Analysis Expert System Factors in IT Project Selection using Fuzzy AHP

Mohammad Taghi Taghavi Fard (PhD)
Assistant Professor, Allameh Tabatabaei University, Tehran, Iran

Hamid Reza Jafari
Department of Industrial Engineering, Faculty of Engineering, Abhar Branch, Islamic Azad University, Abhar, Zanjan, Iran.

Seyed Ehsan Shojaie
Department of Industrial Engineering, Faculty of Engineering, Abhar Branch, Islamic Azad University, Abhar, Zanjan, Iran.

Abstract
The intended use for the expert system is to make decisions based on an input and provide a recommended design process including enhancing tools as an output. An expert system by definition is a computer program derived from Artificial Intelligence that takes reasoning and knowledge from humans and converts it to an intelligent engine following logical reasoning and capable of solving problems. Basic project management tools and processes are essentially the same whether the project is in IT, construction, or another engineering environment; however, the IT project itself is not like construction or engineering. Organizations heavily depend on Information Technology (IT) to translate their strategic plans into actions and perform effective and efficient operations. In addition, IT helps organizations to gain competitive advantage, provide value-added services to customers, and respond rapidly in a cost-effective way to meet customer needs. Since IT brings significant changes to organizations, IT projects are considered highly risky. This study tries to identify and prioritize mail factors effecting IT project selection using an FAHP expert system. Based on literature review, we found seven dimension of IT project selection and ranked them using FAHP based on a survey in branches of Mellat bank in Tehran.
Keywords: *Expert System, IT project, Banking Industry, Fuzzy AHP*

Introduction

More than 20% of the global economic activities are created through projects, to bring strategic change and add value to the organizations (Bredillet, 2010). Project management is a blend of scientific and professional specializations that help organizations to become efficient, effective, and competitive. Despite efforts made by researchers and professional organizations like the Project Management Institute (PMI) and International Project Management Association, projects continue to fail. This causes major concern to professionals and organizations in understanding the factors that produce project success and failure (Ika, 2009; Patanakul, Iewwongcharoen, & Milosevic, 2010; Rivard & Dupré, 2009). This study used the existing body of knowledge within project management to define criteria for project success, identify causes of IT project failures, and explore the possibility of increasing IT project success by integrating project management processes and expert systems. IT projects are unique, complex, and the outcomes are intangible. Jun, Butler, and King (2007) conducted a longitudinal study involving 51 database development teams. They indicated that software projects are complex, dynamic, comprised of unstructured tasks, and dependent on diverse skill-sets of individuals. While analyzing complex adaptive systems and agile development practices, Meso and Jain (2006) stated that software development is affected by internal, external, and social factors. Organizations depend on software development methodologies to make software development efficient and predictable. These practices include well defined development process, planning, and documentation, better development team and coding techniques. Meso and Jain (2006) suggested that best practices for software development to meet customer needs include (a) testing and validating the information systems (IS) solution with customers iteratively by getting their feedback; (b) measuring the results in each development phase; and (c) involving customers and listening to customer comments, concerns, and needs. In addition to the unique and complex nature of software development, it poses additional challenges to measuring success. Barclay and Osei-Bryson (2008) proposed the project objectives measurement model using a case study method to measure IT project outcomes. They indicated that academic research focuses on traditional measurement of project success, using time, schedule, and specification requirements. This creates a misalignment between research and practice to measure project outcomes. They argued that stakeholder value is the key to measuring project success. According to Hartman and Ashrafi (2002), the most common causes of software failure are lack of clarity and understanding of customer requirements, optimistic schedules and budgets, inadequate risk assessment, inconsistent standards, management resources, unclear project charter, and lack of communication. They surveyed 12 projects in Canada and interviewed 36 project owners. The study revealed that many owners did not even measure project success. They also stated that meeting the needs of the customers, aligning with stakeholders to improve communication, and reduced rework are important factors to improve project success. The significant findings of their study were linking projects to business strategy, aligning with stakeholders, simplifying project metrics, and providing effective communication throughout the life cycle of the project. IT plays a crucial role in an organization's survival and success. IT projects have high failure rates, complexities, and challenges (Peppard, 2010). According to Parent and Reich (2009), one third of capital spending has been invested in IT projects, while IT project failures cause significant impact to organization and stakeholder value. Another unique characteristic of an IT project is the identification and number of stakeholders. Typical IT projects have more stakeholders than traditional projects, and they are harder to identify (Taylor, 2004). Cerpa and Verner (2009) conducted a quantitative study by analyzing 70 failed software projects to understand the causes of failures. They stated that projects fail due to multiple reasons. One of the prime causes of failures was related to customer requirements. Some of the problems include delivery decision was made without getting complete requirements and customers did not spend enough time defining their requirements. The majority of the expert systems developed so far have been built for software applications even though expert systems are now becoming fundamental in other applications such as design method selection which is the research subject of this work.

