Investigation of BIM Implementation Barriers in Iranian Construction Industry

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ABSTRACT

Building Information Modeling (BIM) is a revolutionary technology and process that has quickly become a way of understanding, designing, constructing and commissioning buildings. BIM is a rich set of smartly designed information that the right data can be extracted and analyzed according to the needs of users to be used to decide and improve the building information process. Building Information Modeling BIM is a simulated multi-dimensional model of building geometry, spatial relationships, geographic information, quantities and properties of all building components and their interconnectedness. The use of BIM in project planning and its early stages allows the project team to analyze relevant environments and understand the complexities of the environment and to understand relevant laws and regulations in an effective way. Reduced time and costs for the project are capable of effectively implementing value engineering for the project and can also reduce project overlaps and inconsistencies. In this regard, this study aims to examine the barriers and challenges ahead in implementing the Building Information Modeling (BIM) approach.

Therefore, by identifying these barriers and distributing a questionnaire among the statistical population, which consisted of 200 employer managers, construction consultants and contractors in Tehran province and other cities, each of them was prioritized by using a hierarchical analysis method. Overall, several major categories of personal barriers, organizational barriers, technical barriers, financial barriers, and cultural barriers are the identified important factors of this study. In general, the results indicate that most construction industry stakeholder such as employers, contractors, and consultants are not familiar with the benefits of construction building information modeling and the top facilitator as results are: Government pressure, Support from top management, Rising the BIM understanding, Request by clients, the Training program for BIM.

Keywords: Building Information Modeling; Civil Engineering; Projects; Prioritization; Analytical Hierarchy Process; BIM barriers; facilitators.

ÖZ

Bina Bilgi Modellemesi (BIM), binaları hızlı bir şekilde anlamanın, tasarlamanın, inşa etmenin ve işletmeye almanın bir yolu haline gelen devrim niteliğinde bir teknoloji ve süreçtir. BIM, bina bilgileri sürecine karar vermek ve iyileştirmek için kullanılacak kullanıcıların ihtiyaçlarına göre doğru verilerin çıkartılabileceği ve analiz edilebileceği akıllıca tasarlanmış zengin bir bilgi setidir. Bina Bilgi Modellemesi BIM, bina geometrisinin, mekansal ilişkilerin, coğrafi bilgilerin, tüm bina bileşenlerinin miktarlarının ve özelliklerinin ve birbirine bağlılıklarının simüle edilmiş çok boyutlu bir modelidir. BIM'in proje planlamasında kullanımı ve ilk aşamaları proje ekibinin ilgili ortamları analiz etmesine ve çevrenin karmaşıklıklarını anlamasına ve ilgili yasa ve yönetmelikleri etkin bir şekilde anlamasına olanak tanır. Proje için azaltılmış zaman ve maliyetler, proje için değer mühendisliğini etkin bir şekilde uygulayabilir ve aynı zamanda proje çakışmalarını ve tutarsızlıklarını azaltabilir.

Bu bağlamda, bu çalışma Bina Bilgi Modellemesi (BIM) yaklaşımının uygulanmasındaki önündeki engelleri ve zorlukları incelemeyi amaçlamaktadır.

Bu nedenle, bu engelleri belirleyerek ve Tahran ilindeki ve diğer şehirlerdeki 200 işveren yöneticisi, inşaat danışmanı ve yükleniciden oluşan istatistiki nüfus arasında bir anket dağıtarak, her birine hiyerarşik bir analiz yöntemi kullanılarak öncelik verilmiştir. Genel olarak, kişisel engeller, örgütsel engeller, teknik engeller, finansal engeller ve kültürel engeller gibi çeşitli ana kategoriler bu çalışmanın tanımlanmış önemli faktörleridir. Genel olarak, sonuçlar, işverenler, yükleniciler ve danışmanlar gibi inşaat endüstrisi paydaşlarının çoğunun inşaat yapı bilgi modellemesinin faydalarına aşina olmadığını ve en üst düzey kolaylaştırıcı eşek sonuçlarının aşağıdakileri gösterdiğini göstermektedir: Devlet baskısı, Üst yönetimden destek, BIM anlayışını arttırmak , Müşteriler tarafından talep, BIM için bir Eğitim programı.

Anahtar Kelimeler: Bina Bilgi Modellemesi; İnşaat Mühendisliği; Projeler; Önceliklendirme; Analitik Hiyerarşi Süreci; BIM engelleri; kolaylaştırıcılar.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

1.1 Background

The implementation and assumption of the Building Information Model (BIM) are continuously increasing in industrial companies (Salleh and Fung, 2014). One of the most important reasons for BIM adoption is to keep in an appropriate condition balance among the project management triangle of scope (features & quality), cost, and time (Olawumi and Chan, 2018).

The Building Information Model is primarily a three-dimensional digital representation of a building and its intrinsic characteristics. BIM made of intelligent building components, which includes data attributes and parametric rules for each object (Saeed, 2013).

On the other hand, during a finished project, the companies viewpoint expressed that BIM used for the process of build and design to improve the project delivery process, creating maximum amount for employers and maximum efficiency makers. Also, BIM used for scheduling, risk management, communication, and cost estimation (Aladag et al., 2016).

In today's world, the necessity of utilizing all sciences to fulfill the goals is essential. Also, the same story in sciences of management projects; researchers and pioneers of this field are using a phrase with the name Building Information Modelling (BIM) about 40 years, and it has described as a phrase which is a kind of phenomenon in designing and implementation of structures (Eastman, 2008).

Nowadays, advances and researches have been done on this technology that is so huge. Areas where Building Information Modelling technology can enter them, are also vast. For example, designing optimizers, more precise implementation with more quality, time management, financial management, safety management, etc. are the parts of these fields. (Isikdog, 2012). Iran has professional design engineers and big computing even in international class but also has many visible weaknesses in the managerial aspect. The goal of this study is to introduce and analyze the barrier implementation of this technology to improve the services of Civil Engineering in Iran.

1. Research Aim and Objectives

Shortly, building information modeling (BIM) will be used unlimitedly as a sole source for activating the ability of information integrity, which will accelerate the processes of building's life cycle mainly. Building information modeling is a revolutionary technology and progress which has quickly become a way to understand, design, build, and set up the buildings. BIM is a rich collection of information designed intelligently, which made it possible to extract and analyze that proper information based on user needs, that will use for decision making and improve the process of building information. The process of building information modeling can be used from the first process of the project (concept) until the destruction. The correct and harmonious definition of a project before the beginning of construction will make construction work more efficient, and the construction period gets shorter. The construction industry is quickly accepting BIM to reduce costs, time, and improving quality and peripheral sustainability. Currently, in most architecture projects, AutoCAD plans are getting used , and this software reduces or omits the possibility of making changes from the project's structure.

Not using information integration systems can be rooted in architects' and engineers ' lack of familiarity with this system. Lack of done researches in Iran around building information integrating software and problems which are rooted in not using them and new necessity of integrity due to increasingly expanding of project's dimensions and coordinating problem which is rooted in the complexity of them especially in big projects is one of the necessities of research around this issue.

BIM technology is one of the methods that can create a database for building and its components and made it possible to make timely decisions and a significant decrease in changes due to integration. Building information modeling is a simulated multi-dimensional model related to building geometry, spatial relationships, geographic information, amount, and all component of the building's attributes and their intelligent connections with each other. Usage of BIM in project planning and its beginning steps will allow the project team to plan with analyzing space and understanding various environmental complexities and awareness of laws and rules. In this way, all the time and costs of the project will be reduced significantly, can implement amount engineering effectively for the project, and also can reduce reworks and contradictions of the project.

Therefore, this research will be executed with the aim of :

1- Identification of the barriers, challenges, and difficulties in the current state at the Iranian construction industry for adoption of building information modeling (BIM) concept.

2- Proposing a particular solution toward each identified barriers to mitigate them.

3- Suggestion of solution to identified challenges to improve BIM implementation in Iran.

1.3 Scope and Limitation

The scope of this study includes the investigation of BIM application in the Iranian construction industry and identification of barriers and facilitators for BIM implementation in Iran as well as the solution proposition to mitigate those barriers. This study is limited to BIM implementation in Iran.

1.4 Research Methodology

This research, due to the mentioned goals is an applied research type which has done with the usage of first research result to evaluate executive challenges of BIM systems. The goal of applied research is to develop applied knowledge in a specific field, which in this research, the feasibility of establishing BIM application has been assessed.

The research steps are including: first, studying the BIM system available in the literature and then collecting that information that will guide this research. It should be noted that questionnaires will be distributed among experts of some companies in Iran and then analyzed with the usage of software such as Expert Choice 11.5 Pro and EXCELL.

1.5 Overview of the Thesis

This research consists of five chapters, each chapter containing an introduction and chapter description.

- The introduction, the background, the problem statement, the goals of research, the scope, and the limitation and general structure is presented in Chapter 1.
- Chapter 2 examines the literature and research theory about BIM definition, the maturity levels, the barriers, the facilitators, and the benefits for stakeholders.
- Chapter 3 presents the research method, including information about the questionnaire and the methods used to analyze the results.
- Chapter 4 presents a review of the case study with the result in the discussion.
- Chapter 5 contains conclusions and suggestions for future study.
- As mentioned, this research examines the barriers of BIM implementation in Iran's construction industry.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Building Information Modelling Technology (BIM) is one of the methods that allow building secure databases for building and its components, as well as creating and providing rich information identifiers for them or making decisions about projects at any stage possible. The implementation of BIM to a project has significantly reduced the time and cost of executive management and construction. Building Information Modelling (BIM), which has emerged with the help of (CAD), can now provide the initial stages of defining an architectural design, structure, mechanical and electrical design object-centered in a multi-dimensional model and applying the technical specifications. The location of their deployment, the way they operate, and other relevant materials, thus creating a safer, less costly environment, and to reach a better quality. In the process of implementing Building Information Modelling, all project members must have the necessary cooperation in design and construction so that design errors reduced and the productivity of the construction industry increases. Barriers and cultural problems, legal and contractual, economic and security, and management issues are the most critical challenges and issues in implementing this technology. Hence understanding the challenges of implementing BIM is the first step in finding a solution for them.

Undoubtedly, with the advent of each technology and the new process, there will be many problems with its implementation, some of them will be solved with the passage of time and advances in various technologies, but new issues may remain full pending application of technology.

2.2 History of Building Information Modelling (BIM)

The basic concept of building information modeling, begun in 1970 and 1980 with the introduction of AutoCAD software by AutoCAD company. In 1982 the idea of building information became more realistic in Hungary with introducing Revit software, and eventually, in 2000 introduction of Revit software by AutoCAD company was the turning point in the implementation of BIM (Autodesk, 2017).

Unfortunately, with the passage of two decades since the advent of the BIM, implementation in construction is relatively slow, many studies have been conducted to investigate the implementation of BIM researcher has shown that significant changes have taken place since the start of the BIM. In recent years, the use of BIM has increased from 28% in 2007 to more than 70% in 2012 in the world (McGraw-Hill Construction Report, 2012). Recent surveys also show that the implementation of BIM in leading countries such as the United States and England, as well as in developing countries such as Brazil and Australia, is increasing, and most government and private owners want to recognize their benefits (Peter Smith, 2014). In 2014 the European Union made a significant decision for BIM implementation. Similarly, since 2016, 28 members of the European Union use BIM (NBS,2017).

So far, Britain, the Netherlands, Norway, and Finland have required the use of BIM in government projects. The first step in achieving the biological ideal of BIM barriers and challenges to its implementation (NBS, 2017). This tricky story was created of competition between the business designing software systems in the countries of eastern Europe and the countries of the Soviet Union and the United States to complete and create a solution to solve the structural problems in two-dimensional design that, it was created with the help of CAD system. It is possible to limit the start-up time of this technology to 1962 when Douglas Engelbart described an abnormal outlook for future architecture in his article entitled "Human Growth."

This person was not only American researchers and inventors but also a pioneer in computer science and the Internet. He is known for his work on the challenges of human-computer interaction, the result of this is the invention of the mouse, the development of the hypertext, the computer network, and the graphical interface of the user. He is an advocate and committed to the development and use of computers and computer networks to help to confront the growing and complex world of problems instantly where the first glimpse of the emergence of BIM can be seen in the way that person thinks. BIM-related processes and technologies are evolving for at least 40 years.

The demand for this technology is becoming increasingly popular, after forming this association and doing activities and mutual acceptance between engineers and stakeholders. Figure 2.1 shows increasing BIM adoption by architects, engineers, and contractors between 2009 and 2012, with an increase of 12%, 15%, and 14%, respectively. Figure 2.2 shows increasing BIM adoption by the contractor of a developing country.

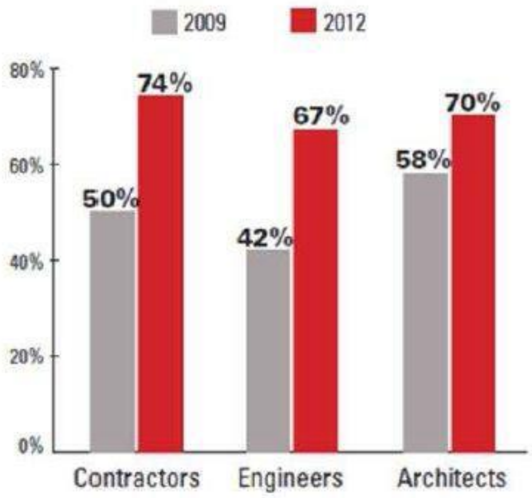

Figure 2.1: Increasing BIM adoption (McGraw-Hill Construction, 2012)

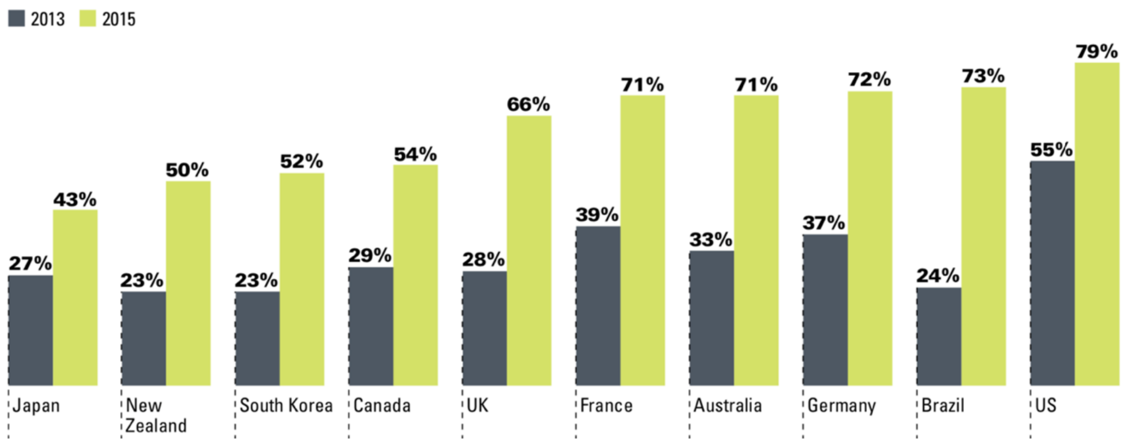

Figure 2.2: Increasing BIM adoption by the contractor (McGraw-Hill Construction, 2013)

2.3 Building Information Modelling (BIM) Definition

BIM technology is one of the methods that can create a database for buildings and its components and made it possible to make timely decisions and a Significant decrease in changes due to integration (Al-Ashmori et al. 2019). Building information modeling is a simulated multi-dimensional model related to building geometry, spatial relationships, geographic information, amount, and all component of the building's attributes and their intelligent connections with each other. Building information modeling (BIM) sees the project as a combination of elements that stand together and create a coherent whole; these components might be undefined or designed according to the specific model. Building information modeling (BIM) is a technology and also a process. Details of this technology will help stakeholders of the project to retrieve whatever supposed to make, in a simpler environment. BIM is a development and usage process of the simulated model in planning, design, and structure which has a collection of building information and their relationship so that with the change in one small part of the group, all other parts adopt themselves with that (Azhar. S, 2008).

Building Information Modelling is a full digital replica of the physical condition as well as the technical specifications of a building. BIM creates a standard reference for building-related information, which is a reliable basis for decision-making throughout the life cycle of the project, from conceptual design to reconstruction and even the destruction of that project (US national standard).

2.3.1 Definition of Building Information Modelling as a Technology

Technically, a building information model is simulated by a multi-dimensional model that has all the information it needs to understand, construct, and implement the project. This information is used by various groups such as planning, design, and implementation teams, but one of the most important reasons and, of course, the advantages that BIM finds in the 3D models. In other words, in previous models, building information consisted of several components, but unlike previous BIM models, it has a unique integration that makes it one of the top technology (Autodesk,2017).

2.3.2 Definition of Building Information Modelling as a Process

Building an information model as a process can be seen as a virtual workflow that allows all aspects and rules of a project to be delivered to all project members within a virtual model. In this way, along with this view, the whole project will be coordinated much more and will result in higher speeds than traditional ones (Ding et al., 2014).

