neighbor, inductive reasoning and knowledge guided indexing (Barletta, 1991 cited in Gupta, 1994). Frequently, systems use a combination of all three methods. In the nearest neighbor approach, the system selects the case whose attributes most closely match those of the current problem. Among current machine learning methodologies, inductive learning is the most widely used. An example of inductive learning systems is ID3 (Quinlan, 1986 cited in Li, 1996), which the majority of the case-based systems implement. The objective of induction algorithm is to generalize decision rules from past examples. These methods use an intelligent approach to retrieve cases based on the most meaningful and discriminating features of each case. On the other hand, in knowledge-based indexing, domain knowledge about each case is used to determine the features in past cases that are most relevant to the current problem. This method is generally used to enhance and supplement the other two indexing approaches due to the difficulty to implement this method since explanatory knowledge cannot be successfully and profoundly captured using if-then rules (Gupta, 1994).

5.2.1.3. Retrieval

The indexing mechanism determines the cases that should be selected while the case retrieval process ensures that the most relevant case is selected for further analysis. Given a description of a problem, a retrieval algorithm retrieves the most similar cases to the current problem or situation by using the indices in the case library. The retrieval of relevant cases depends on a good indexing of the cases that select an appropriate set of indices. The system retrieves the matched cases according to a predefined similarity function, which evaluates the degree of similarity of each case in the case base (Yau and Yang, 1998a).

CBR systems should include a strong memory-based retrieval system; cases should be retrieved intelligently and systematically by finding the closest match

between attributes of past cases and those of the current problem (Gupta, 1994). When the case memory is large, a hierarchical organization of the memory is necessary because a simple linear list is very inefficient for retrieval. The basic idea is to organize specific cases that share similar properties under a more general structure called a "generalized episode" (Mantaras and Plaza, 1997). A general episode contains norms, cases and indices where norms are features common to all cases, indexed under a general episode and indices are features, which discriminate between the cases of a general episode (Mantaras and Plaza, 1997).

5.2.1.4. Adaptation

Once a matching case is retrieved, a CBR system should adapt the solution stored in the retrieved case to the needs of the current case. In general, there are two kinds of adaptation in CBR as structural adaptation in which adaptation rules are applied directly to the solution stored in cases and derivational adaptation that reuses the algorithms, methods or rules that generated the original solution to produce a new solution to the current problem (Kolodner, 1993).

Most research on case adaptation has assumed that adaptation should be done in a completely autonomous way through the rules. There are alternatives of decreasing the need for adaptation rules suggested by Leake (1996), some of which are using flexible adaptation rules, using adaptation cases, combining rules and cases for adaptation learning and reusing subcases. Adaptation rules as proposed by Bailey and Smith (1994 cited in Ng, 2001) are developed to guide the adaptation process.

The next step after a case is adapted in accordance with the requirements is the incorporation of that case into the case base so that it can be used in the future. This feature of CBR provides the algorithm to become stronger since the following problems will be solved more accurately with a larger database.

If the proposed solution is successful then the system incorporates the solution and the representation of the current case into the case memory. Sometimes, the system may not propose a solution to the problem. In such cases, if the solution fails, then the system provides an explanation as to why it failed and documents it in the system library (Gupta, 1994).

5.2.2. Advantages of Case-Based Reasoning Over Other Techniques

Reasoning in CBR is based on experience or remembering. CBR approach focuses on how to exploit human experience, instead of rules, in problem solving and thus improving the performance of decision support systems (Chen and Burrell, 2001). CBR does not require an explicit domain model; main task is gathering case histories since CBR systems can learn by acquiring new knowledge. Identifying significant features to describe a case is much easier than creating an explicit model. By utilizing database techniques, CBR is enabled to manage large volumes of information that increases the reliability of the solutions it proposes. Case-based systems are preferable when the expert knowledge is hard to be modeled and large amounts of cases are available. In this respect, case-based systems that aid problem solving in construction are assumed to be attractive as they provide a model to store previous construction projects in entirety as cases and reuse them when similar new problems occur (Li, 1996).

There are several alternative approaches in the AI domain over which CBR has various advantages. These systems include artificial neural networks (ANNs), rule-based expert systems and model-based systems. Rule-based systems have well-defined structures and excellent explanation facilities; in this respect they are more advantageous compared to ANNs, which cannot easily generate explanations for their results. Indeed, combination of rule-base systems or model-based systems with CBR could give more satisfying results since the strengths of one system may compensate the weakness of another. CBR allows decision makers to interact with and review the reasoning process and even

perform heuristic adjustments on the derived result where necessary (Chua et al., 2001). CBR is applicable to solve problems and make decisions when the knowledge needed is so vague that formatting decision rules is infeasible but cases are available (Li, 1996). CBR eliminates the bottlenecks of other systems and facilitates development of expert systems. It benefits from how humans reason and it is based on experience, which should not be necessarily transformed to rules or models; it addresses ill-defined problems by tolerating human interpretation, which provides acceptable explanations on the solutions derived. Following paragraphs give a detailed analysis of each technique and discuss their similarities with CBR and the discriminating features between those methods.

5.2.2.1. Artificial Neural Network

ANN is a computer program that imitates human decision making at a low level in an attempt to replicate the capacity of human reasoning to surpass the structure of rigidly defined rules and formal logic (Li, 1996). A more comprehensible definition is given by Caudill and Butler (1990) who define ANN as a type of information processing system whose architecture is inspired by the structure of biological systems (cited in Arditi and Tokdemir, 1999a).

The development of an ANN based system consists of designing and training the ANN. Bailey and Thompson (1990) describe the design parameters in constructing an ANN model at three different levels: node level (type of input accepted, transfer function and means of combination), network level (number of layers, number and type of nodes, size of hidden layers, number and type of output nodes and connectivity) and training level (learning algorithm and learning parameters) (cited in Arditi and Tokdemir, 1999a). Unfortunately, there is no structured methodology for designing an ANN (Shiver, 1988 cited in Li, 1996). Training consists of presenting input and output data to the network (Nelson and Illingworth 1991 cited in Arditi and Tokdemir, 1999a). For each example presented to the network, outputs are produced and these outputs are

compared with those expected. The error is back propagated to the hidden units and the weights of the connections are modified using a modification rule (Li, 1996). The process is performed many times until the error is reduced to a preset level.

Obviously, there are some similarities between two approaches. Both are based on the experiential knowledge and are designed by acquisition of inputs and outputs to the system. It should be noted that CBR is a more advanced approach, it allows human interference in deciding indexing methods, but ANNs work like a black box (Yau and Yang, 1998b), as the algorithm cannot be understood completely by humans. In addition, ANNs require to be completely trained; they perform at lower efficiency when there are many features and do not allow updating the system without retraining, so they can be regarded as difficult systems to develop. Another drawback of ANNs is that they are designed to deal with only numerical figures. On the other hand, CBR systems seem to be more flexible since they are good at handling missing data, incorporating new cases into the case base and coping with a vast amount of features due to the indexing abilities. ANN is useful in identifying underlying patterns to be used for forecasting where available data are noisy and complex (Li, 1996) so, construction cost estimation may be an application area.

5.2.2.2. Rule-Based Expert Systems

Expert systems are computer programs that use heuristics and inference techniques to solve complex problems that ordinarily require expertise (Gupta, 1994). A rule-based expert system consists of a knowledge base to store the expert's knowledge and facts as rules, an inference engine that facilitates a reasoning process to solve a specific problem, a context memory that contains the information about the problem to be solved and a user interface that inputs and outputs information (Li, 1996). The essence of an expert system is a knowledge base represented primarily by transparent if-then rules, so it is limited by the process of acquiring knowledge. Moreover, in most cases, an expert

system cannot learn and has an extremely limited tolerance of incomplete input information when the system's default values are inadequate to solve the new problem (Yau and Yang, 1998b).

Expert systems and CBR have a common goal of enhancing the intelligence of machines and making them more human-like. One important distinction is that expert systems solve problems by deductive reasoning from first principles (Rich and Knight, 1991 cited in Gupta, 1994) whereas CBR systems solve new problems through analogical reasoning using the knowledge gained from past experiences.

Instead of relying solely on general knowledge of a problem domain or making associations along generalized relationships between problem descriptors and conclusions, CBR is able to utilize the specific knowledge of previously experienced, concrete problem situations (Aamodt and Plaza, 1994). As a CBR system modifies its behavior based on past learning experiences, it may be assumed to be a more dynamic approach than rule-based expert systems, which are based on strict if-then rules. This is supported by Kolodner (1991) who believes that expert systems are unsuccessful in solving problems that require creativity and common sense but case representation sometimes overcomes such problems. CBR systems are preferred over expert systems if rules are inadequate to express the richness of the domain knowledge.

5.2.2.3. Model-Based Systems

In model-based systems the actual performance of a process or task is compared with predicted behavior or expected performance (Li, 1996). Model-based reasoning uses structural knowledge of the domain in problem solving; it provides causal explanations; lead to robust and flexible problem-solving and allow transfer of some knowledge between tasks since science strives for generally applicable theories. Besides these strengths, some disadvantages may be regarded as lacking experiential knowledge of the domain; requiring an explicit domain model; being highly complex and being unable to handle

exceptional situations (Luger, 2002). Model-based systems are beneficial for diagnosing problems for which a complete and accurate mathematical model exists (Li, 1996). In contrast, CBR does not require extensive analysis of domain knowledge and it enhances problem solving through the indexing strategies.

5.3. Case-Based Reasoning Applications in Construction Management

In the experience-oriented construction industry, knowledge and assessments of previous experience are critical to resolving problems that may reoccur. Although the output of construction industry is unique projects, construction processes show similar characteristics. As CBR is an analogical learning technique and is based on experiences, it seems to be a suitable approach to solve construction problems, which are generally resolved through past experience and knowledge of experts. By its applications in architecture design, decision support, scheduling and structure diagnoses, CBR has shown a great potential in the field of engineering and management (Chua et al., 2001).

Yau and Yang (1998b) has identified potential application areas of CBR in the life cycle of a construction project. This study revealed that from feasibility study and conceptual planning to construction and operation there are various fields in which problems can be solved using CBR systems. Among these are risk analysis, feasibility analysis, project requirements in design, costs and duration, selection of construction methods, conceptual time/cost estimates, architectural or systems design, selection of contractors, bidding price prediction, schedule generation and control, quality control and operation problems resolution.

The following paragraphs provide detailed information on how CBR principles are applied in construction problems including prequalification, bid decision-making, selection of procurement methods, selection of construction methods, design, scheduling, cost and time estimation and construction litigation.

5.3.1. Prequalification

Contractor prequalification is an important task not only for clients who will select contractors but also for the contractors who can make self-assessment. Contractor selection is a process that generally adopts cluster analysis, multiple attribute analysis, program evaluation review technique (PERT), database management system, decision support system, rule-based expert system and fuzzy set models (Ng, 2001) to make a decision. CBR is an alternative approach that handles contractor information together with the requirements of the clients in a database.

Ng (2001) proposes a CBR system assist inexperienced clients throughout the process of contractor prequalification by the adoption and adaptation of past experience. The system, namely EQUAL, consists of five interrelated case bases as algorithm, screen, score, finance and project modules. EQUAL satisfies the functional requirements of users with the help of its modular structure.

The algorithm case base determines a set of decision criteria that reflects the organizational and project objectives. After the criteria are compiled by algorithm, they are transmitted to screen and score modules for the next stages of the process. The performance of a candidate contractor in previous construction projects is stored in the project case base. The purpose of the screen case base is to determine the contractors' suitability before proceeding to any further detailed evaluation. There are two functions of the score case base, one of which is to determine the suitability of contractors to be included in the approved list of contractors. The other function is to retrieve a previous case with similar levels of capabilities. The purpose of the finance case base is to store and convert the raw data into useful financial ratios. EQUAL conducts a rule-based assessment automatically to determine if the candidate satisfies the requirements of the screening stage. The overall suitability assessment is carried out by the score case.

5.3.2. Bid Decision-Making

Bidding decision problems are highly unstructured to be analyzed and formulated; there are numerous factors related to the specific features of the project and the dynamic environment that affect the contractors' bidding behaviors (Chua et al., 2001). As observed by Hegazy and Moselhi (1994), the solutions for bidding devised in practice are primarily based on analogy with previous cases coupled with a mixture of intuition and experience (cited in Chua et al., 2001).

A system, namely CASEBID that utilizes CBR principles is established by Chua et al. (2001) in order to optimize the markup value based on the probability distribution of the low bid markup. CASEBID adopts optimizes the latter method to evaluate the probability of winning and optimizes the markup value. To achieve this process, several bid cases are represented by sets of attributes focusing on four reasoning subgoals as competition, risk, need for work and company's position in bidding. The factors contributing to these groups are the internal and external factors. Internal factors such as the company's expertise, experience, financial ability, resource and current workload and the external factors relating to the nature of the work, bidding requirement and the social and economic environment are the parameters affecting the subgoals (Chua et al., 2001). The system retrieves similar cases to assess the possible level of competition and risk margin in order to be able to assign a proper markup value for the bid price.

