BENEFITS AND BARRIERS OF INTEGRATING BIM IN E-PROCUREMENT IN CONSTRUCTION SECTOR

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ABSTRACT

The construction industry is currently facing multiple challenges in the shape of reduced efficiency, lower productivity, conflicts, and contractual disputes between concerned stakeholders of a project. The reason lies in the utilization of outdated and conventional methods of executing projects. To overcome these challenges, the current study emphasizes the need for integration and adoption of building information modeling (BIM) in e-procurement. Therefore, the purpose of this study is to highlight the significant benefits and barriers of integrating BIM in e-procurement in the construction industry. Through a comprehensive review of the literature published between the years 2009–2019, the paper first identified benefits and barriers of BIM and e-procurement integration, followed by comprehensive content analyses to rank and screen out the least important benefits and barriers. This helped in quantitative and qualitative investigation questionnaire survey and expert opinions that respectively assisted in utilizing systems thinking approach to establish causality. In total five CLDs are developed, three for benefits and two for barriers. The CLDs consist of benefits and barriers prioritized because of their strength and speed of influence in the system. The results obtained from the analysis indicate that quality enhancement, cost control, and optimized efficiency are the most significant benefits, whereas lack of interoperability, incomplete standards and resistance to change are top barriers in the integration of BIM and e-procurement. The results of the study can be very helpful in decision-making by construction industry professionals. As the conventional procurement practices consume a lot of time and resources, therefore, from the results of this study, the barriers and benefits are indicated in the integration of BIM and e-procurement.

Chapter 1

INTRODUCTION

1.1 STUDY BACKGROUND

In Architecture, Engineering, and Construction (AEC) industry process of procurement is highly important and equally intensive and it occurs throughout the lifecycle of a project. (Aguiar Costa and Grilo, 2015) But if a comparison is made with other industrial sectors it is found that the industry of AEC is mainly characterized by the procurement of extremely unstructured services as well as materials, as a result of which the adoption of electronic procurement platforms for procurement process becomes highly unlikely, chiefly because most of the required data for the contractual agreements are not properly structured and not a proper processing format. (António Grilo a, 2011) Traditional procurement is a manually managed system which is based on paper, excel sheets and dealings which are done face to face whereas in E-procurement the dealings are done online and the process becomes integrated and somewhat efficient. (Bakar et al., 2016)

In recent years the construction sector has realized the need of improvement and it has started to speed up the its efforts in order to save cost and improve efficiency (Tran et al., 2011). Hence there is a clear need to reduce waste and increase the efficiency of construction process. According to previous studies, as a response to the ever increasing need of limiting the waste of a construction project and also to increase the performance, progressive technologies like E-procurement and BIM have been developed in the construction sector (Aguiar Costa and Grilo, 2015). These modern information and communication technologies known as ICT have totally defied the conventional methods of work for example the use of 2-D drawings and old procurement techniques, hence they have inspired change and novelty, especially in the field of e-procurement and process of building information

modelling (BIM) (Froese, 2010). Hence, the construction sector has started to adopt and promote modern strategies like IPD, embracing the latest methods just like the set of software of Building Information Modeling (BIM) and procurement platforms like e-Procurement. (Tran et al., 2011)

The process of e-procurement is gaining a lot of popularity in commercial practices and its multiple advantages like competitiveness, costs reduction etc. have encouraged its adoption. (Hashim et al., 2013). In view of different publishers the rate of adoption of e-procurement clearly shows an astonishing drop of over 3% of total cost without any substantial reductions in results (Duyshart et al., 2003) In majority of the cases e-procurement gives an edge because it helps in reducing complications, increasing the competitiveness as well as making the process transparent, it also helps in establishing an integrated process to support the advanced electronic equipment in order to coordinate and properly manage contracts throughout lifecycle of a project (Costa and Tavares, 2013). Previously the researches have claimed that it is highly likely for e-Procurement to bring radical changes in companies, but only a limited bit of information is available about the actual results it might bring if its implemented in the construction industry (Hashim et al., 2013)

The construction industry does recognize the fact that substantial improvements can be reached by adopting e-business. Nevertheless, severe interoperability issues still obstruct further adoption of electronic procurement process. (Mell and Grance, 2010b) For the time being the practical application of e-procurement in construction is somewhat limited in order to rationalize the process of quantity takeoffs, tendering procedures, cost estimates and procurement process of the conception phase dealings among clients, contractors and consultants (Castro-Lacouture et al., 2007) Hence it is the need of hour that e-procurement platforms must evolve towards new developing standards; e-procurement should incorporate those tools which help in collaboration, provide assistance for social networking techniques, and try to increase the interoperability problems among systems so that it might enhance collaboration, boost trust and finally device tactical methods to improve network relationships in a project (Costa and Tavares, 2012)

Considering the above stated issues, an innovative technique for e-procurement is to incorporate BIM in this processes (Aguiar Costa and Grilo, 2015) Now proposed theory behind integration of BIM in the process of e-procurement is that by doing so we may reduce the undesirable effects of the fragmented construction sector all the way through development of a project, by providing integration and reliability of information across the procurement processes (Aguiar Costa and Grilo, 2015)

Foregoing in view adoption of BIM has increased internationally in developed countries (Smith, 2014a). BIM related benefits like integration of data, efficiency etc. have motivated many developed nations to set a deadline for its implementation. (Akinade et al., 2017) The adoption of Building Information Modelling in construction market is seen as a positive catalyst for the novelty as well as rapid growth in the construction sector and no doubt BIM can deliver a reasonably sustainable project that may play its part in order to eradicate poverty of developing nations (United Nation Millennium Goals). This has provided awareness to some developing countries that if they don't embrace new techniques like BIM they could be left behind. (Smith, 2014b) While the application of BIM is rapid in developed countries, its adoption in context of developing nations is slow and non-substantial. (Bui et al., 2016b) Researches have recognized that the construction companies operating in developing countries struggle from multiple limitations related to the socio-economic and technical environment (Bui et al., 2016b) Many researchers are trying address its implementation in industry (Bryde et al., 2013)

In the current scenario, BIM is regarded as a fairly complex and challenging to use (Kumar et al., 2009). Hence, the firms of developing nations consider BIM as an 'uncertain' investment because its business value remains indistinct (Harris et al., 2014) BIM is being gradually imposed in developed nations, conversely, application of BIM among the developing nations is not up to the mark. (Ismail et al., 2017) As far as integrating BIM in E-procurement is concerned the literature review clearly states that construction industry in developing countries is at present, not practicing E-procurement via BIM (Ali et al., 2018) If we consider the developing states, the construction industry is mostly fragmented and organizations are practicing conventional construction procurement method in which we first design then the

contractor bids and builds, also in this process common 2-D CAD drawings are used which make the project delivery system somewhat inefficient. (Fatima et al., 2016) There is a need to increase the accessibility of data which is related to cost benefits (both direct and indirect) regarding e-procurement which will be one of the principal incentives for construction stakeholders in the industry to embrace these modern tools (Hashim et al., 2013) Furthermore, this technique may revolutionize our traditional procurement which is consuming redundant time, human resources and money (Mehran, 2016)

The paper begins with reviewing the current knowledge about of BIM and E-procurement. Later it would elaborate in detail about the major benefits as well as barriers that might occur while integrating BIM in E-procurement and it will highlight the significant factors that have highest impact on this subject. System dynamics technique would be applied to show the desired results. This research will add to the current body of knowledge by providing a proper database on whether BIM integrated in E-procurement is beneficial or has negative impact BIM in E-procurement so that is it will help in decision making about integration of BIM in E-procurement.

1.2 RESEARCH OBJECTIVES

- To help identify the benefits as well as barriers of integrating BIM in E-Procurement in construction sector
- To develop a system dynamics model to address complexity in integration of BIM in e-procurement
- To validate the system dynamics model

1.3 RESEARCH SIGNIFICANCE

This research will provide an overview of the trends of our construction sector towards BIM based E-procurement. It would provide information regarding advantages and disadvantages in its adoption. It can make the decision easier for a local firm looking to adopt this technique in a developing country. Furthermore, this technique can modernize our traditional procurement which is consuming

unnecessary time, human resources and money. The research intends to show the relation among top shortlisted factors for both benefits and barriers.

Chapter 2

LITERATURE REVIEW

2.1 PROCUREMENT

The construction sector is facing multiple problems like low efficiency, slow rate of output, confrontational relations and contractual clashes between the client, consultants, builders and all of the stakeholders of a project. (De Marco and Karzouna, 2018) These are the factors that often generate problems like cost overruns, postponements of timetable which then lead to poor end quality of project.(De Marco and Karzouna, 2018) All of these factors ultimately degrade the value of project in multiple ways. The basic cause for this is the outdated methods repeatedly being used and the reluctance of construction industry to embrace new project delivery methods that include E-procurement, BIM and IPD.

Procurement has been defined in a number of ways one of them being the process of acquiring services or buying products at the lowest conceivable costs. (Bakar et al., 2016) Procurement could be performed by a number of unique procurement methods available, which may constitute different methodologies. However, a few aspects remain common which are involved in the traditional procurement methods like it normally commences with the determination of what is to be acquire and ends with the validation that the acquired item or the final product received (i.e., goods, services or works) are in accordance with the stipulated specifications. (Ruparathna and Hewage, 2015) In majority of the scenarios for a particular building project, the project delivery system is often carefully chosen based on the past experiences of management team. It has a substantial flaw that it might cause a vicious cycle in which same mistakes are repeated again and again in successive tenders just like cost or schedule overruns. (Pöyhönen et al., 2017) Hence major shortcomings here are the strategy, development process, market input and

competitiveness as well as the available assets which are a necessary function while deciding the method of project delivery system.

