

Studying the Interrelationship amongst Various Barriers in Adoption of BIM in Developing Countries using ISM Methodology

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ABSTRACT

Building Information Modelling is an emerging area of technology which deals with the process of creating and using design models for design, construction and operation of projects. However, it is still in its nascent stage in developing countries and suffers due to various barriers which hinder its development and adoption. Present research work deals with recognizing such barriers in adoption of BIM in developing countries like India and further studying the inter-relationships amongst them using ISM methodology.

Keywords

Interpretive Structural Modeling Methodology (ISM); Building Information Modeling (BIM); Architectural Engineering and Construction (AEC) industry

1. INTRODUCTION

Building Information Modelling (BIM) is an emerging area of technology that is set to transform the way buildings are designed, constructed and ultimately managed. McGraw Hill regularly publishes smart market reports on Building Information Modelling which provides regular updates focused on benchmarking the adoption and value of BIM. "The Business Value of BIM" Report (2009)¹ defines BIM as, "The process of creating and using digital models for design, construction and/or operations of projects." The level and acceptance of BIM differs from country to country. For example, in US it has been made mandatory to large extent while in developing countries like India, despite being new, it is a highly acceptable concept. In a survey report, BIM is not only approachable for architectural and construction management firms who have a financial incentive to use it on their project but also expanded its domain to those who are rigorously involved in designing for Hi-Tech facilities which includes labs, healthcare, higher education as well as government facilities.

Despite its popularity at one end, it also faces a series of impediments. For example, a two phase survey based research is conducted by [1] to identify the drivers and barriers to BIM implementation and its fair adoption in India. Based on the interaction with industry professionals, it is found that use and implementation of BIM is still in its nascent stage despite displaying an upward trend in recent years. A qualitative survey is used by [2] to identify the various factors affecting the productivity of construction projects in Iran. In a similar research, [3] identify various barriers to implementation of BIM in scheduling and planning phase in Iran. Next section explains some of the common barriers which BIM normally faces while being adopted by AEC firms in developing countries. Presents research identifies these barriers and apply Interpretive Structural

Modelling methodology (ISM) to recognize the interrelationship amongst these barriers.

The paper is arranged as follows. Section 2 presents the review of literature with respect to BIM adoption. Section 3 presents the ISM methodology and development of ISM model.

2. LITERATURE REVIEW ON VARIOUS BARRIERS TO BIM IN DEVELOPING COUNTRIES

A survey based research was conducted by [4] to see the barriers with respect to adoption of BIM in Jordanian industry. Similarly, [5] investigate the barriers to adoption of building information modelling in construction projects of Iraq through a quantitative approach by conducting a questionnaire targeting professional in the field of construction projects in the public and private sectors and found that there are three basic barriers i.e. weakness of government efforts, poor knowledge about benefits of BIM and resistance to change. [6] used the questionnaire survey and applied data visualization methods to collect data from 44 industry practitioners active on construction projects in Iran found that lack of knowledge, unavailability of infrastructure, lack of support from managers, lack of practical standards are some of the common barriers. Further, internet search through google search engines for various keywords such as barriers to BIM, BIM implementation etc. have been searched over internet to get relevant abstracts of research papers or full research papers based on the topic. In order to broaden the timeline of the survey, the same and/or similar keywords have been utilized for performing a further search through the web-based GoogleScholarTM tool, Mendeley software and Research Gate engine. The following table cumulates the various barrier studied by various researchers with respect to developing countries.

Table 1. Common barriers to BIM in developing countries

	Barrier	Author and Publication year
1.	Lack of knowledge and awareness (LKA)	[7] , [5], [4] , [6]
2.	Lack of support from policy makers not requesting (LS)	[7] , [8] , [4]
3.	Unavailability of standards and guidelines (USG)	[7] , [9]
4.	Initial costs / costs of implementing BIM (IC)	[4] , [8] , [10]
5.	Training and learning issues (TLI)	[8] , [9] , [11]
6.	Incompatibility and interoperability problems (IIP)	[10] , [11]
7.	Lack of demand(LD)	[4] , [9] , [10]
8.	Lack of skilled personnel (LSP)	[9] , [10]
9.	Resistance to change (RC)	[4] , [5] , [8] , [10]
10.	Weakness of government efforts (WGE)	[5]

3. ISM METHODOLOGY

Suggested by [12] , the technique has been used widely to develop a map of the relationships between the many elements in the form of a hierarchy graph. Group's judgement decides whether and how the items are related.