5.3.3. Selection of Procurement Method

Procurement selection process due to the complex and dynamic parameters involves uncertainty and vagueness that makes it difficult to be represented by a generalized set of rules (Luu et al., 2003). Decisions for procurement selection are generally based on intuition and past experience. In order to provide users with a system that make use of the previous experiences, CBR is a very suitable approach to adopt.

Luu et al. (2003) have developed a prototype system to support decision-makers in selecting an appropriate procurement method. The system is comprised of procurement selection cases that are represented by a set of attributes elicited from experienced procurement experts. To satisfy the decision makers, the system should account for the requirements and conditions of the client and the project; it should be able to address the interrelationships of procurement selection criteria describing the distinctive characteristics of the client, project and external environment and the procurement method proposed should reflect the industry practice (Luu et al., 2003).

The framework of Case-based Procurement Advisory system for construction (CPAS) consists of three key modules as input, selection and output. Features considered as procurement selection criteria are time certainty, cost certainty, speed, flexibility, responsibility, complexity, price competition, risk allocation and quality. Fuzzy similarity retrieval was adopted to retrieve similar cases and similarity scores between two cases are computed in accordance with a formula. Users are presented five cases having the highest similarity scores. Users submit the necessary data to the input module; depending on the weights of attributes of the cases, similar cases are retrieved by the selection module and the output module generates the hypothetically ideal solution.

5.3.4. Selection of Construction Method

The example for this decision is about a system that identifies a set of feasible retaining-wall systems from a case base consisting of 254 previous retaining wall cases in design reports in Taiwan. As far as the inclusion of the issues of safety, economics, constructability and pollution prevention is concerned; selection of the most appropriate system at the project planning stage becomes an important decision for the experts (Yau and Yang, 1998a). The system considers excavation depth, pollution constraint, ground water level, and soil strength as major factors of the site conditions when storing a case in the case base. For a new project, the system, namely CASTLES, generates outputs in two parts being

the acceptable solutions (possible retaining wall systems used in the selected top three cases) and recommended solutions (the most frequently used retaining wall system in the three cases).

5.3.5. Design and Cost Estimation

Case-based design can be defined as the process of creating new design solutions by combining or adapting previous design solutions (Perera and Watson, 1998). Applications in the design domain include architectural design, integrated design and construction, building design and structural design (Tah et al., 1999).

A prototype system developed by Perera and Watson (1998) namely; NIRMANI, was implemented to support collaborative design. The retrieved design is adapted if required, in accordance with the architectural, structural and services requirements. Depending on the extent of adaptation of the design, costs for the chosen design are adapted to provide an elemental cost plan for the building that acts as a budgetary guide for further design development. The entire case-based estimation and design process is interactive that gives the design team authority to guide the design (Perera and Watson, 1998).

The system has a multi-level indexing structure with four main perspectives as architectural, structural, services and estimating. In NIRMANI, cases are ranked according to the degree of match to a set of weighted retrieval criteria and adaptation is performed through rule-based guidance by four main adaptation processors namely; architectural, structural, services and cost adaptation. The cost estimation performance of NIRMANI was tested against a commercially available estimating package and the design performance is qualitatively evaluated by several experts (Perera and Watson, 1998), both revealed satisfactory results.

Case-based estimating can be defined as the process of estimating the cost of a new artifact, process or project by referring to previous estimates or cost analyses (Perera and Watson, 1998). Systems that adopt CBR approach can be

used to estimate construction duration and costs of building construction projects at the preliminary design stage.

The system namely, CBR-CURE (Yau and Yang, 1998b), is built to aid decision-making in the estimation domain by using previous problem-solving experiences. This study benefits from 60 hypothetical projects to estimate the duration and cost of a building project. The construction schedule and construction costs are derived by using cases that are represented by 17 features. Among these, 10 features are identified as the input information required for a new project. After the retrieval of similar cases from the case base, the new project's target values for construction duration and costs are computed by an equation (Yau and Yang, 1998b).

5.3.6. Construction Planning and Scheduling

In literature there are several examples of planning systems that benefit from AI opportunities. Among these are GHOST (Navinchandra et al., 1988), PLANEX (Zozaya-Gorostiza et al., 1989), OARPLAN (Darwiche et al., 1989) and Know-Plan (Morad and Beliveau, 1991) which utilize knowledge comprising of a hierarchy of components for a particular type of project and planning rules or constraints that are acquired from expert practitioners, based on rules of thumb or stated in the literature (cited in Dzeng and Tommelein, 1997). Two examples, one for planning and one for scheduling will be given to demonstrate the applicability of CBR in these construction problems.

The prototype software, CBRidge Planner, was developed to estimate the construction duration, cost and quantities. In this respect, detailed information from fifteen highway bridge construction projects are used in the system. Semi-structured interviews were conducted with chief planners and project managers to identify the factors that govern the formulation of plans and obtain sample projects and historical information for use as cases. It is observed that the design, the specification, construction methods and the risk factors that affect project outcomes are the main parameters in construction planning (Tah et al., 1999).

Case adaptation testing was performed to ensure that the final output values proposed by the system, such as quantities, times, and costs were correct. This was achieved by the comparison of the results generated by CBRidge Planner with manually computed values for the test case (Tah et al., 1999).

Common to many construction tasks, scheduling is also performed by the experts who benefit from their past experiences. When they give up working, they take their expertise and knowledge with them. Moreover, most of the valuable project knowledge is lost in considerable amounts of documentation of a paper-based archival system (Dzeng and Tommelein, 1997). As a result new employees cannot exploit from past knowledge. Indeed, previously developed schedules may be reused in similar projects. In order to facilitate such reuse, the CasePlan System is established to support and augment the scheduling activity of people who reason about cases to generate new project schedules. CasePlan, a case-based planner and scheduler for construction does not only create cases using project descriptions and schedules but also selects activities and determines the proposed project's duration (Dzeng and Tommelein, 1997).

CasePlan constructs a schedule by determining a network of activities describing the construction process for each component and then combines them into a single large network. One main advantage of CasePlan is that it generates a new schedule by reusing subnetworks from different cases instead of the entire network from a single case. In short, CasePlan is a decision support tool that allows schedulers to use their own judgment in browsing and copying reusable parts from schedules of previous cases whose products are similar to the new one (Dzeng and Tommelein, 1997).

5.3.7. Construction Litigation

There are various risk factors involved in a construction projects that may cause disputes to be resolved in courts. These risk factors may be miscommunication; inadequate plans and specifications; rigid contracts; changes in site conditions; non-payment; catch-up profits; limitations on manpower, tools, and equipment;

improper supervision; notice requirements; constructive changes not recognized as such by the owner; delays; and acceleration orders often result in disputes (Adrian, 1988 cited in Arditi and Tokdemir, 1999a). It is very difficult to predict the outcome of construction litigation with 100 % accuracy since it depends on a large number of variables such as social, psychological, regional, cultural, religious, time-related, and political factors (Arditi and Tokdemir, 1999b). In order to model the problem, Arditi and Tokdemir (1999a) have adopted two approaches namely ANN and CBR. As the prediction rates of 83 % in the CBR study and 67 % in the ANN study were obtained, it can be concluded that CBR was a more effective method (Arditi and Tokdemir, 1999a).

In the context of the study, 102 Illinois circuit court cases were used to develop the system and an additional 12 cases were used for testing. Each case was defined by 43 input features that affect the winner of the court and 1 output feature determining the winner. The decision of the circuit court is estimated through a process first by ranking the retrieve cases from the case base in the order of their similarity scores. After the cases are retrieved depending on the similarity criteria established previously, manual adaptation methods proposed by the researchers are applied to predict the outcome of the target case. The performance of the model was tried to be enhanced through adjustment of number of features of the cases and the similarity assessment methods (Arditi and Tokdemir, 1999a).

As it is clear from the above examples, CBR is a promising technique to be applied to solve construction management problems. CBR when used for the strategic decisions of a company becomes a decision support tool. In the previous chapter, international market entry was found to be an important decision for construction companies that should be supported by a computer program. Since CBR allows users to benefit from the past experiences in a systematic and time-saving manner, it may be utilized to develop a computer program that aids construction companies in strategic decision-making. The next

section demonstrates the details of the DSS (for international market entry) created under a software package that adopts CBR approach.

5.4. A Decision Support System for International Market Entry: CBR-INT

CBR is a well-established decision support tool for the companies that desire to take the advantage of capturing previous information of past projects and learning from several other companies. The methodology behind CBR lies in the utilization of previously stored knowledge at the time it is needed. This is achieved through a stepwise procedure as retrieval of similar cases, adaptation of the new case to the retrieved ones, incorporation of the adapted case to the case base and reusing it for the next time when a solution is required.

As mentioned earlier, in order to establish a model based on CBR principles to be used as a decision support tool, there is a software requirement. Some of these packages are ART*Enterprise, CasePoint, CasePower, CASUEL, CBR-Express, Eclipse, ESTEEM, KATE, ReCall, ReMind and S3-Case (Leake, 1996).

Being a user friendly software and freely available for the research studies, ESTEEM Case-Based Development Tool is selected to carry out the application phase of a model to predict the attractiveness of an international construction work and competitiveness of a Turkish company among other competitors that are bidding for that job. The following sections describe how to make use of the program in this respect and explain the logic behind its reasoning process. The model developed to help estimate the attractiveness and competitiveness values for an international project is presented and each step is discussed in detail.

The CBR shell, ESTEEM Software Version 1.4, allows the developer to specify case libraries through the definition of case bases. Case base definition requires the list of feature names and feature types. The next step is the acquisition of the cases; values of each feature are given for the available cases. The higher the number of case collection, the easier it is for the program to find similar cases for a new case whose solution is asked. The success rate of the retrieval process is

increased through the well-defined similarity metrics. As a result of retrieval, the user receives most similar cases in the descending order of their similarity scores and previously specified features of the cases are viewed. Adaptation, which can be either manually or automatically generated, provides the end-user to adapt solution to new problems with the help of previous solutions of most similar cases. The case library can be enriched by the incorporation of the latest case and a larger collection can be used for the retrieval step for the solution of the next problem.

Figure 5.1 shows the model generated under the ESTEEM program representing the necessary steps to end up with the best prediction model that would give the most reliable results.

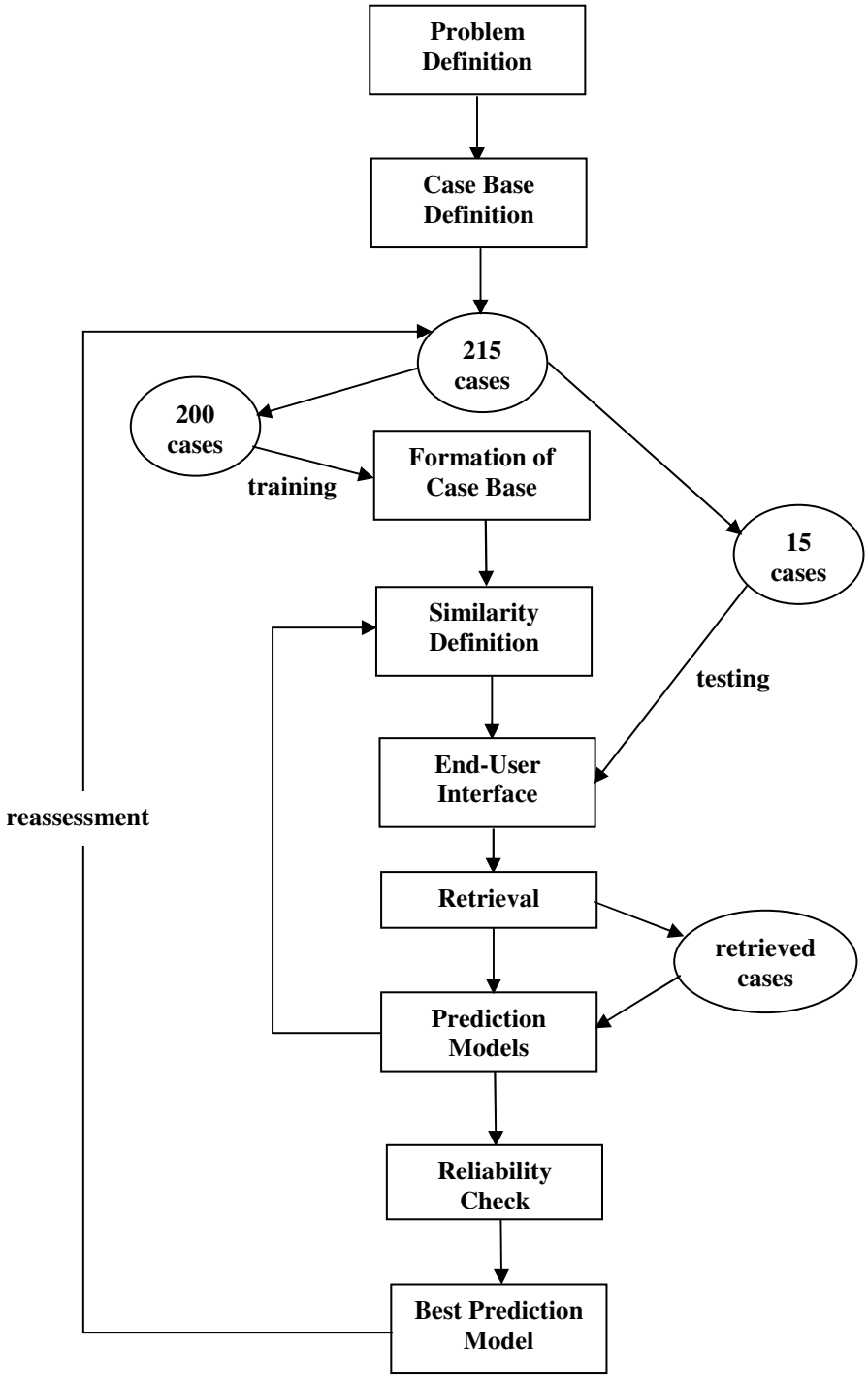

Figure 5.1. Model development chart

5.4.1. Problem Definition

As mentioned earlier, CBR is proposed as a decision support tool for the construction companies to aid in international market entry decision. The captured information about the previously undertaken works abroad is utilized by this technique to give estimations for future projects. To demonstrate the applicability of CBR for international market entry decisions, the first step is to define the problem with its inputs, outputs and the models used for the topic. Figure 5.2 presents the context of the problem, which is tried to be modeled through the ESTEEM program.