2.3.3 Examining BIM Usage and Abilities

Considering the issues mentioned above, as well as studying the potential applications of this technology, including its capabilities, it can be stated as follows :

- Safety management in Civil projects.
- Upgrade the process of timing and project control.
- Planning for destruction and waste management of Civil projects.
- Architectural design optimization in projects.
- Planning for destruction and waste management of Civil projects.
- Improved monitoring of the construction process.
- Financial Management and Economic Estimates of Projects (Hardin B,2009).

2.3.4 BIM Deployment and Implementation Plan

The BIM implementation plan is a plan with details and relevant attributes, which defines how to implement, monitor, and organize a project, relying on the BIM. Therefore, the main objective of the BIM implementation plan is to provide a general method to ensure that all parties involved are well aware of their priorities and responsibilities in implementing BIM. Therefore, this plan should be considered as a changeable document.

In general, the plan defines why it is necessary to use BIM in the project and includes the following:

- Project information.
- Essential communication and project contacts.
- Project objectives.
- Organizational roles.
- BIM design process.
- BIM information exchanges.

2.3.5 The Concept of Maturity Level in BIM

The goal of the project management maturity model is to integrate processes, tools, and maturity models in line that Improves the effectiveness of project management in project-based organizations and provides the opportunity to the organization's maturity level that can be measured in the project management (Arayici, 2015).

Explore the different levels of shared collaboration and information throughout the lifecycle of a building asset, and these are known as BIM maturity levels.

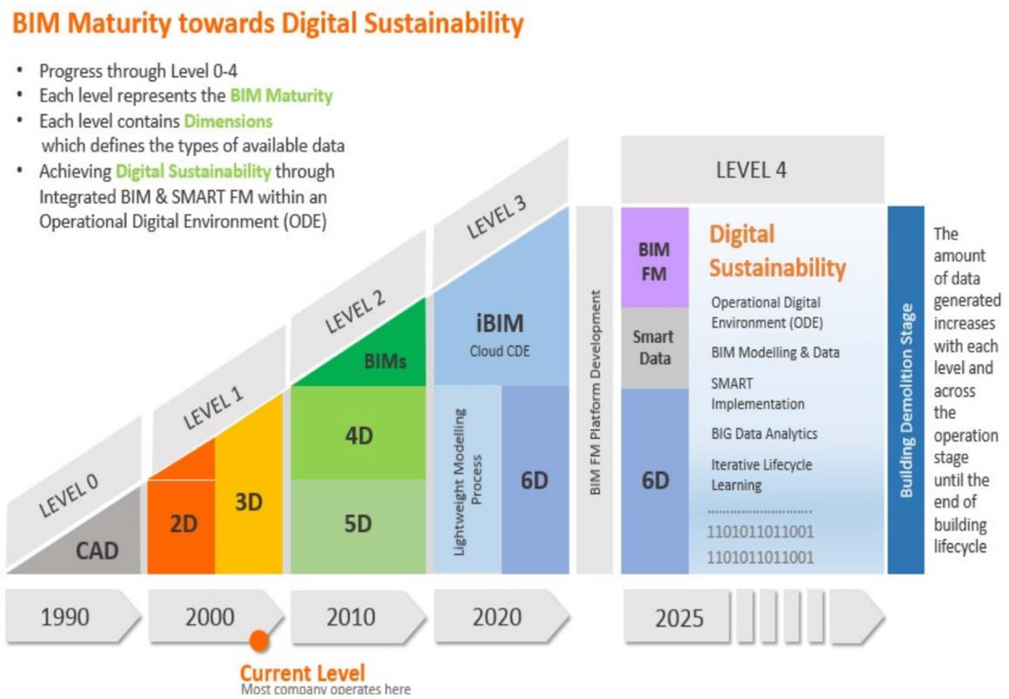

Figure 2.3: BIM Maturity Level (K.Kiong,2018).

Level 0 (Low Collaboration): At Level 0, there is no coordinated effort between parties grouping data about a built asset. Most information is accessible in 2D (likely CAD) drawings, and any exchange in data is done, so utilizing paperwork.

Level 1 (Partial Collaboration): Most companies today are leading their work at this level. A Common Data Environment (CDE) is utilized for this situation. It is a typical online vault, where all the necessary project information is gathered and managed. BIM Level 1 spotlights on the progress from CAD to 2D/3D snippets of data.

Level 2 (Full Collaboration): At Level 2, a coordinated effort is presented among groups, and the procedure of BIM is currently being finished. There is still an absence of a single source of information, but significantly any information gathered about a built asset is presently shared. There is a shared trait in the information structure which empowers a combined BIM model to be produced.

Level 3 (Full Integration): Level 3 is where full coordination Building Information Modeling (BIM) of data is accomplished in a cloud-based condition. This is practiced using a typical shared model. Another measurement (6D BIM), which is otherwise called BIM for Facilitate Management (FM), is relied upon to advance and create at this phase to address the necessities of FM operators.

Level 4 (Digital Sustainability): This level explains how 6D BIM technology can be all around incorporated with SMART Data to build up the last BIM FM Model inside the Operational Digital Environment (ODE). A more significant level of insight can be accomplished through included data produced by big data analytics. This condition (ODE) creates predictive and prescriptive capacity – from iterative domain processes that optimize work efficiency through continuous learning all through the lifecycle of the structure. The total procedure of BIM development movement towards digital sustainability includes two phases of "change." Initially, it will experience a model change at Level 3, where a "Substantial weight" BIM (as assembled) Model is "changed" into a "Light-weight" 6D BIM Model. Irrelevant data that is not required for facilities management purposes will be taken off from the completed BIM (as built) Models. Besides, to be applicable for Facility Management (FM), the last change process at Level 4 into an Asset Management System or "BIM FM" operational availability is hence essential. This final phase of change will lay on the Operational Digital Environment (ODE) for future digital sustainability.

2.3.6 Characteristics of Building Information Modelling

Building Information Modeling (BIM) has the following characteristics (Azhar, 2008):

• Intelligent: Parametric motors will help to clarify the relationship between components and to integrate the overall structure continuously.

• Information base: It can be applied by different laws (building regulations with design principles or other building construction standards).

• Scalable: The ability to reconcile and adapt information from various sources of information is visible and establishing communication.

2.3.7 Concept of Building Information Modelling

BIM has introduced with this description: building information modeling is the development and application of a computer software model for simulating construction and utilizing the structure. The building information model is a wealthy parametric, and intelligent digital display needs can be extracted and analyzed and get used in making information for decision making and improvement in the provision of facilities. BIM does not just mean using intelligent 3D models but also make meaningful changes to the workflow and project delivery processes. BIM also supports the concept of project delivery process which is a new project delivery approach that focuses on the integration of individuals, systems, business structure, and participatory methods to lower wastes and optimize productivity throughout all stage of the project life cycle (Associated General Contractors of America (AGC) report, 2019).

2.4 Benefits of BIM Technology

- A detailed Multi-dimensional model complete with a complete database.

- More efficient and faster processes: More information is easy to share and can be upgraded.

- Better design: Building designs can be carefully analyzed, simulation is done quickly, and building performance is benchmarked and improved.

- Quality: Construction is done with higher quality.

-Better customer service: Through accurate visualization, a better understanding of the design, and customers or employers make more decision-making (DEMIAN.P, 2008).

2.4.1 BIM Benefits at Different Stages of Construction

Design and Planning: The concept of building information modeling means that a pre-construction building is physically examined to examine problems and simulate and analyze potential impacts. After completing the building model, which is built-in 3D, it is assisted by professional teams with the information needed to design, procure, manufacture and manufacture the materials and activities of building construction and besides, to repair and do maintenance to these facilities before construction where the construction will be displayed in the exact dimensions of the building. BIM model has been created for sharing digital open standards to develop inter-group collaboration capability (Latiffi et al., 2013).

Estimating Employer Needs: Building information modeling as collaborating with different stakeholders at different stages of the life cycle to enter, summarize, view, update or modify the model to support and reflect stakeholder role is the most critical aspect of BIM it allows the design team as a whole to delegate user rights to suppliers for a better and more accurate workflow and to estimate the number of materials and duration of the project. Because one of the primary reasons for the delay in construction is the delay in the delivery of materials (Ashworth, 2016).

2.4.2 Benefits of BIM for Designers

With the advent and awareness amplification of using BIM in the construction industry, has caused many types of research that took place related to the utilization and implementation of building information modeling. Many types of research have brought some evidence that shows the usage of BIM that can make the construction process more efficient and more effective. Benefits like speed and integrity in designing, facilitation in coordination and cooperation, synchronizing designing and planning of construction, detection of collision and cross components, more usage of prefabricated parts, and managing supply chain more efficiently have been detected (Abdelmohsen S, 2012).

The following benefits were identified for using BIM:

- Reduce net costs and risks for owners, designers, and engineer.
- Develop a schematic model before the implementation of the building, which allows designers to have a more accurate evaluation of the suggested design (proposal) and also to evaluate whether the design is according to the owner's operational requirements or not. This feature helps to increase the general function and quality of the project .
- Productivity improves due to easy information retrieval.
- The coordination of construction documents increases.
- More coordination of construction which reduces the time of build and change commands.
- Increases the completion and delivery speed of the project and faster utilization of that.

The pre-designing phase during building designing is one of the essential executive phases of structure which all next phases are somehow affected by that. Computer-assisted designs (CAD) are not able to make complicated analyze, such as analyzing sustainable systems:

- Better designs with wider analyzes
- Initial assessment and ensuring the efficiency and gaining the confidence of employers

- Anticipating problems and obstacles of the task in initial phases and solving conflicts with functions of other involved groups in the project
- Accelerating the preparation and referral of final maps

Figure 2.4 shows the BIM life cycle with a different type of stakeholder.

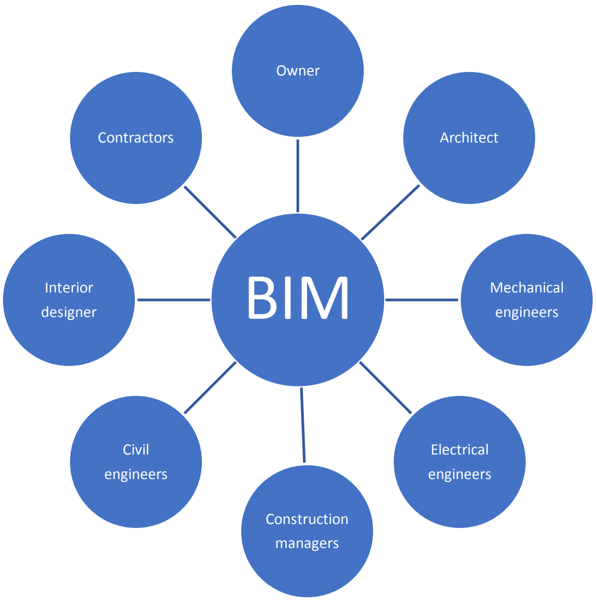

Figure 2.4: BIM life cycle with different groups of Stakeholder (Sebastian, K. 2005)

2.4.3 Benefits of Using BIM for Contractors and Owners

Contractors can also benefit from accessing building information models and solving construction problems on-site as soon as they arise. Besides, BIM use for off-site prefabrication of building components reduces the cost and duration of a project BIM utilization for prefabrication, and visualization also decreases the number of construction workers on-site, which can result in better safety performance (Elliott, 2019).

Owners are willing to adopt BIM if they see their effectiveness. Benefits due to the use of BIM realized by both contractors and designers increase the owner's revenue by saving time and cost. The majority of the owners noted that BIM use improved their ability to plan project phasing and logistics and provided better construction documents. Owners reported that BIM utilization improved labor productivity and decreased the need for site labor due to prefabrication on complex projects. Owners also indicated that reduced document errors and omissions were the top benefits of BIM use while, similar to contractors, owners noted that BIM use was beneficial due to reduced rework (Elliott, 2019).

Table 2.1: Benefits of Using BIM (Eastman,2011)

BIM Benefits for Contractors	BIM Benefits for Owners
Analysis ad planning of construction	Necessary and regular design assessment
Estimating time and cost	Manage the complexity of facilities, scheduling assets
Early anticipation of mistakes and shortcomings ahead and trying to solve them	Reliability and cost management
Stronger relationships with project owners and avoid frequent conflicts	Sustainable development
Optimal cost and timing	Low investment risk due to unpredictable events
Achieving the best quality	Comprehensive and complete information of the building in one file

2.5 Barriers and Challenges of BIM

The idea of integrating BIM overlaps responsibilities and makes them is unclear, For example. In contrast, an employer complains about a design flaw in the design of an architect-engineer and others, any person involved in the project can attribute the problem to another, thereby giving rise to ambiguity in the scope of responsibilities, which comes from the idea integration of the project, The loss of data, the difficulty of communicating, and reduced productivity of work are other disadvantages of using BIM (Haijiang Li, 2017).

According to the researchers, it would not be possible to expect optimum use of the BIM system when it is not available. The improvement of a national technique for BIM implementation would set out national needs and give guidance over the entire industry. It is essential to standardize the BIM procedure and distribute rules for its usage (Azhar, 2011). Moreover, there is a requirement for well-developed practical methodologies classifying the industry's sorts of work (Bernstein and Pittman, 2004). In any case, there is no clear general understanding concerning BIM implementation and use. Some structure guidelines have been developed, but no general standard exists to arrange industry practice. Norms are regular all through the Architecture, Engineer, and Construction (AEC) industry (Laakso, 2010). However, BIM implementation requires the improvement of new measures. The absence of a national standard for sharing information between all stakeholders in the implementation procedure is viewed as a barrier (Allen Consulting Group, 2010).

Data irregularity is the most prominent data-related issue, and information adaptability for sharing or exchange is the second most common (Alreshidi et al., 2014). Readiness to share data among project stakeholders is viewed as fundamental. This implies BIM should include the capacity to transmit and reuse the data inserted in the graphical mode, and along these lines, an absence of data sharing could establish a barrier to BIM implementation (Aibinu and Venkatesh, 2014).

While BIM is expected to give considerable advantages to the AEC business, its implementation requires costs, as with any technology. The perceived expenses of implementing BIM include education and training expenses, organization and start-up expenses, and progress and behavioral costs. The cost of usage is frequently recognized as a barrier to BIM implementation. The expansion in the implementation of BIM in the industry is basically within large companies which have the resource (Ganah and John, 2014). BIM implementation requires explicit software and data storage, which means a noteworthy cost to a company. The expense of purchasing new software relies upon the company's current IT office, while that cost could introduce barriers to small firms. This issue of cost forces investors and potential BIM adopters to consider the choices cautiously (Allen Consulting Group, 2010).

Education and Training issues have two broad components: guaranteeing a company to have the required personnel, either by hiring new staff or retraining existing staff, to set up and integrate BIM technology into its tasks; and retraining most of existing staff to support the social and organizational changes required to ultimately adopt BIM technology within a business model (Allen Consulting Group, 2010). Studies have indicated that BIM education can fundamentally upgrade students' competitiveness in the present job market (Wu and Issa, 2014). Nowadays, the construction industry continues to inform its associated members and stakeholders about BIM implementation in different ways. The core of BIM development is education and training (Sharag-Eldin and Nawari, 2010), which is viewed to be a solution that can accelerate the BIM learning curve. It appears that post-secondary BIM education results still cannot seem to meet the desires of the industry. Most BIM education and training were accessible to focus on the utilization of specific BIM software packages, with less consideration regarding practical applications. The absence of adequately trained BIM experts has blocked BIM implementation and use in the AEC industry (Becerik-Gerber et al., 2011). This gap in skills is a barrier to promote BIM implementation. This circumstance is probably going to turn out to be worse because of a persistent shortage of capable BIM experts throughout the following 20 years (Smith and Tardif, 2009).

The organizational issues with BIM implementation incorporate professional liability, process issues, and trust (Won et al., 2013). The communitarian work managed by BIM emphasized the problem of interoperability (Demian and Walters, 2014). Senior management is hesitant to introduce new technologies and procedures to the organization, while the management support for BIM implementation is fundamental (Ruikar et al., 2005). A bottom-up approach is viewed as more efficient in dealing with resistance to change (Arayici et al., 2011).

Cultural problems contain so many items that can mention some most important of them, such as; resistance to change, lack of cooperation among project members, and also the absence of a real executed BIM model (Hedges, K. 2013).

Most construction industry activists like employers, contractors, and counselors don't have enough familiarity with benefits derived from BIM before construction and have doubts for changing functions and learning new concepts and technologies and not showing any interest from themselves (Iqbal, N. 2010). These people implement their projects traditionally and not willing to achieve their projects with the usage of technology and believe that BIM is in progress technology with limited abilities (Denzer, A. 2013).

