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Identifying and Ranking the Barriers to Buildings Designed with BIM from the point of view of the Construction Industry Experts Using Fuzzy Delphi Technique

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Research Article

Abstract

Construction industry is one of the wide, decentralized and highly aboriginal industries in any country, therefore this industry considered as an indicator for growth and development or economic recession in many countries. This industry is currently suffering from many inefficiencies. One of the main reasons for this problem is the lack of growth in the technical field. The use of traditional methods is known as one of the main factors inhibiting productivity in the construction industry in Iran, because most of the traditional methods and their nature led to time delay and waste of resources. In addition, on account of increasing complexity of projects, there is a fundamental need to use more integrated, compatible and cost-effective approaches and technologies for the entire project life cycle. Today, one of the most thriving and flourishing technologies in AEC industry is Building Information Modeling (BIM). Despite the many advantages mentioned about the new BIM system, there are also some challenges and problems associated with it, which in some cases they can be very serious and bring great risks. In this research, with the intension of emphasizing and recognizing the barriers to BIM implementation, some challenges and obstacles of using this technique have been investigated. In order to identifying the barriers, questionnaires and interviews were used, and then the barriers were identified and ranked using the fuzzy Delphi technique. Among the sub-criteria, the lack of instructions for the use of BIM in related organizations, which is a sub-criterion of managerial and procedural barriers, ranked first.

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Keywords: Building Information Modeling (BIM); Barriers of BIM; Fuzzy Delphi Technique

1. Introduction

Due to the strategic and infrastructural importance of the construction industry in the economy of a country and the significant increase in construction in this era, the use of traditional and non-scientific methods can no longer handle the existing problems; therefore, the use of new technologies in construction, implementation of scientific models, improvement and reduction of construction costs, … have been important goals of most building constructors. Among the problems of modern constructions, the lack of coordination of plans, mistakes and duplication of efforts, employer request changes during implementation, etc. will not only increase the cost of construction, but also lead to a decrease in the quality of the work.

Another problem is the numerous changes for various reasons at each stage of the project, which may have significant negative impacts on some cases like costs and schedule delays; and in the same way, the interference that may happen between the architecture of the structure and the facilities during the implementation, wastes time and money; and if the collision or interference is critical, it will lead to duplication in efforts and critical changes. Critical changes result in successive delays in the project schedule, re-estimation of the statement of work and additional demands for equipment, materials, manpower and overtime (Reinertsen, 1997). The issue of duplicate efforts also has negative effects on the functional aspects of the project such as time, cost and satisfaction of stakeholders. Direct impacts duplicate efforts on project management includes: a: additional time to redo the work, b: additional cost to cover events of rework, c: Additional materials for rework and carrying contraction waste, c: additional labor force for rework and additions related to monitoring force. Three elements related to duplicate effort including loss of capital, time and demoralization of employees have significant detrimental effects on project coordination and productivity. Therefore, as projects become progressively complex and owners demand faster delivery and greater productivity, contractors have to adopt new methods of project management.

In Iran, the low productivity of the construction industry and the huge volume of unfinished and failed construction projects have caused many problems over the years. Among the important reasons for the low productivity of the construction industry, traditional methods, poor communication and incomplete cooperation between executive agents in information exchange can be mentioned. Considering the multidisciplinary approach of construction projects, clear communication and effective cooperation between project team members is essential. Therefore, information technology performs an important role in facilitating this. All over the world, researchers have thought about fundamental changes in existing traditional processes and expanding the use of information technology in this industry (Chuck Eastman et al., 2011).

Given to the numerous issues in the construction industry, it is crucial to use scientific and modern construction methods and utilize new technologies. One of these technologies is the building information modeling, which is called multidimensional modeling or virtual simulation technology too. It is a revolutionary development that has accelerated the changes.