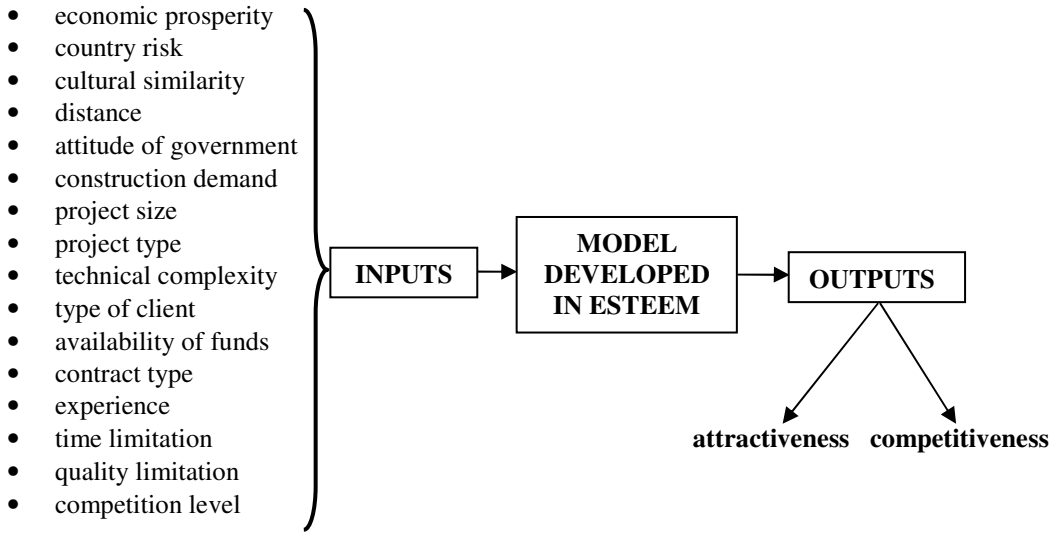

Figure 5.2. Problem definition

In order to obtain the attractiveness and competitiveness values for a specified international construction work, there are 16 independent parameters as inputs provided by Dikmen (2001). These parameters are economic prosperity of the country, country risk, cultural and religious similarity, attitude of the host government, construction demand in the related country, size of the project, type of the project, technical complexity of the project, type of client, fund availability, contract type, experience, time limitation, quality limitation, competition level of the bidding respectively. The data also includes the country names as input information although there is no relevance of the country names

to the solution of the problem, but the country specific features are obtained according the host country of the concerned project. The required project data are supplied by the Department of International Contracting Services under the Turkish Prime Ministry. Some of the input features are rated by the experts and some come from the country or project specific facts. For attractiveness and competitiveness assessment process, 10 top managers were involved and finally a data set of 215 projects is obtained. Details of data collection can be found in Dikmen (2001).

The acquired database is used for the analysis with Neural Network and the dominant parameters affecting the attractiveness of an international construction work and the competitiveness of a company in the bidding are identified (Dikmen, 2001). The classification of input variables was performed so as to reflect the requirements and efficiency of the program employed. Since CBR has some similarities and differences compared to Neural Network, it was inevitable to adjust the feature representations and prediction methods used. The most important step of the reasoning methodology of CBR is the retrieval stage. For the more similar cases to be selected from the database, precise similarity definitions should be made and features should be defined accordingly. After reviewing the case base definition, similarity definition, end user interface and other editor properties offered by ESTEEM, most suitable feature types, similarity definitions and methods are put into operation so as to end up with an effective and efficient model that could be generated by utilizing the CBR problem solving technique.

5.4.2. Case Base Definition

To build the database, a case base should be defined with the feature names and feature types. For the retrieval to run properly, feature types should be selected such that selection of cases similar to the target case becomes easier. There are 6 feature type definitions suggested by the program, namely; Yes or No, Text, Numeric, One of a List, Case and Multimedia. The appropriate types are marked

as Text for country name, Yes or No for time limitation and quality limitation and Numeric for the other elements that require numeric values within the specified ranges. With the input and output features, there are 19 attributes to define the case base. Table 5.1 shows the input feature characteristics, which are considered to be the most fitting to reflect the data in hand.

Table 5.1. Case base definition

	Feature name	**Feature type**
1	CountryName	Text
2	EconomicProsperity	numeric (min:1, max:4)
3	CountryRisk	numeric (min:1, max:5)
4	CulturalSimilarity	numeric (min:1, max:3)
5	Distance	numeric (min:1, max:3)
6	AttitudeOfGovernment	numeric (min:-1, max:1)
7	ConstructionDemand	numeric (min:1, max:5)
8	ProjectSize	numeric (min:1, max:3)
9	TypeOfProject	one of a list (infrastructure, industrial, building, housing, rehabilitation)
10	TechnicalComplexity	numeric (min:1, max:5)
11	ClientType	one of a list (government, private)
12	FundAvailability	numeric (min:-1, max:1)
13	ContractType	one of a list (lump sum, unit price, cost plus fee, turnkey)
14	Experience	numeric (min:1, max:3)
15	TimeLimitation	Yes or No
16	QualityLimitation	Yes or No
17	CompetitionLevel	numeric (min:1, max:5)
18	Attractiveness	numeric (min:1, max:5)
19	Competitiveness	numeric (min:1, max:5)

Economic prosperity of a country is divided into four by referring to the World Bank's classification where 1 contributes to low income level having Gross National Product (GNP) less than 735 USD, 2 is equal to low to middle level having GNP between 736 USD and 2935 USD, 3 is used for the middle to high level of GNP between 2936 USD and 9075 USD and 4 constitutes the high income level that has more than 9076 USD. Country risk is grouped into 5 so as to distribute 20 points to each group where the country risk values are between 0

and 100. Cultural similarity, distance to the host country and experience of the company in a similar project are classified as low, medium and high that correspond to 1, 2 and 3 respectively. Attitude of government takes the values of –1, 0 and +1 according to the negative, neutral and positive attitudes of the host government. Construction demand in the host country, technical complexity of the project, competition level among the bidders, attractiveness and competitiveness values are assessed in a 1-5 scale where 1 is equal to very low and 5 is equal to very high. Project size takes 1 when the project value is less than 25 million USD, 2 if it is between 26 and 100 million USD and 3 when it is a project worth more than 101 million USD. Type of project, client type and contract type are classified as in the above table; the users are directed to select one of these proposed types. Fund availability should take –1 if fund is not available; 0 if fund is partially available and +1 if fund is fully available. Time limitation and quality limitation are equal to yes or no in accordance with whether there is a limitation.

5.4.3. Formation of the Case Base

215 international projects were utilized for the model developed by Dikmen (2001). Considering the requirements of the artificial neural networks, this data set was grouped into two as training and testing samples. Since CBR follows a similar logic as the neural network approach, database can be divided into two with the same manner. As there are 215 projects, it would be proper to select 15 out of these 215 to be testing cases. The key point at the choice of the testing cases lies on the reflection of the overall data according to the input distribution. In this respect, 15 random are selected to compile the testing case group, which can be seen on Table B.1 in Appendix B. The collection of these 15 testing cases is experimented with 7 similarity definitions and 5 prediction models. Among the prediction models, one of them was selected as the most successful according to the performance values of each. Finally, in order to reassess the best prediction model, another testing set is used for the estimation of the outputs.

This time a sample composed of again 15 random cases is obtained. This reassessment step proved the success of the selected prediction model.

5.4.4. Similarity Definition

At the forth step of model development a similarity definition is required. For the retrieval process to effectively take place several similarity definitions were defined and those were tested with some of the first set of testing cases and a general idea about the performance of the similarity methods was obtained. As mentioned earlier retrieval process is based on the indexing mechanisms used in the model. These methods can be one of the tree types as nearest neighbor, inductive reasoning and knowledge guided indexing (Barletta, 1991 cited in Gupta, 1994). In this step, to predict the outcome of the problem, best match (the case having highest similarity score) was chosen and the reliability of each similarity definition was evaluated. Then the range of the similarity definitions was narrowed and only the most proper ones were selected. There are 3 main similarity definitions included in the program.

5.4.4.1. Feature Counting Method

Feature counting method which adopts the principles of nearest neighbor indexing method, evaluates the cases by analyzing each feature one by one and considers their weights are all equal to 1. Total similarity score of a case with respect to a target case is computed by the summation similarity of each feature of the target case to that of the cases in the case base. This definition ignores the dominance of anyone of the input variables that would have effect on the outputs.

5.4.4.2. Weighted Feature Computation

This method offers three types as ID3, Gradient Descent and Manual Weight Generation. The program attains importance weights to the input parameters by any of these 3 options.

- *ID3 weight generation method*

This automatic weight generation method creates a decision tree for the cases in the current case base by using the ID3 (the letters ID standing for "iterative dichotomiser") algorithm of Quinlan (1986 cited in Li, 1996) and then uses the tree produced to compute weights for the features that were used in the tree. ID3 has become the basis of a variety of commercial rule induction packages. The main disadvantage of ID3 Weight Generation Method is that it works only for features using the "Exact" or "Equal" match types in case of the one of a list and numeric features respectively.

After selecting the ID3 method, the user specifies one target feature for which the generated tree could be used to predict. The user is required to click on the desired target feature among the list of all features appearing in a window that is enabled in the similarity definition editor. Then, the user specifies the features to be used in the generated tree to predict the target feature. Given the target and the source features, ESTEEM generates a decision tree and it stops after it is finished. As the weights for the source features are calculated, the Similarity Definition Editor window is updated accordingly. The weight for target feature and features having zero weights are disabled; source features with non-zero calculated weights are set to the calculated weights. These features are shown with their match types either "Exact" or "Equal" and their weights at the end of the analysis.

- *Gradient descent weight generation method*

Unlike the ID3 method, the Gradient Descent weight generation method works for all characteristic. It seems to be more appropriate to use this method as the case base has features of different types. As it is in the case of ID3 method, the user should specify the target and source features from the features list appearing in the Similarity Definition Editor. Different from ID3 method, more than one target feature can be selected but since the two outputs whose prediction values

are required are assumed to be independently assessed, this property of Gradient Descent is not utilized.

The method's basic algorithm starts working by selecting several random cases from the case base and finding most similar cases to these, based on the current weights of the source features. Weights of the source features are incremented or decremented by some amount depending on how well the matching cases' source feature values match as well as how well the matching cases' target feature values match. The resulting "weight updates" vector is normalized, scaled by a factor Delta and added to the current source weight vector after examining several random cases. Then with a decreased value for the factor Delta, the algorithm carries on examining more random cases from the case library. The algorithm works until Delta reaches a certain value or the end-user wishes ESTEEM to stop. Final weights for the features are shown on the screen when the process is completed.

When the user tries different initial weight settings and descent parameters, the algorithm may produce different results. The method is known to run quickly when a high final (minimum) value for Delta is used, "Arithmetic" method is chosen (using a large Step Size Update Parameter), a small number of cases per step is tested. If a low final (minimum) value for Delta is preferred, "Geometric" Delta update method is used and a large number of cases per step are tested, the algorithm will run accurately but slowly. Considering these facts in the analysis, the default parameters are adjusted to give more accurate results.