Literature Review

Many of the projects undertaken by organizations involve IT systems, which can be considered as distinctive types of projects (Karlsen et al., 2005). Bennington and Baccarini (2004) defined an IT project as “a finite piece of work that implements information technologies within cost and time constraints, and is directed at achieving a stated business benefit” (p. 20). IT includes not only computer technology, but also the software and hardware components and “the integration of these subsystems into a total, functional, and usable system” (Taylor, 2004, p. 3). IT projects are usually a part of business process reforms and can have an immense impact upon organizational activities and possibly modify the organization’s vision (Kuruppuarachchi et al., 2001). IT projects are different from other projects because of the unique risks, rapid development requirements, short technology life, rush-to-market demands, and the multiple dependencies on other projects (Taylor, 2004). IT projects are also negatively distinguished from other projects because of the difficulty in successfully balancing time, budget, and quality requirements (Bennington & Baccarini, 2004; Rosacker & Olson, 2008; Sauer et al., 2001). Taylor (2004) stated that the basic project management tools and processes are essentially the same whether the project is in IT, construction, or another engineering environment; however, the projects themselves are not. The issue is that “too many organizations and project managers still attempt to manage IT projects as if they were engineering or construction projects” (Taylor, 2004, p. 2). Taylor further stated that to be successful, an updated management approach is needed that reflects the current business environment and management processes, as well as tools adapted to account for the specific characteristics of an IT environment. IT projects also require considerable management expertise, not only because of the significant IT factor, but also because of the way technology is used and constantly changes (Johnstone et al., 2006).

Therefore, the management of change is vital in IT projects (Kuruppuarachchi et al., 2001). The literature on IT project management has not kept pace with the general project management community and the application of generic project management tools to IT has had little or no success (Taylor, 2004). Additionally, most literature addresses the software development aspect of IT, but there is an overall failure to address IT as a system. Taylor believed focusing exclusively on a single IT component could lead to project failure in the end. As managers, program managers should possess the general management skills of leading, communicating, negotiating, and problem solving, as well as the ability to influence the organization (PMI, 2000). Lee-Kelley and Leong (2003) stated that project management "has evolved from its engineering scientific management origin into a horizontal, cross-disciplinary approach" (p. 584) and that project management theory, practice, and associated tools are therefore very transportable between different types of projects. The authors asserted that the performance of project management requires the use of strong interpersonal (soft) skills as well as structured (hard) skills. Projects often fall short of achieving anticipated results not from a lack of project management but from a lack of project leadership. Project leaders must possess a measure of both hard and soft skills rather than solely relying on the structured logic of project life cycle planning, and scheduling and controlling workflows for success (Lee-Kelley & Leong, 2003). Most of the literature on project management treats management success and product success interchangeably. However, Baccarini (1999) conceptualized a distinction between the two must be made to adequately determine success. For project management, Baccarini used the traditional definition of project success: meeting cost, schedule, and performance objectives. On the other hand, product success was based upon the users' perspective of meeting requirements, such as response times and reliability. Therefore product success is based upon three components: meeting the project owner's strategic organizational objectives (goals), satisfying users' needs (purpose), and satisfying stakeholders' needs. Stated succinctly, project management success entails the project management process and product success is concerned with the project's product. Success criteria for project management are internal measures because they satisfy a group within the organization. Conversely, product success criteria are external measures whereby developers are concerned with its outside effectiveness (Baccarini, 1999). An inference can be made that key stakeholders such as end-users consider product success more important than process success.