In fact, BIM is a combination of technology and process which allows practitioners to simulate and examine all required parameters in design, construction, implementation and operation in the 3D environment. This superiority, that is, the ability to control components and simulate them before the start of the project, which is available to experts, practitioners and employers, makes it possible to improve the quality of work, ensure the performance of the components, shorten the duration of design, control and updating the projects, and consequently reduce costs at each stage of work (Zou, Kiviniemi, and Jones, 2016; Salazar and Almedia, 2004).

BIM presents a way to overcome low productivity in construction and other barriers to innovation in the industry. This technology provides a wide range of direct and indirect benefits and has made the design and manufacturing processes simpler and more clarity in various aspects (Lee, Bae, & Cho, 2012).

But despite having many advantages, this technique faces a series of challenges and obstacles. According to how BIM is implemented and barriers to it, many articles and books have been written in industrialized countries such as North America, Southeast Asian countries, Europe and Australia. But it should be remembered that the construction industry is an indigenous industry due to the impossibility of exporting or importing the final product from one country to another; therefore, each region and country has its own characteristics, methods and tools based on various conditions such as climate, economy and culture. etc. As a consequence, building information modeling process, implementation, utilization and obstacles are different depending on the substrate in each region.

Due to the necessity of integrated information management in the design of buildings and the increasing need to use of BIM, in this investigation, that is applied research, it is try to follow the barriers to implementation of this technique in a targeted and comprehensive way to improve the removal these barriers. For identifying the obstacles, in addition to library studies and reading related articles, interviews were conducted with experts and BIM specialists. Finally, by setting up a questionnaire about implementation of the Delphi Fuzzy technique, the obstacles were determined and ranked. Among the identified sub-criteria, the lack of attention of related organizations to the use of this technology was prioritized.

2. Literature Review

Due to the political, economic, technological and social challenges in the construction industry, it is essential to develop BIM technologies. BIM is useful in all stages and processes of projects, from the design phase to implementation, and is of special importance (Fig 1).

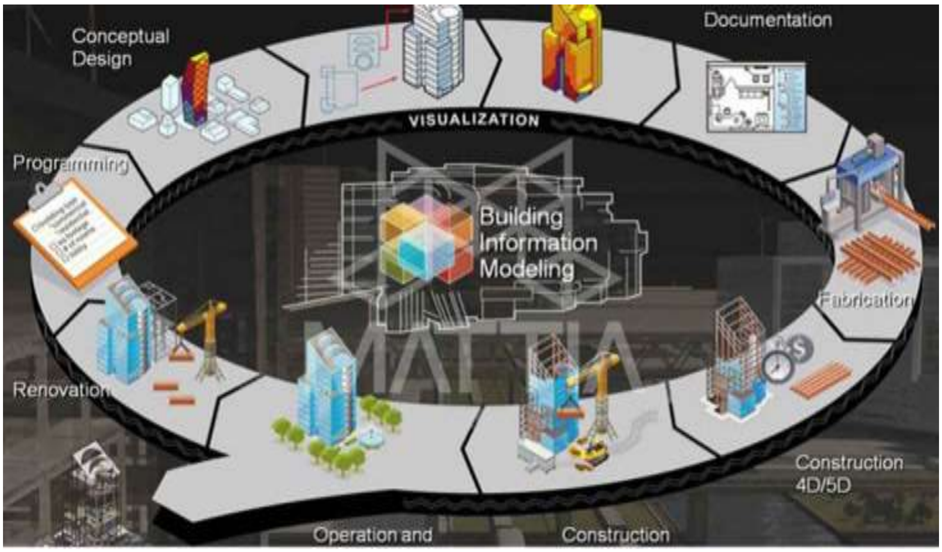

Fig 1 BIM technology applications in the building life cycle

The implementation of the execution plan in line with the BIM national development document of the country in the perspective of 2025 requires the participation of all relevant and interested groups in the country's construction industry. Therefore, considering prevalence of building information modeling in different countries, studies have been conducted on the benefits and obstacles of BIM implementation, which are as follows:

In 2010, Bureuakinci and Fernand carried out a study on a large installation project with an area of 210000 square meters, during which there were many mechanical and electrical installations. They identified a variety of interferences in two parts. The first part was detected using overlaying 2D maps on the light table, and the second part was recognized using BIM in Navis works. Many interferences and conflicts which were unrecognizable in the first part, such as clash between cable tray and mechanical equipment structures, could be fully visible and automatically detected in the 3D models in BIM related software, especially in Navis works. Therefore, manual detection errors were significantly reduced and it caused all interferences and conflicts to be identified in the design phase before implementation, and saved at least 25% of the time and money on such a project. Here, the importance of using BIM could be recognized more than ever and provided a valid reason for employers to use the system.