In traditional procurement processes the value of products tend to be on higher side as there is no proper development for them during the design or conception phase of a project. (Pöyhönen et al., 2017) Hence conventional procurement has disadvantage in the form that owner is unable to account for the fluctuating user functions in the building stage because usually most of the building plans are locked prior to the participation of the builder in initial phase and if there is even any slight last minute alteration it may lead to a disagreement between all stakeholders (Pöyhönen et al., 2017) Therefore the modern construction procurement techniques like e-procurement may be a way out as they allow for a very creative and critical thinking while choosing a project delivery system to be adopted and allow more rapid and thorough communication between client, consultant, contractor and any other stakeholder.(Mora-Monge et al., 2010) This also encourages the involvement of contractor conception phase hence ensuring an integrated process delivery (IPD) approach which is the essence of BIM.

Integrated Project Delivery (IPD) is a more collaborative technique, and it has been developing as a very encouraging process which may help to evade a few of the most common customary inadequacies of traditional tendering process, and it also encourages to achieve the maximize success levels for a construction project. However, there exists a limitation in the application of IPD in construction sector as there is no clear way to understand to understand the values that it can unlock. (De Marco and Karzouna, 2018) A recent study shows us that, despite 84% of members interviewed for the research were aware of IPD process, just 40% had an understanding of what IPD is, and just 13% were practically implementing and using it. (Ilozor et al., 2012) It is a clear fact that, despite having many promising and revolutionary benefits like reduction in fragmentation, efficiency etc. this technique i.e. IPD has a very slow adoption rate and it is lagging behind the timetable in construction sector and the statures which could be achieved by IPD are still indistinct to experts and professionals which is the main reason that even till today the understanding of IPD is not to the community of AEC sector. (De Marco and Karzouna, 2018). For this purpose, the paper suggests that a survey is may be carried

out to find the advantages and issues that industrial professionals are facing while practicing IPD technique in a construction project, which is a part of this research. The modern day technologies like e-procurement are highly beneficial and may provide vigorous answers for the procuring companies while buying different good, works or services and e-procurement may plays a critical role by giving innovative support and assistance to the current outdated ways in which an organization carry out its customary procurement process, by automating, systemizing and streamlining multiple business procedures and dealings (Bakar et al., 2016)

2.2 E-PROCUREMENT

The way in which internet technology is evolving throughout the world is drastically altering the way business is being performed in construction sector and also value increases by adoption of e-commerce methodologies, specially like e-Procurement, are apparent and multiple industries like construction etc. have accepted it (Mora-Monge et al., 2010). Electronic procurement is a modern day business technique used by organizations to procure goods, services and it may be defined as the establishment of private as well as public, online procurement marketplaces that computerize transactions, online communications and effective collaboration between all members of a supply chain, therefore enhancing the teamwork, cost control, rationalizing processes and increasing the exchange of data within as well as across organizational confines. (Bakar et al., 2016) Presently the adoption of this technique is much more certain as even the developing countries have sufficient basic internet facilities to implement this technique in their construction sector.

Currently, it can be argued that productivity advances by application of e-procurement are acknowledged and technological feasibility for its practical application is under process because adoption of e-procurement is a promising methodology for construction sector. (Othman et al., 2013) This is probable mostly because of the fact that e-procurement aids in decreasing the complexity, improving overall competitiveness, clearness and constructing collaborative electronic system which may help the innovative electronic tools to coordinate and monitor contracts of a project (Aguiar Costa and Grilo, 2015) Despite all of the previously mentioned factors the rate of adoption and application of e-procurement are comparatively slow,

especially its application in construction sector is reasonably lagging as compared with other industries particularly in developing countries. (Aziz and Salleh, 2011) Construction industry in general is slow at adoption of modern technologies due to its extremely complex nature. Hence there is an urgent need to carry out a thorough research on how the policies of government and other related factors have an impact on the readiness level of adoption of e-procurement in the construction industry for developing nations (Tran et al., 2011)

Now the businesses in developing countries is a little different as it is not common practice to deal with non-cash payments and also there is little or no unknown electronic platform based business associations, which is a significant aspect in e-commerce. (Tran et al., 2011) Kimberley claimed that firms cannot be forced to adopt a new technology solely on the basis of its benefits therefore firms must be motivated to modernize their ways and methods. (António Grilo a, 2011) Henceforth if a thorough study regarding the motivating and demotivating factors is available then there is much more ease in decision making regarding the adoption of these modern procurement techniques.

One of the most significant advantages associated with adoption of e-procurement is related to the issues about factors like communication or work processes, and it is hoped that application of e-procurement would be the real deal in streamlining the complete procedure of tendering and it may mechanize transactions which in turn is an encouraging factor as it helps in bringing the process to the desired pace, other advantage being the replacement of labor and also a thorough impact on the administration of contracts as well as an effective means to search for the suitable supplier (Hashim et al., 2013)

Some previous studies suggest that there are multiple advantages like competitive advantage that is increase in number of suppliers, cost savings in procurement, improved productivity, time savings, managerial effectiveness, enhanced opportunities for public projects, data security and non-released benefit/cost. (Tran et al., 2011) In addition to previously mentioned advantages there are a few more which include a general increase in overall quality of the process, better customer satisfaction, quick responsiveness, satisfactory services, novelty, growth of market, reduction in time for procuring and overall reduction of

manpower. Indeed, this innovation has been utmost important to the construction companies as by its practice the firms have been able to produce a vast source of data with regards to both usage and application and numerous empirical studies are available which clearly advocate the claim that e-procurement is aiding in making the process of procurement highly productive as well as efficient plus it is having a big influence performance of construction companies. (Mora-Monge et al., 2010) Despite having all of these advantages, in another research again it was claimed by Lou that the apparent advantages associated with information technology are only as good as the concurrence of construction firm which wants to adopt these innovations into their working systems before investments but unluckily for the developing nations, the construction industry is defined by the small and medium enterprises shortly known as SMEs and they have a disadvantage in the form of low level of acceptance for the new business proposals hence making it difficult to practically embrace, apply and take advantage from IT techniques like e-procurement (Lou, 2010)

Now having mentioned all the benefits which could be achieved by implementing the process of e-procurement it is to be mentioned here that there are also a certain amount of discouraging factors which hinder its adoption and they are responsible for the frequently very slow rate of practical application of e-procurement in construction sector hence for this purpose the management related solutions of process of business, human resource management, technological administration, IT and related issues must be studied in detail for proper solutions. (Tran et al., 2011) The previous researches establish that e-procurement might be the right technique to bring some substantial value for companies, but the thing is that very little information is available regarding its empirical actual outcomes if we implement it practically in the construction sector and these findings may provide useful guidelines which may help firms in decision making regarding the application of the process of e-procurement in building firms (Hashim et al., 2013)

There exists another complexity in the form of evaluation of all the costs related to investments made in the sector of information and technology the construction sector which is highly complex due to the reason that for every project its nature is unique for example financing required is different, user requirements

vary as per customer needs, fragmentation of industry etc. Detailed metrics required to determine the extremely haphazard chains which are the trademark for construction sector and they affect overall budget savings and enhancement of quality, have only been roughly drafted (Hashim et al., 2013). Again, in these studies there is a lack of complete disadvantages in a form of a list which might help in decision making.

Literature review shows that no doubt that some of the learned people are accepting e-procurement with open arms in business practices and numerous advantages have been determined which encourage its application, such as increasing competitiveness among stakeholders, reducing costs of supply chain etc. but these researches and studies points towards an alarming particular condition; most of these studies are unable to provide a generalized, comprehensive and a thorough list of related advantages for a particular sector. (Hashim et al., 2013) According to the e-business Watch Organization, the Construction industry firms are not utilizing the available ICT tools' to their full advantage hence these firms are taking a very little advantage from the modern day novelties of products, services, and process and hence they are rated much below conventional industrial divisions. (Jardim-Goncalves and Grilo, 2010). Hence there is a need of a generalized study which may establish all the benefits and shortcomings related to construction industry of developing countries as conditions might be slightly different when compare with the construction industries of developed world, so that the adoption is encouraged in developing countries as well.

2.3 BUILDING INFORMATION MODELLING

2.3.1 BIM definition and relation with developing countries

The World Bank states that there are around 135 middle to low economies known as the developing countries and in these states there exists a large information gaps, these nations are described by a very outdated system and there is only occasional actual advancement in technology, and here the construction sector has high dependencies on labor (Bank, 2019) It has been a known fact that construction encourages and provides a more sound foundation for employment opportunities and it aids in a more convenient use of human resource and capital, hence making the

construction sector a pioneer when it comes to growth or accomplishment of developmental goals of a country thus making a sound and successful construction sector the backbone for progress of these developing nations (McCann and Van Oort, 2019) But we know that the construction sector is complex and fragmented in nature (Vass et al., 2017)

Now if we consider a developing country scenario, application of BIM is highly complicated in general. (Chan et al., 2019) And one of the major reasons of complex nature of construction industry is the use of paper resulting in to hundreds of different documents and complex drawings that are being made manually and its use becomes tedious (Latiffi et al., 2014). In normal practice, the construction stakeholders are still happy to use the conventional 2-Dimensional drawing data which often results in confusion hence results into misunderstandings between them which is inappropriate for complex projects, therefore these miscommunication in building projects may result in to miscalculations or errors in the process for example cost overrun, blunder in design; poor quality of works, drawings not being updated, delays, as well as undetectable design clashes. (Latiffi et al., 2014) Hence now a days technique like Information Communication Technology are being considered for multiple uses like to administer a bunch of decision making activities or information and it may also help to provide a higher quality of reliable and usable information in a construction project. (Latiffi et al., 2014) Construction developments can be rendered more productive and efficient with implementation of ICT techniques and one of these techniques is the set of soft wares called the Building Information Modelling (BIM), which may be beneficial in supporting construction process throughout the lifecycle of a project providing more sustainable solutions (Musa et al., 2019)