Also, they feel that it's very complicated to use BIM and it is better to implement their project with the usage of non-BIM tools which are easier to use despite that BIM has been a revolution in construction industry and because it includes all items in construction industry, which considers in progress technology with unlimited abilities (Dawood, N. 2010).

Since so many people are involved in the achievements of the BIM project, the success of the project is based on cooperation and contemplation of the project team rather than argument and focusing on goals that guarantee the success of the project. Lack of collaboration in each project member could cause severe damage to the whole project and affect the success of it. In general, the implementation of BIM in construction projects requires more cooperation and reliable delivery of the project (Hedges, 2013).

The other reason that people are not convinced is inaccessibility of real executed model of those project which had been done by BIM technology in that exact area (Denzer, A. 2013).

Table 2.2 shows the most critical barriers for implementing BIM, Implementation of BIM in the construction industry has been limited by many obstacles, which can be classified by five major groups and each group can be divided by sub-groups (Chunlu, L. 2015).

Table 2.2: Most Important Barriers Implementation in the Construction Industry

Category	Item	Researchers
Personal Barriers	• Lack of information sharing in BIM • Lack of awareness about BIM • BIM training and education issues • Refuse to learn BIM	(Bernstein & Pittman, 2004); (Thomson & Miner, 2006); (Björk, 2010); (Azhar, 2011); (Venkatesh, 2014); (Alreshidi et al., 2014)
Financial Barriers	• Expensive software • The high cost of implementation • The high price of training • Lack of investment in BIM • Less benefit from BIM for small projects • Lack of client demand	(Azhar, 2011); (Ganah & John, 2014); (Yan and Damian, 2008) ; (Coates et al, 2010); (Crotty, 2012)
Technical Barriers	• Lack of technical experts • Slow adoption of new technology • Lack of national standard & guidelines • Lack of technological skills • Current technology is not sufficient	(Arayici et al, 2009); (Smith & Tardif, 2009); (Allen Consulting Group, 2010); (Nawari, 2010); (Becerik-Gerber et al., 2011); (NATSPEC, 2013) ;(Wu & Issa, 2014).
Organizational Barriers	• Process problems • Lack of senior support • Lack of government support • Lack of opportunity for BIM implementation	(Arayici et al., 2011) ; (Won et al., 2013) ; (Aibinu & Venkatesh, 2014) ; (Demian & Walters, 2014).
Cultural Barriers	• Lack of cooperation among project members • Social and habitual resistance to Change • Absence of real implemented model • Traditional methods of contracting	(N.Iqbal, 2010) ; (N. Dawood, 2010) ; (K. Makanae ,2010) ; (A. Denzer, K. Hedges,2013) ; (A Ranjbardar , 2016).

2.6 Presenting solutions to overcome BIM Barriers

Without providing BIM adoption facilitators, BIM implementation will remain an issue. Many researchers identified BIM facilitators from different perspectives. Organizational culture factor defined as the top facilitator for BIM in terms of creating a culture that can accept new processes and new technologies and preparing professionals who are familiar with this environment (Arayici et al., 2009).

These elements can quickly help to understand the worries about barriers to BIM adoption.

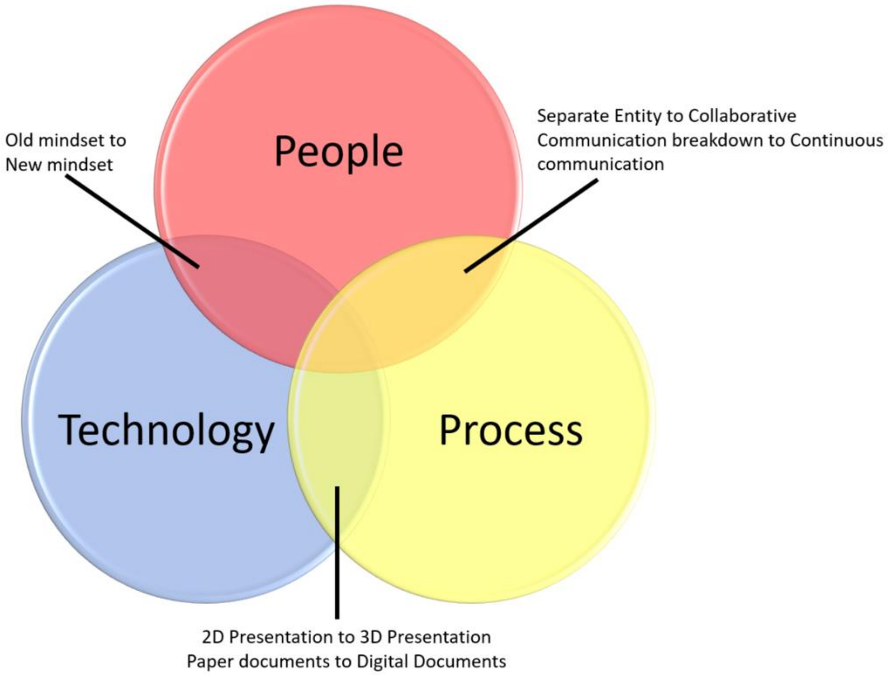

Figure 2.5: Main factors that solve concerns barriers BIM adoption (Naha, S. 2014)

Technology plays a significant role in encouraging BIM adoption; numerous methodologies can be created with technical support to improve BIM adoption performance.

Companies will prompt BIM experts turning into their employees with the assistance of senior management. Different strategies can be actualized in the organization to encourage BIM usage, for example, offering guidelines for BIM training programs, people including experts and customers will support factors to expand the rate of acknowledgment of BIM (Naha, S. 2014).

Also, with the support of the government, many methods can be developed to succeed in BIM adoption. Table 2.3 Shows BIM adoption facilitators by researchers.

Table 2.3: Most Important Facilitator to BIM Implementation in the Construction Industry

Facilitators	Researchers
• Reduction of the project cost • Government pressure • Improve design quality • Support from top management • Provide training for staff • Introduction of BIM in the university curriculum • Risk reduction • Request by clients • Rising the BIM understanding • Training program for BIM • BIM requirement by other project team members • Awareness of the project benefit of BIM	(Newton and chileshe , 2012); (Eadie et al., 2013); (Zikic,N , 2009) ; (Akkaya ,2012) ; (Olugboyega and aina ,2016) ; (Kiani et al ., 2013).

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

As mentioned before, in the general structure of this study, this chapter reviews the research methodology. So in the first part of this study, the method that was used in this research is described. The adopted system to accomplish this research uses the following techniques: information collection, the data about the research design, look into the research population, survey appraisal, questionnaire design, statistical information investigation, content validity, and reliability of the study.

3.2 Data Analysis Method

Since making a correct and timely decision can have a significant impact on achieving the goal, the need for a reliable technique that can help a person in this field is quite tangible. One of the most effective of these techniques is the Analytical Hierarchy Process, which was first introduced by Thomas El Saaty in 1980. This technique is based on paired comparisons and allows managers to examine different scenarios. The Analytical Hierarchy Process has been welcomed and followed by various executives and users due to its simple yet comprehensive nature. Also, over the past twenty years, academic communities have always been considered. The general structure of this process consists of three components of purpose, criteria, and options. And judgments can be made through paired comparisons with a small amount of one to nine (as a fraction of these numbers). Thus first importance of criteria toward purpose and then the preferences of options toward each criterion in the pair matrices will be presented, and ultimately the weight of the criteria and options will be determined.

The advantages of this method, in comparison with other methods, are simplicity and comprehensibility of it. To calculate the incompatibility of judgments, the hierarchical structure of the process, and the possibility of considering qualitative and quantitative criteria. Another reason for choosing this structural method is to provide group participation. For the integration of different judgments of individuals, the matrices of the paired comparison are received by all, and with using one of the following methods. We can make all judgments as one and then obtain the relative weights of criteria and options:

1. Least squares method: The method of least squares is a standard approach in regression analysis to approximate the solution of overdetermined systems (sets of equations in which there are more equations than unknowns) by minimizing the sum of the squares of the residuals made in the results of every single comparison.
2. Logarithmic least-squares method: Statistical technique for estimating straight-line (linear) relationships between two or more variables where one or more independent variables influence a dependent variable).
3. Eigenvector method: In linear algebra, an eigenvector or characteristic vector of a linear transformation is a nonzero vector that changes at most by a scalar factor when that linear transformation is applied to it. The corresponding eigenvalue is the factor by which the eigenvector is scaled.
4. Approximation method (Approximation method is a quantitative part of functional analysis. Diophantine approximation deals with approximations

of real numbers by rational numbers. Approximation usually occurs when an exact form or an exact numerical number is unknown or difficult to obtain. However, some known sort may exist and may be able to represent the original form so that no significant deviation can be found. It also is used when a number is not rational, such as the number π, which often is shortened to 3.14159, or $\sqrt{2}$ to 1.414).

As previously stated, in Analytical Hierarchy Process, the elements are compared in pairs, and the pairing matrix will be created, then using this matrix and one of the above-presented methods, the relative weights of the elements are calculated. In general, a paired comparison matrix is shown as follows, which in this case (Aij), is a preference of parameter **(** I) towards parameter (j).

$$A = \begin{pmatrix} a11 & a12 & \cdots & a1n \\ a21 & a22 & & a2n \\ \vdots & & \vdots & \vdots \\ an1 & an2 & \cdots & ann \end{pmatrix} \quad A = [aij] \qquad i,j = 1,2,\dots,n$$

The Analytical Hierarchy Process (AHP) is a graphical representation of real complex issues at the top of it. There is a general goal of the problem and at the next levels, criteria, and options. Although there is no fixed and definite rule for hierarchical modeling, some people have tried to express a set of general rules in this regard. For example, the analytical hierarchy process from Dyer and Forman's point of view is revealed, as shown in Figure 3.1.

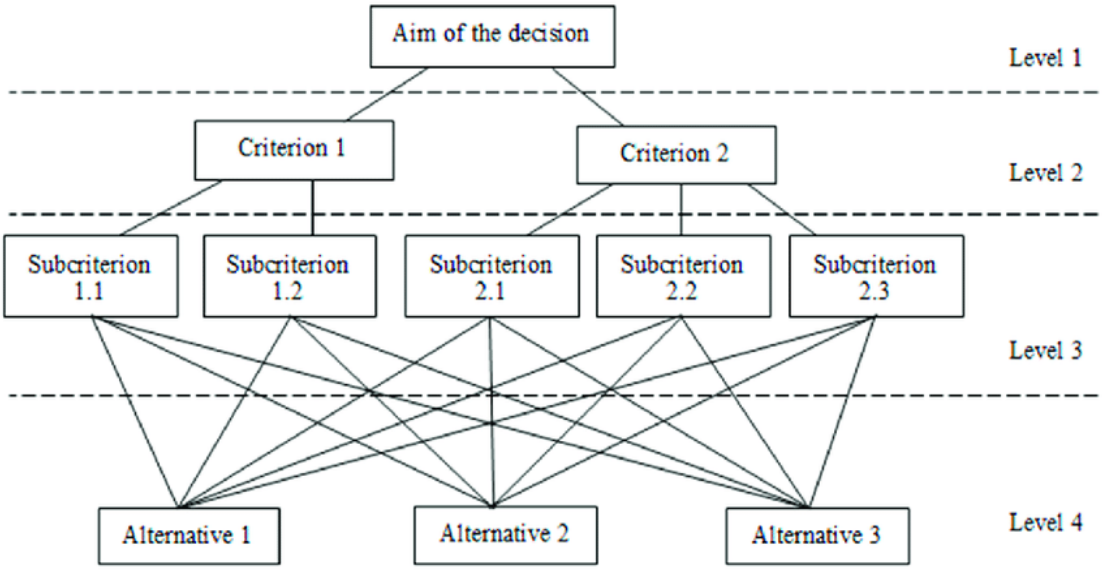

Figure 3.1: A general example of a hierarchical model building (Wątróbski, 2016)

One of the decision making's issues for managers is how to choose an option among several available options, which should be done according to the criteria for selection. Even if making a choice is not considered, we may need to know the extent to which the priority of the options towards each other. In this case, each option is given a score based on the ratings assigned in comparison with each other and about the importance of the indexes towards each other, which indicates the better capability of that option according to the defined criteria. But fixing scores is not straightforward and may result in deviations in the final results, so the need for a methodical approach is scoring. In this regard, in the 1970s, a technique or Analytical Hierarchy Process "AHP" by Thomas L. Saaty was designed to solve such a problem. In a general view, it can be said that the construction of an Analytical Hierarchy Process model depends on the type of decision and the purpose to be taken. For example, if the considered decision is choosing an option, it can start from options and show them in the lowest level, and the next level will be the criteria that will be used to select the options and be placed at the highest level of the hierarchical target which is an element.

In general, the decision-making process is divided into two continuous and discrete categories in terms of decision space, and decision-making in discrete space is divided into two groups of single-criteria and sub-criteria. The criteria themselves are divided into three categories: qualitative, quantitative, and composite (qualitative and quantitative) criteria.

The analytical hierarchy process (AHP) is a method that provides the right decision-making opportunity with the presence of quantitative and qualitative criteria. Figure 3.2 shows up the process of the AHP method.

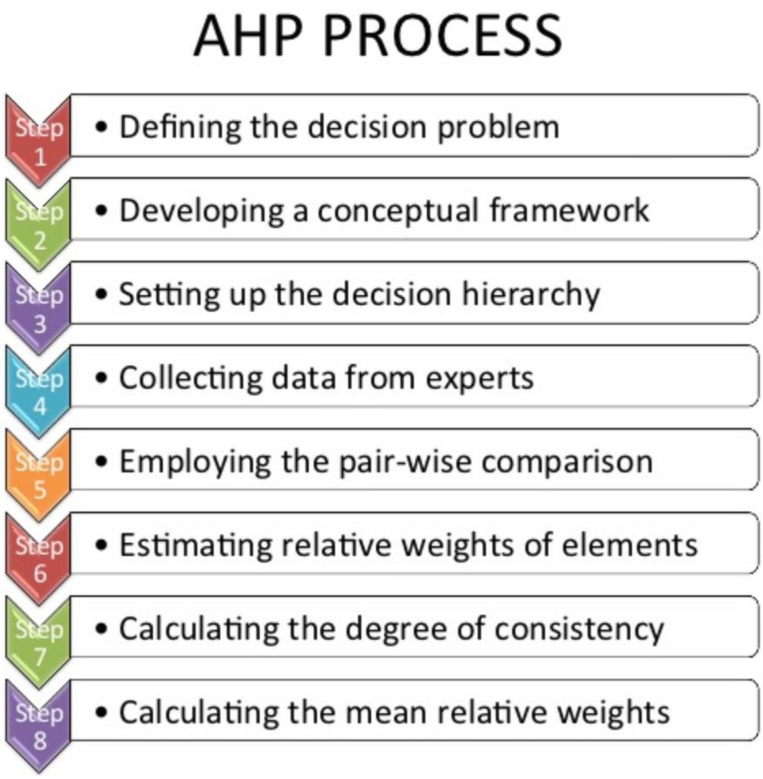

Figure 3.2: The general principles of analytical hierarchy process

3.3 Reasons for Using the AHP Method in this Study

The high degree of hierarchy analysis and selection criteria used in this study based on the ranking of some managers and supervisors of current projects in the country, the questionnaire is based on the methodology of the hierarchical analysis method. In the questionnaire, It is being prepared for distribution between the project implementation factors. In the field of industry, the decision-making process is sometimes so important that the occurrence of an error may impose irreparable losses. The decision-making process faces numerous problems with several quantitative and qualitative criteria, for example, in choose a beautiful car, the criteria for beauty, model and price are the following, the following problems arise:

- Absence of standard for measuring qualitative criteria
- Not having a unit to convert criteria (qualitatively and quantitatively) to each other.

Also, due to problems with the decision-making process with multiple criteria, including the complexity and lack of standardization, speed, and precision of decision making have been greatly reduced and cause the process to be largely dependent on the individual decision-maker be Analytical hierarchy process is one of the most comprehensive systems designed for decision making with multiple criteria because it can:

- Formulate the decision-making process.
- Different qualitative and quantitative criteria.
- Make decision choices of the problem.
- Analyze sensitivity to criteria and sub-criteria.
- Additionally, consider the compatibility and incompatibility of the decision, which is one of the distinguishing features of this process.

Several methods have been used in previous studies; each of them has its disadvantages and advantages. The AHP method is used in this study:

- Simplicity,
- Flexibility,
- Ability to use quantitative and qualitative criteria simultaneously,
- The ability to control the logical compatibility of judgments used in determining priorities,
- Possibility of the final rating of options, and
- Possibility to use group opinions (collective judgment),

Are the reasons for using the AHP method.

3.4 Data Collection

In gathering information in this study, two methods have been used:

1.Documentary and library methods. The use of documentary and library research methods to formulate the theoretical foundations of research has been the most important part of this study.

2. Designed a Pair-wise comparison questionnaire to compare each pair of the criteria, sub-criteria, and alternatives (facilitators) and to identify to what extent one criterion or alternative is more/less important/preferred to another. The respondents to this questionnaire are a committee of experts in the field of engineering and management.