Knight, Roth, and Rosen (2010) believe that the detection of conflicts in the construction industry is to check possible conflicts which are due to poor design in the design phase, and mainly these conflicts are between mechanical, electrical equipment and building elements. According to the investigations, the cost of interference sometimes reaches 25% of the contract amount, which is remarkable in large projects. Both the contractor and the employer will lose because of this cost increase (Knight, Roth, and Rosen, 2010).

Reinertsen states that mistakes and interferences occur in the implementation phase following the design phase because if an integrated system is not used in the design phase, it will cause interference, duplicate effort and waste of time and money. As a result, time, money and capital will be lost and the investment income will be reduced (Reinertsen,1997).

Paravan, (2012) examined 30 construction project, some of which used BIM and some of which did not. They found that those projects which used BIM had a 30% reduction in time in the design process, a 10% reduction in time in the construction process, and a 16% reduction in interferences and duplication of efforts throughout the project. While the projects that did not use BIM had the most interference, duplication of efforts and changes, which automatically increase cost and time.

In a research, Chelson (2010) concluded that using BIM and creating stronger synergy between project team members will significantly reduce interferences, duplication of efforts and delays in the construction process in civil projects. Additionally, the use of BIM can play an important role in planning and improving the control system. They came to the important conclusion that projects which used BIM in design process had a 90% reduction in interference, as well as 35% time and 20% cost savings.

Kymmel (2008) realized that detection of interferences is an integral and vital part of the process of developing a 3D BIM model. BIM makes it possible to find overlaps and interferences before the implementation phase by forming a complete model of the project. According to Kymmel's research, the most interferences occur between structures and mechanical, electrical equipment, which can be reduced by using BIM, since this technology is able to identify interferences before the implementation phase in the design process.

In a study, Eadie et al. (2014) investigated barriers to BIM implementation in Kingdom state. These barriers included: the cost of purchasing software and hardware, failure to adopt BIM by the senior project manager, the cost of staff training, failure to adopt BIM by employees, lack of technical expertise, legal problems, lack of perspective, lack of culture of flexibility and change in methods, etc.

Kekana, Aigbavboa, and Thwala (2014) identified barriers to BIM by reviewing existing projects which used BIM, as well as articles and research conducted in South Africa. The main obstacles were the lack of a standard for the use of BIM, the lack of a design team familiar with this technology, and issues related to the intellectual property of data entry.

In research on the Malaysian construction industry, Zakari et al. (2014) determined the barriers to BIM implementation by distributing questionnaires and asking for experts' views. These questionnaires consisted of three parts. The first part was about respondents' personal information, the second part included the identification of barriers to BIM implementation and the last part was related to the prioritization of the barriers. The identified barriers in order of importance were: lack of knowledge about BIM, expensiveness of BIM, increased planning time, reluctance of employers, clients and contractors to use BIM, etc. Eventually, they stated that for the success of the BIM development plan in Malaysia, government's pressure alone is not enough and believed that all the teams involved in the construction industry are responsible for promoting this method.

Santos, Costa, and Grilo (2017) reviewed the research conducted on BIM during the years 2005 to 2015 and divided them into 9 general categories, which were as follows in the order of frequency of articles: 1) collaborative and interoperability environments 2) sustainable construction 3) adoption and standardization of BIM 4) BIM programming 5) image processing, laser scanning 6) facility management and safety analysis 7) construction management 8) review articles 9) BIM and spatial information.