Multiple definitions of BIM have surfaced during the past few year, it may be defined as a set of tools used for management of design in AEC sector which provides assistance to develop a more collaborative and a better communicated system between the construction stakeholders, it also helps to administer the documentation activities in much more efficient way and it has developed into mainly six perceptions which are known as the design of the project, cost or quantity estimation, management of construction process, analysis throughout building life

cycle, effective performance and use of innovative technologies. (Latiffi et al., 2014) If we talk about functionality then few of the functions desired by BIM include simulations, interference check, process management, production of design as well as drawing, analysis of structure, facility management, automatic estimate, ROI and visualization and sustainability analysis. (Seo and Kim, 2012)

2.3.2 Benefits

Now after giving a brief introduction of BIM the real question is that what may be the necessary reason for applying BIM in construction sector? Answer to this question lies in one of the earliest international organizations associated with BIM called building SMART which highlights the words better, quicker, economical and lately the addition of words safer and sustainable as encouraging factors for BIM adoption. (Seo and Kim, 2012) BIM technology can efficiently overcome the traditional technological barriers and it may become one of the most effective ways to integrated design of building energy efficiency and consumption of energy assessment throughout the life cycle (GhaffarianHoseini et al., 2019) During a research made by (Migilinskas et al., 2013) where application of BIM was evaluated against a real life project it was found that BIM helped in decreasing the time for plan and views to about 20% as compared with that of AutoCAD drawings and it also decreased the required time if redrawing was necessary for error corrections when changes are detected in early stages, apart from that BIM's ability to incorporate all of the available information related to the design clarifications and potentially occurring complications helps save 10% of time to look for possible solutions and lastly the work quantities that have been calculated by the help of BIM model helps to reduce "Human nature" errors in during the supply of the products and materials desired at a very strict and hectic schedule. Another important thing to mention here is that economic benefits that were achieved by the application of this system and cost reductions that were achieved by using BIM based software and precise bill of quantities did not surpass less than 10 times of the additional management costs for use of this technology that is BIM (Migilinskas et al., 2013) During a research study by (Ahuja et al., 2017) after a lot of research the following beneficial BIM capabilities were shortlisted in Table 1: BIM Capabilities which are as follows:

- Visualization
- Integration of design
- Prefabricated and modular construction
- Scheduling of activities
- Sustainability Analysis
- Collaborative Site Plan
- Change in Management Styles
- Structural Analysis of a Building
- MEP Modelling
- Ease in Quantity Take-off calculations
- Facility Management
- Throughout the lifecycle Constructability Analysis
- Overall Collaboration and Coordination
- BIM for As Built
- Effective management of Supply Chain

2.3.3 Barriers

Now despite having multiple benefits the rate of adoption is slow in developing countries which is pretty evident from following researches for example in China if we consider industry wide BIM usage and diffusion, it has been observed that below 20% of its construction companies are practicing BIM, whereas a developed nation like the US has a much higher rate of BIM implementation which is about 70% hence there is a clear gap (Bui et al., 2016a) Similarly in India as compared with the other nations, a moderately low implementation of BIM is observed which is about 22% only. (Ahuja et al., 2017) The research articles which have been previously conducted mostly present an analysis about the BIM implementation as well as adoption related research in the developed nations but it is astonishing that almost no research exists on role of BIM in developing countries prior to the year 2013, and even these current researches are limited to a few of the developing countries like China, India, and Malaysia and there is still a lot of work to be done (Bui et al., 2016b) The factors like slow adoption and no proper studies

prompt us to come to the conclusion that there is a need for more effort towards the development of new BIM strategies that are addressed to the requirements of the local construction market of a developing nation (Bui et al., 2016b) The research shows us that how the construction firms struggle in a developing countries due to unavailability of a proper technological support as per their needs and unavailability of sufficient budget for implementation of these innovations. (Bui et al., 2016b) Furthermore, a detailed list of barriers which might arise while implementing BIM in construction industry are given below.

One of the factors of slow adoption rate may be the BIM awareness which is evident from the survey results carried out by Ju Ki Bum (2010) in building sector, about 81.3% people were aware about BIM and its usage but about 16.3% people had no idea about BIM technology which is astonishing. (Seo and Kim, 2012) The restriction elements in proper application of BIM are defined quarrels among construction stakeholders, unavailability of proper government policies, deficiency of data on available successful studies on real life scenarios, outdated equipment, costly new products and unavailability of professional operators. (Seo and Kim, 2012)

BIM is based on the information sharing among all the construction stakeholders for providing an integrated design work across multiple organizations therefore, a reasonably there are major levels of organizational as well as technical disadvantages for application of BIM and among them the frequently experienced BIM implementation barriers are no proper support from management support, deficiency of knowledge regarding advantages of BIM, unwillingness of professionals to change and adopt new technologies, and cultural misfits, to creating modified and up to date processes for BIM interoperability issues (Chan et al., 2019) Furthermore during their research (Vass et al., 2017) identified the following barriers or challenges in BIM adoption

- Changing work practices
- Providing education and learning
- Developing a mutual BIM definition
- Evaluating the business value of BIM
- Demanding BIM in procurement

- Creating incentives
- Including maintenance department
- Creating new roles
- Managing interoperability

If we really want BIM to be a success then there is a need to improve current working methods, dealings with client, level of skills of staff, project implementation plans as well as the contractual agreements among parties (Migilinskas et al., 2013) As the construction industry is fragmented and every project is unique so practically every member of project team must have Knowledge regarding BIM methodology therefore it is mandatory that BIM implementation methodology should overcome a few hurdles of different nature and break some borders which are persistent in our current scenarios. (Migilinskas et al., 2013) As mentioned previously there is a greater number of hurdles in the in small local markets of developing countries, where the construction firms are small to medium and hardly have sufficient manpower and technology to achieve their full potential from BIM solutions. (Migilinskas et al., 2013) Hence in these markets there are many other barriers as well and these are having a negative impact in the construction sector regarding BIM because people are afraid that they might not achieve the success promised by BIM technologies hence resulting in reservations of very little success or a huge failure as there is a very small margin for a profitable turnover, high initial investment costs and uncertain return of investment which makes it a high risk thing, also time is required to learn BIM software which means that there is a clear deficiency of skilled professionals currently and perhaps biggest barrier of them all in developing countries is the little backing from higher management of the company which are reluctant to look for new methods and insist on working with same old techniques. (Bui et al., 2016a) Hence there is a real need to develop a set of standards for the construction project's stakeholders, then there is a need for new contractual clauses to incorporate BIM in Construction sector for various countries. (Seo and Kim, 2012)

2.3.4 Solutions

The process of BIM is evolving at a very rapid pace and software are being developed at a very rapid pace to support BIM, but they are not able to achieve their

maximum potential as the proper and fluent application of this process requires an addition of new supportive clauses in contract agreement which is currently outdated, it also requires up-to-date government policies and lastly there should be more emphasis on finding a general solution for project delivery method and a strong discouragement towards fights for individual benefits which is a strong trait of current construction process, which may prove to be beneficial for all of the stakeholders involved (Migilinskas et al., 2013) Having mentioned that it is the need of hour that software manufacturing companies as well as governments must step up and must make such policies related to BIM which strengthens the cooperation system and also helps in providing policies and schemes at a national level for formulation of relevant standards, trainings regarding BIM for the professionals and education of BIM for students as a part of their course on urgent basis (Seo and Kim, 2012) From a technical view it can be achieved with collaborative standards such as open BIM and from the managerial view, it is about time that effort is placed in order to find a most suitable implementation strategy regarding BIM in the developing nations (Bui et al., 2016a).

2.4 INTEGRATION OF BIM IN E-PROCUREMENT

2.4.1 Introduction

It has been established that the procurement activities hold great value and are quite intensive as well as significant in the construction sector, and they occur from the conception phase till the handing over i.e. throughout lifecycle of a construction project and these include procurement of either services, products or both and in nature they are standard, extremely streamlined or of repetitive type. (António Grilo a, 2011) Now a days the focus is on an innovative procurement technique which uses the electronic platform for execution of procurement activities called e-procurement has been found as a promising technology for construction procurement (António Grilo a, 2011) According to studies these electronic procurement platforms have provided substantial positive results in the administration of complete supply chain and also the number of advantages that could be achieved is diverse, now these benefits include simply price related benefits during operations and more thorough strategic advantages like enhancement of

customer/client flexibility and remarkable responsiveness (António Grilo a, 2011) Despite all those benefits in comparison with other industries, the procurement which is being conducted in the industry of AEC is under major influence of high levels of fragmentation in the shape of unstructured goods and works, which in turn is causing a major hindrance in the implementation of electronic platforms for project delivery and making the process highly problematic. (António Grilo a, 2011) Especially when most of the data available for the contractual arrangements is not streamlined and its processing format is not what is required in current scenario hence it can be implied that there are a lot of issues in AEC which are causing the AEC sector to be left behind other industries in realizing the importance of e-procurement but currently due to development of new construction software like Building Information Modeling technology, the approach of companies working in the construction sector might change (António Grilo a, 2011) Hence a brief intro of BIM integrated with E-procurement is discussed below.