It should be noted that the proposed development model was available to several experts and, after its approval, will be the basis for the continuation of this study.

3.5 Research Population

This research targets most of several executives of employers, consultants, and contractors in the construction industry in Iran. Twelve of the companies were selected to fill in the questionnaire. These Twelve companies have departments and specialists in implementing construction projects; that's why they were selected. The number of professionals in these twelve companies is almost two hundred 200, a total of 163 completed questionnaires were received back from the professionals. This represents 81.5 % of the total distributed questionnaires. The survey was sent through email to participants.

3.6 Questionnaire Assessment

Experts speaking to two boards were reached to assess the questionnaire validity. The first board was asked to confirm the legitimacy of the questionnaire subjects and their relevance to the study goals. The second board, which comprised of experts in statistics who were asked to recognize the validity of the instrument used, in the questionnaire and tests among factors. At the point when the questionnaire is finished, it is then the design of the survey is closed, and any arrangement plan for its organization is settled (Gill and Johnson, 2002).

3.6.1 Questionnaire Design

After interviewing academics and experts who were dealing with the subject at different levels, the questionnaire was developed with closed-ended questions. The criteria list was compiled from previous studies discussed. The questionnaire developed for this investigation is administered to engineers, architectures, and academicians in the Iranian construction industry. The questionnaire was designed in both the Persian and English languages, as most members of the targeted population were unfamiliar with the English language to ensure that the criteria used in this questionnaire are understandable. The questionnaire was provided with a cover letter that explained the purpose of the study, the way of responding, the aim of the research, and the security of the information in order to encourage high response.

The questionnaire divided into four sections as:

- Section A: Respondents profile.
- Section B: Practices and Knowledge of Modeling Building Information.
- Section C: Barriers to BIM implementation.
- Section D: Facilitator for BIM adoption.

3.6.2 Questionnaire Validity

There are two ways to evaluate questionnaire validity: content validity and statistical validity. In this study, the content validity test was led by counseling two groups of professions. The first was requested to assess and recognize whether the questions agreed with the extent of the items and the extent to which these items reflect the idea of the study issue. The other was requested to assess that the instrument used is substantial statistically and that the survey was designed well to provide relations and tests between factors. The two groups of experts agreed that the survey was legitimate and appropriate enough to quantify the idea of interest with some minor changes.

The statistical validity, which was evaluated by Cronbach's alpha (α) coefficient, is an accreditation method that evaluates the internal consistency of the test and demonstrates how much test questions can measure the unit's specificity. Considers the questionnaire as a test, in general, it can be said that a good test should have desirable features such as objectivity, ease of implementation, practicality, the comfort of interpretation and interpretation, validity, and reliability to lead to correct results.

Among these features, validity and reliability are more important. In this research, Cronbach's Alpha method is more commonly used than other methods.

The method of using Cronbach's alpha ($\propto$)coefficient is to determine the reliability of a questionnaire or test with an emphasis on internal correlation. In this method, components or parts of the questionnaire are used to measure the test's reliability. If the questions are considered in two cases (true = 1 and false = 0), the alpha coefficient can be calculated from the following equation.

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum pq}{s^2}\right)$$

Where k is the number of questions; p; the number of correct answers; q; the number of false answers; S^2 is the variance of all questions; and if the questions are of amount (each question has its amount value). Cronbach coefficient alpha value between 0.0 and + 1.0 and the higher values reflect a higher degree of internal consistency, the reliability of this study was calculated using the Cronbach's coefficient alpha which is 0.96. Cronbach coefficient is acceptable when ($\propto > 0.6$).

Chapter 4

RESULTS AND DISCUSSION

4.1 Introduction

As noted shortly, Building Information Modeling (BIM) will be used as a unique resource to enable unrestricted information integration capabilities, which will significantly facilitate building life cycle processes. Building information modeling is a revolutionary technology and means that it has quickly become a way of understanding, designing, constructing, and commissioning buildings. BIM is a rich set of smartly designed information that the right data can be extracted and analyzed according to the needs of users, which is used to decide and improve the process of building information. The method of building information modeling can be applied from the first project process to demolition. Correct and coordinated project definition before construction begins will make construction more efficient and the construction period shorter. The construction industry is rapidly adopting BIM to reduce costs and time and improve environmental quality and sustainability. AutoCAD drawings are currently used in most architectural works, and this software eliminates or undermines changes to the structure of the project and may cause problems and mismatches if any changes occur. The reason for this can be attributed to the lack of integration of information in all departments, both in design and construction. The lack of integration systems can be attributed to the lack of familiarity with the system and its failure to be used by architects and engineers. Inadequate research in Iran on building information integration software and the problems associated with this failure.

4.2 Methodology

In the following, this study will prioritize each of these factors by preparing a questionnaire that was presented in the previous chapter by the AHP method, and finally, the results will be analyzed and concluded. Expert Choice 11.5 Pro and Microsoft Excel is used to achieve these goals. Once the research methodology has been determined using the appropriate tools, the data needed to test the hypotheses has been collected, it is now time to utilize proper techniques that are compatible with the research methodology, the type of variables and has to categorize and analyze the data collection so that the hypotheses that have guided the researcher to this stage of the research can finally be put into the test plant. Linking the research subject to a range of existing information requires creative thinking. The process of data analysis is a multistage process in which data collected through the use of data collection tools in the statistical community are collected, categorized, and finally processed to enable a variety of analyzes. The relationship between these data is provided to test the hypotheses. Information analysis is considered as the scientific stage of the necessary foundations of any scientific research, by which all research activities are controlled and guided to the conclusion. Therefore, this chapter presents the results of the analysis of the data collected in the research. Table 4.1 shows the statistics about respond profile of participant.

4.3 Statistics about Respondent Profile

Table 4.1: Detail statistic about respondent profile

No.	Details of the respondent		Number	Percentage
1	Participants	Tehran	98	39.9
		Others	65	60.1
2	Gender	Male	86	52.8
		Female	77	47.2
3	Education	BSc	87	53.4
		MSc	60	36.8
		PhD	16	9.8
4	Experience	Less than 3 Years	5	3.1
		From 3 – 5 Years	22	13.5
		From 5 - 10 Years	80	49.1
		More than 10 Years	56	34.3
5	Job Position	Engineers	79	3.1
		Architects	68	13.5
		Academics	16	49.1
6	Work Sector	Building project	101	62
		Infrastructure	40	24.5
		Both	22	13.5
7	Software Usage	AUTO CAD	101	28.7
		3D MAX	53	15
		SKETCHUP	32	9.1
		REVIT ARCHITECTURE	36	10.2
		REVIT STRUCTURAL	17	4.8
		MS PROJRCT	52	14.7
		ARCHICAD	13	3.7
		PRIMAVERA	42	12
		Others	6	1.7
8	Awareness about BIM	Yes	103	58
		No	80	44
9	BIM usage in firms	Yes	75	46
		No	88	54
10	Level of knowledge	Very few	15	9.22
		A few	35	21.47
		Medium	64	39.26
		High	33	20.24
		Very high	16	9.81

4.4 Analyze Barriers of BIM Implementation with AHP Method

4.4.1 Structuring the Hierarchy

The goal is to choose the most critical barriers to BIM implementation in the Iranian construction industry. The goal is placed at the top of the hierarchy. The hierarchy descends from the more general criteria in the second level to sub-criteria in the third level to the alternatives at the bottom or fourth level. General criteria level involved five significant criteria: personal barriers, financial barriers, technical barriers, organizational barriers, and cultural barriers. Figure 4.1 shows a hierarchical representation of the most critical obstacles of the BIM implementation model.

4.4.2 Performing Pair-wise Comparisons

After constructing the hierarchy, pair-wise comparisons were performed systematically to include all the combinations of criteria and sub-criteria relationships. The criteria and sub-criteria were compared according to their relative importance with respect to the parent element in the next upper level. Hence, a questionnaire including all possible pair-wise comparison combinations was distributed to the experts. They first made all the pair-wise comparisons using semantic terms from the major scale and then translated them to the corresponding numbers, separately. The questions to ask when comparing two criteria being examined, which is considered more remarkable by the experts selecting the best supplier, and how much more critical is it concerning the selection of the best supplier. After performing all pair-wise comparisons by the experts, the individual judgments were aggregated using the geometric mean, as suggested by Saaty, 1990. The decisions were based upon the gathered information through the questionnaires. The results are then combined by applying the geometric mean.

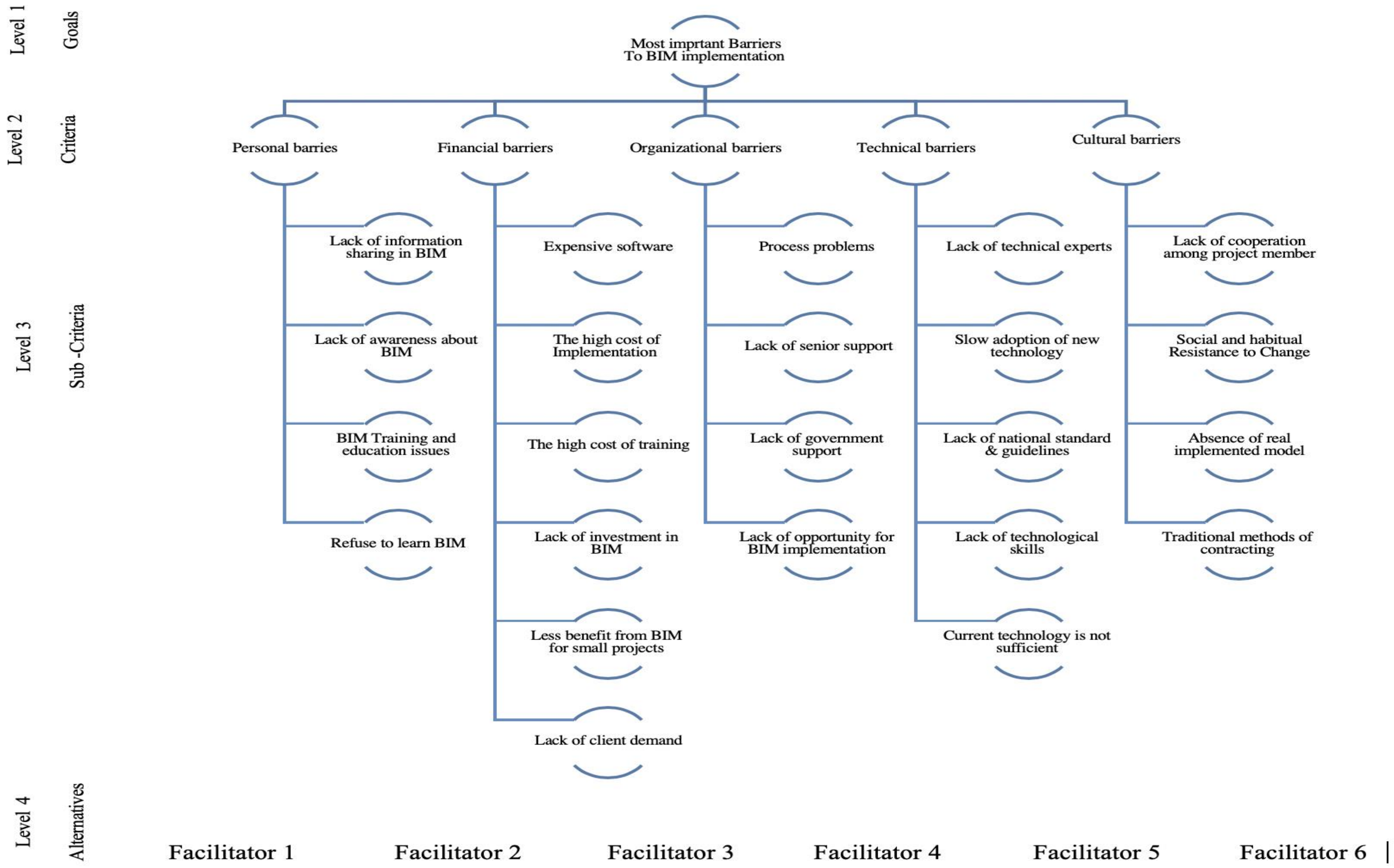

Figure 4.1: A hierarchical representation of the top barriers to BIM adoption

4.4.2.1 Types of Comparison

There are three comparison types used in the Expert Choice to choose one of them: importance; is appropriate when comparing one criterion with another; likelihood; is relevant when examining the probability of an outcome. (It can be used with either criteria or alternative), and preference, used when comparing the alternatives.

4.4.2.2 Modes of Comparison

Expert Choice provides various options for comparing criteria, sub-criteria, and alternatives, so there are three comparison modes: numerical, verbal, and graphical. Numerical options where the decision-makers can enter numerical values between 1 and 9 oral option where semantic terms can be used; and a graphical choice where the decision-makers can make comparisons by contrasting the graphical bars. The direct estimation is where the user simply produces a set of values reflecting the relative preference for the compared elements. Before the study, numerical pair-wise comparison mode should be chosen.

4.4.2.3 Barriers Pair-Wise Analysis

The Participants (163) has filled the pair-wise comparison matrices. The responses of each professional were analyzed using Expert Choice Pro 11.5 to calculate the consistency ratio (CR) and the weighting vectors of each main criterion and sub-criterion. As mentioned earlier, the pair-wise comparison matrices obtained from 163 respondents are combined using the geometric mean approach at each hierarchy level to get the corresponding consensus pair-wise comparison matrices, as shown in Figures (4.2) to (4.7). Each of these matrices is then translated into the relevant most significant eigenvalue problem and is solved to find the normalized and unique priority weights for each criterion. According to Saaty 1980, the judgment of a participant is accepted if $CR \leq 0.10$.

Figure 4.2 shows the importance of the main criteria to each other from the expert's point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Main Criteria Barriers	Personal	Financial	Organizational	Technical	Cultural
Personal	1	3	2	4	2
Financial		1	1/3	1/3	1/2
Organizational			1	2	2
Technical				1	3
Cultural					1

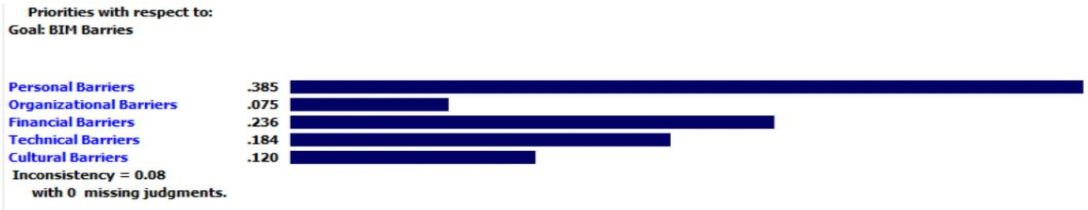

Figure 4.2: Pair-wise matrix and priorities for main criteria

Figure 4.3 shows the importance priorities with respect to personal barriers category from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Personal barriers	Lack of information sharing in BIM	Lack of awareness about BIM	BIM training and education issues	Refuse to learn BIM
Lack of information sharing in BIM	1	1/3	1/3	1/3
Lack of awareness about BIM		1	3	2
BIM training and education issues			1	1/4
Refuse to learn BIM				1

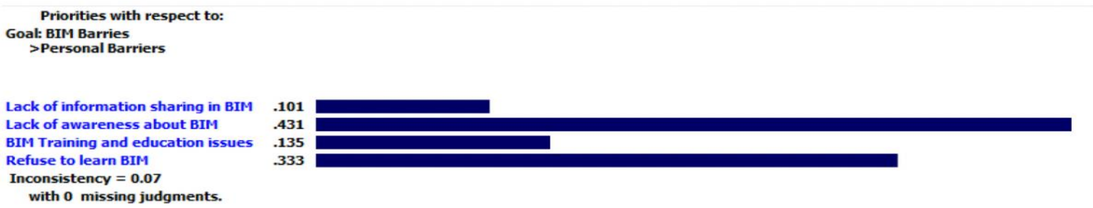

Figure 4.3: Pair-wise matrix and priorities for personal barriers

Figure 4.4 shows the importance priorities with respect to financial barriers category from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Financial barriers	Expensive software	The high cost of implementation	The high cost of training	Lack of investment in BIM	Lack of client demand	Less benefit from BIM for small project
Expensive software	1	2	1/3	1/3	1/3	4
The high cost of implementation		1	1/2	1/3	1/2	2
The high cost of training			1	2	1/2	3
Lack of investment in BIM				1	1/2	4
Lack of client demand					1	2
Less benefit from BIM for small project						1