Additionally, Jin, Tang, and Fang used BIM for building information modeling. BIM technology has been supported in many countries including China. For example, in China in 2016, it was approved that all construction projects with an area of more than 20000 square meters and green buildings must use BIM technology in the design and construction phases. Furthermore, in China, construction projects are required to use BIM technology from the end of 2016.

Cao et al. (2017) conducted a study on the impact of requirements of government and related agencies on the use of BIM technology. In this research, in order to experimentally test the theoretical model and research hypotheses, they used the survey research to collect data from organizations participating in BIM-based construction projects. Therefore, questionnaires were prepared and the target community including construction industry activists in China answered them. Before this survey, the validity of the answer letters was checked by selecting 21 contractors. Revised questionnaire had two parts. The first part composed of project information, including project size, project type, type of ownership of the organization participating in the project; and the second part covered motives for construction companies to use BIM technology which were determined by studying past articles and surveying experts as follows: apparent motives, reactive motives, economic motives. In the next step, criteria were prioritized by using analytic hierarchy and pairwise comparisons.

In a study conducted in the form of an experts' survey and a review of performed activities, Hanna, Yeutter, and Aoun (2014) pointed out the benefits of using BIM, especially in electrical equipment.

Research entitled BIM applications and global strategies, Smith (2014) by reviewing published paper, discussed the innovations and access that countries achieved in this field. This researcher investigated the implementation strategy of this technology in countries such as North America, Scandinavia, England, Singapore, China, Hong Kong, Australia, Brazil and South Korea, and stated that the use of BIM technology is rapidly expanding all over the world thanks to the support of governments; and clients and contractors have realized the advantages of using BIM in the long and short term.

McGraw Hill (2014) carried out a study on the world's ten largest markets, including China and India. The research results showed that the use of BIM is increasing rapidly. Based on BIM's capabilities, this technology reduces 56% of variations during the construction phase and 59% of variations during the implementation phase (29).

Giel and Issa (2013) investigated and calculated payback period in the use of BIM. Studies showed that many companies do not tend to use BIM, due to the high initial cost of using this technology. Therefore, three construction projects, some of which used BIM and some of which did not used this technology, were selected and analyzed. The amount of potential savings of an owner in using BIM was estimated by calculating the profit and costs of using this technique. They evaluated the amount of potential savings of an owner in using BIM by calculating the profit and cost of using this technique. The use of BIM reduced deviations from plans, changes in plans and requests for information (RFI). ROI (return on investment) was estimated from 16 to 1.654% according to the size of the project.

Arzaghi and Sadat Far (2013) studied the functions of BIM technology, the prospects of this technology and the benefits of BIM in Iran and some domestic projects. BIM technology is a technique with parametric modeling that when one component of the model is changed, other components of the model are changed too for maintaining previous relationships and compatibility with other components. In the continuation of the research, they compared BIM technology with traditional 3D CAD technology and pointed out the superiority of BIM technology. In addition, they mentioned the software used in this technology. One of them is Revit software, which is used in the field of architecture, structure and facilities. They determined the applications of this technology in the building life cycle. Among the applications of BIM were the use of this technology in the planning and design phase of the project, the pre- construction, construction and post- construction stages. Finally, they mentioned the benefits of BIM.

Khosrowshahi and Araiisi (2012) investigated the challenges and benefits of using building modeling information system. They examined the BIM technique by preparing a questionnaire, surveying contractors in Finland, reviewing published paper and conducting qualitative and quantitative studies. The results were presented in forms as a guide for the correct use of BIM at operational levels. These findings offered three structural models for systematically dealing with issues related to technology, process and people in BIM implementation. The structural models included organizational culture, training and information management. Eventually, the results were presented as a roadmap for better use of this technology in England. The result of the research was the more extensive use of BIM in the UK and the creation of a sound strategy for the use of BIM.

Morlhon, Pellerin, and Bourgault (2014) studied the benefits of using BIM by reviewing the literature in several stages. At first, in order to examine the subject in general, the research was focused on projects related to BIM implementation. With the case study, critical success factors (CFS) for the use of BIM technique and BIM capability maturity model (CMM) were prepared and presented in tabular form. Therefore, for the optimal implementation of such a system, different levels of maturity should be considered to be able to provide key performance indicators.