Methodology & Approach

As first step for determining effective factors on IT project selection in banking industry, we identified seven factors as below:

1- Project effects in making organizational learning

2- Increasing of inter relationships between working teams

3- Project effects on decreasing organizational process

4- Project effects on customer communication

5- Project requirements for support costs

6- Project ROI (Return on Investment)

7- Project Coordination with E-Government vision

The target population for this study consisted of individuals who managed IT projects among Mellat bank branches of Tehran equal to 23 people. The individuals did not need to be certified project management professionals. Wilson-VanVoorhis and Morgan (2007) insisted that researchers pay attention to power during the design phase of the project. This protects both researchers and respondents in detecting the difference at a high enough level to test and verify research hypotheses. Since the main objective of the work is prioritize the effective factors through multi-standard decision making in fuzzy environment, following fuzzy numbers used to do fuzzy AHP:

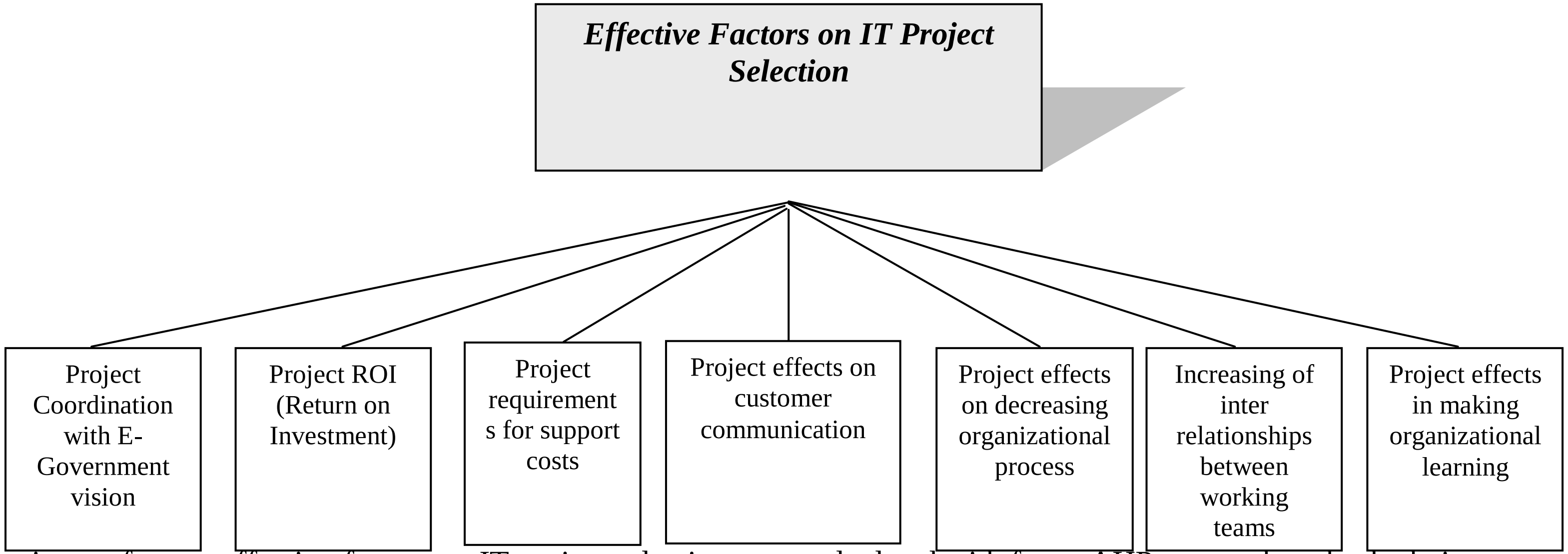
Table 1: Fuzzy numbers (Deb, 2012)