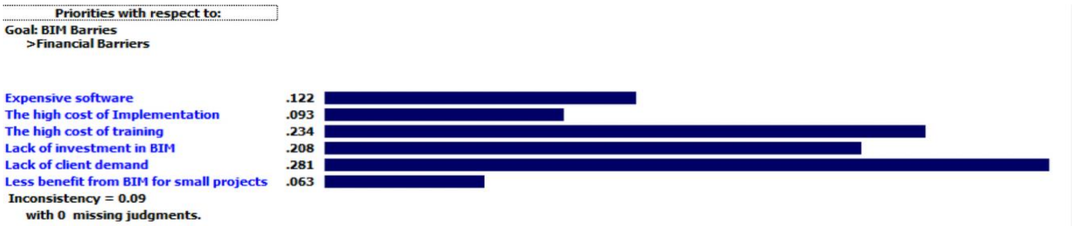

Figure 4.4: Pair-wise matrix & priorities for financial barriers

Figure 4.5 shows the importance priorities with respect to organizational barriers category from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Organizational barriers	Process problem	Lack of senior support	Lack of government support	Lack of opportunity to implement BIM
Process problem	1	1/2	1/4	3
Lack of senior support		1	1/2	3
Lack of government support			1	4
Lack of opportunity to implement BIM				1

Figure 4.5: Pair-wise matrix & priorities for organizational barriers

Figure 4.6 shows the importance priorities with respect to technical barriers category from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Technical barriers	Lack of technological skills	Lack of technical expert	Lack of national standard and guidelines	Current technology is not enough	Slow adoption of new technology
Lack of technological skills	1	1/2	1/2	3	2
Lack of technical expert		1	1/3	4	3
Lack of national standard and guidelines			1	3	2
Current technology is not enough				1	1/2
Slow adoption of new technology					1

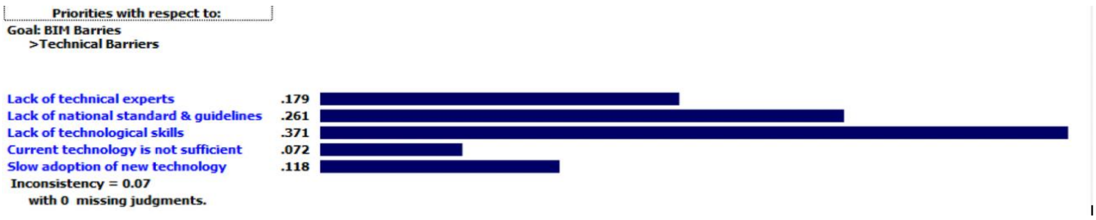

Figure 4.6: Pair-wise matrix & priorities for technical barriers

Figure 4.7 shows the importance priorities with respect to cultural barriers category from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Cultural barriers	Lack of cooperation among project member	Resistance to change	Traditional Methods of contracting	Absence of real implemented model
Lack of cooperation among project member	1	5	2	3
Resistance to change		1	1/2	3
Traditional Methods of contracting			1	3
Absence of real implemented model				1

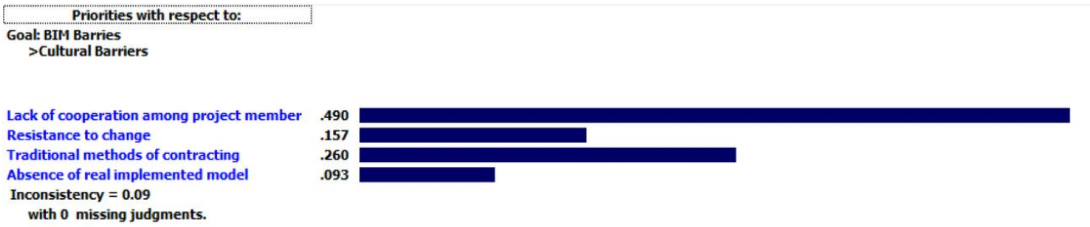

Figure 4.7: Pair-wise matrix and priorities for cultural barriers

4.4.2.4 Final Weights of Each Criterion

To find the final (global) weight of each sub-criterion, the results of the weighting vector for standing criteria list was arranged in Table 4.2 the main criteria weighting vectors (1) are multiplied by the corresponding sub-criteria weighting vectors (2) to obtain the (global) criteria weight (3). The ten highest weighted sub-criteria for standing list were: Lack of awareness, Refuse to learn BIM, Lack of technological skills, Lack of client demand, Lack of cooperation among project member, The high cost of training, BIM Training and education issues, Lack of investment in BIM, Lack of national standard & guidelines and Lack of information sharing in BIM.

Table 4.2: Priority weights for criteria and sub-criteria used in this case study

Criterion	Local weight (1)	Sub-criterion	Local weight (2)	Global weight(3)
Personal Barriers	(0.385)	Lack of information sharing in BIM	(0.101)	0.0388
		Lack of awareness about BIM	(0.431)	0.1659
		BIM Training and education issues	(0.135)	0.0519
		Refuse to learn BIM	(0.333)	0.1282
Financial Barriers	(0.236)	Expensive software	(0.122)	0.0287
		The high cost of Implementation	(0.093)	0.0219
		The high cost of training	(0.234)	0.0552
		Lack of investment in BIM	(0.208)	0.0491
		Less benefit from BIM for small projects	(0.063)	0.0148
		Lack of client demand	(0.281)	0.0663
Technical Barriers	(0.184)	Lack of technical experts	(0.179)	0.0329
		Slow adoption of new technology	(0.118)	0.0217
		Lack of national standard & guidelines	(0.261)	0.0479
		Lack of technological skills	(0.371)	0.0682
		Current technology is not sufficient	(0.072)	0.0132
Organizational Barriers	(0.075)	Process problems	(0.163)	0.0122
		Lack of senior support	(0.264)	0.0198
		Lack of government support	(0.488)	0.0366
		Lack of opportunity for BIM implementation	(0.085)	0.0037
Cultural Barriers	(0.120)	Lack of cooperation among project member	(0.490)	0.0588
		Social and habitual Resistance to Change	(0.157)	0.0188
		Absence of real implemented model	(0.260)	0.0312
		Traditional methods of contracting	(0.093)	0.0117
Total	**1.000**	**Total**		**1.000**

4.5 The Facilitators Pair-Wise Comparison

The final step in the pair-wise comparison is comparing each pair of alternatives (suppliers) concerning each criterion. In analyzing the five important facilitators, the participants were answered which supplier is preferred with respect to each criterion in Level 3. Table 4.10 shows the facilitators and Figures from (4.8 – 4.12) explain the pair-wise matrix and priorities for each criterion.

Table 4.13: The important facilitator to overcome with BIM barriers

Facilitator 1	Government pressure
Facilitator 2	Support from top management
Facilitator 3	Improve design quality
Facilitator 4	Rising the BIM understanding
Facilitator 5	Request by clients
Facilitator 6	Training program for BIM

Figure 4.8 shows the importance priorities for facilitators with respect to personal barriers from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Personal Barriers	Government pressure	Support from top management	Improve design quality	Rising BIM understanding	Request by clients	Training Program for BIM
Government pressure	1	3	2	1/2	1/4	1/3
Support from top management		1	3	1/4	1/2	1/3
Improve design quality			1	1/5	1/2	1/4
Rising BIM understanding				1	2	1/2
Request by clients					1	1/2
Training Program for BIM						1

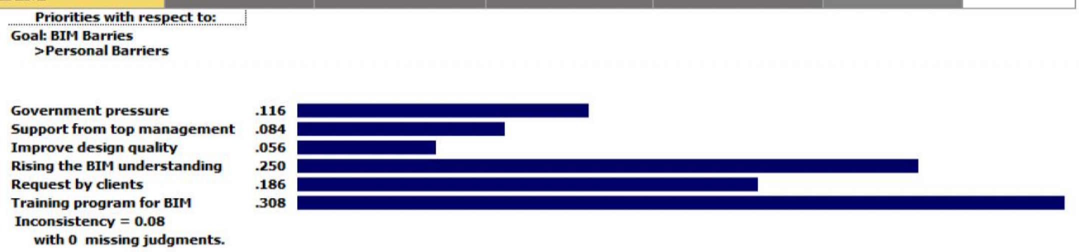

Figure 4.8: Pair-wise matrix and priorities for Personal Barriers

Figure 4.9 shows the importance priorities for facilitators with respect to organizational barriers from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Organizational Barriers	Government pressure	Support from top management	Improve design quality	Rising BIM understanding	Request by clients	Training Program for BIM
Government pressure	1	3	3	2	2	3
Support from top management		1	2	3	3	2
Improve design quality			1	2	3	1/2
Rising BIM understanding				1	2	1/3
Request by clients					1	1/2
Training Program for BIM						1

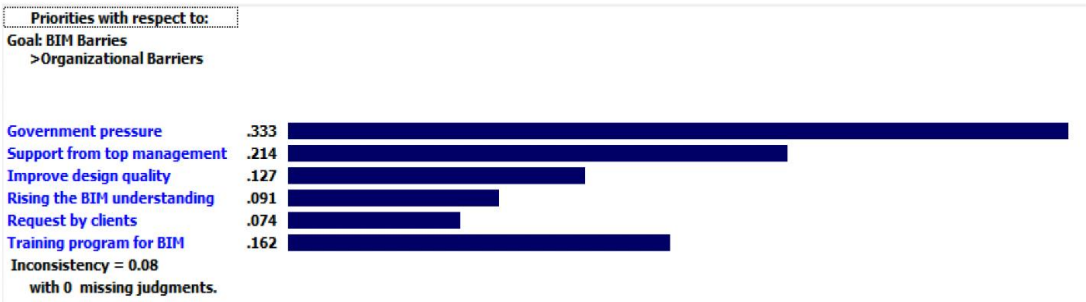

Figure 4.9: Pair-wise matrix and priorities for Organizational Barriers

Figure 4.10 shows the importance priorities for facilitators with respect to financial barriers from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Financial Barriers	Government pressure	Support from top management	Improve design quality	Rising BIM understanding	Request by clients	Training Program for BIM
Government pressure	1	1/2	3	3	1/2	2
Support from top management		1	3	2	1/2	4
Improve design quality			1	2	1/3	1/2
Rising BIM understanding				1	1/2	1/3
Request by clients					1	2
Training Program for BIM						1

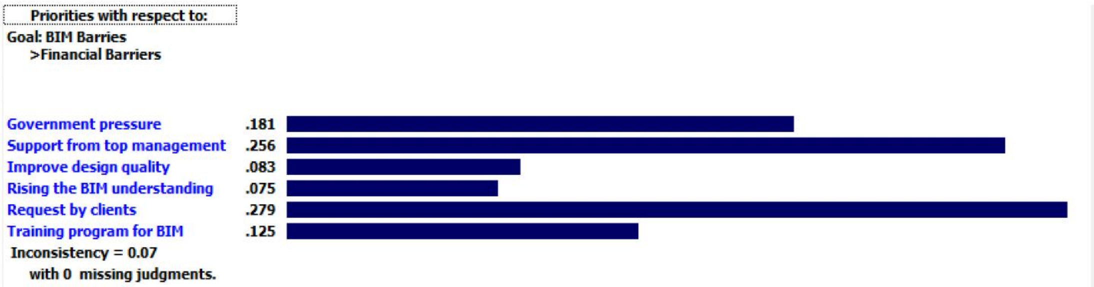

Figure 4.10: Pair-wise matrix and priorities for Financial barriers

Figure 4.11 shows the importance priorities for facilitators with respect to technical barriers from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Technical Barriers	Government pressure	Support from top management	Improve design quality	Rising BIM understanding	Request by clients	Training Program for BIM
Government pressure	1	2	1/4	1/3	2	1/3
Support from top management		1	1/3	1/2	3	1/3
Improve design quality			1	3	5	1/2
Rising BIM understanding				1	2	1/3
Request by clients					1	1/4
Training Program for BIM						1

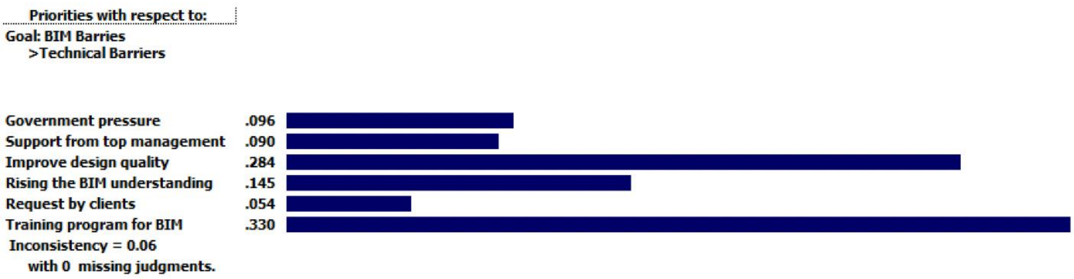

Figure 4.11 : Pair-wise matrix and priorities for Technical barriers

Figure 4.12 shows the importance priorities for facilitators with respect to cultural barriers from the experts point of view and shows the local weight of each criterion from Expert Choice Pro11.5.

Cultural Barriers	Government pressure	Support from top management	Improve design quality	Rising BIM understanding	Request by clients	Training Program for BIM
Government pressure	1	4	2	2	3	2
Support from top management		1	2	3	2	1/2
Improve design quality			1	1/3	2	1/3
Rising BIM understanding				1	3	1/2
Request by clients					1	1/2
Training Program for BIM						1

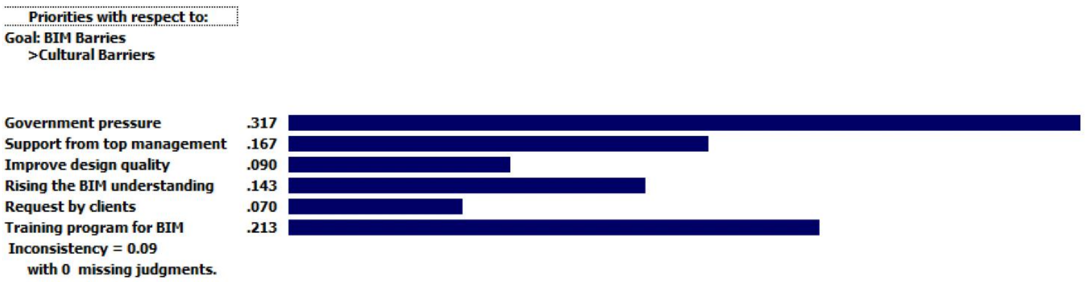

Figure 4.12: Pair-wise matrix and priorities for Cultural Barriers

4.6 Synthesizing the Results

Expert Choice 11.5 provides two ways of synthesizing the local priorities of the alternatives using the global preferences of their parent criteria: the distributive mode and the ideal model. In the distributive model, the weight of a criterion reflects the importance that the decision-maker attaches to the dominance of each alternative relative to all other alternatives under that criterion. In our case, the distributive mode would be the way to synthesize the results. After deriving the local priorities for the criteria, and the alternatives through pair-wise comparisons, the priorities of the criteria are synthesized to calculate the overall priorities for the decision alternatives. As shown in Figure 4.13, the facilitator is ranked according to their global priorities. Factor 6 (Provide training for BIM**)** turns out to be the preferable facilitator among the facilitators, with an overall priority score of 0.243.

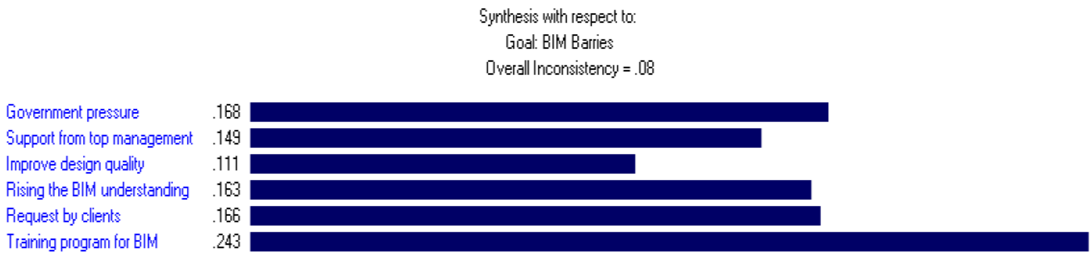

Figure 4.13: Synthesizing the local priorities of the alternatives

4.7 Sensitivity Analysis

It is necessary to examine the sensitivity of the alternatives due to changes in the priorities of the (SSM) models the main criteria with respect to the goal. A series of sensitivity analyses were conducted to investigate the impact of changing the priority of the criteria on the Facilitators ranking. The Expert Choice software has the ability to deal with such changes and has five ways to display the result of such changes. These ways include gradient sensitivity, two-dimensional sensitivity, performance sensitivity, dynamic sensitivity, and weighted differences sensitivity.

For this research, Dynamic and Performance sensitivity were performed. Dynamic sensitivity analysis is used to dynamically change the priorities of the criteria to determine how these changes affect the priorities of the alternative choices. The performance sensitivity shows the relative importance of each of the objectives as bars and the corresponding preference for each alternative concerning each objective as the intersection of the alternatives curves with the vertical line for each objective.