- *Manual weight generation method*

Manual weight generation method allows users to determine the weights of features manually. Unlike the automatic weight generation methods namely; ID3 and Gradient Descent, this method asks for the users to assign weights of each feature in the features list appearing in the Similarity Definition Editor. If the user does not have any idea about the weights of features, then the program uses its algorithms to compute the weights, otherwise the user specifies the weights.

5.4.4.3. Inferred Feature Computation

The third and the final way to put forward a similarity definition is assigning weights to the features by the help of rules which may be considered as knowledge guided indexing. Inferred feature computation provides the exploitation of rules defined by the developer to calculate the importance weights of the features.

Regarding the fact that changing the similarity definitions and making adjustments on the feature characteristics would have considerable effects on the resulting output variables, for the first trial, 21 similarity definitions are created with several combinations. Unpredictable performance levels of the proposed definitions made it unavoidable to test each one's reliability. Looking at the best matches, the most reliable methods were revealed and the similarity definitions were then modified so as to best reflect the requirements of the data set and characteristics of the methods offered by the program. The number of similarity definitions was decided to be 7 covering all possible combinations, which would make sense.

Table 5.2 shows the similarity definitions utilized for the prediction process. It should be noted that since attractiveness and competitiveness are assumed to be independent from each other, for each output similarity definitions, which require weights of features, are developed individually. One similarity definition that gives reliable results may not be so efficient for the other one. In short, the program was run for attractiveness and competitiveness independently with the selection of their corresponding similarity definitions.

At the end of the analyses, ID3 and Gradient descent give weights of the features for the target parameters being attractiveness and competitiveness. Expecting the feature counting least successful but not discarding it, ID3, GD and manual weight generation methods are applied with the appropriate feature matching types.

Table 5.2. Similarity definitions

Similarity definition	Type of similarity	Target output feature	Weight generation method
SIM1	Feature counting	attractiveness and competitiveness	–
SIM2	Weighted feature computation	attractiveness	ID3
SIM3	Weighted feature computation	competitiveness	ID3
SIM4	Weighted feature computation	attractiveness	Manual
SIM5	Weighted feature computation	competitiveness	Manual
SIM6	Weighted feature computation	attractiveness	Gradient descent
SIM7	Weighted feature computation	competitiveness	Gradient descent

- *Numeric type of feature*

The program gives Equal, Range, Fuzzy Range, Absolute Fuzzy Range and Inferred matching types for the "Numeric" feature type. In case of 'Equal', the similarities between the numeric features of target case and the current case are calculated as 1 if they are the same numbers and 0 if they are different. As the closeness of 1 to 2 should be considered in reality, this matching type would not be appropriate because the program regards close but different values as dissimilar. If 'Range' is the matching type, then the similarity of two values is calculated within the specified tolerance, the result is again 1 or 0 in respect of being inside the range or not. When 'Fuzzy Range' is selected, the similarity is calculated within a range of a specified percent of the numeric value and a similarity score between 0 and 1 is obtained. Since the input features have a small range (the greatest range is 4), this method would not give accurate results. The most proper matching type is thought to be 'Absolute Fuzzy Range' as it evaluates the similarity between two numbers with the distance of them within

the greatest possible range. If the feature values vary between 1 and 5 as in the case of TechnicalComplexity of the project, 2 is computed to be similar to 3 by 75 % where the total range is given as 5-1 = 4 meaning that the distance of values are 25% each. The 'Inferred Feature Match' computes the similarity score referring to a predefined rule in the rule base.

- *One of a list type of feature*

The program presents Exact, Partial, Exact (case indifferent), Partial (case indifferent) and Inferred for "One of a List" type. 'Exact' states 1 for same features and 0 for different ones just like 'Equal'. 'Partial' considers the partial similarity between two features. Options indicating 'case indifferent' do not consider two values dissimilar if their cases are different.

- *Yes or No type of feature*

The program offers only Exact for the "Yes or No" matching type.

Considering the properties of the feature matching types, final 7 similarity definitions were obtained. As an example, the properties of SIM4 that uses manually generated weights for the features, to predict attractiveness, are shown on Table 5.3. For this similarity definition, weights are assigned by the experts and manual weight generation is adopted as the similarity method. The evaluation form used to compute these weights is given on Table C.1 in Appendix C. Details of the other six similarity definitions are given in Appendix D.

Table 5.3. Properties of SIM4

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	absolute fuzzy range:3	0,120	70%
2	CountryRisk	absolute fuzzy range:4	0,140	70%
3	CulturalSimilarity	absolute fuzzy range:2	0,002	70%
4	Distance	absolute fuzzy range:2	0,002	70%
5	AttitudeOfGovernment	absolute fuzzy range:2	0,100	70%
6	ConstructionDemand	absolute fuzzy range:4	0,185	70%
7	ProjectSize	absolute fuzzy range:2	0,030	70%
8	TypeOfProject	exact	0,017	70%
9	TechnicalComplexity	absolute fuzzy range:4	0,050	70%
10	ClientType	exact	0,001	70%
11	FundAvailability	absolute fuzzy range:2	0,180	70%
12	ContractType	exact	0,100	70%
13	Experience	absolute fuzzy range:2	0,050	70%
14	TimeLimitation	exact	0,001	70%
15	QualityLimitation	exact	0,002	70%
16	CompetitionLevel	absolute fuzzy range:4	0,020	70%

5.4.5. End-User Interface

ESTEEM software offers the program developers several editors like case base definition editor, similarity definition editor and rule base editor. In order to give chance to the end users to interfere in the modification stage of a file, the developer specifies some options provided by another editor, which is the end user interface editor. Figure 5.3 shows the screenshot of the End-User Interface Editor. With this editor, the developer defines which features from the whole list will be entered for the target case, which at most two features will be shown as retrieved case features and which as much as desired will be viewed as the selected case features. The developer may also fill in the additional end user functionality preferences where the end user is allowed to incorporate new cases to the case base, modify similarity definition, auto-adapt the retrieved cases and some other similar options. For the model in this study, as auto adaptation of a retrieved case would not be sufficient to observe the reliability of the predefined prediction models, none of the possible additional functions are used. Instead,

final prediction is performed through the analysis on Excel files by manual adaptation models.

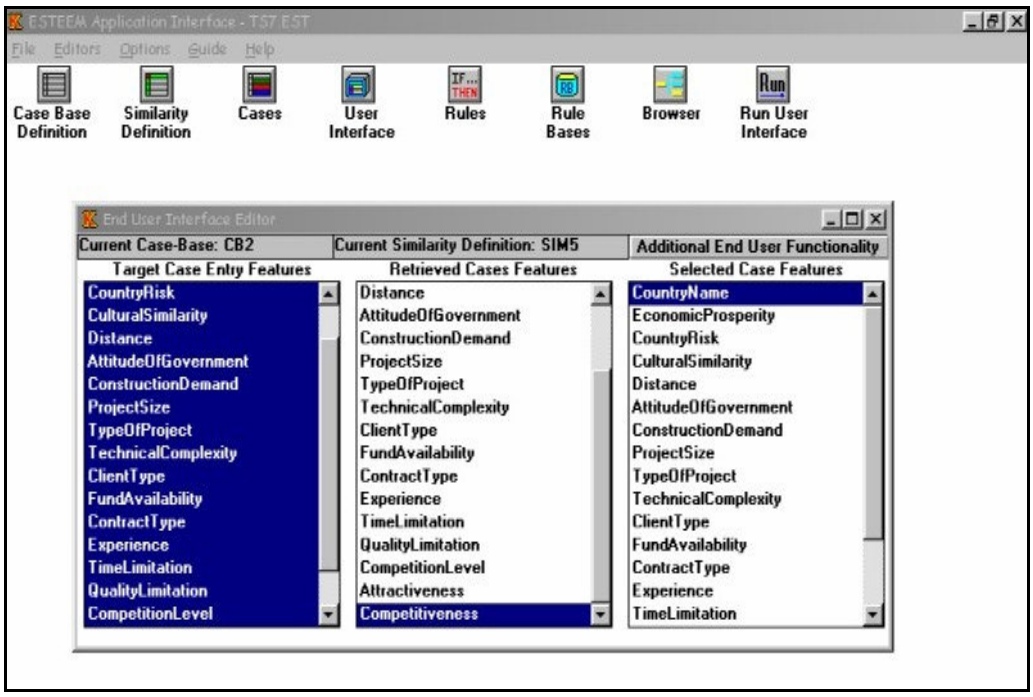

Figure 5.3. End-user interface editor

5.4.6. Retrieval

The central role of the CBR approach is the retrieval of similar cases from the case library. Each step in the prediction process is adjusted to increase the performance of the retrieval stage. The more similar cases are recalled from the case base, the more accurate will be the estimate for the new case. Beginning from the case base definition (deciding on the feature value types), similarity definition types (selection of weighted feature computation or manual weight generation) and feature matching types are all defined so as to give proper methods to the program and make its job easier in the way to find closer matches for the target cases.

When a target case is entered in the run editor of the program, the required values for specified features are viewed on the related window and filled by the

end user within acceptable ranges. If a value given by the end user is not within the predefined feature values, then the program warns the user and lists all possible values for that feature. Another option is to right click and see the value range before giving any value and selecting from the offered list. After the necessary features are filled, the user clicks on the 'Retrieval' tab and similar cases are listed in the descending order of their similarity scores above the specified threshold value. To be more accurate, 70 % similarity score is assumed to be sufficient enough to be used in the final prediction step. After the retrieval of the similar cases in the order of their similarity scores, next step is the adaptation where a solution to the new problem is proposed.

5.4.7. Prediction Models

As CBR is proposed as a decision support tool, it should give estimates for the solution of problems. ESTEEM brings solutions to new cases by adapting the solutions of the retrieved ones. The adaptation process can be performed through manual or automatic adaptation. In manual adaptation, after similar cases are retrieved, the end user can apply a method he or she generates. In the latter case, the program gives the result by applying the rules in the rule base, which were previously generated by the developer. For automatic adaptation the end user selects one of the retrieved cases and employs adaptation over this case. To avoid such limitations, for the sake of including more cases at the prediction stage, more cases are examined to arrive at accurate estimates and retrieved cases for each similarity type are transferred to an Excel file and analyzed with the final prediction models developed.

As the final prediction models, five models are developed and the performance of the testing sample is measured. Table 5.4 shows the explanations for these five final prediction models.

Table 5.4. Final prediction models

Final prediction model	Explanation
M1	Best match among the retrieved cases
M2	Average of the feature values of all cases in the retrieved cases list
M3	Mode of the feature values of all cases in the retrieved cases list
M4	Average of the feature values of top ten cases in the retrieved cases list
M5	Mode of the feature values of top ten cases in the retrieved cases

The first model, M1 assumes that the right solution of the problem belongs to the most similar case in the retrieved cases list meaning that the one getting the highest similarity score out of 100. It is doubtful that the correct answer would always be the same with that of the most similar one. The total similarity value obtained through the assessment of each feature one by one may not contribute to the output alone. Since in some cases the output is governed by some specific elements, the true solution may be hidden in cases holding lower similarity scores. Supposing the deficiency of M1, other 4 models are constructed to involve at least the top 10 cases in the retrieved cases list.

M2 and M4 take the weighted average of the values revealed in the retrieved cases with the distinction that M2 includes all cases above 70% similarity whereas M4 ignores the ones under the top 10.

M3 and M5 seek for the most frequent values occurring in the retrieved list, the difference being the same one between M2 and M4.

5.4.8. Reliability Check

Being aware of the fact that no model can give perfect results, the optimum pattern was tried to be composed of the combination of a proper similarity

definition and a suitable prediction model. Seven similarity definitions were matched with five models to give estimates for the attractiveness and competitiveness values. For each of these two output features, 20 combinations are tried and final predictions are recorded. Table 5.5 and Table 5.6 illustrate the success levels of the related combinations in % values.

Table 5.5. Reliability results for attractiveness (%)

	M1	**M2**	**M3**	**M4**	**M5**
SIM1	77	77	77	77	77
SIM2	85	88	88	88	88
SIM4	87	87	85	88	88
SIM6	87	83	83	85	87

Table 5.6. Reliability results for competitiveness (%)

	M1	**M2**	**M3**	**M4**	**M5**
SIM1	78	85	78	87	77
SIM3	85	83	83	88	90
SIM5	87	88	82	90	88
SIM7	83	80	77	85	85

5.4.9. Best Prediction Model

Analysis of the results obtained through the reliability checks tells to employ ID3 weight generation as the similarity definition (SIM2) for attractiveness and manual weight generation (SIM5) for competitiveness. Since none of the similarity definitions has a striking success over the others, selection of best method is performed by evaluating the average success levels of the similarity definitions under each model. This is resulted in the selection of SIM2 and SIM5. The next step is the selection of the most appropriate final prediction model. Having chosen the similarity definition, best model is adopted as the one that works best with that similarity definition. For SIM2, almost all models work with the same efficiency, whereas for SIM5, M4 (taking the average of top 10

cases) is the most successful model. So, M4 is selected as the final prediction model for each output.