Terms	*Fuzzy numbers*
Priority or equal importance	*(0 ،1 ،2)*
Priority or low importance	*(2 ،3 ،2)*
Priority or high importance	*(2 ،5 ،2)*
Priority or very high importance	*(2 ،7 ،2)*
Priority or complete and absolute importance	*(2 ،9 ،2)*

Research results:

Using fuzzy numbers, now let's estimate weight of each factors using this technique. Following diagram illustrates hierarchy structure of seven groups of factors effecting on IT project selection in banking industry. Fuzzy AHP process in this study is based on (He et al, 2012) paper titled: A fuzzy AHP based integer linear programming model for the multi-criteria transshipment problem.

Figure 1: Hierarchy Process Tree of Factors Effecting on IT Project Selection



Dual comparisons of seven effecting factors on IT project selection were calculated with fuzzy AHP approach and calculating geometric average of fuzzy numbers for all samples, resulted weights are as follows:

Table 2: Fuzzy Mean

IT Project Selection	Project effects in making organizational learning	Increasing of inter relationships between working teams	Project effects on decreasing organizational process	Project effects on customer communication	Project requirements for support costs	Project ROI (Return on Investment)	Project Coordination with E-Government vision
Project effects in making organizational learning	(1, 1, 1)	(0.17, 0.21, 0.28)	(2.82, 3.87, 4.89)	(6.92, 7.93, 8.94)	(2.82, 3.87, 4.89)	(1.41, 1.73, 2)	(0.11, 0.12, 0.14)
Increasing of inter relationships between working teams	(3.46, 4.58, 5.65)	(1, 1, 1)	(2.82, 3.87, 4.89)	(2.82, 3.87, 4.89)	(1.41, 1.73, 2)	(0.40, 0.44, 0.5)	(0.31, 0.33, 0.35)
Project effects on decreasing organizational process	(0.20, 0.25, 0.35)	(0.20, 0.25, 0.35)	(1, 1, 1)	(0.25, 0.33, 0.5)	(3.46, 4.58, 5.65)	(0.14, 0.16, 0.20)	(0.14, 0.16, 0.20)
Project effects on customer communication	(0.11, 0.12, 0.14)	(020, 0.25, 0.35)	(2, 3, 4)	(1, 1, 1)	(4, 5, 6)	(3.46, 4.58, 5.65)	(0.12, 0.14, 0.17)
Project requirements for support costs	(0.20, 0.25, 0.35)	(0.5, 0.57, 0.70)	(0.17, 0.21, 0.28)	(0.16, 0.2, 0.25)	(1, 1, 1)	(0.25, 0.33, 0.5)	(0.16, 0.2, 0.25)
Project ROI (Return on Investment)	(0.5, 0.57, 0.70)	(2, 2.23, 2.44)	(4.89, 5.91, 6.92)	(0.17, 0.21, 0.28)	(2, 3, 4)	(1, 1, 1)	(0.12, 0.14, 0.17)
Project Coordination with E-Government vision	(6.92, 7.93, 8.94)	(2.82, 3, 3.16)	(4.89, 5.91, 6.92)	(5.65, 6.70, 7.74)	(4, 5, 6)	(5.65, 6.70, 7.74)	(1, 1, 1)

Using results in table 2, and fuzzy AHP process, what follows discusses about calculation weight of each effective factors on IT project selection based on fuzzy AHP