3. Methodology

To determine the obstacles, not only library studies and reading related articles, but also conducting in-depth interviews and expressing the results are necessary. Therefore, interviews were conducted with experts and activists in the field of construction who were familiar with BIM technology and had implemented projects in a practical way. After the initial interviews with the mentioned people, the criteria were identified. Then the analysis performed on the results raised questions about the main phenomenon of the research. Therefore, the next round of interviews was conducted in order to ensure the theoretical saturation of the criteria (categories). In the following, taking into account the main phenomenon and its related sub- criterion, more interviews were put on the agenda. In these interviews, the researchers focused on the questions which helped to perceive the nature of the main research phenomenon and its relationship with the relevant categories.

After understanding the categories and ensuring their theoretical saturation, the third round of interviews was performed. At this step, other interviews were conducted to find theoretical examples of the identified categories and relationship between them in order to provide a basis for modifying the researchers' theory. The main research experts included a number of university lecturers and active specialists who designed construction projects in a practical way using BIM software.

3.1. Open Coding

At this stage, considering the sub- questions of the research including the following, open coding was done:

Legal barriers to BIM implementation

Technical barriers to using BIM

Cultural and educational barriers to BIM

Managerial and procedural barriers to using BIM

Political and legal risks of using BIM

After reviewing the interview text, a code was assigned to each subject. To assign the codes to the text, either the specific word expressed in the sentences or according to the researcher's perception of the sentences was used; or that stated sentences were confirmations of the matter that had already been mentioned in the previous studies, in which case, by using those studies, the appropriate code was given to that part. In open coding, the data was divided into different categories. After identifying barriers, Delphi Fuzzy technique was used for final confirmation of them. The barriers were set up in the questionnaire, and its validity and reliability were checked before sending it to the experts. Additionally, content validity index (CVI) was used to assess validity of the questionnaire. CVI was presented by Waltz and Bausell. In order to calculate the CVI, experts were asked to rate the degree of relevance of each item to the following four- part scale:

Irrelevant

It needs to be thoroughly reviewed

Relevant but it needs to be reviewed

Entirely relevant

The number of experts who chose options 3 and 4 was divided by the total number of experts. If the resulting value was less than 0.7, the item was rejected; if it was between 0.7 and 0.79, it was reviewed; and if it was higher than 0.79, it was acceptable.

For determining the reliability, 8 experts were surveyed and the reliability index was obtained. Some items that their CVI index was below 0.7 were rejected, and the items which their CVI index was from 0.7 to 0.79 were reviewed. One of the prevalent methods of measuring reliability is the use of Cronbach's alpha coefficient. This method is used to calculate the internal consistency of measurement tools, including questionnaires or tests that measure different characteristics. If the

Cronbach's alpha coefficient of the variables is more than 0.7, it confirms the reliability of the questionnaire.

To calculate reliability, Cronbach's alpha coefficient was used. Eventually, by implementing the Fuzzy Delphi technique, barriers were identified, finalized and ranked.

4. Results

The identified barriers and challenges of BIM were presented in the following table, after library studies and reviewing the conducted research.