The impact of changing the priority of five main criteria on overall results was investigated. As shown in Figures (4.15 – 4.19), the results indicate that the Facilitator ratings are not sensitive to changes in the importance of the main criteria. The priorities of the main model criteria were changed one at a time concerning the goal as follows:

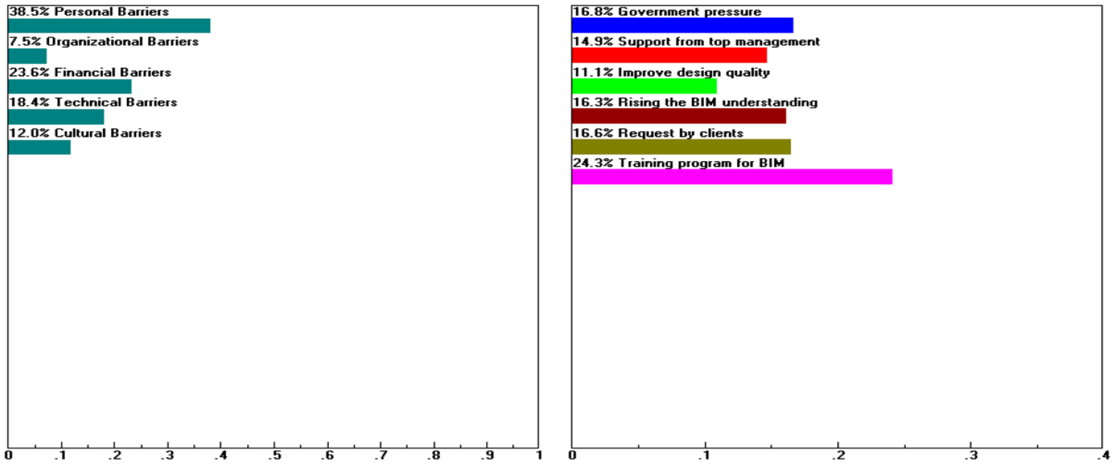

Figure 4.14: Dynamic sensitivity for Barriers to BIM implementation

Figure 4.15 shows when the importance of Personal Barriers is increased from 38.5% to 45% the rising the BIM understanding (Facilitator 4) has become more important that Request by Client (Facilitator 5) and when importance of personal barriers decreased from 38.5% to 35% , overall rank of the final outcome is preserved.

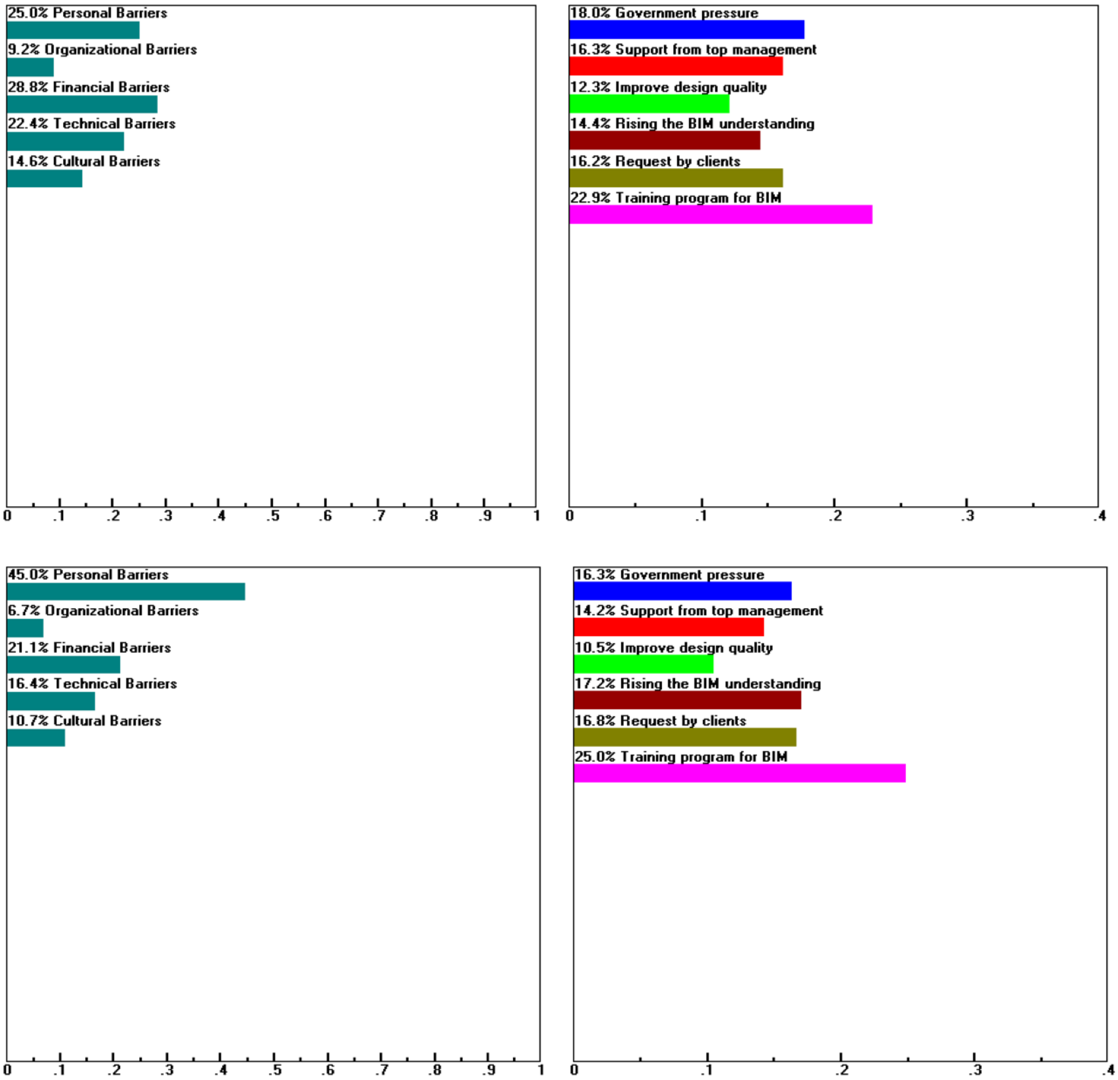

Figure 4.15: Change in alternatives' priorities due to change in personal barriers

Figure 4.16 shows that the relative importance of Organizational Barriers is increased from 7.5% to 15% or decreased from 7.5% to 2%. In this analysis, overall rank of the final outcome is preserved.

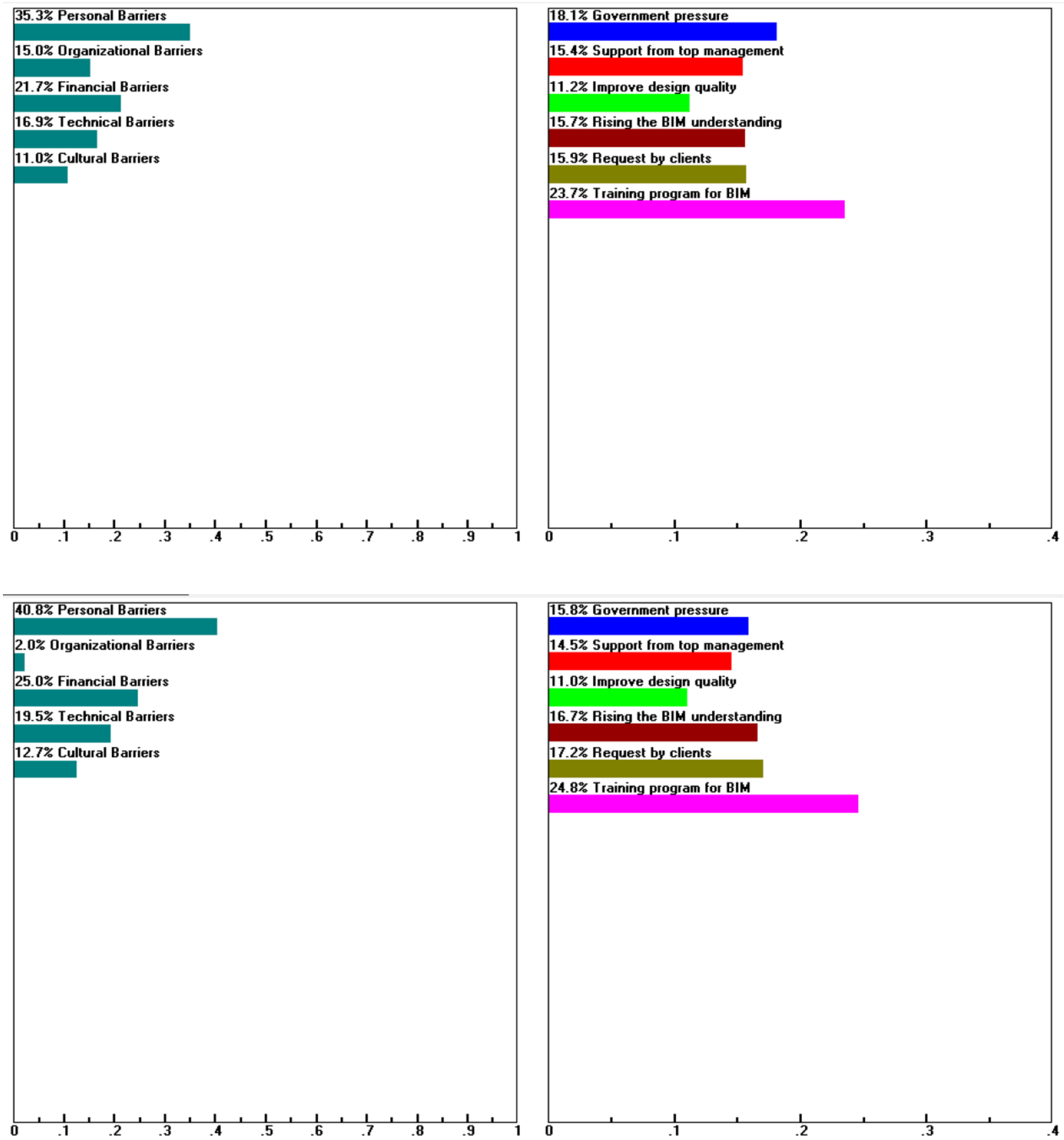

Figure 4.16: Change in alternatives' priorities due to change in Organizational barriers

Figure 4.17 shows When the importance of Financial Barriers is increased from 23.6% to 35.1% overall rank of the final outcome is preserved, and when importance of Financial Barriers decreased from 23.6% to 35% , the rising the BIM understanding (Facilitator 4) has become more important that Request by Client (Facilitator 5).

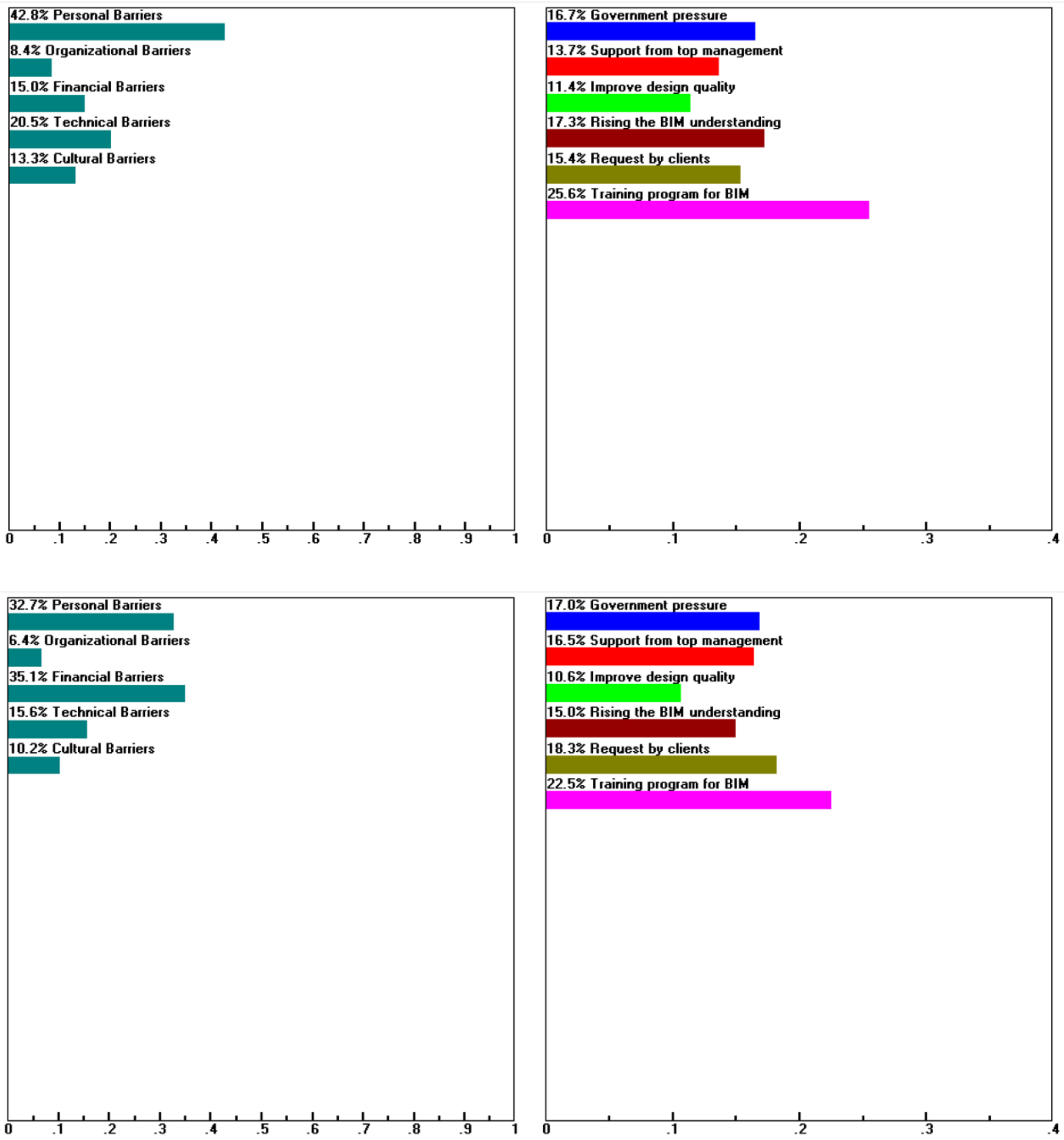

Figure 4.17: Change in alternatives' priorities due to change in Financial barriers

Figure 4.18 shows When the importance of Technical Barriers is increased from 18.4% to 30.2% the rising the BIM understanding (Facilitator 4) has become more important that Request by Client (Facilitator 5) and when importance of Personal Barriers decreased from 18.4% to 8% , overall rank of the final outcome is preserved.

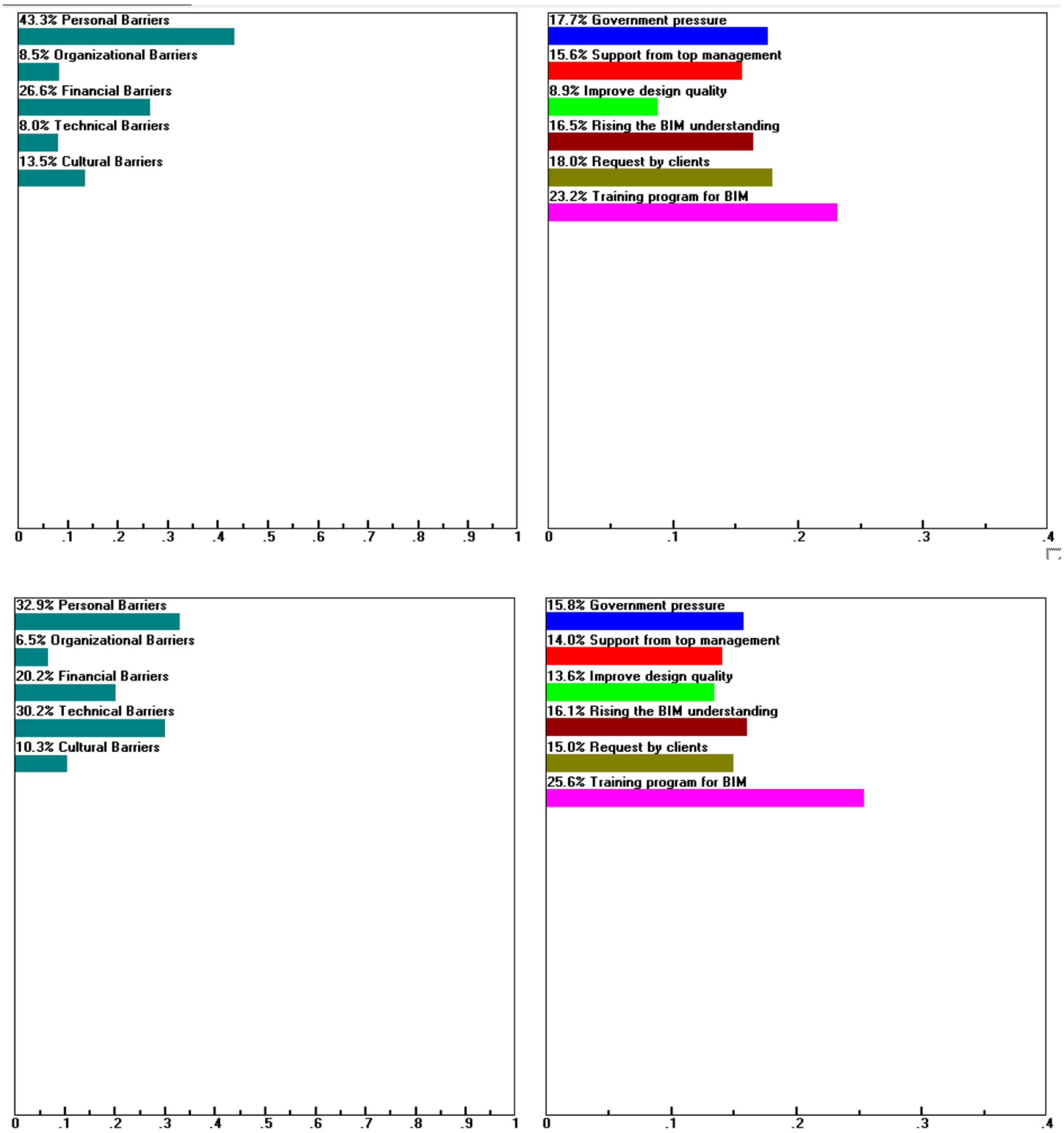

Figure 4.18 : Change in alternatives priorities due to change in Technical Barriers

Figure 4.19 shows when the importance of Cultural Barriers is increased from 12% to 25% the rising the BIM understanding (Facilitator 4) has become more important that Request by Client (Facilitator 5) and when importance of Personal Barriers decreased from 12% to 4% , overall rank of the final outcome is preserved.