First phase: Fuzzy Mixed Expansion

$$\sum_{j=1}^{7} M_{g_1}^{j} = (1,1,1) + (0.28, 0.21, 0.17) + (4.89, 3.87, 2.82) + (8.94, 7.93, 6.92) + (4.89, 3.87, 2.82) + (2, 1.73, 1.41) + (0.14, 0.12, 0.11) = (15.28, 18.75, 22.17)$$

$$\sum_{j=1}^{7} M_{g_2}^{j} = (5.65, 4.58, 3.46) + (1,1,1) + (4.89, 3.87, 2.82) + (4.89, 3.87, 2.82) + (2, 1.73, 1.41) + (0.5, 0.44, 0.40) + (0.35, 0.33, 0.31) = (12.25, 15.84, 19.3)$$

$$\sum_{j=1}^{7} M_{g_3}^{j} = (0.35, 0.25, 0.20) + (0.35, 0.25, 0.20) + (1,1,1) + (0.5, 0.33, 0.25) + (5.65, 4.58, 3.46) + (0.20, 0.16, 0.14) + (0.20, 0.16, 0.14) = (5{,}41, 6.77, 8.27)$$

$$\sum_{j=1}^{7} M_{g_4}^{j} = (0.14, 0.12, 0.11) + (0.35, 0.25, 0.20) + (4, 3, 2) + (1,1,1) + (6, 5, 4) + (5.65, 4.58, 3.46) + (0.17, 0.14, 0.12) = (10.9, 14.11, 17.33)$$

$$\sum_{j=1}^{7} M_{g_5}^{j} = (0.35, 0.25, 0.20) + (0.70, 0.57, 0.5) + (0.28, 0.21, 0.17) + (0.25, 0.2, 0.16) + (1,1,1) + (0.5, 0.33, 0.25) + (0.25, 0.2, 0.16) = (2.46, 2.78, 3.34)$$

$$\sum_{j=1}^{7} M_{g_5}^{j} = (0.70, 0.57, 0.5) + (2.44, 2.23, 2) + (6.92, 5.91, 4.89) + (0.28, 0.21, 0.17) + (4, 3, 2) + (1,1,1) + (0.17, 0.14, 0.12) = (10.70, 13.09, 15.55)$$

$$\sum_{j=1}^{7} M_{g_5}^{j} = (0.35, 0.25, 0.20) + (0.70, 0.57, 0.5) + (0.28, 0.21, 0.17) + (0.25, 0.2, 0.16) + (1,1,1) + (0.5, 0.33, 0.25) + (0.25, 0.2, 0.16) = (30.96, 36.26, 41.52)$$

$$\sum_{i=1}^{7}\sum_{j=1}^{7} M_{g_i}^{j} = (15.28, 18.75, 22.17) \oplus (12.25, 15.84, 19.3) \oplus (5{,}41, 6.77, 8.27) \oplus (10.9, 14.11, 17.33) \oplus (2.46, 2.78, 3.34) \oplus (10.70, 13.09, 15.55) \oplus (30.96, 36.26, 41.52) = (88, 107.64, 127.51)$$

$$\left(\sum_{i=1}^{7}\sum_{j=1}^{7} M_{g_i}^{j}\right)^{-1} = (0.007, 0.009, 0.011)$$

Where S1: Project effects in making organizational learning

S2: Increasing of inter relationships between working teams

S3: Project effects on decreasing organizational process
S4: Project effects on customer communication
S5: Project requirements for support costs
S6: Project ROI (Return on Investment)
S7: Project Coordination with E-Government vision

$$S_1 = (15.2, 18.7, 22.1) \otimes (0.007, 0.009, 0.011) = (0.11, 0.17, 0.25)$$

$$S_2 = (12.2, 15.8, 19.3) \otimes (0.007, 0.009, 0.011) = (0.096, 0.14, 0.21)$$

$$S_3 = (5.41, 6.77, 8.27) \otimes (0.007, 0.009, 0.011) = (0.42, 0.62, 0.93)$$

$$S_4 = (10.9, 14.1, 17.3) \otimes (0.007, 0.009, 0.011) = (0.085, 0.13, 0.19)$$

$$S_5 = (2.46, 2.78, 3.34) \otimes (0.007, 0.009, 0.011) = (0.019, 0.025, 0.038)$$