Table 1 The identified barriers and challenges of BIM

Row	Barriers	Definition
1	The complexity of BIM and its learning curve	It is hard and time consuming to learn
2	The difficulty of the initial setup of BIM	Initial setup of BIM requires powerful hardware, A lot of software and many experts in this field
3	BIM is not suitable for all kinds of projects	It is suitable for large- scale projects
4	I is difficult to measure the effects of BIM	It is practically difficult to measure the use of BIM and its effect on reducing rework, project delay and construction wastes
5	Implementation of work details based on traditional perspectives, not based on executive plans	The implementation of BIM details may be based on traditional perspectives
6	The need for high- performance hardware to manage the large amount of data	Due to large volume of data, powerful hardware is required for data management
7	Lack of global use of BIM in the local construction industry	BIM is not usually used in small- scale local construction
8	Cultural issues and constant social resistance to change	Usually society resists change
9	Lack of demand from employers and contractors (They consider it as an additional cost)	Employers and contractors usually consider it as an additional cost due to lack of knowledge of the capabilities of this technique
10	Poor training services	Limited training courses are held and training services are not enough in this field
11	High cost of buying software, hardware and BIM tools	The cost of buying software and hardware is high
12	The cost of using BIM technology	The cost of using BIM technology is high compared to traditional methods
13	New activities, new organizational chart and lack of information about new salaries	BIM's organizational chart is different from the organizational chart of traditional methods
14	Procedural issues, change in organizational structure and rules, and non- stabilization the BIM process	Being different of process and change in the organizational structure of this technology has caused its instability
15	Lack of full support from senior officials and decision makers	Usually, since this technology is unknown, senior officials do not support it
16	Responsibility and control of data entry	Responsibility for maintaining and controlling input data is not clear
17	Rate of return (ror) is not clear	The economic feasibility is unclear and the cost

		of using BIM is unpredictable
18	Lack of access to BIM tools	BIM implementation requires powerful hardware
19	Shortage of research in this field	There is not sufficient research on all aspects of BIM technology in Iran
20	Legal and contractual issues (absence of a specific contract template)	absence of a specific contract template
21	In BIM, the line of responsibility of each person is unclear	BIM's organizational chart is different from traditional methods, and the line of responsibility of each person in the new chart is unclear
22	Traditional methods of contracting	The methods of contracting in BIM must be different, but it is still done in the traditional way
23	Low computer skills among people working in the construction industry	People working in construction industry do not have enough computer skills
24	Lack of demand and neglect of clients to use BIM technology in design and construction	Clients are reluctant to use this technology in the design of construction projects
25	Lack of awareness of BIM and its benefits by the stakeholders	Usually, the stakeholders are not fully aware of the capabilities of this technology
26	Lack of access to BIM risk insurance policies	Lack of insurance coverage to support the BIM process
27	Lack of scientific manpower aware of the evolution of the model and having a proper understanding of BIM and organizational BIM	There is very little scientific manpower who is fully aware of the evolution of BIM
28	BIM authorization issues	Being different BIM process and related authorization and the problems of obtaining authorization

The Table 2, shows the barriers identified based on interviews with experts. In addition, open coding was done on the interview results (The data that was not seen in the review of the articles but was mentioned in the interviews).

Table 2 Barriers of BIM identified based on interviews with experts

Code	Barriers	Definition
B29	Incompatibilities and functional limitations between software	Some of these software have limitations in input and output data that may cause problems in implementation
B30	Lack of software with integrated functionality	A lot of software is needed to design different parts of the energy discussion and check costs
B31	The country's software embargo for using Auodesk's online capabilities to share files online among consultants and other stakeholders	Due to sanctions against Iran, many Autodesk's online capabilities cannot be used
B32	Spending a lot of time to convert CAD drawings into BIM model	It is difficult to convert AutoCAD drawings into a suitable format for BIM software
B33	It is time-consuming to create some new objects with different applications	Defining new objects which do not exist in existing archives is difficult and time-consuming
B34	Lack of architects/ skilled engineers at using BIM programs	Architects and engineers usually use traditional methods and do not aware of BIM programs
B35	Negative attitude towards information sharing	Since the plan details are provided to a person familiar with BIM to be implemented in the environment of BIM software, there is a