Recently there have been multiple developments in the use of modern day techniques in construction sector for example the use of Information and Communication Technologies, and this involves a technique called Building Information Modeling technology which is very promising and it would introduce some major changes in the way we deal with visualization of project, coordination among different steps and overall planning of all the practices applied to a construction projects like building projects. (António Grilo a, 2011) But if we review the literature it is reveals that there has been little or no effort in most of the countries when it comes to the integration of BIM with innovative techniques like e-procurement (António Grilo a, 2011) Now one of the basic things which makes BIM unique in comparison to other techniques being used now a days is that not only it provides with very realistic three dimensional parametric models, but it is the streamlined and detailed data that is manageable in an effective way, and it can be thoroughly explained and shared among different stakeholders of a project. (Ren et al., 2012)

In the research paper it has been mentioned that BIM adoption in the process of e-procurement is still doubtful and the reason which can be deduced from research is that each building/engineering project is somewhat unique in nature, hence it

becomes very critical for success of the e-procurement process that the interoperability issues must be addressed and universally interoperable standards must be developed for all of the dimensions that are used in this process, hence making the set of these innovative technologies user friendly and easily accessible. (António Grilo a, 2011)

According to Autodesk the BIM based solutions contains assessable information related to a building that helps the computer to understand a model to be as a building by three dimensional parametric modelling, real-time sustainability analysis, dynamic model in building design and these BIM-based solutions in return may help us to cut the undesirable effects caused by fragmentation throughout the lifecycle of a project via collaboration, integration as well as integrity of all the data throughout procurement. (Aguiar Costa and Grilo, 2015)

2.4.2 Benefits

Building Information Modeling (BIM) has multiple benefits when integrated with e-procurement, a few of them mentioned by (António Grilo a, 2011) during his research are as follows:

a) First and the most basic advantage is that it allows the visualization, better and more thorough understanding about the construction project in three dimensions.

b) BIM is the most suitable option if we want to recreate a real-life model in three-dimensional parametric model and run simulated analysis. Now these three-dimensional models can be of two types namely surface and solid. The surface model is the one which assists us in visualization of a model, and it contains important data related to size, location etc. which helps the user in understanding the model in a much more convenient way.

c) Another thing that makes BIM to be a significant development to aid in the process of e-procurement is the ability of "mapping" the customary fragmented data prevailing in construction sector into much more streamlined set of information and it also helps in solving the problems regarding the interoperability of information among stakeholders

d) BIM provides a more strategic approach towards e-procurement by improving the overall information management system in a project, stimulating

effective collaboration among stakeholders and improving supply chain management to its full potential.

e) Generally, in a traditional e-procurement system, the collaboration comes mainly from procuring necessities via the process of specification development in which usually instantaneous communication and interchange of information is being used but in the integration of BIM software in process of e-procurement these capabilities are not only limited to specification development but rather it may start from design as well as developing the products, manufacturing processes, strategies for distribution and logistics.

In another research of BIM integration in e-procurement it was found that one of the main advantages in sharing the information via BIM among all of the construction stakeholders like engineer, architect, draftsman etc., is a reduction in the time required for the quantity takeoffs of a project. (Ren et al., 2012) Now if we look into the traditional cost estimating solutions, we know that material quantity takeoff is mostly performed manually or by human labors using the available CAD drawings, due to which it is more likely that an error might occur due to the fact that humans are prone to making errors and any inaccuracies that are present may accumulate resulting in waste and inefficiency. (Ren et al., 2012) If the designers, consultants or engineers make changes in the information in any view, a lot of time and human labor is required in traditional material method to make amendment on all material take offs, all of the views, timetables and so on but with the help of BIM, it becomes much easier for design professionals to extract referenced standards , data related to quantity takeoff, specifications, financial warranties and all the working requirements of a project (Ren et al., 2012)

Further in the same studies another issue regarding the architects were addressed that there might be a few things prompting a few concern in the heart of an architect that a contractor may be heavily dependent on the developed model and in case of some mishap he would surely be holding the architect responsible for errors that might occur in material quantities but the architect has the luxury to utilize the data available inside their models to manually cross examine by double checking the estimating quantities.(Ren et al., 2012) However with BIM, when we cause a change either in the design or in the shop drawings, all of the data which is present

in a particular view or multiple views, existing throughout all of the schedules and material takeoffs is automatically updated in the files and the most interesting thing is that all of this data is highly reliable as well as properly coordinated and internally consistent which is very remarkable (Ren et al., 2012)

A list of advantages were also given by (Ren et al., 2012) regarding significant advantages of integration of methodology of BIM in the E-commerce platforms specifically for procurement purposes over traditional drawing-based system which include:

a) Decreasing the manual efforts required to calculate takeoffs
b) Enabling enhanced communication
c) Proper Coordination among stakeholders
d) Fewer miscommunications/misunderstandings amid all of the stakeholders like owners, designers, engineers, contractors, fabricators, etc.
e) Proper collaboration between team
f) Reduction of overall time and budget
g) provides more precise calculations related to material costs which makes the evaluation of contractor/consultant easy during awarding of contracts process.
h) Helps in dipping the quantification work which in turn helps contractors to exercise their time and energy to other activities of greater preference like estimation activities, risk calculations of the project and so forth

Hence we can say that E-commerce platforms provide a viable solution for materials procurement by the use of non-customary techniques hence and crafting a favorable environment for almost all of the construction members (Ren et al., 2012) BIM combined within e-procurement process has a highly likely chance to restructure the workflow of procurement activities throughout the project lifecycle from the conception of a project till the completion stage, estimation of materials and it streamlines the activities during the award of tender (Ren et al., 2012)

In another research a case study was carried out by (Aguiar Costa and Grilo, 2015) grounded on the knowledge and proficiency of the questioned professionals of construction industry, it was deduced that if BIM is incorporated within e-procurement system it may help in reduction of the time for overall project activities

and it may also decrease the effort which is required to process information which might be causing difficulty in contractual or administrative activities. It may also help to properly manage the lengthy and tedious documentation, as the software used in BIM serve like a very exclusive storehouse to all this data for all the stakeholders which include the owner or client, contractors, consultant and subcontractors. (Aguiar Costa and Grilo, 2015) Moreover, another positive outcome which can be anticipated is that several of the stakeholders participating in the e-procurement practice may be able to reuse all of the BIM elements if required, customers and clients boost the integrity of data which in return increases the dependability on data being used hence lessening the number of errors that might occur during any stage of procedure. (Aguiar Costa and Grilo, 2015) Hence the perceived advantages of BIM incorporated with e-procurement are somewhat promising.

2.4.3 Barriers

There is no doubt many promising advantages of integrating BIM with e-procurement and most of the times advantages over shadowed the costs involved in this process which are linked with the additional hard work one has to put while making edits to the files and to maintain association of these documentations with BIM and then manage the whole process of procurement using comprehensible data in defining a product, perfecting a model, estimating the quantities and managing the contracts via BIM software. (Aguiar Costa and Grilo, 2015) But in order to carry out this level of editing we require highly trained technical professionals who can process this data and then incorporate different groups of information into the process of e-procurement which is based on BM. (Aguiar Costa and Grilo, 2015) Although during the conventional procedures in construction we still require to edit a lot information during procurement, but this effort does not involve a unified conduct of all the available documents and more fragmented approach is adopted towards information and documents management which is sometimes more manageable (Aguiar Costa and Grilo, 2015)

Moving forward we see that the interoperability is a major discouraging factor as it causes trouble in proper use of electronic business tools during procurement etc. (Mell and Grance, 2010a) It has already been discussed that fragmentation is one of the main aspects in our current construction markets and the

customary methods being used in our construction sector uses the skills of multiple disciplinary professionals brought together in a single project and therefore to neutralize the effects of this heterogeneity a great effort must be made to strengthen the means of integration and coordination throughout the lifecycle. (Isikdag and Underwood, 2010) Hence due to issues like inability to deal with the unstructured procurement, even though these innovative techniques like BIM and e-procurement are meant to revolutionize our current economic sector, but these techniques are is still falling short of their promised maximum potential construction industry (António Grilo a, 2011)

It is important to mention here that use of BIM for procurement purposes is a difficult task as it requires skilled professionals to make the detailed models which contain all the essential data being used to carry out the tendering activities. (Aguiar Costa and Grilo, 2015) Another problem faced during a case studies was that when the researcher converted the BIM based model into industry foundation class shortly known as IFC, this IFC based info transferred by using BIM software was not be complete and due to this problem model one may lose data of high significance and also presently no particular IFC classes are being developed for information associated with procurement process. (He et al., 2018) Now if we want to shift from paper based analog methods to a more suitable computerized solution for effectively administering bids, firstly the owner has to transform the contents of the bidding process into such a format which could be uploaded on a computer with ease however, one important thing which must be mentioned here is that the current model checking techniques can not completely remove the role of a jury as it is impossible for machines to completely replace humans and some specifications cannot be completed decided based on online procurement techniques. (Ciribini et al., 2015) Another research also suggested a problem that the current professionals are facing is that in some of the cases in order to develop a composite project, multiple team members hired and they might be working from a vast diversity of geography using their own particular software and tools for work, hence many issues related to interoperability occur and it is the need of hour that a single interoperable solution is developed to operate among different reference files, software tools etc. (He et al., 2018) Hence it is about time that these discouraging factors must be put forward in

front of professionals too so that they can evaluate their options and properly address the issues while deciding about BIM and e-procurement.

Now no doubt that BIM totally revolutionizes the way in which our construction companies are carrying out their work practices, and it encourages to adopt the new procedures for collaboration and integration (Grilo and Jardim-Goncalves, 2010) However, still only a little percentage of the effort is directed towards its adoption and proper usage in construction sector for the e-procurement activities (Grilo and Jardim-Goncalves, 2010)

During a research based on identification of budget and analysis of overall cost, it was established that the advantages and disadvantages shortlisted may be provide a rich source of information for future references and it may help software vendors to develop their products accordingly, it may also improve procurement of materials and supplier's assessment criteria. (Ren et al., 2012) For a successful procurement process and related profits, it is vital to have a detailed method for assessment of performance of a bidder and BIM combined with e-procurement procedures may provide us a groundbreaking, advanced and efficient procurement technique and performance assessment criteria constructed on BIM incorporated with e-procurement will be more accurate and precise. (Ren et al., 2012) This research provides a great base as its related to construction industry and procurement related to construction materials is involved which could be further implemented and associated with e-procurement in general because the process of procurement is somewhat same.