As one testing sample could be misleading to decide on the prediction model, additional 15 cases are selected to constitute the second testing data. The second set of testing cases can be found in Table B.9 in Appendix B. This experiment would be fairly straightforward since there is only one similarity definition and one prediction model for each of the two outputs namely; attractiveness and competitiveness. This model is tested among the new set of cases and estimations are recorded. Table 5.7 shows the reliability level of the final prediction model for attractiveness and competitiveness. It is obviously seen that the performance of the selected combination is high and the success of the model is not accidental.

Table 5.7. Reliability level of final prediction model for the second set

Test case	**Target att.**	**att. of SIM2**	**%**	**Target comp.**	**comp. of SIM5**	**%**
p4	**2**	3	75	**4**	3	75
p24	**2**	3	75	**3**	3	100
p56	**1**	2	75	**1**	2	75
p67	**4**	4	100	**3**	3	100
p71	**4**	3	75	**4**	3	75
p74	**5**	4	75	**2**	3	75
p110	**3**	3	100	**3**	3	100
p133	**4**	3	75	**2**	2	100
p142	**3**	3	100	**4**	4	100
p153	**3**	3	100	**2**	2	100
p163	**3**	3	100	**5**	4	75
p180	**3**	3	100	**4**	4	100
p187	**4**	4	100	**2**	3	75
p193	**2**	3	75	**3**	3	100
p212	**2**	1	75	**2**	2	100
Reliability %			**87**			**90**

As far as the system is established with its final prediction model and similarity definitions, the generated program is ready to be given a name and to be run by

the users. Since the system is developed to aid construction companies in decision-making for international market entry and uses CBR approach, it is named as “CBR-INT”. The next section illustrates an example for which the attractiveness and competitiveness values of an international project are required.

5.5. An Application in CBR-INT

This system is generated for the construction companies, which would like to enhance decision-making capabilities through the help of computer programs. As long as the development and utilization of the model is concerned, this decision support tool is highly based on the OM of a company. The related data to construct the case base of the program is acquired from the other companies’ experiences in foreign markets. This information is stored in the database of the company. These processes enhance the OM of a construction company. Using CBR as the problem solving approach in a DSS leads to the provision of exploiting the stored past experiences that constitute a component of the OM. With these features, this tool can be regarded as an enhancer of OL in construction companies.

In order to prove the applicability of the system in the industry, the Business Development Manager of Company F was asked to provide the data of a real international project and use CBR-INT.

The users will make use of this DSS that is generated under ESTEEM by using the editors of the program and specifying the required parameters. After starting ESTEEM, the user should select “Load Application” from the File Menu. In the “examples” folder, when CBR-INT is selected, the program loads the related data for this system. Below paragraphs give some instructions about the usage of CBR-INT.

5.5.1. Selection of the Similarity Definition

As previously mentioned, in order to obtain a retrieved list of similar cases to the target case, similarity definition should be specified. The final prediction model makes estimates of attractiveness and competitiveness individually, so different similarity definitions should be selected for each. When the user clicks on the "Similarity Definition Editor" icon, a window appears for the selection of the similarity definition. SIM2 is selected to predict the value of attractiveness as seen on the screenshot given on Figure 5.4.

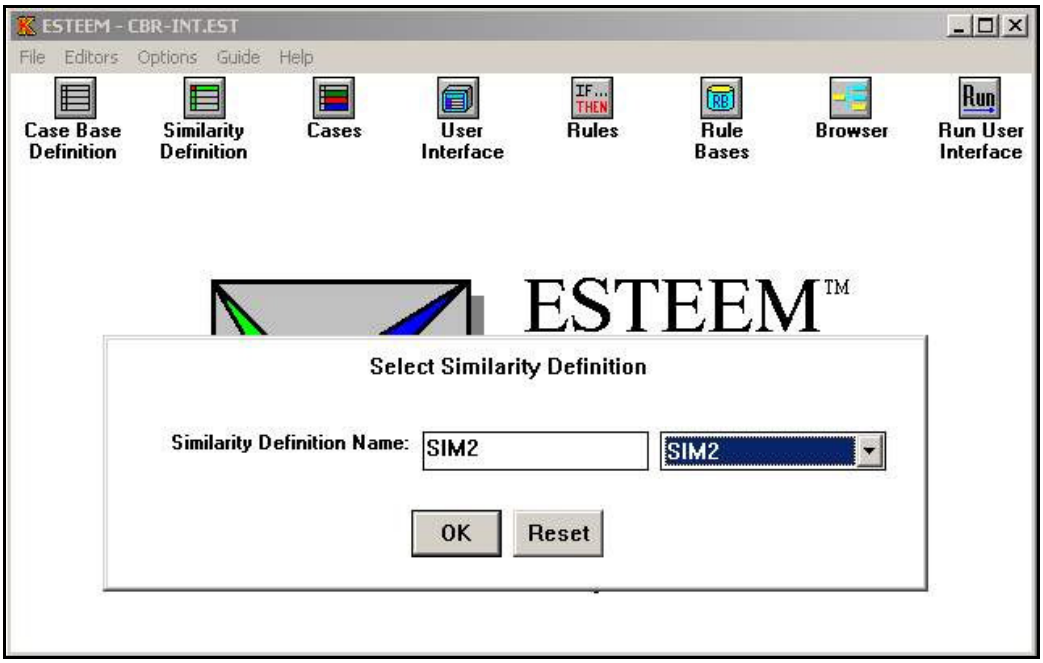

Figure 5.4. Similarity definition selection

5.5.2. Running the Program

The next step for the user is to select the "Run User Interface" from the Editors Menu or directly click on the icon. Figure 5.5 shows the appearance of the selected editor.

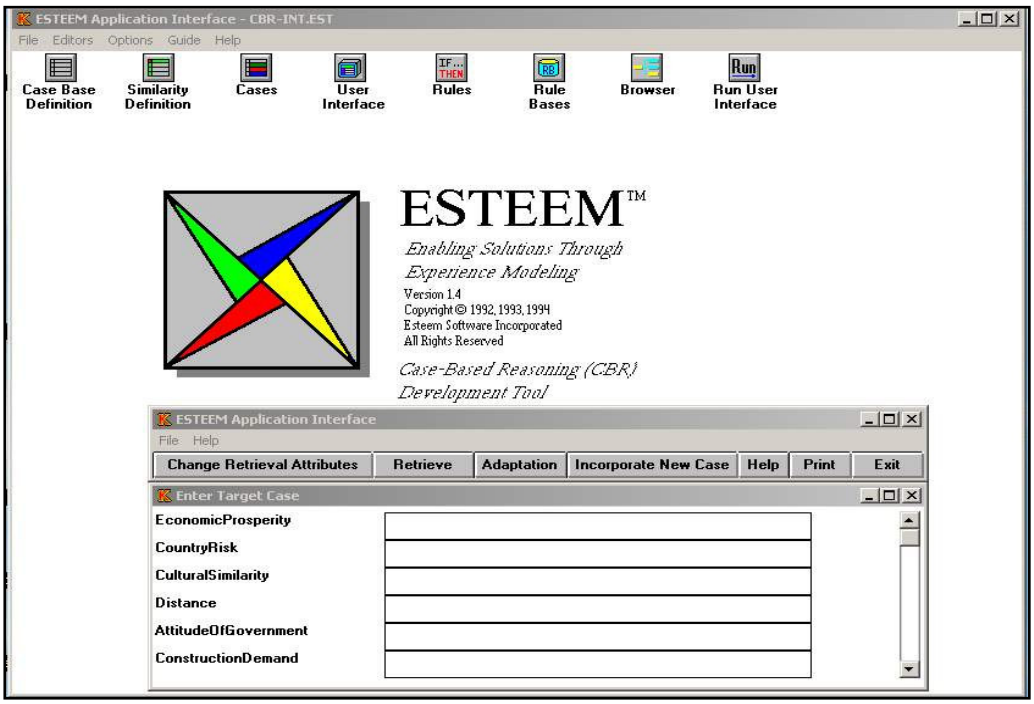

Figure 5.5. Run user interface editor

The window requires the user to enter the target case. When developing the model, case base was defined and feature names and types were specified. The user should fill the feature values for the example international project. Figure 5.6 shows some part of the feature values entered by the user.

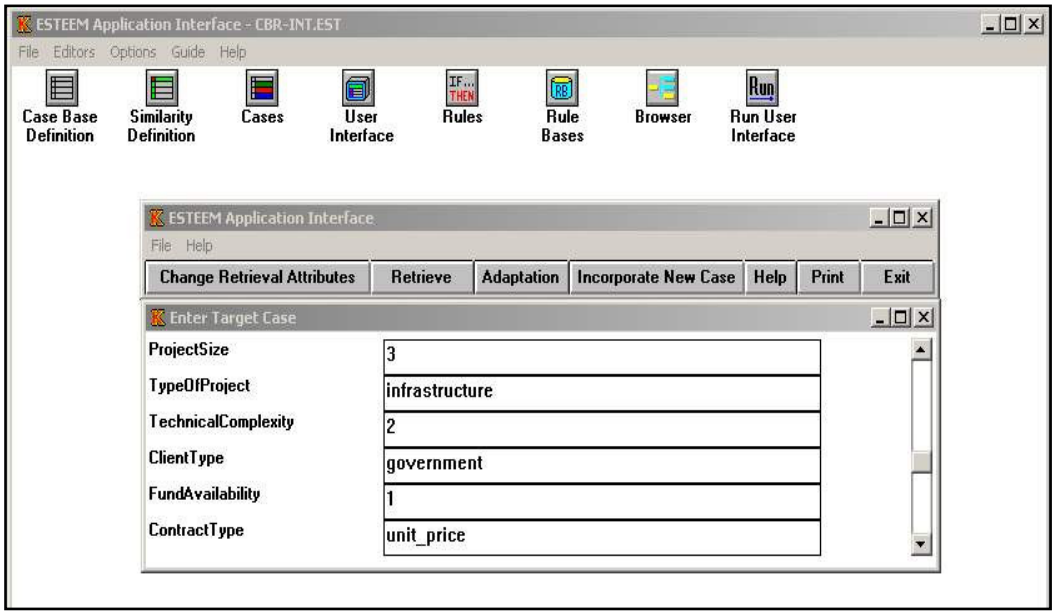

Figure 5.6. Target case entry

The target case is an infrastructure project in Pakistan that requires high experience and where there exist strict competition conditions. When all features necessary for the target case are specified, the user clicks on “Retrieve” menu on the application interface window. The program retrieves similar cases in accordance with the similarity definition and gives a list of similar cases having similarity scores greater than 70 as it was specified in the development stage. Figure 5.7 presents the retrieved cases list on which similarity scores, case names, attractiveness and competitiveness values appear.

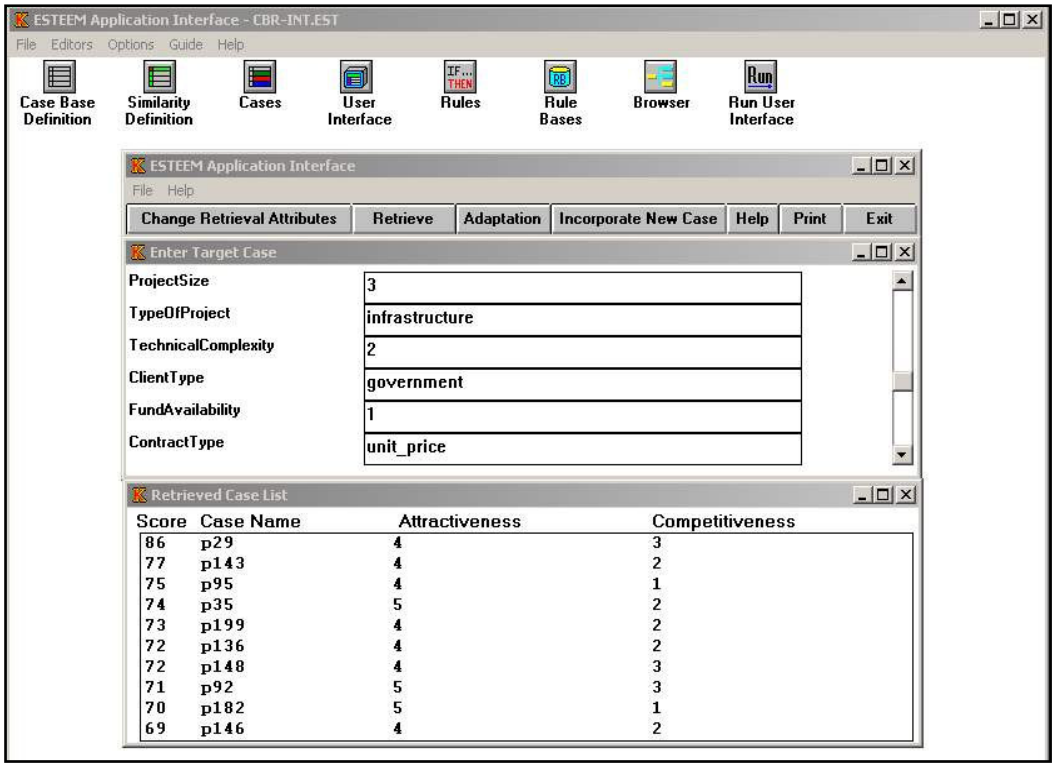

Figure 5.7. Similar cases retrieved for the target case

5.5.3. Final Prediction

M4 that was adopted as the final prediction model is based on taking the average of the feature values of top ten cases in the retrieved cases list. The user should copy the attractiveness values corresponding to the ten cases having highest similarity scores in the list and take the average of these values to obtain the attractiveness value of the target case.