		possibility of copying
B36	Lack of professional interaction and extensive use of BIM	The implementation of information in the BIM environment takes place in several stages and in different fields, including structure, architecture, facilities and costs. Therefore, it is necessary for active people in different fields to interact well with each other.
B37	A lot of time and money is required to train and hire human force	Hiring an expert familiar with this technology or training experts is both time-consuming and expensive
B38	The cost of purchasing licenses for the software used	To use the original software, it is need to purchase a license
B39	Challenges of cooperation between team members and different stakeholders, and negative attitude towards teamwork	In BIM implementation, a team needs to work together, but this usually causes challenges due to poor teamwork skills
B40	The uncertainty of the responsibility of managing the entire model and the instability and lack of integrity of the model	Because of the many different fields of design, it is difficult to manage the whole project and integrate it
B41	Lack of support from industry policymakers in setting standards and lack of evaluation process and lack of awareness of international standards	No measures have been taken by the policy makers of this industry to formulate the necessary international standards and determine the evaluation process
B42	How to prevent copying of information and legal ownership of the model	It is difficult and uncontrollable to prevent copying of information
B43	Lack of government regulations to fully support BIM implementation	There are no coherent laws and government regulations to support the implementation of BIM process

After identifying the barriers, a questionnaire was prepared and vested in the experts to estimate its validity. Following determining validity, less important barriers were removed and the barriers reduced to 39 items. The reliability of the questionnaire was determined by Cronbach's alpha method.

Reliability Statistics

Cronbach's Alpha	N of Items
.738	39

Following reliability and validity assessment, the questionnaire was made available to exports. Fuzzy Delphi technique was implemented in three stages and after reaching a consensus, the barriers to the use of BIM were determined and ranked.

Table 3 The barriers of BIM were determined and ranked

Row	Criteria	Identified sub criteria	Consensus percentage	Weight	Rank
1	Technical and technological risks	The complexity of the software and the difficulty of learning and implementing BIM stages	73.33	0.026	11
2		Lack of software with integrated functionality	80	0.026	10
3		BIM is not suitable for all kinds of projects	73.33	0.023	20

4		Lack of access to BIM tools (software and hardware)	73.33	0.028	4
5		The country's software embargo for using Auodesk's online capabilities to share files online among consultants and other stakeholders	73.33	0.024	16
6		It is time-consuming to create some new objects with different applications	73.33	0.026	11
7		Implementation of work details based on traditional perspectives, not based on executive plans	80	0.026	6
8		The need for high-performance hardware to manage the large amount of data	73.33	0.026	11
9	Educational and cultural risks	Cultural issues and social and constant resistance of people in various positions including owner, contractor, employer… to change	73.33	0.028	4
10		Lack of demand from employers and contractors to use BIM in the design and construction of the project (They consider it as an additional cost)	73.33	0.028	4
11		Lack of awareness of BIM and its benefits by the stakeholders	73.33	0.023	20
12		Lack of demand and neglect of clients to use BIM technology in the design and construction of the project	80	0.026	10
13		Low computer skills among people working in the construction industry	73.33	0.024	18
14		Lack of skilled exports familiar with using BIM	73.33	0.026	7
15		Poor educational and research services in Iran	73.33	0.028	2
16		Negative attitude towards information sharing	73.33	0.026	5
17		Lack of professional interaction and extensive use of BIM between architectural, civil, utility	73.33	0.024	14

		and electrical professionals			
18	Financial risk	The high cost of purchasing software, hardware and BIM tools	73.33	0.022	23
19		The high cost of using BIM technology compared to traditional methods of BIM implementation	80	0.022	22
20		A lot of time and money is required to train and hire human force (waste of resources)	73.33	0.024	14
21		A lot of time and money is required to design a highly detailed model and integrate complex models	80	0.024	17
22		New activities, new organizational chart and lack of information about new salaries	73.33	0.028	2
23		The cost of purchasing license of the used software	80	0.024	17
24	Managerial and procedural risks	Lack of scientific manpower aware of the evolution of the model and having a proper understanding of BIM and organizational BIM	73.33	0.024	14
25		Procedural issues, changes in organizational structure and rules and non- stabilization of the BIM process	80	0.024	19
26		Challenges of cooperation between team members and different stakeholders, and negative attitude towards teamwork	73.33	0.024	18
27		The uncertainty of the responsibility of managing the entire model and the instability and lack of integrity of the model	80	0.024	13
28		Lack of full support from senior officials and decision makers	73.33	0.024	15
29		No obligation to use BIM	73.33	0.026	5
30		Neglect of the departments and interest organizations to the use of BIM	86.66	0.028	3
31		Lack of instructions for using BIM in related	73.33	0.029	1