2.5 LEVEL OF RESEARCH ON SIMILAR TOPIC: AN OVERVIEW

So if we consider the previous level of research the first research regarding this topic was carried out by (António Grilo a, 2011) in which they discussed the implementation procedure for SOA4BIM framework combined with the e-procurement methodology and they supported their stance with an industrial research case study in the commencement phase and the design stage of a particular construction project. Later a second paper on a similar topic was published by (Ren et al., 2012) in which incorporation of Building Information Modeling tools and electronic commerce platforms was discussed in a scenario of procurement of

material to refine the three aspects which are the overall procurement procedure, estimation of budget and quantity takeoff. Another research appeared on a similar topic by (Ciribini et al., 2015) in which it was discussed that how can one combine the process of bidding with Model checking tools like BIM in order to provide a compliance between the clients and bidders in a digital process. Another research was carried out in the same year (Aguiar Costa and Grilo, 2015) in which they established a BIM centered design in an electronic environment and ran a pilot case study to check the validity if their setup. Lastly in a research carried out by (He et al., 2018) industrialized construction components were removed from BIM centered models and later they were transformed in to resource description framework format and then comparable sets of information from multiple sources was also transformed in to RDF and ultimately a solution for industrialized construction platforms of e-commerce was established.

2.6 CURRENT RESEARCH GAP

Now this research the main focus is on developing countries and the study is intended to help the construction stakeholders on establishing an opinion regarding the adoption of BIM in e-procurement. Previous studies were mostly based on a single case study, and they were focusing more on 'how to adopt BIM in e-procurement' but this study would provide the answer to the question that is 'why to adopt BIM in e-procurement'. Top benefits and barriers would be highlighted using relative index and their relationship would be shown via system dynamics casual loop hence providing the future researchers with a reliable data base for literature and it will also help people from construction industry in deciding whether it is beneficial for their organizational structure.

Chapter 3

METHODOLOGY

3.1 INTRODUCTION

In order to achieve our research objectives, selecting an appropriate methodology is of utmost importance. It helps in streamlining the process of research to attain the desired goal. For this research the system dynamics approach was selected. For the research purpose multiple techniques were used which started with literature review and then the preliminary questionnaire survey was developed which helped in shortlisting the critical factors and finally the prime survey was developed on system dynamics approach. One of the most important aspects of system dynamics approach is that it makes it easier for the reader to interpret all sorts of relationships between factors which might impact one another most.

3.2 RESEARCH STRATEGY

BIM has a lot of benefits and some barriers when integrated in E-procurement which has been somewhat justified by its rate of adoption in developed nations. The system dynamics approach helps us in shortlisting the benefits and barriers of integrating BIM in E-procurement for developing countries and it helps us in identifying the most important relationships hence addressing the research gap effectively. Hence this approach directed towards the problem statement which is discussed below.

After establishing and finalizing the approach research objectives were defined. Keeping these objectives as base a detailed literature review was then carried out in which the research articles from year 2009 to year 2019 were thoroughly studied by using Google Scholar, Elsevier, Emerald Insight, American Society of Civil Engineers and multiple other libraries using the key words “BIM”, “E-procurement”, “Developing Countries” “BIM adoption in developing countries” and “Benefits and barriers of integrating BIM”. After that a total of 30 concerned

articles i.e., 3 articles per year were selected and which helped in shortlisting the benefits and barriers of integrating BIM in E-procurement in developing countries.

Since there is a shortage of literature on WHY integrate BIM in E-procurement for developing countries therefore a preliminary survey was carried out to shortlist the most significant benefits as well as barriers of BIM. The preliminary questionnaire was circulated among 50 professionals from industry out of which 30 responses were considered. This research targeted the developing countries and hence the demographics of preliminary survey were

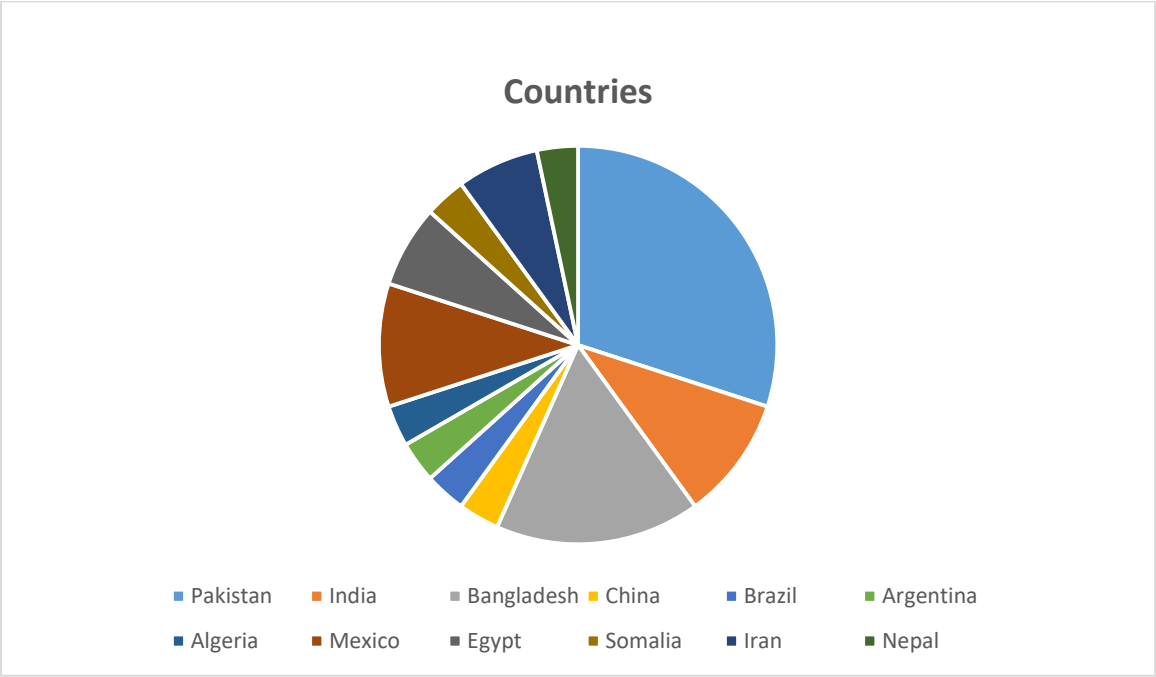

Figure 1 Respondent's Country

Figure 2 Respondent's Organization

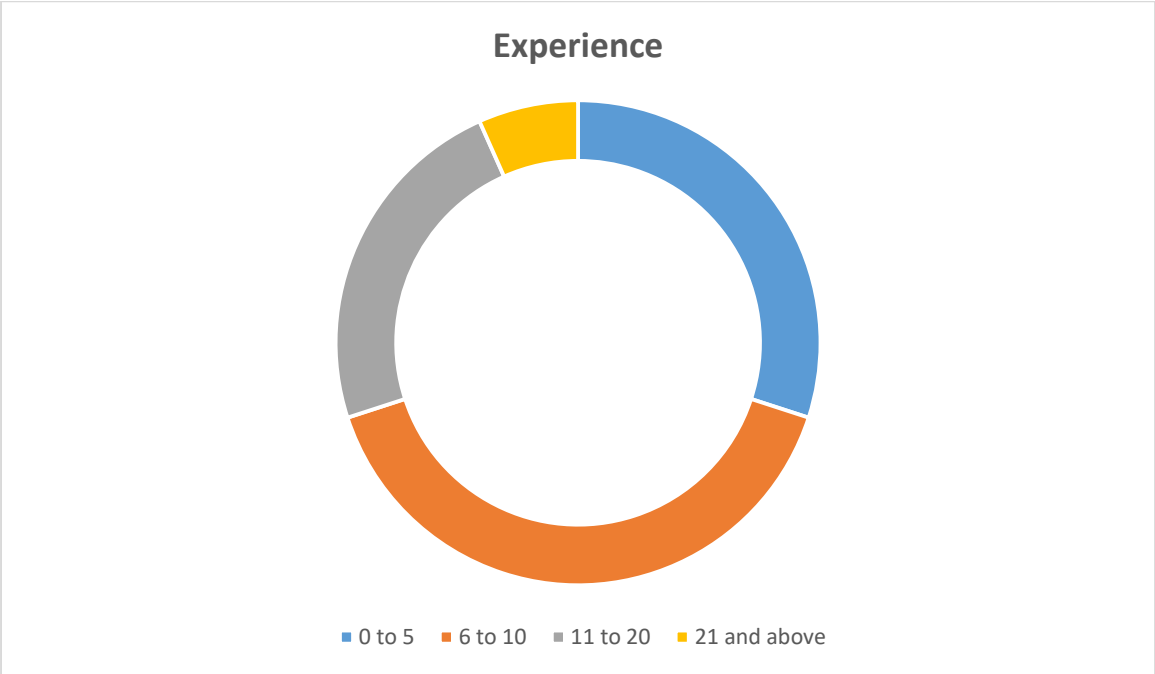

Figure 3 Respondent's Experience

A total of 43 benefits and 31 barriers were shortlisted from literature review out of which the top significant factors were to be shortlisted. For this purpose, content analysis was performed which consisted of two parts. In first part study of relevant research papers was carried out which led to identification of significant factors (benefits and barriers) hence determining the literature score. In the second part a questionnaire survey was conducted with experts from construction industry so that industrial score can be calculated. The demographics of survey have been shared in Table No. 1, 2 and 3. In the starting part i.e., literature analysis frequency and occurrence of each significant factor was observed and shortlisted whereas in part two i.e., preliminary survey a qualitative score was calculated by using a 5-point Likert Scale (1= not significant & 5= highly significant). These scores were later normalized before arranging them in a descending order.