The same procedure is applied for the prediction of the competitiveness value; this time SIM5 is selected as the similarity definition and competitiveness value for the target case is estimated using M4.

At the end of the application the project seemed to be highly attractive but the competitiveness value of the company was medium. This situation was expected because the company was meeting the requirements to perform the job but the threat of the competitors was almost impossible to avoid.

5.6. Benefits and Shortcomings of the System

In the light of the above discussions, it can be concluded that this DSS has some benefits and shortcomings due to the problem solving approach, software package and the problem itself. This proposed model is beneficial for the construction companies that seek for a mathematically constructed program that reveals the numerical outputs of a problem.

CBR is a technique that relies on the past experiences to solve current problems. CBR follows the principles of human reasoning that finds solutions to problems by adapting the solutions of past similar problems. With this feature, it is suitable to solve construction problems that are generally solved through the past experience, expertise and intuition of expert people. This technique is good at storing and reusing the past experiences but since it produces numeric outputs, for the prediction of problems requiring more than concrete facts, it can only support the decisions. Moreover, the accuracy of estimation is directly proportional to the extent of the case base. As the number of the cases increases, the reliability of the model increases too. Collecting more specified cases will also enhance the performance of the model.

During the development of the model, there were several steps that would affect the solution of the problem. Collected data should fit the feature types specified in the case base definition; each input variable should be converted to feature types that can be analyzed by the algorithms of the software program namely,

ESTEEM. Input parameters are classified according to some assumptions that lead to some simplifications. More detailed classification of features may lead to more accurate results. For example, project types can be further divided into subcategories to reveal the properties of more specific construction projects.

Similarity definitions are able to generate weights of the attributes through the indexing methods where the importance weights cannot be assigned by the users. The output is given by considering the similarity scores of cases in the case base computing the weighted similarity values of each feature in a case. Attaining weights is a plus of the program as all of the input variables do not have equal importance weights. When selecting the adaptation model, five models were proposed since auto adaptation could be performed on only one case. Several cases were considered to predict the output values but due to the scale of the feature values, accurate values could not be revealed in the estimated output values. Due to the properties of ESTEEM, after the retrieval of similar cases, adaptation was performed in Excel files. An integrated system would be better in terms of data exchange and saving time.

Since international market entry decision is a highly complex problem and cannot be solved through only computation of some real facts of an international project, this system cannot be solely used for the solution of this problem. There are some other factors influencing the market entry decisions such as the company strategies, intuition of the decision makers and personal considerations of the company owners. These parameters finalize the decision but CBR-INT shows the mathematical facts related to a project and gives ideas to the decision makers. As previously mentioned, this system increases the OL potential of a company by the collection, storage and utilization of information acquired through the experiences of other companies in foreign markets. Such DSSs are helpful in the creation and utilization of OM that is the core element of the OL cycle of an organization.

CHAPTER 6

CONCLUSION

Many researchers have studied the concept of OL that is seen recently an influential element of sustainable competitive advantage. Companies need to learn and apply new ideas and behaviors in order to cope with the environmental changes. To gain a competitive edge, companies should seek ways to exploit the opportunities and avoid the threats offered by the environment. The only way to achieve these is to incorporate learning activities into the daily operations of the organization. Despite the fact that OL concepts are more applicable for manufacturing industry, construction industry has also considerable potential to learn and make use of the knowledge gained through the learning process. As the final output of learning, what is tried to be obtained is the OM. All activities are carried out to reach an organizational asset because organizations behave within their cultures that are composed of common values, norms and beliefs. Learning organizations and OL are extensively investigated and several views are proposed in the literature. Although how learning takes place in the organizations is clear, how organizations benefit from the output of learning process is vague.

One of the main concerns of this thesis is to find out how construction companies create OM and how they utilize this corporate value. In this context, an interview study is conducted with large Turkish construction companies and as a result of the research findings, a DSS is proposed to aid construction companies in international market entry decision.

In the context of this study, OL and learning organization concepts are presented and some essential points of OL are explained; levels and types of learning are mentioned. As a different perspective, concept of OM is introduced. Then, dimensions that constitute the learning organization are discussed; learning, organization, people, knowledge and technology components are analyzed in detail. DSSs and IT tools are proposed as means to exploit OM, which increase OL competence of the companies. Besides, OL in construction industry is also highlighted. How construction companies learn is explained, enablers of OL are discussed and finally the strategic role of OL for construction companies is emphasized.

In order to reflect the conceptions and applications of the companies on OM, an OL framework is developed. In this framework construction companies are assumed to acquire knowledge from the own experiences of the company, other companies' experiences and external resources. Knowledge gained through these three main sources is interpreted within the organization and institutionalized in order to achieve the most important intangible asset of a company, namely the OM. OM is then utilized in the strategic decision-making process. New ideas and insights obtained from the strategic decisions are then revised and added to the OL cycle. This framework has shaped the content of the interview study. The major premise of this framework is that OM is a usable asset for construction companies and by the help of OM, companies make more accurate decisions and revision of knowledge provides a continuous and dynamic aspect to OL.

The interview study has revealed some facts of the Turkish construction industry. Since the research study covers a small sample, these facts could not be generalized as if the answers of the respondents reflect all companies in the industry. Due to this, research findings are presented as case studies; eight companies participated in the interviews are discussed under each heading of the interview. Most striking points are identified and some common ideas are explored. The following conclusions can be drawn from the interview study:

- Construction companies learn from several sources; it is observed that they are very good at acquiring and storing knowledge but they cannot share knowledge among employees widely. All companies are successful at the creation of project memory. Although project information is shared among other members of the organization, strategic information is only accessible by the managerial level personnel due to some confidential concerns.

- In spite of the fact that learning from other companies' experiences does not constitute a high proportion in terms of knowledge acquisition, company managers express that their companies regard JV partners as serious learning sources. This is an expected result since a leading company compensates for the weaknesses of its partner in a JV.

- Almost all of the companies highly utilize the recommended external resources so as to gain knowledge. Besides, they have added more external knowledge sources to the proposed list.

- It is a fact that almost all respondent companies learn mainly from their own experiences; learning from other companies' experiences and external resources constitute nearly the half of the OM constructed in the companies. When the knowledge structure of OM is analyzed, it is observed that the proportion of tacit knowledge, which is generally composed of personal experiences that cannot be easily transferred to other members in the company, is equal to the explicit knowledge, which is codified in the databases in an organization.

- One of the most significant points is that the role of OM in strategic decision-making is limited for the construction companies. Managers make strategic decisions generally based on their intuition, experience and expertise. Scientific data is not always required to decide on taking a new job, entering a new market or making new investments. So, the low frequency of DSS

usage is not a surprising result since those systems benefit from the OM of an organization.

- When the knowledge management activities are reviewed, it is seen that companies are most successful at acquiring and revising knowledge. However, they believe that knowledge sharing and utilization of knowledge in decision-making are the most important two activities, which should be carried out in the construction companies.

- One of the main barriers of OL is the high employee turnover rate that prevents companies embed knowledge within the organization. The other important factor is the structure of the company that determines the effectiveness of the learning environment.

- As a result of this chapter, major finding is the lack of DSSs to aid the companies in strategic decision-making. Respondents suggest that DSSs would be beneficial for them since these tools provide useful data on their future projects. Construction companies especially need a decision support tool for international market entry as the company managers express. In this respect, a DSS is developed to meet the requirements of the industry.

The system namely, CBR-INT developed for this purpose provides outputs to help decision makers for international projects. This model is proposed to increase the OL competence of companies since it requires the acquisition of several data, interpretation of data and transferring into information, storing in a database and utilization of knowledge at the decision-making stage. The model is generated under a software package that adopts CBR principles. Within the thesis, CBR approach is discussed in detail; basic definitions are given, problem solving process is explained, applications in construction industry are mentioned. Then the model is presented as an aid to construction companies and benefits and shortcomings of the system are discussed. The following are some points to be emphasized about this tool:

- CBR is a problem solving technique, which finds solutions to current situations by adapting the solutions of past similar problems. With this feature it can be considered to follow the principles of human reasoning. In addition, it is a very suitable approach to solve construction problems that are generally solved through the past experience, expertise and intuition of expert people. The reliability level of the system also approves the success of CBR and shows that it is the right choice to model a construction management problem.

- The performance of the system may be enhanced by some arrangements in the case base, adaptation models and the overall software. In order to increase the reliability level of the system, the case base may be enlarged, more specific cases may be added to the case base, number of input features may be increased and more detailed features may be added. The accuracy of results can be improved through some adjustments in the adaptation models, which may comprise some rules that would allow automatic adaptation instead of manual computation methods. Besides, in order to remove the deficiencies of the program, an integrated system may be designed where input data entry, running of the analysis in ESTEEM and adaptation models can be performed in a single software package.

- This model is not a perfect solution and it cannot be solely used since international market entry decision is a highly complex problem that involves some considerations other than some solid facts. However, it is believed to serve as an advisory system for the decision makers who will finalize their decisions based on their intuition, expertise, experience and their companies' own concerns on an international project. This tool is also proposed to increase the OL competence of a construction company by allowing the acquisition of several cases to form the case base through the storage of both project and strategic information, interpretation of this information to define a strategic problem and utilization and revision of this corporate knowledge to solve that problem.

From the above discussions, it can be concluded that construction companies are successful at the creation of OM but unfortunately they cannot make use of it. Storage of project and strategic information leads to the provision of OM but more importantly to modeling and solving some upper level decisions in the organizations. Companies should be aware of the fact that OL creates competitive advantage for them in their markets and they should provide their employees with an effective environment that would support the learning process.

It is also observed that companies are unfamiliar with the DSSs to aid them in their strategic decisions, which would make them use their OL potential. In order to meet the requirements of the industry in terms of a DSS, a model is developed to assist companies in making decisions on international projects to solve the international market entry problem. This tool is proposed to increase the OL competence of construction companies through the provision of all knowledge management activities that should be carried out in the construction companies. Obviously, this is not the only way to increase the OM of a construction company; each organization can increase its learning potential through the utilization of recommended knowledge sources in the OL framework and application of several IT tools in parallel with its objectives and corporate strategies.

As a future work, to develop a product that can be used in construction industry, an integrated system may be designed. Rules may be incorporated to the software that uses CBR approach so that a hybrid model is obtained. The program may be combined within a single package that allows all processes to solve the problem are performed in a time saving and easy manner. The explanation capability may be strengthened through the involvement of more detailed input data and by producing more output features. As a final recommendation, having a high performance level for the international market entry problem, such systems may also be developed in future to solve other similar construction management problems.

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APPENDIX A

A SAMPLE OF THE QUESTIONNAIRE

CONTENTS

1. GENERAL INFORMATION ABOUT THE COMPANY

2. ORGANIZATIONAL LEARNING FRAMEWORK

Presentation of the organizational learning framework and the role of organizational memory in strategic decision-making and in this respect explanation of the objectives of the research study.

3. LEARNING FROM OWN EXPERIENCES OF THE COMPANY

3.1. Knowledge acquired through company's own experiences

3.2. Documentation-based methods used for the creation of the project memory

- Project evaluation
- Micro articles
- Learning histories
- Formation of case bases using computer programs

3.3. Process-based methods to store the results of strategic decisions

- Post-project appraisal
- After action review

4. **LEARNING FROM OTHER COMPANIES' EXPERIENCES**

   Determination of the mechanisms used by the construction companies to learn from the experiences of other companies and exploration of how the acquired knowledge are stored and disseminated within the company.

5. **LEARNING FROM THE EXTERNAL RESOURCES**

   Investigation of the frequency of utilization of the external learning resources and examination of how the acquired knowledge is stored within the company.

6. **ORGANIZATIONAL MEMORY**

   Determination of the distribution of the resources and knowledge types contributing to the organization's memory.

7. **EXPLOITATION OF ORGANIZATIONAL MEMORY IN STRATEGIC DECISION-MAKING**

   Examination of the importance and exploitation frequency of the codified knowledge in strategic decision making and determination of the significance and existence of the decision support systems in strategic decision making process.