$$S_6 = (10.7, 13.0, 15.5) \otimes (0.007, 0.009, 0.011) = (0.083, 0.12, 0.17)$$

$$S_7 = (30.9, 36.2, 41.5) \otimes (0.007, 0.009, 0.011) = (0.24, 0.33, 0.47)$$

Second phase: Preference orders

Table 3: Preference orders

$V(S_1 \geq S_2) = 1$	$V(S_1 \geq S_3) = 0.143$	$V(S_1 \geq S_4) = 1$	$V(S_1 \geq S_5) = 1$	$V(S_1 \geq S_6) = 1$
$V(S_1 \geq S_7) = 0.058$	$V(S_2 \geq S_1) = 0.769$	$V(S_2 \geq S_3) = 0.018$	$V(S_2 \geq S_4) = 1$	$V(S_2 \geq S_5) = 1$
$V(S_2 \geq S_6) = 1$	$V(S_2 \geq S_7) = 0.014$	$V(S_3 \geq S_1) = 1$	$V(S_3 \geq S_2) = 1$	$V(S_3 \geq S_4) = 1$
$V(S_3 \geq S_5) = 1$	$V(S_3 \geq S_6) = 1$	$V(S_3 \geq S_7) = 1$	$V(S_4 \geq S_1) = 0.666$	$V(S_4 \geq S_2) = 0.903$
$V(S_4 \geq S_3) = 0.008$	$V(S_4 \geq S_5) = 1$	$V(S_4 \geq S_6) = 0.98$	$V(S_4 \geq S_7) = 0.004$	$V(S_5 \geq S_1) = 0.043$
$V(S_5 \geq S_2) = 0.063$	$V(S_5 \geq S_3) = 0.084$	$V(S_5 \geq S_4) = 0.091$	$V(S_5 \geq S_6) = 0.123$	$V(S_5 \geq S_7) = 0.011$
$V(S_6 \geq S_1) = 0.545$	$V(S_6 \geq S_2) = 0.787$	$V(S_6 \geq S_3) = 0.018$	$V(S_6 \geq S_4) = 0.894$	$V(S_6 \geq S_5) = 1$
$V(S_6 \geq S_7) = 0.015$	$V(S_7 \geq S_1) = 1$	$V(S_7 \geq S_2) = 1$	$V(S_7 \geq S_3) = 0.147$	$V(S_7 \geq S_4) = 1$
$V(S_7 \geq S_5) = 1$	$V(S_7 \geq S_6) = 1$			

Third Phase: Convex fuzzy number

$$V(S_1 \geq S_2, S_3, S_4, S_5, S_6, S_7) = \min(V(S_1 \geq S_2), V(S_1 \geq S_3), V(S_1 \geq S_4), V(S_1 \geq S_5), V(S_1 \geq S_6), V(S_1 \geq S_7)) = 0.058$$

$$V(S_2 \geq S_1, S_3, S_4, S_5, S_6, S_7) = \min(V(S_2 \geq S_1), V(S_1 \geq S_3), V(S_2 \geq S_4), V(S_2 \geq S_5), V(S_2 \geq S_6), V(S_2 \geq S_7)) = 0.014$$

$$V(S_3 \geq S_1, S_2, S_4, S_5, S_6, S_7) = \min(V(S_3 \geq S_1), V(S_3 \geq S_2), V(S_3 \geq S_4), V(S_3 \geq S_5), V(S_3 \geq S_6), V(S_3 \geq S_7)) = 1$$