The qualitative impact score on the scale of a high, medium, and low was assessed through content analysis. In doing so, papers were thoroughly read and critically analyzed to figure out the importance of a factor given by the article's authors as explained above. This method has been successfully applied and published

by many research groups. Furthermore, since one individual was analyzing the impact scores, the inter-rater reliability of the process, which may not be applicable due to a single expert/respondent, was 100%. Also, “total no of papers x 5” is used because it was done to harmonize the two scales – qualitative and quantitative. The qualitative scale is further treated as a semi-quantitative scale (where high=5, medium=3, and low=1). Since the qualitative scale is maximized at 5, the quantitative scale is also normalized by multiplying the no of papers with 5. This is again a published method. Furthermore, since one individual was analyzing the impact scores, the inter-rater reliability (inter-rater reliability is the degree to which two or more analysist or observers agree) of the process, which may not be applicable due to a single expert/respondent, was 100% (Irfan et al., 2020).

The literature score is later estimated utilizing Equation 1, in which 5 is the maximum impact value and frequency is the result of quantitative assessment. This was performed to harmonize the two scales – qualitative and quantitative. The qualitative scale is then further considered as a semi-quantitative scale (where high=5, medium=3, and low=1). Since the qualitative scale is maximized at 5, the quantitative scale is also normalized by multiplying the no of papers by 5. This is also a published method (Ullah et al., 2017; Ahmad et al., 2018; Ahmed et al., 2019; Irfan et al., 2020).

$$\text{Literature score calculation} = \text{Impact score} \times \left(\frac{\text{Frequency}}{\text{Total no.of Papers} \times 5}\right) \quad (1)$$

After calculation of the literature scores, for more subjective results, industry survey was conducted. The effect of the responses from literature and industry scores were combined with the help of Equation 2. The outcome from Equation 2 was used to shortlist and rank the factors based on normalized total scores and cumulative normalized total scores. IS in Equation 2 is industry score and LS is literature score. Subsequently, the factors whose cumulative total scores were less than 0.5 were finalized for the primary questionnaire survey. The results of primary survey were used to develop the Casual Loop Diagrams.

$$\text{Total normalized score} = (\text{IS} \times 0.6) + (\text{LS} \times 0.4) \quad (2)$$

After a thorough content analysis, the following significant benefits and barrier were shortlisted via preliminary survey:

Table 1 Benefits of Integrating BIM in E-procurement

Sr. No.	Significant Factors	Normalized Score	Cumulative Score	Rank
1	Enhances quality	0.09276	0.05609	1
2	Cost control	0.09276	0.10839	2
3	Increased Efficiency	0.06494	0.15335	3
4	Accessible and durable documentation	0.06494	0.19831	4
5	Better Coordination	0.06122	0.23799	5
6	Better Information Processing	0.05566	0.27544	6
7	Better Visualization	0.04453	0.31224	7
8	Decision making	0.03711	0.34607	8
9	Time saving	0.03711	0.3799	9
10	Clash detection	0.04638	0.41364	10
11	Integration of project	0.04638	0.44739	11
12	Less disputes	0.04638	0.48113	12

Table 2 Barriers of Integrating BIM in E-procurement

Sr. No.	Significant Factors	Normalized Score	Cumulative Score	Rank
1	Lack of interoperability	0.15931	0.08873	1
2	Incomplete standards	0.12255	0.16275	2
3	Resistance to change	0.06128	0.2185	3
4	Government policies	0.05882	0.27328	4
5	Uncertain ROI	0.08578	0.32635	5
6	Shortage of Professionals	0.05147	0.37819	6
7	Training (cost and time)	0.05882	0.42672	7
8	Costly software (initial cost)	0.06618	0.47194	8

Now after this phase the primary questionnaire was developed based on these shortlisted factors. Later it was circulated throughout the developing nations. A total of 100 questionnaires were circulated out of which 60 were found to be as per requirement of this research and as per (Darko et al., 2018) the minimum requirement for sampling is 30 which is sufficient to justify the research. The details of this survey are represented in following tables and graphs:

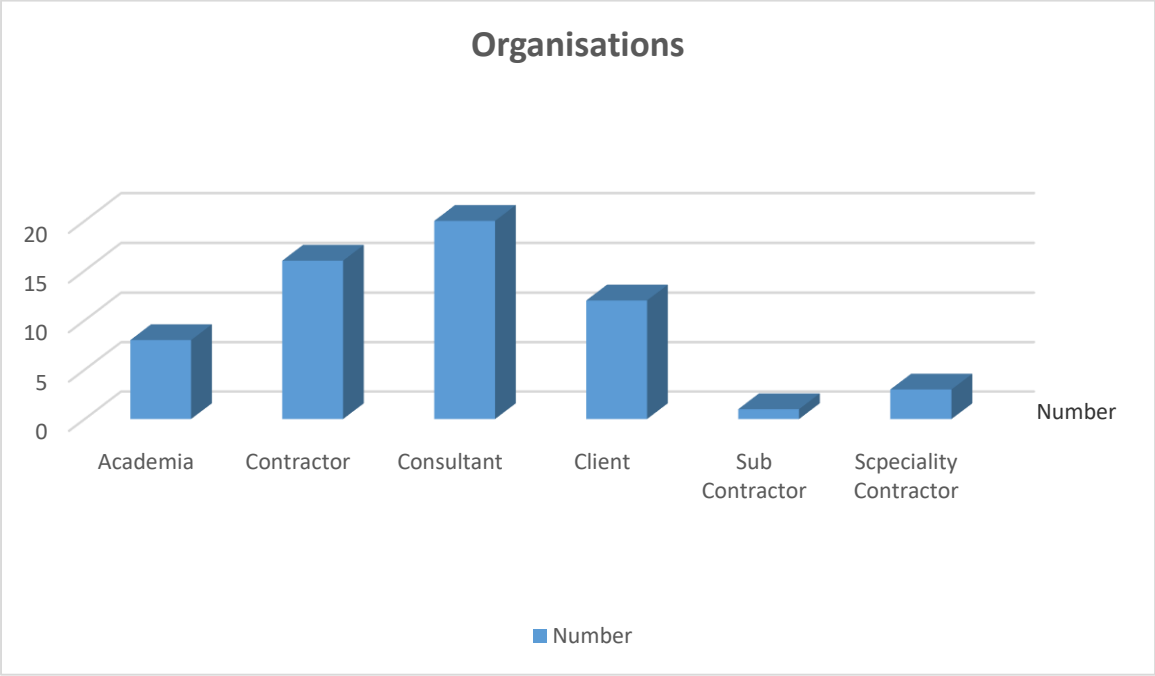

Figure 4 Distribution of organizational affiliation of respondents

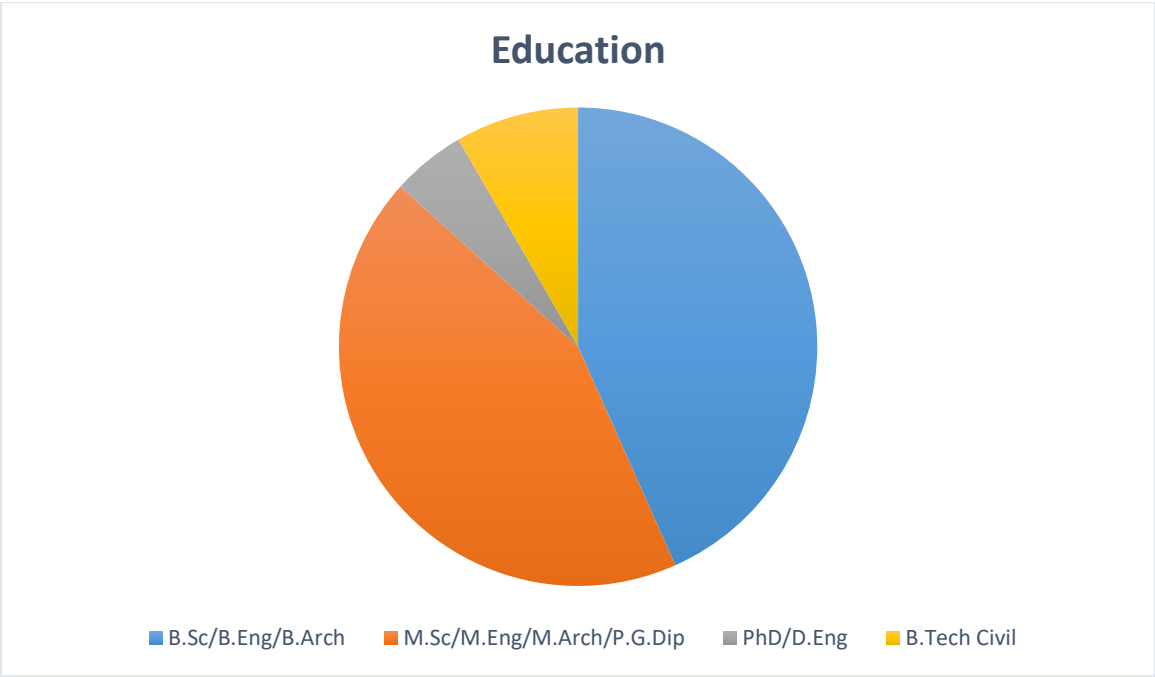

Figure 5 Education of respondents

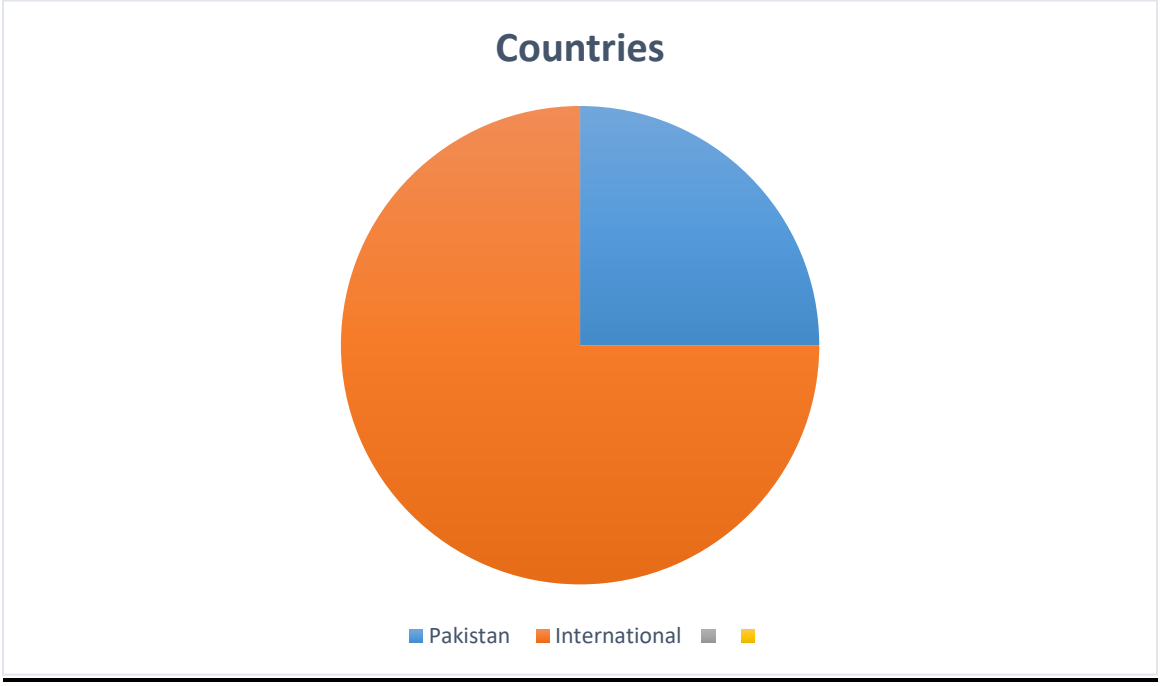

Figure 6 Country wise distribution

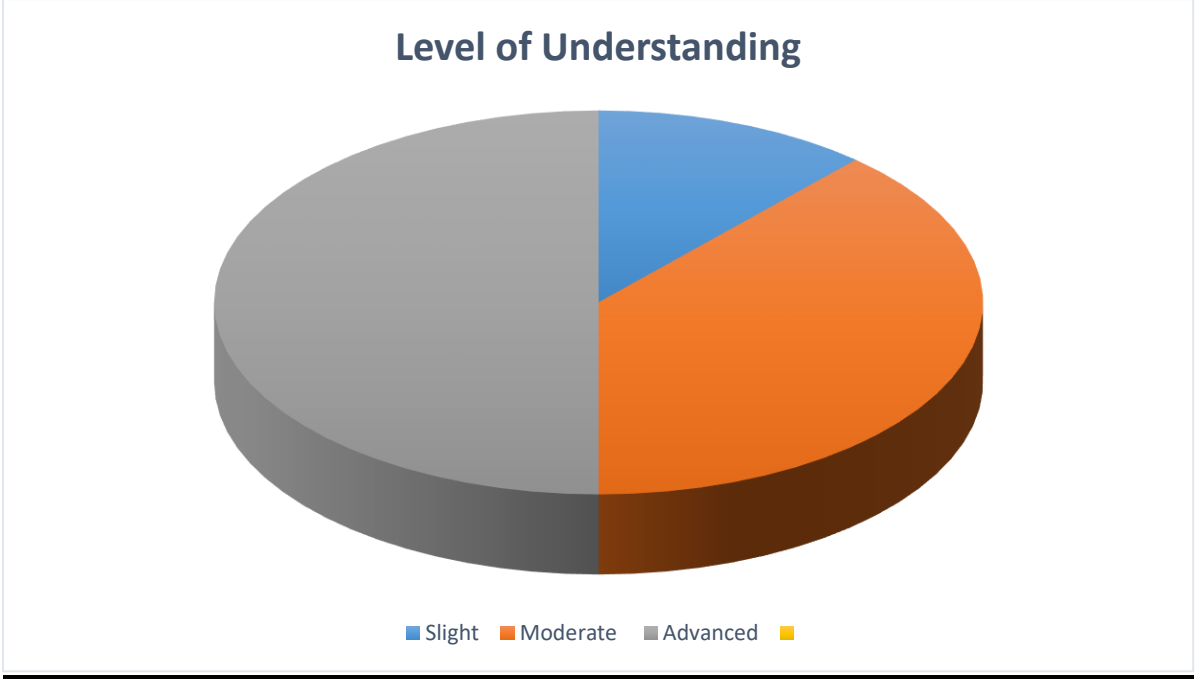

Figure 7 Level of understanding

3.3 Explanation of Charts

As per the above made graphs it can be clearly seen that most of the responses i.e., 45 responses were from developing countries other than Pakistan. The questionnaire survey targeted a specific group of people and after high scrutiny via

Social Media Platforms like LinkedIn, Facebook, Emails etc. The concerned professionals with understanding of BIM were approached for the responses and the turnout was that 30 people with high level understanding of BIM, 27 with moderate level of understanding and 03 people with slight understanding.

The experience of the respondents was that 17 professionals were from 0 to 5 years, 21 from 6 to 10, 17 from 11 to 15, 2 from 16 to 20 and from 21 and above. The reason for low to medium respondents was that BIM is a comparatively new technology hence people are still reluctant to adopt it and have many doubts about its adoption in their business structures.

As far as the organizations are concerned the maximum number of professionals were from consultant that is 20 then 16 from contractors, 12 from client,8 from academia, 1 sub-contractor and 3 specialty contractors. The education level of the respondents was 26 were B.Sc./B.Eng./B.Arch., 26 from MSc/M.Eng/M.Arch/P.G.Dip, 3 from PhD/D.Eng. and 5 from B. Tech Civil. Hence the respondents were chosen carefully as per requirements of this research.

3.4 SYSTEMS THINKING APPROACH

In this stage the significant shortlisted factors were used to develop a primary questionnaire survey which was then used to develop a casual loop diagram. The data collected was assessed and used to develop a two separate diagrams for benefits and barriers. The diagram representing benefits consisted of three loops whereas the one representing the barriers had 2 loops. Both these loops were used to represent the interdependencies of most significant factors. The software VENSIM was used to represent these links between factors. Arrow heads are used to represent different links and connect different variables effectively. A negative polarity is used to represent indirect relation between two variables whereas the positive sign shows direct relation. This diagram provided the supportive results to justify the research objectives further. The diagram is made on modeler's perception (Dhirasasna and Sahin, 2019) which in this case was made based on the responses received.

Chapter 4

RESULTS AND DISCUSSIONS

A separate Casual Loop Diagram was made each for benefits and barriers of including BIM in E-procurement. The explanation of the loops is as follows

4.1 BENEFITS

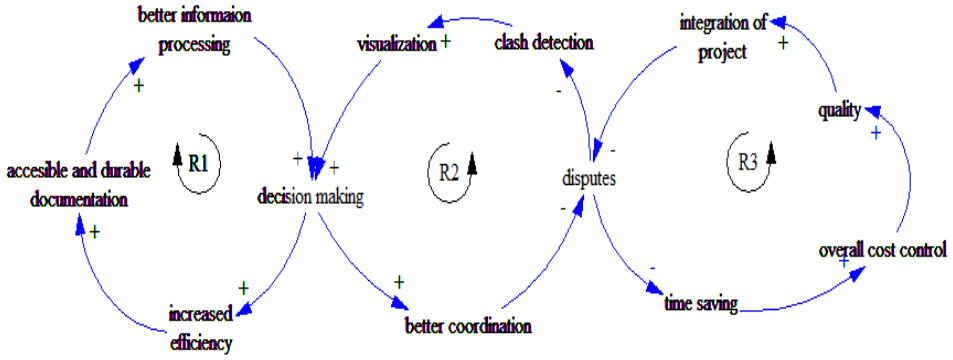

Figure 8 CLD for benefits

The benefits consisted of three loops and the two most significant factors were decision making and disputes which made the base of our loops which are explained as follows

i. Loop Number 01(R1)

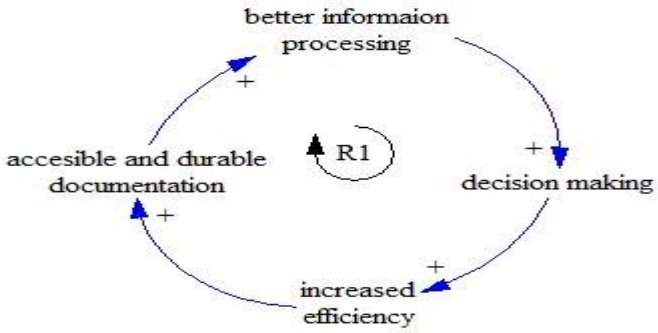

Figure 9 R1 loop

The first loop R1 is a reinforcing loop. It consists of four significant factors namely decision making, increased in efficiency, accessible and durable documentation and better information processing.

The decision making is one of the most critical factors of BIM adoption in E-procurement which helps us in choosing the right way to approach a project. The first relation was that increased decision making helps in increase of efficiency in project. The set of software BIM provides include each and every step from 3-D drawings to sustainable solutions. Hence BIM provides a thorough data base and authentic knowledge in detail. Based on this knowledge the project process becomes more effective and efficient making BIM one of the most key software for future construction industry.

The second relationship of this loop was that increased in efficiency increases the accessible and durable documentation. A BIM integrated E-procurement project has everything stored online which makes it highly accessible and safer as compared to paperwork. An efficient project has streamlined activities and it helps in keeping a proper and detailed data base which in turn keeps the documents safe and readily available.

The third relationship was that the accessible and durable documentation leads to increase in better information processing which is understandable for the reader. If a readily available documentation system is being adopted, then it will help the project stakeholders in processing the information in a proper way.