		organizations			
32	Legal and policy risk	It is unclear who is responsible for controlling and entering data into the relevant software	73.33	0.021	24
33		Legal and contractual issues (Lack of a specific contractual template)	73.33	0.026	8
34		Information security and legal and intellectual ownership of the model	66.66	0.025	12
35		Lack of government regulations to fully support BIM implementation	73.33	0.026	8
36		In BIM, the line of responsibility of each person is unclear	73.33	0.024	14
37		The existence of many legal obstacles, including protocols, standards, the use of BIM in lawsuits and issues related to cyber problems	73.33	0.023	21
38		Traditional methods of contracting	73.33	0.026	5
39		Lack of insurance policies which support accidents and possible problems using the BIM process	73.33	0.026	9

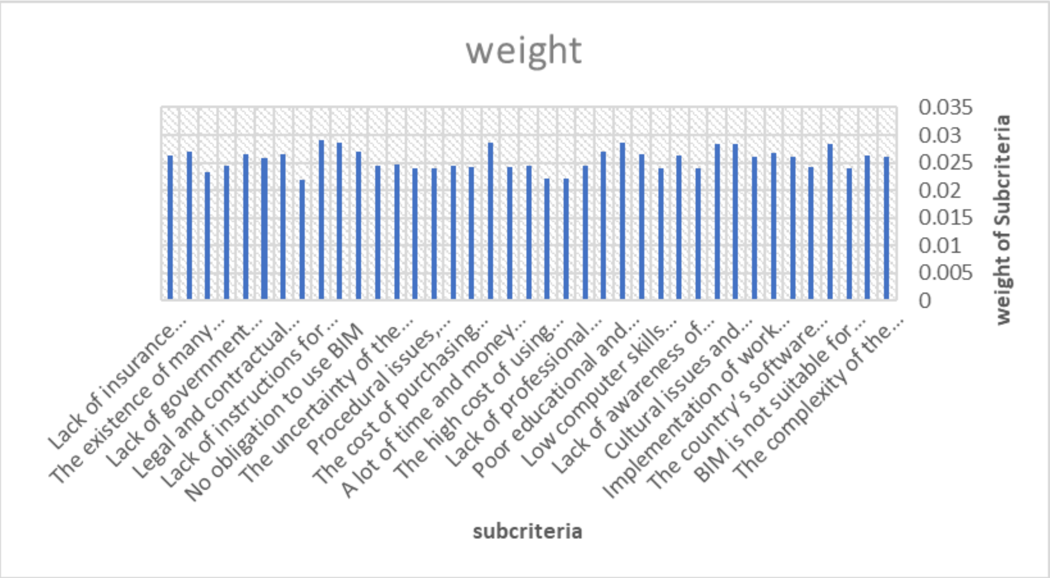

Fig 2 Rank of barriers (sub- criteria)

5. Conclusion and Suggestions

The priority level of each barrier, based on the level of consensus of the respondents is shown in figure 2 as a bar chart. In the figure, barriers (sub- criteria) are placed in the technical and technological, educational and cultural, financial, managerial, procedural, legal and political categories. Among the barriers, the lack of guidelines for the use of BIM in related organizations, located in the managerial and procedural category, ranked first. Poor educational and research services in Iran, new activities, new organizational chart and lack of information about new salaries jointly ranked second. The results showed that Iran's construction industry is still in the stage of BIM adoption and has not fully entered the stage of its implementation in organizations. Therefore, the government should take appropriate measures to support and implement BIM in the subsidiary organizations. BIM adoption in the construction industry requires the creation of legal infrastructures including determination of the model ownership, the responsibility for model defects and errors, and provision of BIM standard contracts by the legislative authority. Additionally, barriers and challenges which are social- organizational type, should be resolved by determining the standard organizational chart. Furthermore, it is necessary to carry out educational and research activities competently by starting up incubators and forming research teams in this field.

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