$$V(S_4 \geq S_1, S_2, S_3, S_5, S_6, S_7) = \min(V(S_4 \geq S_1), V(S_4 \geq S_2), V(S_4 \geq S_3), V(S_4 \geq S_5), V(S_4 \geq S_6), V(S_4 \geq S_7)) = 0.004$$

$$V(S_5 \geq S_1, S_2, S_3, S_4, S_6, S_7) = \min(V(S_5 \geq S_1), V(S_5 \geq S_2), V(S_5 \geq S_3), V(S_5 \geq S_4), V(S_5 \geq S_6), V(S_5 \geq S_7)) = 0.011$$

$$V(S_6 \geq S_1, S_2, S_3, S_4, S_5, S_7) = \min(V(S_6 \geq S_1), V(S_6 \geq S_2), V(S_6 \geq S_3), V(S_6 \geq S_4), V(S_6 \geq S_5), V(S_6 \geq S_7)) = 0.018$$

$$V(S_7 \geq S_1, S_2, S_3, S_4, S_5, S_6) = \min(V(S_7 \geq S_1), V(S_7 \geq S_2), V(S_7 \geq S_3), V(S_7 \geq S_4), V(S_7 \geq S_5), V(S_7 \geq S_6)) = 0.147$$

Fourth phase: Normalization

$$W' = (0.058, 0.014, 1, 0.004, 0.011, 0.018, 0.147) \Rightarrow W_N = (0.046, 0.011, 0.798, 0.003, 0.008, 0{,}014, 0.117)$$

Following table lists and ranks weight of each factor effective on IT project selection.

Table 4: Prioritizing IT Project Selection Factors

Factor	*Preference order*	*Rank*
Project effects on decreasing organizational process	0.798	1
Project Coordination with E-Government vision	0.117	2
Project effects in making organizational learning	0.046	3
Project ROI (Return on Investment)	0.014	4
Increasing of inter relationships between working teams	0.011	5
Project requirements for support costs	0.008	6
Project effects on customer communication	0.003	7

Conclusion:

The expert system provides tools for mapping information provided by the user using an input with a database containing information that had been previously compiled. In 1995, the U.S. spent $81 billion on software projects that were abandoned before completion due to problems with cost, schedule, and functionality (performance) (Sauer et al., 2001). Researchers found that the traditional approach to resolving these issues is to have better project management tools, techniques, and discipline. However, Sauer et al., believed it unlikely that this “more of the same” (p. 40) traditional approach would yield significant performance improvements for IT projects. The authors stated that organization and project management capabilities should be implemented at the enterprise level. The subsequent outcome of such an approach would be improved performance at the individual project level.

The Sauer et al. (2001) study focused on the construction industry and provided key elements for creating a project management-centered organization for achieving IT project performance success. Normally, project managers are chosen because they are technical specialists with management potential. Senior manager support is provided in the form of a manual that details project management procedures and software tools, ranging from very simple to the highly complex (Sauer et al., 2001). The British Royal Academy of Engineering studied the state of IT project management in the United Kingdom. In 2003, only 16% of the 1,500 public and private sector IT projects were considered successful, as reported in an Oxford University/Computer Weekly survey (Huber, 2003; Royal Academy of Engineering [RAE], 2004). The Computer Weekly success criteria for IT projects were budget, schedule, and scope/functionality (Huber, 2003). Another study published by the Royal Academy of Engineering of the British Computer Society determined that only three of over 500 development projects met similar success criteria (RAE, 2004). The report provided eight common reasons for project failure, among which was the lack of effective engagement with stakeholders. The researchers also noted, “The evidence received clearly and unanimously identified management factors and human, rather than technical, issues as the prime causes of project failure” (RAE, 2004, p. 29). All of these discussions support this idea that IT project selection using traditional methods make failure of companies. So, this study selected seven main factors in this case and determined weight of each factors. We found that (Project effects on decreasing organizational process) is the most important factor for IT project selection in banking industry.

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