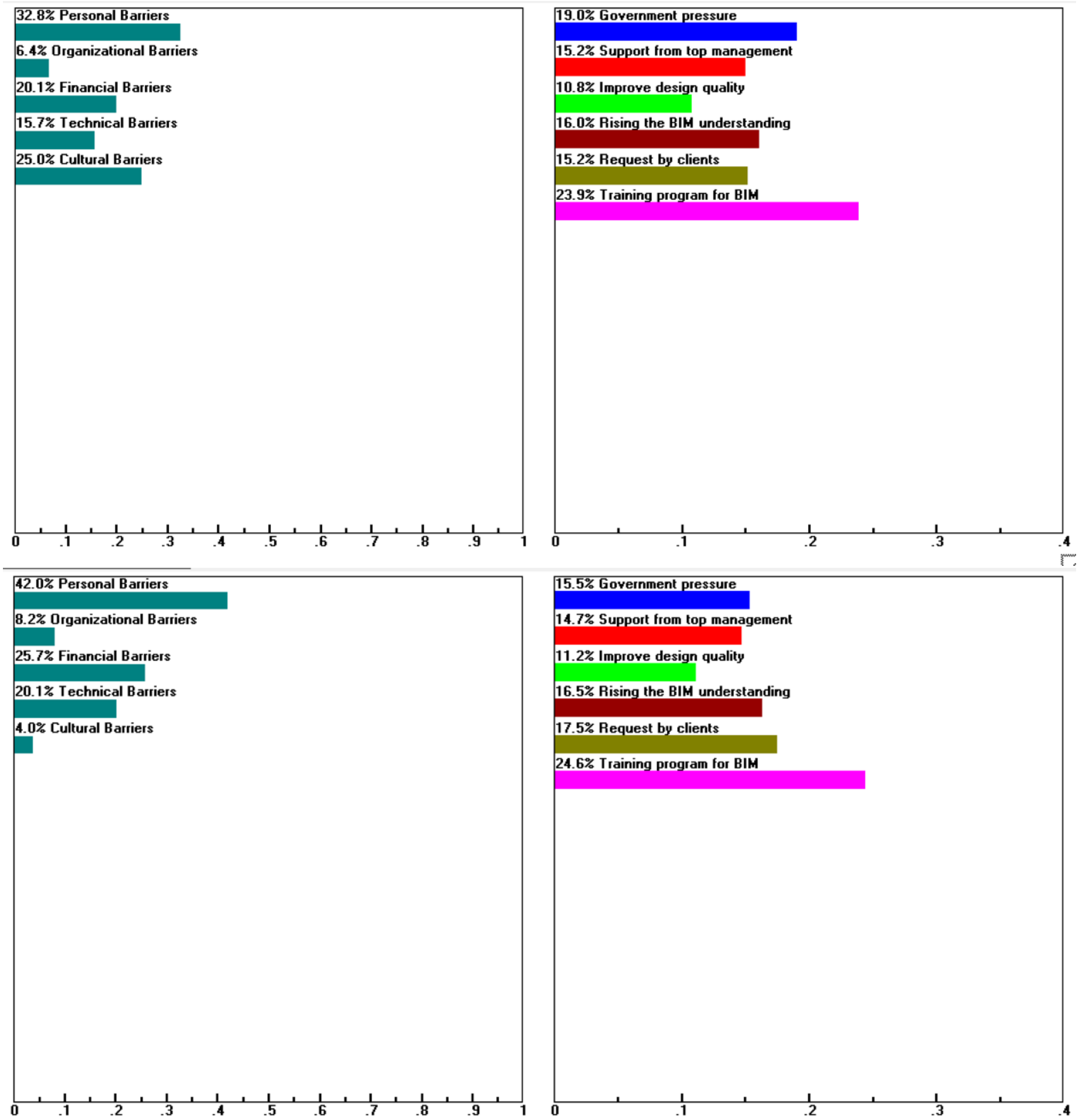

Figure 4.19 : Change in alternatives' priorities due to change in Cultural barriers

Performance sensitivity analysis may help decision makers to see what may happen if the weight of the factors changes (Figure 4.20). To see the impact of the changes, e.g., when the importance of Financial Barriers is increased to 0.5, Request by client (Facilitator 5) has become the best alternative (Figure 4.21).

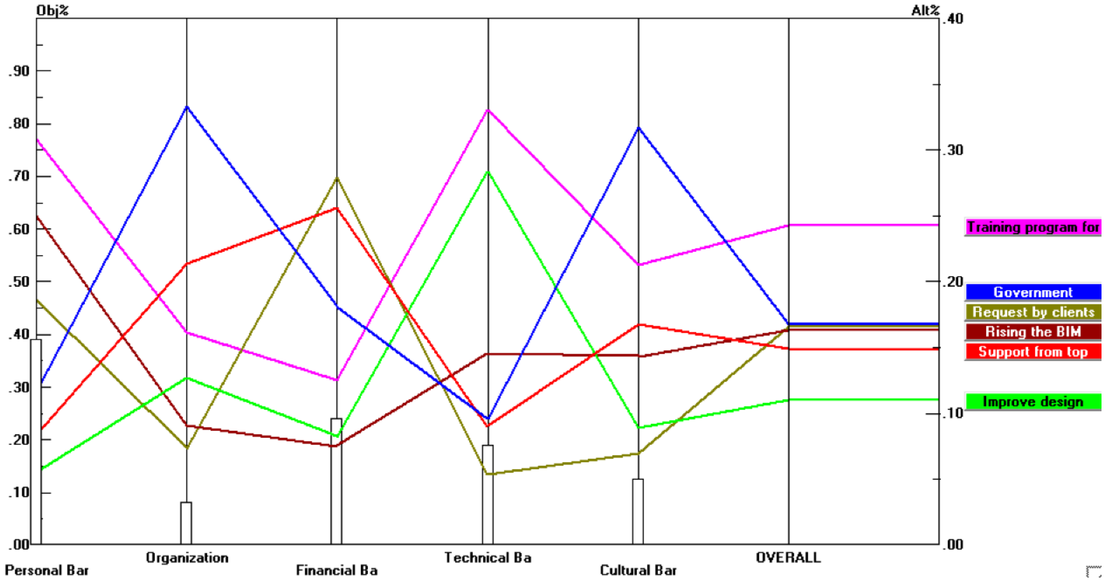

Figure 4.20: Performance sensitivity analysis for the main criteria

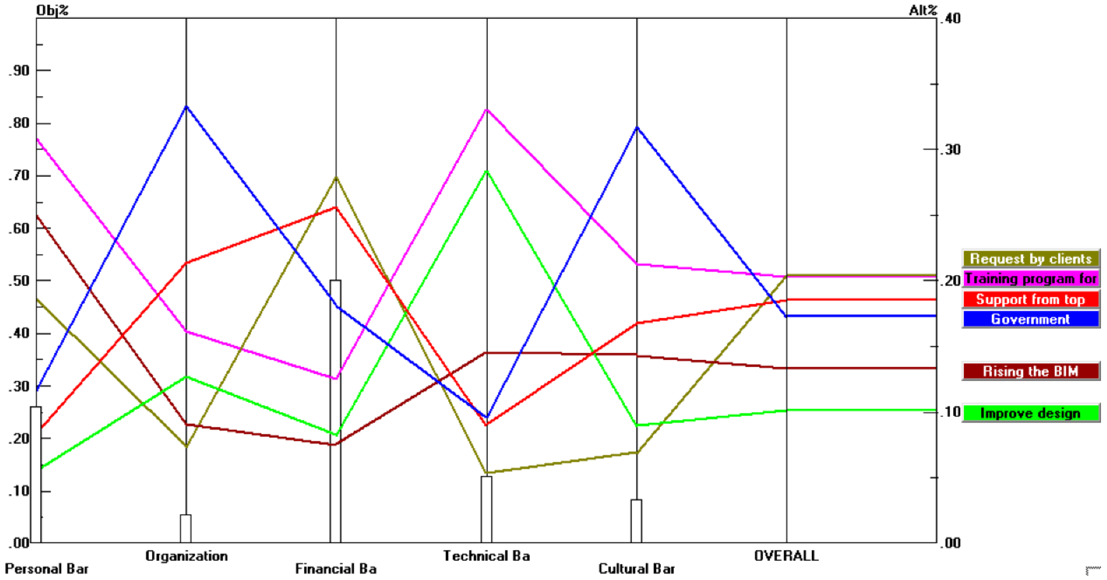

Figure 4.21: Performance sensitivity analysis for change in Financial barriers

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

The final section summarizes and concludes all the chapters of the past, and all the researcher's efforts are summarized in its conclusions and suggestions. An AHP model was proposed to ranked barriers to BIM implementation and facilitator to overcome those barriers. AHP was se1ected as a methodological basis for this study. This research proposes an AHP model for finding barriers and their facilitator in Iran. The major advantage of this research is that it can be used for both qualitative and quantitative criteria. Pair-wise comparison used in this work reduces the dependency of the model on human judgment. The results show that the model has the capability to be flexible and apply in ranking barriers and facilitators to BIM implementation. The final priority weight of each alternative at the last level of the hierarchy will lead to a recommended best option. It can be concluded that the model could facilitate decision making. The existence of easy-to-usee commercial software (Expert Choice) helps in developing the model and synthesizing the results.

5.2 Major Finding

As a result of the data analysis about the barriers of BIM implementation in the Iranian construction industry were analyzed. This research revealed that there is a large set of selection criteria. These criteria are developed and ranked by barriers of BIM implementation in order to understand their view with the help of a questionnaire survey.

Personal Barriers, as the main criterion, is ranked first. This is due to the fact that participants consider this category is the most effective category of barriers to BIM implementation. The Financial Barriers, as the main criterion, is ranked the second.

The main barriers to BIM of the Iranian construction industry in term of categories criterion (Main Criteria) were identified and ranked as follow:

1. Personal Barriers.
2. Financial Barriers.
3. Technical Barriers.
4. Cultural Barriers.
5. Organizational Barriers.

The most important barriers to BIM implementation in Iran are Lack of awareness about BIM, Refuse to learn BIM, Lack of technological skills, Lack of client demand, and Lack of cooperation among project members. In terms of sub-criteria Top five barriers to BIM implementation in the Iranian construction industry is identified and ranked as follow:

1. Lack of awareness about BIM.
2. Refuse to learn BIM.
3. Lack of technological skills.
4. Lack of client demand.
5. Lack of cooperation among stakeholders.

The most important facilitators to overcome with BIM barriers in Iran are Provide training programs for BIM, Government pressure, Request by the client, Raising the BIM understanding, Support from tom management. In terms of sub-criteria Top five facilitators to BIM implementation in the Iranian construction industry is identified and ranked as follow:

1. Provide a training program for BIM
2. Government pressure
3. Request by client
4. Rising the BIM understanding
5. Support from tom management

5.3 Overall Conclusion

Most construction industry activists, such as employers, contractors, and consultants, are insufficiently familiar with the benefits of construction building information modeling and are reluctant to change practices and learn new concepts and technologies.

These people do their projects traditionally and refuse to do their projects using this technology and believe that BIM is an evolving technology with limited capabilities.

They also feel that the use of BIM is very complex and it is better to use non-BIM tools to make their projects easier while the BIM technology revolution includes everything in the construction industry with unlimited capabilities that only a few of companies know about BIM building information modeling and use this technology and the benefits for their projects.

The main objective of the research is to identify the major barriers to BIM implementation in the Iranian construction industry. The model was implemented for ranking important barriers and solving them with facilitators, in a practical way by comparing prospective facilitators in terms of selection criteria. The model concept is concerned with selecting a capable and competent facilitator based on several criteria to facilitate the BIM barriers within a training program for BIM, Government pressure, Request by the client, Rising the BIM understanding, Support from tom management. The implementation proved that the model is consistent, practical, and effective.

5.4 Recommendations

Based on the results obtained in this study and in line with ongoing research, the following suggestions are offered:

- The Iranian government must collaborate with pioneer countries in BIM technology to get progress in this content. They can invite BIM experts to develop education and training for this technology, also develop guidelines and standards for BIM use in Iran.
- Iranian Universities and Institutes should collaborate together to introduce the basics of BIM to staff and students, and they should add BIM courses in all academic programs. Also, they should add this course in vocational training organizations with government subside.
- Professionals in Iran should change their traditional way and adapt to the new process. They should be updated as an expert to be adopted with technology.
- The government must force companies to do their project with BIM. Also, the construction companies should create BIM departments in their firms that deal with everything regarding BIM and give them the authority to manage projects.

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APPENDIX

Sample of Questionnaire Survey

<u>Section A: Respondent's profile</u>

1. Job position ?

a) Engineers ☐ b) Architects ☐ c) Academics ☐

2.Gender ?

a) Male ☐ b) Female ☐

3.Education level ?

a) BSc ☐ b) MSc ☐ c) PhD ☐

4.Work experience?

a) - 3 Years ☐ b) 3-5 years ☐ c) 5-10 years ☐ d) +10 years ☐

5.Location ?

a) Tehran ☐ b) Other cities ☐

6. work sector?

a) Building project ☐ b) Infrastructure Project ☐ c) Building and Infrastructure together ☐

<u>Section B : Current Practices and Knowledge of Modeling Building Information</u>

1 . Which software does your firm ? (Select one or more)

a) AUTODESKAUTOCAD ☐

b) 3D MAX ☐

c) SKETCH UP ☐

d) REVIT ARCHITECTURE ☐

e) REVIT STRUCTURAL ☐

f) MS PROJECT ☐

g) ARCHICAD ☐

h) PRIMAVERA ☐

i) Other (specify please) ☐

2. Have you ever heard about Building Information Modeling (BIM) and the promise of applications and solutions?

Yes ☐ No ☐

3. Does BIM use in one of your organization's projects?

Yes ☐ No ☐

4.How would you describe the current level of knowledge of BIM in the Architecture, Engineering (AEC) and construction in Iran?

Very few ☐ A few ☐ Medium ☐ High ☐ Very high ☐

Section C : Barriers to BIM implementation

Instructions for completing the questionnaire:

Please answer the questions of this questionnaire according to the following range and description.

Preference Weights/ Level of Importance	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective
3	Moderately	Experience and judgment slightly favor one activity over another
5	Strongly	Experience and judgment strongly or essentially favor one activity over another
7	Very strongly	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extremely	The evidence favoring one activity over another is of the highest degree possible of affirmation
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above
	Reciprocals for inverse comparison	

a) Comparison of the main criteria

In your opinion, which of the main influencing criteria in prioritizing effective factors, Are the more privileged than each other? How much?

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Personal Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Organizational Barriers
2	Personal Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Financial Barriers
3	Personal Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technical Barriers
4	Personal Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cultural Barriers
5	Organizational Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Financial Barriers
6	Organizational Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technical Barriers
7	Organizational Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cultural Barriers
8	Financial Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technical Barriers
9	Financial Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cultural Barriers
10	Technical Barriers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cultural Barriers

b) Comparison of options level (Sub-criteria) with criteria : Personal Barriers

In your opinion, which of the main influencing criteria in personal barriers criterion, Are the more privileged than each other? How much?