The first loop closes at the relationship that better information processing leads to better decision making. An informative decision is much better and efficient as compared to a decision with lesser available data. Whereas if the information is properly processed then it becomes easier to take positive decisions with good impact on project lifecycle.

ii. Loop Number 02(R2)

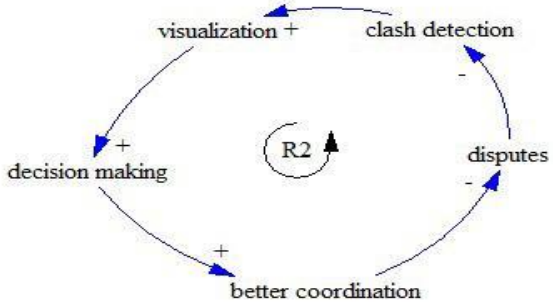

Figure 10 R2 loop

The second loop R2 is a balancing loop. It consists of four significant factors namely decision making, better coordination, disputes, clash detection and visualization.

The second loop starts with better BIM based smart decision making leading to the increase in coordination of a project which is because sound decisions make the project well-coordinated as there are not many conflicts and information processing is strong which makes the running of a project smooth.

The second relationship is that better coordination in a project leads to lesser disputes. When a project is well coordinated it runs smoothly which in turn causes a decrease in disputes. All the parties are satisfied by well managed situations where any conflict is addressed at time dues to proper coordination which leads to cost and time saving and lesser litigations.

Disputes are then dependent on clash detection, the decrease in disputes leads to increase in clash detection or we can say better clash detection. BIM provides us a such software which can be used for clash detection. Clash detection in earlier stages can help us reduce the disputes. In human made drawings and estimate there is a greater chance for error whereas the software is able to detect minute and details and alert the stakeholders about these conflicts helping avoid these conflicts.

The increase in clash detection leads to better visualization. Visualization is one of the most important features of BIM. In E-procurement integrated with BIM if there is proper communication between client and contractor many costs and time over runs can be avoided with certainty. Visualization helps us see our finished

project in 3-D which helps the stakeholders to properly communicate with one another about what they want exactly. Hence the changes can be made in early stages and these images are more understandable for laymen as compared with 2-D drawings which often cause confusion about the desired final product.

The final relation of this loop is between visualization and decision making. As it has been already explained in the previous relationship that visualization removes many confusions for the client and their desires. Hence a good visualization software certainly helps in removing any doubts about the decision making. The decision making depends on what a client desires, and these desires become clear only when the final product is visible from foundations to finished form. BIM integrated in e-procurement fulfils this purpose very effectively.

iii. Loop Number 03(R3)

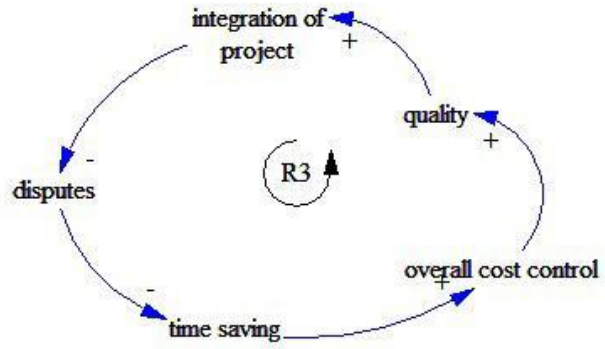

Figure 11 R3 loop

The next relationship is that time control leads to overall cost control. When we are utilizing the time effectively it means that all the resources are being managed efficiently and the cost is being saved. BIM and e-procurement is helping us control cost by multiple benefits and it is helping us save time as it is a well-known fact that saving time saves cost and vice versa.

Now the next relation shows us that the overall cost control is leading to a positive impact on quality of project. To understand this, we need to carefully study the effects of BIM on cost control i.e., how BIM and e–procurement achieve their

cost efficiency. BIM software can do anything like 3-D models, estimation, planning, energy analysis etc. these functions help us in avoiding any conflicts later on as the structure is well planned and well managed. Hence this leads to cost savings because the design and management are perfect which then leads to increase in quality.
When the quality of ac certain activity increases then it leads proper integration of project. All the activities are aligned, and the tasks are being performed effectively. All the stakeholders are involved in this e-procurement platform. The data and changes are being made in a centralized system using BIM and E-procurement methods. Hence making it possible to achieve a greater sense of integration throughout the process of procurement as well as construction.

And finally, the integration of project leads to lesser conflicts. This point was pretty much agreed upon by the respondents because integrated projects are well managed projects. All stakeholders are in constant touch and giving their opinions on time and the response time due to e-procurement systems and BIM platform is also quick hence making the communication much better. Timely communication is the key to avoid conflicts.

4.2 BARRIERS

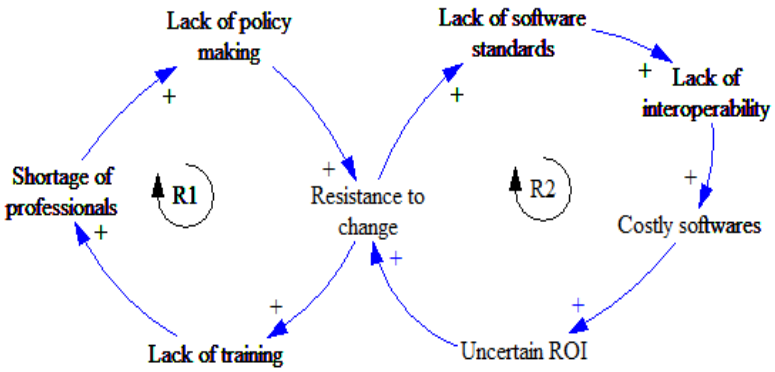

Figure 12 CLD for barriers

As far as barriers of integrating BIM in E-procurement are concerned, two loops were formed which were both reinforcing loops. The description of loops is as follows

i. Loop Number 1(R1)

Figure 13 R1 loop

The first loop was a reinforcing loop, and it starts with the resistance to change. Resistance to change leads to lack of trainings (cost and time). When there are professionals who do not want to be involved in adopting new technologies and are not flexible enough to accept the change specially in developing countries, people are reluctant to invest in new technologies which might prove to be highly useful. Therefore, they avoid wasting resources in training professionals in these new technologies like BIM and e-procurement.

The next relationship being that lack of trainings leads to shortage of qualified professionals. This is pretty much obvious that when people are reluctant to invest in trainings of BIM and E-procurement then there will be a great shortfall of professionals with sound knowledge about these innovative technologies. Which in turn would slow down the adoption rate and cause more doubt in minds of professionals.

The next relationship being that the shortage of professionals will lead to lack of policy making. When there are not enough technical people in construction market of the developing countries then there is no chance that policies are made with ease for adoption of BIM. As mentioned in the literature review, some authors have quoted that in developed nations like UK, BIM adoption is a serious issue and there are government level policies for its adoption. Unfortunately, this is not the case in developing countries and as per responses received more professionals must be trained on urgent basis to make BIM adoption easier.

The loop closes on the relation that this lack of policy making then leads to resistance in change. When there is lack of support from law and professionals then these things lead to negativity and people avoid taking unnecessary risks. Government has a high role in promoting these innovative technologies. If government can provide proper policies and rules for its adoption and make things easier for construction sector, then automatically BIM adoption in E-procurement will increase. Government policies must encourage the construction stakeholders to adopt BIM in their organizational structure.

ii. Loop Number 2(R2)

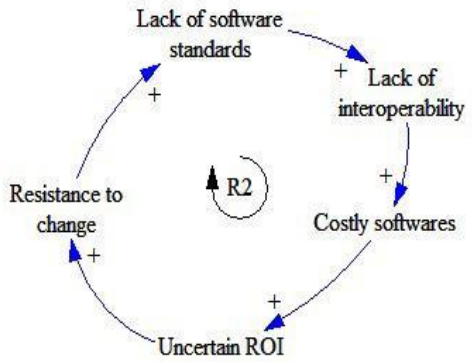

Figure 14 R2 loop

The second loop for barriers is also a reinforcing loop. The loop starts with resistance to change being the main factor which then leads to lack of software standards. When professionals are not willing to adopt BIM in their organization or train professionals then there isn't much development with regards to software which in turn will lead to a lack of software standards.

Then the lack of software standards causes lack of interoperability. When there are no proper standards for software development and software adoption, different organizations develop or use a certain set of software as per their need. When this data is to be shared among other organizations or countries it is not compatible. And when the data is not compatible it causes problems of interoperability. Hence making it a discouraging factor.

When there is lack of interoperability then the cost of software would be defined by individuals. As mentioned before there are no proper standards in international market so the market can be easily exploited by development houses as per their needs. Hence this makes the price of software as per the need of its developer making the controlling of price very difficult.

When the price of software is not controlled internationally by some standards then we can never calculate a certain return of investment. The risks of adoption of BIM become high hence discouraging the construction stakeholders. If there are clear cut instructions and the price is controlled by a central system, then accurate ROI can be calculated hence making it easier for the professionals to calculate a certain risk factor associated with this modern technique as per their business structure.

Finally, an uncertain ROI leads to resistance in change. Due to uncertain ROI the adoption of BIM is not as per desired rate. Due to this there is no clear way that proper working can be done as to what would be the perfect return of investment. This is a reasonably huge drawback for new adopters of BIM in developing countries. The risk element for adoption of BIM in E-procurement is very high because it’s not clear. Hence uncertain ROI is a very discouraging factor which ultimately leads to resistance to change.

Chapter 5

CONCLUSION

This research serves its purpose in providing a complete and thorough data base for a construction stakeholder who wants to adopt BIM in E-procurement. Most significant barriers and benefits of integrating BIM in E-procurement have been shortlisted and their complexities and dependencies have been established. The achieved results clearly show that both benefits and barriers have their own significance in integration of BIM in E-procurement. However, the benefits overweigh the barriers and have a more positive effect. Also, the number of shortlisted benefits is greater as compared to the barriers. The barriers can be easily addressed by spreading awareness regarding BIM as the majority of barriers depend upon resistance to change. If adequate measures are taken at government level and an international standard is maintained, then it is possible to extract maximum benefit from these technologies. If the developing countries want to be at par with developed world BIM and E-procurement is the definite way forward.

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