8. **EVALUATION OF THE COMPANY IN TERMS OF ORGANIZATIONAL LEARNING COMPETENCE**

   Questioning the importance of knowledge management activities and the success level of the company in the learning process.

9. **ORGANIZATIONAL LEARNING BARRIERS**

   Determination of the factors preventing learning at the organizational level.

GENERAL INFORMATION ABOUT THE COMPANY

1. Number of years that the company has been in the sector is **……years.**

2. Company's **domestic** turn over realized **so far** is **.....US Dollars.**

3. Company's **overseas** turn over realized **so far** is **.....US Dollars.**

4. Considering the projects undertaken within the last **5 years**, please state **the annual average** turnover of your company in US Dollars ($).

Domestic projects: ..... $/year

Overseas projects: ..... $/year

5. Concerning the turnovers of the jobs undertaken;

a. What is the frequency of your company in working with **foreign partners**?

1=Never 2=Seldom 3=Sometimes 4=Usually 5= Frequently

□ □ □ □ □

b. What is the frequency of your company in working with **domestic partners**?

1=Never 2=Seldom 3=Sometimes 4=Usually 5= Frequently

□ □ □ □ □

6. Please state the other sectors related/unrelated to construction that your company is in.

.....

SECTION 1: ORGANIZATIONAL LEARNING FRAMEWORK

Organizational memory is obtained through the interpretation, integration and institutionalization of the knowledge within the organization with the acquisition, sharing, transfer, dissemination and storage mechanisms. Since the companies refer to their memories in strategic decision-making process, organizational learning concept has been accepted as a critical resource for sustainable competitive advantage.

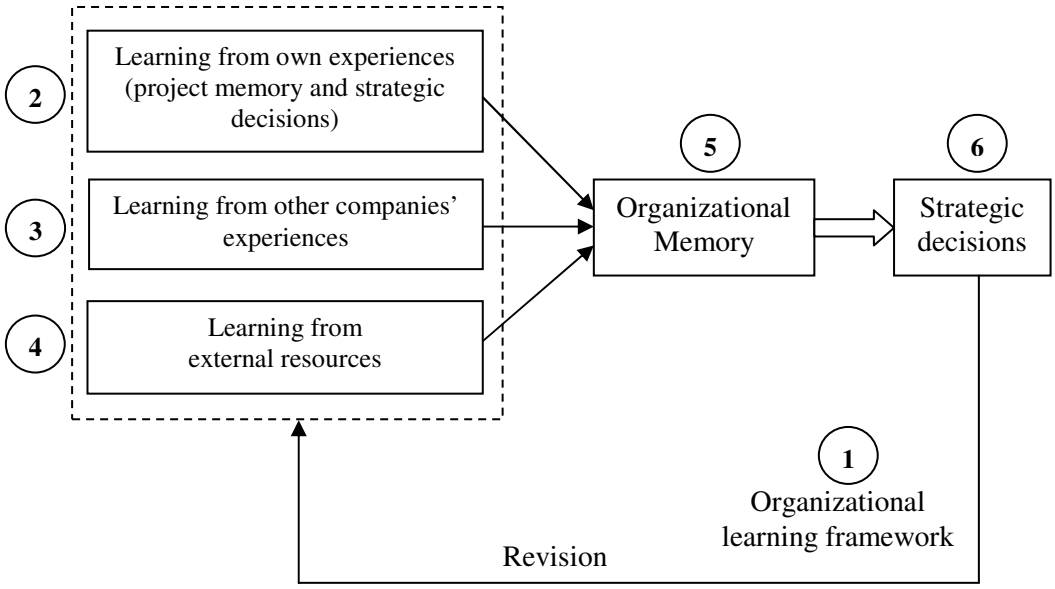

Figure A.1. OL framework

Aim of the research study:

The major objective of this study is to explore how the construction companies create their organizational memories and how they exploit this memory in the strategic decision-making process. In this respect, the headings composing the organizational memory will be examined and then its influence on strategic decision-making will be investigated.

SECTION 2: LEARNING FROM OWN EXPERIENCES OF THE COMPANY

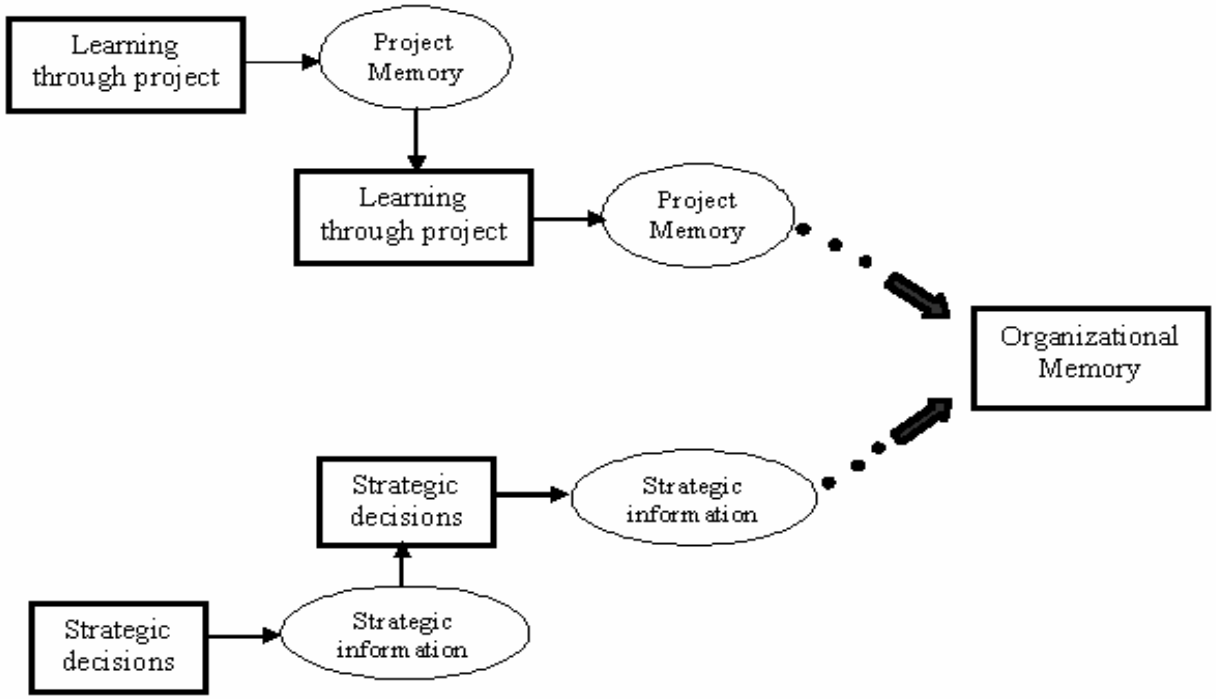

Figure A.2. Learning from own experiences

2.1 Knowledge acquired through company's own experiences

Please mark your answers related to how you store the knowledge types listed below (project information and strategic information) within your organization.

Table A.1. Knowledge gained through own experiences of the company

Knowledge type	**Computer based**	**Partially computer based**	**Individual based**
Project information (about realized projects)			
Information related to job performed: Productivity Methods applied Unit costs …….			
Information related to parties involved in the project: Client information Subcontractor information …….			
Market information: Construction demand Country risk level Success factors …….			
Strategic information (about the potential projects/markets and company performance)			
Rival company information …….			
Market information: Potential market scanning …….			
Performance information: Company performance according to the success criteria …….			

2.2 Documentation-based methods used for the creation of the project memory

2.2.1 Project evaluation is the process of documentation of project experiences during or at the end of the project.

- Is project evaluation a documentation mechanism used in your company?

  ……

- If yes, what kinds of data are collected?

  ……

- Are these data collected at the end of the project or for several times during the project?

  ……

- Who is responsible for this activity in your company? (Such as the project managers or project-external appraisal unit)

  ……

2.2.2 Micro articles can be defined as a method to store experiences of people after completion of a project involving the cause-effect relations and solutions to problems and keywords related to the topic. This knowledge is then transferred into databases and shared through the intranets.

- Do you store micro articles as a documentation mechanism and share them within your company?

  ……

2.2.3 ***Learning histories*** cover the chronological progress, actions taken and results of the decisions in a 20 to 100-page report written by one person by making references to other project members' experiences.

- Are learning histories developed in your company in order to enhance your project memory?

……

2.2.4 ***Formation of case bases using computer programs*** means that experiences of each one are collected in the same system. (Like formation of case bases related to project's critical success factors, results or productivity and performance values)

- Does any system exist for the storage of cases in your database?

……

2.3 Process-based methods to store the results of strategic decisions

2.3.1 ***Post-project appraisal*** is a documentation method performed by external post-project appraisal unit two years after project completion that covers all project information (market, project parties, etc.) and results of strategic decisions to learn from mistakes and transfer knowledge.

- Is post-project appraisal carried out in your company to review the results of strategic decisions?

……

- If yes, are those information codified or stored in the individuals' minds?

……

2.3.2 ***After action review,*** is a collection and storage mechanism performed after each decision stage that covers the answers to questions like "what was supposed to happen", "what actually happened", "why were there differences" and "what can you learn from this experience".

- Is after action review an employed mechanism to store results of the strategic decisions?

  ……

- If yes, are those information codified or stored in the individuals' minds?

  ……

SECTION 3: LEARNING FROM OTHER COMPANIES' EXPERIENCES

Please state, in accordance with the questions, whether you make use of the following learning sources, which methods you adopt to increase your learning capacity, whether you sore the acquired knowledge in computers and shared among employees through the intranets.

1. Do you follow the *experiences of your rival companies*?

…….

Which methods do you apply to learn from the experiences of rival companies?

…….

Which publications do you follow?

…….

Are the acquired knowledge stored in computer-based environment and shared within the company through the intranet?

…….

2. Do you employ *benchmarking* as a learning mechanism?

…….

Are the acquired knowledge stored in computer-based environment and shared within the company through the intranet?

…….

3. Which methods do you adopt to learn from the *experiences of foreign companies*?

…….

Do you make use of Internet?

…….

Are the acquired knowledge stored in computer-based environment and shared within the company through the intranet?

…….

4. Which methods do you utilize to increase your learning potential from *your JV partners*?

…….

Are the acquired knowledge stored in computer-based environment and shared within the company through the intranet?

…….

5. Dou you learn from the experiences *of firms out of the construction industry (such as automotive, finance)*?

…….

Are the acquired knowledge stored in computer-based environment and shared within the company through the intranet?

…….

SECTION 4: LEARNING FROM THE EXTERNAL RESOURCES

Please state whether you use the following external learning sources, store the acquired knowledge in computer-based environment and share them among employees through the intranet within the company.

Table A.2. Utilization of external learning sources

External learning sources	Utilization		Storage		
	Yes	No	Computer based	Partially computer based	Individual based
Universities					
Educational supervisor companies					
Management supervisor companies					
Governmental bodies that are related with the construction sector (other than the clients)					
Other foreign organizations that are not clients (World Bank, etc.)					
Organizations like Chamber of Civil engineers etc.					
Associations (Association of Turkish Contractors, etc.)					
Others (please indicate)					

SECTION 5: ORGANIZATIONAL MEMORY

- The knowledge acquisition resources that compose the memory of a construction company can be grouped into 3 being the company's own experiences, other companies' experiences and exterior resources. Considering learning at the organization level in your company please state the distribution of these resources according to their percent contribution to your organizational memory.

Table A.3. Contribution of learning sources to OM

Resources composing the organizational memory	**Percent contribution to organizational memory**
Company's own experiences	
Other companies' experiences	
Exterior resources	

- Organizational memory consists of codified and tacit knowledge. Concerning your company's organizational memory, please state the percent distribution of these knowledge types.

Table A.4. Shares of knowledge types in OM

Knowledge types in the organization	**Percent share in the memory**
Codified knowledge	
Tacit knowledge	

SECTION 6: EXPLOITATION OF ORGANIZATIONAL MEMORY IN STRATEGIC DECISION MAKING

Strategic decisions given in a company are listed below. Please state, how important you consider the codified knowledge is in strategic decision making process, how frequently you refer to your codified knowledge to give strategic decisions, how important the decision support systems (DSS) are for decision making and whether there exists DSS in your company.

Table A.5. Role of OM in strategic decision-making

Strategic decisions	Importance of codified knowledge					Frequency of utilization of codified knowledge					Importance of DSS in decision making					Existence of DSS	
	Very low 1	Low 2	Medium 3	High 4	Very high 5	Never 1	Seldom 2	Sometimes 3	Usually 4	Frequently 5	Very low 1	Low 2	Medium 3	High 4	Very high 5	Yes	No
International market entry																	
Market entry related/unrelated to construction																	
Bid/no bid																	
Selection of JV partner																	
Bid preparation (determining risk premium and bid price)																	
Developing differentiation strategy (marketing strategy, quality management)																	
Making new investments (IT, etc.)																	
Restructuring of the company (corporate changes to increase productivity)																	

SECTION 7: EVALUATION OF THE COMPANY IN TERMS OF ORGANIZATIONAL LEARNING COMPETENCE

- The aim of knowledge management is to create the organizational memory and provide this memory to be referred to improve the decision making process. Please state how importance you regard the following knowledge management activities and rate yourself according to your success level in 1-5 Likert Scale.