Compare the relative importance with respect to: Personal Barriers

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Refuse to learn BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of awareness about BIM
2	Refuse to learn BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BIM Training and education issues
3	Refuse to learn BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of information sharing in BIM
4	Lack of awareness about BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BIM Training and education issues
5	Lack of awareness about BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of information sharing in BIM
6	BIM Training and education issues	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of information sharing in BIM

c) Comparison of options level (Sub-criteria) with criteria : Organizational Barriers

In your opinion, which of the main influencing criteria in organizational criterion, Are the more privileged than each other? How much?

Compare the relative importance with respect to: Organizational Barriers

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Lack of opportunity for BIM implementation	9	8	7	6	5	4	3	2	$\boxed{1}$	2	3	4	5	6	7	8	9	Lack of government support
2	Lack of opportunity for BIM implementation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of senior support
3	Lack of opportunity for BIM implementation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Process problems
4	Lack of government support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of senior support
5	Lack of government support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Process problems
6	Lack of senior support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Process problems

d) Comparison of options level (Sub-criteria) with criteria : Financial Barriers

In your opinion, which of the main influencing criteria in financial criterion, Are the more privileged than each other? How much?

Compare the relative importance with respect to: Financial Barriers

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Less benefit from BIM for small projects	9	8	7	6	5	4	3	2	$\boxed{1}$	2	3	4	5	6	7	8	9	Lack of investment in BIM
2	Less benefit from BIM for small projects	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of client demand
3	Less benefit from BIM for small projects	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of training
4	Less benefit from BIM for small projects	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of Implementation
5	Less benefit from BIM for small projects	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expensive software
6	Lack of investment in BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of client demand
7	Lack of investment in BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of training
8	Lack of investment in BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of Implementation
9	Lack of investment in BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expensive software
10	Lack of client demand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of training
11	Lack of client demand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of Implementation
12	Lack of client demand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expensive software
13	The high cost of training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The high cost of Implementation
14	The high cost of training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expensive software
15	The high cost of Implementation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expensive software

e) Comparison of options level (Sub-criteria) with criteria : Technical Barriers

In your opinion, which of the main influencing criteria in technical criterion, Are the more privileged than each other? How much?

Compare the relative importance with respect to: Technical Barriers

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Slow adoption of new technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Current technology is not sufficient
2	Slow adoption of new technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technological skills
3	Slow adoption of new technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of national standard & guidelines
4	Slow adoption of new technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technical experts
5	Current technology is not sufficient	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technological skills
6	Current technology is not sufficient	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of national standard & guidelines
7	Current technology is not sufficient	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technical experts
8	Lack of technological skills	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of national standard & guidelines
9	Lack of technological skills	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technical experts
10	Lack of national standard & guidelines	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of technical experts

f) Comparison of options level (Sub-criteria) with criteria : Cultural Barriers

In your opinion, which of the main influencing criteria in financial criterion, Are the more privileged than each other? How much?

Compare the relative importance with respect to: Cultural Barriers

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Absence of real implemented model	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Traditional methods of contracting
2	Absence of real implemented model	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Resistance to change
3	Absence of real implemented model	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of cooperation among project member
4	Traditional methods of contracting	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Resistance to change
5	Traditional methods of contracting	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of cooperation among project member
6	Resistance to change	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of cooperation among project member

Section D : Facilitators for BIM adoption

a) Comparison of the facilitators for BIM adoption with main barriers : Personal barriers.

In your opinion, according to personal barriers (Lack of information sharing in BIM , Lack of awareness about BIM , BIM Training and education issues , Refuse to learn BIM) criteria , which facilitators Are the more privileged than each other? How much?

Circle one number per row below using the scale:
1 = Equal   3 = Moderate   5 = Strong   7 = Very strong   9 = Extreme

1	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Support from top management
2	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
3	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
4	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
5	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
6	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
7	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
8	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
9	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
10	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
11	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
12	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
13	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
14	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
15	Request by clients	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM

b) Comparison of the facilitators for BIM adoption with main barriers : Organizational barriers

In your opinion, according to Organizational barriers (Process problems , Lack of senior support , Lack of government support , Lack of opportunity for BIM implementation) criteria , which facilitators Are the more privileged than each other? How much?

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Support from top management
2	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
3	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
4	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
5	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
6	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
7	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
8	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
9	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
10	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
11	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
12	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
13	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
14	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
15	Request by clients	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM

c) Comparison of the facilitators for BIM adoption with main barriers : Financial barriers.

In your opinion, according to Financial barriers (Expensive software , The high cost of Implementation , The high cost of training , Lack of investment in BIM , Less benefit from BIM for small projects , Lack of client demand) criteria , which facilitators Are the more privileged than each other? How much ?

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Support from top management
2	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
3	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
4	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
5	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
6	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
7	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
8	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
9	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
10	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
11	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
12	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
13	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
14	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
15	Request by clients	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM

d) Comparison of the facilitators for BIM adoption with main barriers : technical barriers.

In your opinion, according to Technical barriers (Lack of technical experts , Slow adoption of new technology , Lack of national standard & guidelines , Lack of technological skills , Current technology is not sufficient) criteria , which facilitators Are the more privileged than each other? How much ?

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Support from top management
2	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
3	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
4	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
5	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
6	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
7	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
8	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
9	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
10	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
11	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
12	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
13	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
14	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
15	Request by clients	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM

e) Comparison of the facilitators for BIM adoption with main barriers : Cultural barriers.

In your opinion, according to Cultural barriers (Lack of cooperation among project member , Social and habitual Resistance to Change , Absence of real implemented model , Traditional methods of contracting) criteria , which facilitators Are the more privileged than each other? How much ?

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Support from top management
2	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
3	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
4	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
5	Government pressure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
6	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improve design quality
7	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
8	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
9	Support from top management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
10	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rising the BIM understanding
11	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
12	Improve design quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
13	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Request by clients
14	Rising the BIM understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM
15	Request by clients	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Training program for BIM

بخش اول: مشخصات پاسخ دهنده

۱. موقعیت شغلی؟

الف) مهندسین ☐ ب) معماران ☐ ج) دانشگاهیان ☐

۲. جنسیت؟

الف) مرد ☐ ب) زن ☐

۳. مقطع تحصیلات؟

الف) لیسانس ☐ ب) کارشناسی ارشد ☐ ج) دکتری ☐

۴. سابقه کار؟

الف) -کمتر از ۳ سال ☐ ب) ۳-۵ سال ☐ ج) ۵-۱۰ سال ☐ د) +۱۰ سال ☐

۵. محل اقامت؟

الف) تهران ☐ ب) سایر شهرها ☐

۶. حوزه ی فعالیت؟

الف) پروژه ساختمانی ☐ ب) پروژه زیرساختی ☐ ج) هردو ☐

بخش دوم: شیوه های فعلی و علم مدل سازی اطلاعات ساختمان

۱.شرکت شما کدام نرم افزارها را استفاده میکند؟ (میتوانید بالای یک انتخاب داشته باشید).

- ☐ ث) REVIT STRUCTURAL
- ☐ الف) AUTODESKAUTOCAD
- ☐ ج) MS PROJECT
- ☐ ب) 3D MAX
- ☐ چ) ARCHICAD
- ☐ پ) SKETCH UP
- ☐ ح) PRIMAVERA
- ☐ ت) REVIT ARCHITECTURE
- ☐ ج) دیگر

۲. آیا تاکنون چیزی در مورد مدل سازی اطلاعات ساختمان (BIM) و اجرای برنامه و راه حل ها شنیده اید؟

۱. بله ☐ ۲.خیر ☐

۲. آیا BIM در یکی از پروژه های سازمان شما کاربرد داشته است؟

۱. بله ☐ ۲.خیر ☐

۳. چگونه سطح فعلی دانش BIMدر معماری، مهندسی (AEC) و ساخت و ساز در ایران شرح می دهید؟

۱. بسیار کم ☐ ۲.کم ☐ ۳.متوسط ☐ =۴.بالا ☐ ۵.بسیار بالا ☐

بخش سوم: موانع اجرای BIM

الف) مقایسه معیارهای اصلی

به نظر شما کدام یک از معیارهای اصلی تأثیرگذار در اولویت بندی عوامل مؤثر، ممتاز تر از یکدیگر هستند؟

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱ = مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

موانع شخصی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع سازمانی
موانع شخصی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع مالی
موانع شخصی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فنی
موانع شخصی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فرهنگی
موانع سازمانی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع مالی
موانع سازمانی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانی فنی
موانع سازمانی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فرهنگی
موانع مالی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فنی
موانع مالی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فرهنگی
موانع فنی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	موانع فرهنگی

ب) مقایسه سطح گزینه ها (زیر معیارها) با معیارها: موانع شخصی

به نظر شما ، کدام یک از معیارهای موثر در معیار موانع شخصی، ممتاز تر از یکدیگر هستند؟

اهمیت نسبی را با توجه به موانع شخصی مقایسه کنید.

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱ = مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

امتناع از یادگیری BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم آگاهی در مورد BIM
امتناع از یادگیری BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	مسایل مربوط به آموزش و پرورش BIM
امتناع از یادگیری BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم اشتراک اطلاعات در BIM
عدم آگاهی در مورد BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	مسایل مربوط به آموزش و پرورش BIM
عدم آگاهی در مورد BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم اشتراک اطلاعات در BIM
مسایل مربوط به آموزش و پرورش BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم اشتراک اطلاعات در BIM

ج) مقایسه سطح گزینه ها (زیر معیارها) با معیارها: موانع سازمانی

به نظر شما کدام یک از معیارهای اصلی تأثیرگذار در معیارهای سازمانی ، ممتازتر از یکدیگر هستند؟

اهمیت نسبی را با توجه به موانع سازمانی مقایسه کنید.

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط۵ = قوی ۷ = بسیار قوی ۹ = شدید

عدم پشتیبانی دولت	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم فرصت برای اجرای BIM
عدم پشتیبانی مقام ارشد	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم فرصت برای اجرای BIM
مشکلات مراحل فرآیند	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم فرصت برای اجرای BIM
عدم پشتیبانی مقام ارشد	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم پشتیبانی دولت
مشکلات مراحل فرآیند	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم پشتیبانی دولت
مشکلات مراحل فرآیند	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم پشتیبانی مقام ارشد

د) مقایسه سطح گزینه ها (زیر معیارها) با معیارها: موانع مالی

به نظر شما کدام یک از معیارهای تأثیرگذار اصلی در معیار مالی ، ممتازتر از بقیه میباشد؟چقدر؟

اهمیت نسبی را با توجه به موانع مالی مقایسه کنید.

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

عدم سرمایه گذاری در BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	سود کم BIM برای پروژه های کوچک
عدم تقاضای مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	سود کم BIM برای پروژه های کوچک
هزینه ی بالای آموزش	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	سود کم BIM برای پروژه های کوچک
هزینه ی بالای اجرا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	سود کم BIM برای پروژه های کوچک
هزینه ی بالای اجرا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	سود کم BIM برای پروژه های کوچک
عدم تقاضای مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم سرمایه گذاری در BIM
هزینه ی بالای آموزش	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم سرمایه گذاری در BIM
هزینه ی بالای اجرا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم سرمایه گذاری در BIM
نرم افزار گران قیمت	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم سرمایه گذاری در BIM
هزینه ی بالای آموزش	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم تقاضای مشتری
هزینه ی بالای اجرا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم تقاضای مشتری
نرم افزار گران قیمت	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم تقاضای مشتری
هزینه ی بالای اجرا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	هزینه ی بالای آموزش
نرم افزار گران قیمت	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	هزینه ی بالای آموزش
نرم افزار گران قیمت	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	هزینه ی بالای اجرا

ه) مقایسه سطح گزینه ها (زیر معیارها) با معیارها: موانع فنی

به نظر شما ، کدام یک ازمعیارهای اصلی تأثیرگذار در معیارهای فنی ، ممتاز تر از بقیه میباشد؟

اهمیت نسبی را با توجه به موانع فنی مقایسه کنید.

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

عدم وفق پذیری با فناوری جدید	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	فناوری جدید کافی نمی باشد
عدم وفق پذیری با فناوری جدید	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم مهارت های تکنولوژیکی
عدم وفق پذیری با فناوری جدید	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	فقدان دستور عمل ها و استاندارد های ملی
عدم وفق پذیری با فناوری جدید	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	کمبود کارشناسان ملی
فناوری جدید کافی نمی باشد	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم مهارت های تکنولوژیکی
فناوری جدید کافی نمی باشد	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	فقدان دستور عمل ها و استاندارد های ملی
فناوری جدید کافی نمی باشد	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	کمبود کارشناسان ملی
عدم مهارت های تکنولوژیکی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	فقدان دستور عمل ها و استاندارد های ملی
عدم مهارت های تکنولوژیکی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	کمبود کارشناسان ملی
فقدان دستور عمل ها و استاندارد های ملی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	کمبود کارشناسان ملی

و) مقایسه سطح گزینه ها (زیر معیارها) با معیارها: موانع فرهنگی

به نظر شما کدام یک از معیارهای تأثیرگذار اصلی در معیار مالی ، ممتازتر از بقیه میباشد؟ چقدر؟

اهمیت نسبی را با توجه به موانع فرهنگی مقایسه کنید.

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

1	عدم وجود مدل اجرایی واقعی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	روش های سنتی پیمانکاری
2	عدم وجود مدل اجرایی واقعی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	مقاومت در برابر تغییر
3	عدم وجود مدل اجرایی واقعی	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم همکاری بین اعضای پروژه
4	روش های سنتی پیمانکاری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	مقاومت در برابر تغییر
5	روش های سنتی پیمانکاری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم همکاری بین اعضای پروژه
6	مقاومت در برابر تغییر	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	عدم همکاری بین اعضای پروژه

بخش چهارم : رفع کننده مشکلات در اجرای BIM

الف) مقایسه تسهیل کننده ها دراجرای BIM با موانع اصلی: موانع شخصی.

به نظر شما طبق موانع شخصی (عدم اشتراک اطلاعات در BIM ، عدم آگاهی در موردBIM ، مسائل مربوط به آموزش و پرورش BMI ، امتناع از یادگیریBIM)، کدام تسهیل گرها از همه امتیاز بیشتری دارند؟

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	پشتیبانی از مدیریت بالا
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
درخواست مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM

ب) مقایسه تسهیل کننده ها دراجرای BIM با موانع اصلی: موانع سازمانی

به نظر شما ، طبق معیارها موانع سازمانی (مشکلات فرآیند ، عدم پشتیبانی ارشد ، عدم پشتیبانی دولت ، عدم امکان اجرای BIM) کدام تسهیل گرها از همه امتیاز بیشتری دارند؟ چقدر؟

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	پشتیبانی از مدیریت بالا
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
درخواست مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM

ج) مقایسه تسهیل کننده ها دراجرای BIM با موانع اصلی : موانع مالی .

به نظر شما ، طبق معیارهای موانع مالی (نرم افزارگران قیمت ، هزینه بالای اجراسازی ، هزینه بالای آموزش ، عدم سرمایه گذاری در BIM ، سود کمتر BMI در پروژه های کوچک، عدم تقاضای مشتری)، کدام یک از تسهیل کننده ها ممتازتر هستند؟ چقدر؟

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	پشتیبانی از مدیریت بالا
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
درخواست مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM

د) مقایسه تسهیل کننده ها دراجرای BIM با موانع اصلی : موانع فنی

به نظر شما ، طبق موانع فنی (عدم وجود کارشناسان فنی ، پذیرش آهسته فناوری جدید ، فقدان استاندارد ملی و دستورالعمل ها ، عدم مهارت های فن آوری ، فناوری فعلی کافی نمیباشد)، کدام یک از تسهیلگران امتیاز بیشتری نسبت به یکدیگر دارند؟ چقدر ؟

با استفاده از مقیاس پایین دور یک عدد در هر سطر خط بکشید:

۱ = مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	پشتیبانی از مدیریت بالا
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
درخواست مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM

ه) مقایسه تسهیل کننده ها دراجرای BIM با موانع اصلی : موانع فرهنگی

به نظر شما مطابق موانع فرهنگی (عدم همکاری بین عضو پروژه و مقاومت اجتماعی و طبق عادت به تغییر ، عدم وجود مدل واقعی اجرا شده ، روشهای سنتی پیمانکاری)، کدام تسهیلگرها از همه امتیاز بیشتری دارند؟ چقدر ؟

با استفاده از مقیاس پایین دوریک عدد در هر سطر خط بکشید:

۱= مساوی ۳ = متوسط ۵ = قوی ۷ = بسیار قوی ۹ = شدید

فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	پشتیبانی از مدیریت بالا
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
فشار دولت با ایجاد قوانین	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	بهبود کیفیت طرح
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
پشتیبانی از مدیریت بالا	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	افزایش درک BIM
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
بهبود کیفیت طرح	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	درخواست مشتری
افزایش درک BIM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM
درخواست مشتری	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	برنامه ی آموزشی برای BIM