Table A.6. Knowledge management activities in the company

Knowledge management activity	**IMPORTANCE**					**SUCCESS**				
	Very low 1	Low 2	Medium 3	High 4	Very high 5	Very low 1	Low 2	Medium 3	High 4	Very high 5
Knowledge acquisition										
Knowledge storage										
Knowledge sharing										
Utilization of knowledge in decision making										
Revision of knowledge										

- How would you evaluate your company's organizational learning competence?

1=Very low 2=Low 3=Medium 4=High 5=Very high

□ □ □ □ □

SECTION 8: ORGANIZATIONAL LEARNING BARRIERS

- Do you think organizational learning competence is an important concept for the construction companies?

  ……

- Would you like to increase your company's organizational learning competence?

  ……

- Why do you think organizational learning is nor at the desired level? How would you list the factors preventing organizational learning when learning and memory are considered to support decision-making process?

  ……

Table A.7. OL barriers

Barriers to organizational learning	**VALIDITY**		**IMPORTANCE**				
	Yes	No	Very low 1	Low 2	Medium 3	High 4	Very high 5
Cultural barriers							
Structure of the company							
High employee turnover							
Uniqueness of each project							
Unsupportive nature of the industry							
Not creating competitive advantage for taking jobs							
Lack of resources							
Lack of consciousness							
Others (please state) ……							

APPENDIX B

TESTING CASES FOR CBR-INT

Table B.1. First set of testing cases

Country name	Econ Pros	Coun. risk	Cult. sim.	Dist	Att. of govn.	Dem.	Proj size	Project type	Tech comp.	Type of client	Fund Avail.	Contract type	Exp.	Time limit	Qual. limit	Comp. level	Att.	Comp
Albania	2	3	2	1	1	2	1	rehabilitation	2	private	1	lump sum	1	Yes	No	4	3	4
Azerbaijan	2	3	3	1	1	4	1	industrial	2	private	1	unit price	3	Yes	Yes	5	5	3
Bosnia Herz.	2	3	3	2	1	5	3	infrastructure	3	government	-1	unit price	3	No	No	3	2	4
Cuba	3	2	1	3	1	4	3	housing	2	private	0	unit price	3	No	No	3	3	4
Morocco	3	2	2	2	1	4	3	infrastructure	5	government	1	unit price	3	Yes	No	4	4	3
Georgia	2	2	3	1	1	4	2	building	4	private	0	cost+fee	3	No	Yes	1	4	5
Kazakhstan	3	2	3	1	0	5	1	building	1	private	1	cost+fee	3	Yes	Yes	1	5	5
Kuwait	4	2	2	2	1	4	2	industrial	5	private	0	lump sum	2	Yes	No	4	4	3
Mongolia	3	2	3	3	1	4	3	infrastructure	5	government	0	turnkey	3	Yes	No	3	3	4
Qatar	4	2	2	3	0	5	1	infrastructure	1	government	-1	turnkey	2	Yes	Yes	1	3	4
Russia	3	3	1	1	1	5	1	rehabilitation	1	private	0	cost+fee	3	No	Yes	2	4	5
Syria	2	2	3	1	0	3	2	infrastructure	4	government	-1	turnkey	3	Yes	No	3	2	3
Turkmenistan	2	2	3	1	1	5	1	rehabilitation	3	private	0	lump sum	3	No	No	3	3	4
Uzbekistan	2	2	3	1	0	3	3	infrastructure	3	government	0	unit price	1	Yes	Yes	4	2	1
Zambia	2	2	1	3	1	3	2	industrial	2	government	0	unit price	3	Yes	No	2	3	4

Table B.2. Second set of testing cases

Country name	Econ Pros	Coun. risk	Cult. sim.	Dist.	Att. of govn.	Dem.	Proj size	Project type	Tech comp.	Type of client	Fund Avail.	Contract type	Exp.	Time limit	Qual. limit	Comp. level	Att.	Comp
Algeria	3	3	2	3	1	4	2	industrial	5	government	0	lump sum	2	No	No	4	2	4
Belarus	3	3	1	2	0	3	2	building	4	government	0	turnkey	3	Yes	Yes	3	2	3
Armenia	2	2	2	1	-1	3	1	building	2	private	-1	turnkey	2	Yes	Yes	4	1	1
Germany	4	1	2	3	0	3	2	rehabilitation	4	government	1	cost+fee	2	Yes	Yes	2	4	3
Ghana	2	2	1	3	1	4	1	housing	1	private	0	cost+fee	2	No	No	2	4	4
Georgia	2	2	3	1	1	4	2	infrastructure	1	government	1	turnkey	2	No	No	5	5	2
Libya	3	2	3	2	-1	4	2	industrial	5	private	0	cost+fee	3	Yes	Yes	2	3	3
Portugal	4	1	1	3	-1	2	1	rehabilitation	2	government	1	cost+fee	2	No	Yes	2	4	2
Russia	3	3	1	1	1	5	3	industrial	4	private	0	turnkey	2	Yes	Yes	2	3	4
S.Arabia	3	2	3	3	-1	4	2	infrastructure	3	government	0	turnkey	1	No	No	3	3	2
Sudan	2	3	3	2	1	4	1	housing	3	government	0	lump sum	3	No	No	2	3	5
Turkmenistan	2	2	3	1	1	5	1	rehabilitation	3	private	0	lump sum	3	No	No	3	3	4
Ukrain	2	3	2	1	0	4	1	housing	3	government	1	lump sum	2	No	No	4	4	2
Uzbekistan	2	2	3	1	0	3	3	industrial	5	government	0	turnkey	3	Yes	No	3	2	3
Hypothetic12	2	2	3	1	-1	1	2	housing	1	private	-1	unit price	3	No	Yes	4	2	2

APPENDIX C

QUANTIFICATION OF IMPORTANCE WEIGHTS OF FEATURES

Please fill in the required areas in 10-100 scale according to the importance weights of each feature in terms of attractiveness and competitiveness.

Attractiveness and competitiveness are assumed as independent parameters.

Attractiveness should be evaluated considering the profit-making capacity of the features.

Competitiveness should reflect the characteristics of a standard Turkish construction company.

Table C.1. Evaluation form for obtaining importance weights of features

	Feature Name	**Attractiveness**	**Competitiveness**
1	Economic Prosperity		
2	Country Risk		
3	Cultural Similarity		
4	Distance		
5	Attitude Of Government		
6	Construction Demand		
7	Project Size		
8	Type Of Project		
9	Technical Complexity		
10	Client Type		
11	Fund Availability		
12	Contract Type		
13	Experience		
14	Time Limitation		
15	Quality Limitation		
16	Competition Level		

APPENDIX D

PROPERTIES OF SIMILARITY DEFINITIONS

Table D.1. Properties of SIM1

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	Absolute fuzzy range:3	1	70%
2	CountryRisk	Absolute fuzzy range:4	1	70%
3	CulturalSimilarity	Absolute fuzzy range:2	1	70%
4	Distance	Absolute fuzzy range:2	1	70%
5	AttitudeOfGovernment	Absolute fuzzy range:2	1	70%
6	ConstructionDemand	Absolute fuzzy range:4	1	70%
7	ProjectSize	Absolute fuzzy range:2	1	70%
8	TypeOfProject	Exact	1	70%
9	TechnicalComplexity	Absolute fuzzy range:4	1	70%
10	ClientType	Exact	1	70%
11	FundAvailability	Absolute fuzzy range:2	1	70%
12	ContractType	Exact	1	70%
13	Experience	Absolute fuzzy range:2	1	70%
14	TimeLimitation	Exact	1	70%
15	QualityLimitation	Exact	1	70%
16	CompetitonLevel	Absolute fuzzy range:4	1	70%

Table D.2. Properties of SIM2

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	equal	0.019	70%
2	CountryRisk	equal	0.069	70%
3	CulturalSimilarity	equal	–	70%
4	Distance	equal	–	70%
5	AttitudeOfGovernment	equal	0.022	70%
6	ConstructionDemand	equal	0.212	70%
7	ProjectSize	equal	0.031	70%
8	TypeOfProject	exact	0.024	70%
9	TechnicalComplexity	equal	0.059	70%
10	ClientType	exact	0.019	70%
11	FundAvailability	equal	0.377	70%
12	ContractType	exact	0.103	70%
13	Experience	equal	0.009	70%
14	TimeLimitation	exact	0.005	70%
15	QualityLimitation	exact	0.025	70%
16	CompetitonLevel	equal	0.025	70%

Table D.3. Properties of SIM3

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	equal	0.015	70%
2	CountryRisk	equal	0.032	70%
3	CulturalSimilarity	equal	0.019	70%
4	Distance	equal	0.022	70%
5	AttitudeOfGovernment	equal	0.283	70%
6	ConstructionDemand	equal	–	70%
7	ProjectSize	equal	0.036	70%
8	TypeOfProject	exact	–	70%
9	TechnicalComplexity	equal	–	70%
10	ClientType	exact	0.030	70%
11	FundAvailability	equal	0.037	70%
12	ContractType	exact	0.023	70%
13	Experience	equal	0.095	70%
14	TimeLimitation	exact	0.014	70%
15	QualityLimitation	exact	0.027	70%
16	CompetitonLevel	equal	0.365	70%

Table D.4. Properties of SIM5

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	Absolute fuzzy range:3	0.001	70%
2	CountryRisk	Absolute fuzzy range:4	0.030	70%
3	CulturalSimilarity	Absolute fuzzy range:2	0.150	70%
4	Distance	Absolute fuzzy range:2	0.005	70%
5	AttitudeOfGovernment	Absolute fuzzy range:2	0.230	70%
6	ConstructionDemand	Absolute fuzzy range:4	0.001	70%
7	ProjectSize	Absolute fuzzy range:2	0.035	70%
8	TypeOfProject	Exact	0.001	70%
9	TechnicalComplexity	Absolute fuzzy range:4	0.001	70%
10	ClientType	Exact	0.020	70%
11	FundAvailability	Absolute fuzzy range:2	0.050	70%
12	ContractType	Exact	0.003	70%
13	Experience	Absolute fuzzy range:2	0.200	70%
14	TimeLimitation	Exact	0.001	70%
15	QualityLimitation	Exact	0.002	70%
16	CompetitonLevel	Absolute fuzzy range:4	0.270	70%

Table D.5. Properties of SIM6

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	Absolute fuzzy range:3	0.021	70%
2	CountryRisk	Absolute fuzzy range:4	0.041	70%
3	CulturalSimilarity	Absolute fuzzy range:2	0.155	70%
4	Distance	Absolute fuzzy range:2	0.126	70%
5	AttitudeOfGovernment	Absolute fuzzy range:2	0.009	70%
6	ConstructionDemand	Absolute fuzzy range:4	0.079	70%
7	ProjectSize	Absolute fuzzy range:2	0.035	70%
8	TypeOfProject	Exact	0.056	70%
9	TechnicalComplexity	Absolute fuzzy range:4	0.025	70%
10	ClientType	Exact	0.052	70%
11	FundAvailability	Absolute fuzzy range:2	0.182	70%
12	ContractType	Exact	0.057	70%
13	Experience	Absolute fuzzy range:2	0.056	70%
14	TimeLimitation	Exact	0.050	70%
15	QualityLimitation	Exact	0.056	70%
16	CompetitonLevel	Absolute fuzzy range:4	—	70%

Table D.6. Properties of SIM7

	Feature name	Type of feature matching	Weight	Threshold
1	EconomicProsperity	Absolute fuzzy range:3	0.048	70%
2	CountryRisk	Absolute fuzzy range:4	0.019	70%
3	CulturalSimilarity	Absolute fuzzy range:2	0.064	70%
4	Distance	Absolute fuzzy range:2	0.008	70%
5	AttitudeOfGovernment	Absolute fuzzy range:2	0.113	70%
6	ConstructionDemand	Absolute fuzzy range:4	0.054	70%
7	ProjectSize	Absolute fuzzy range:2	0.058	70%
8	TypeOfProject	Exact	0.191	70%
9	TechnicalComplexity	Absolute fuzzy range:4	0.030	70%
10	ClientType	Exact	0.017	70%
11	FundAvailability	Absolute fuzzy range:2	0.047	70%
12	ContractType	Exact	0.076	70%
13	Experience	Absolute fuzzy range:2	0.044	70%
14	TimeLimitation	Exact	0.074	70%
15	QualityLimitation	Exact	0.018	70%
16	CompetitonLevel	Absolute fuzzy range:4	0.140	70%