ISM works with the following steps:

1. Identification of elements, which are relevant to the decision maker's problems and issues.
2. Establishing the contextual relationship between elements and with respect to which pairs of elements will be examine.
3. A structural self-interaction matrix (SSIM) may be developed between two variables *i.e.* *i* and *j*. It establishes the "Lead to" relationship between criteria. Four symbols *viz.* V, A , X & O are used for establishing the relationships.
4. SSIM may be further used to develop an initial reachability matrix which has all values in binary form. Rule of transitivity is usually checked at this stage . After removing the transitivity, final reachability matrix will form.
5. Afterwards, the reachability set and antecedent set for each criterion and for each element can be obtained from the final reachability matrix .
6. After that a level partition matrix can be obtained based on establishing the precedence relationships and arranging the elements in a topological order.
7. A Mic-Mac analysis can be performed which categorize the variables as per the driving and dependence power in to autonomous, dependent, driver and linkage category.

8. Finally a diagram can be obtained.

4. Development of ISM model

In this section, ISM model is developed for studying the interrelationships amongst the various barriers to adoption of BIM in India. Ten important criteria are considered viz. Lack of knowledge and awareness (LKA) , Lack of support from policy makers not requesting (LS) , Unavailability of standards and guidelines (USG) , Initial costs / costs of implementing BIM (IC) , Training and learning issues (TLI) , Incompatibility and interoperability problems (IIP) , Lack of demand(LD) , Lack of skilled personnel (LSP) , Resistance to change (RC) , Weakness of government efforts (WGE).

4.1 Construction of Structural Self-Interaction Matrix (SSIM)

This matrix gives the pair-wise relationship between two variables *i.e.* *i* and *j* based on VAXO.

Table 2. Structural self – interaction matrix

Barriers	1	2	3	4	5	6	7	8	9	10
	LK A	L S	US G	HI C	T LI	II P	L D	L SP	R C	W GE
LKA		V	A	V	V	V	V	V	V	V
LS			A	A	A	V	V	V	V	V
USG				V	V	V	V	V	V	X
HIC					A	A	A	A	A	A
TLI						V	V	V	V	A
IIP							V	V	V	A
LD								V	V	A
LSP									V	A
RC										A
WGE										

4.2 Construction of Initial reachability matrix

The SSIM has been converted in to a binary matrix called the initial reachability matrix by substituting V, A, X, O by 1 or 0 as per the case. After incorporating the transitivity, the final reachability matrix is shown below in the table III.

Table 3. Initial reachability Matrix

Barriers	1	2	3	4	5	6	7	8	9	10
	LK A	L S	US G	HI C	T LI	II P	L D	L SP	R C	W GE
LKA	1	1	0	1	1	1	1	1	1	1
LS	0	1	0	0	0	1	1	1	1	1
USG	1	1	1	1	1	1	1	1	1	1
HIC	0	1	0	0	0	0	0	0	0	0
TLI	0	1	0	0	1	1	1	1	1	0
IIP	0	0	0	0	1	0	1	1	1	0
LD	0	0	0	0	1	0	1	1	1	0
LSP	0	0	0	0	1	0	0	1	1	0
RC	0	0	0	0	1	0	0	0	1	0
WGE	0	0	1	0	1	1	1	1	1	1

4.3 Construction of final reachability matrix

After removing the transitivity, final reachability matrix is obtained along with the driving power as well as dependence power. Based on driving power and dependencies, these factors may be classified in to four groups of autonomous, dependent, linkage and independent (driver) factors.

Table 4. Final reachability matrix

	Barriers	1	2	3	4	5	6	7	8	9	10	D. P
		L K A	L S	U S G	I C	T L I	I I P	L D	L S P	R C	W G E	
1.	LKA	1	1	0	1	1	1	1	1	1	1	9
2.	LS	0	1	0	0	1	1	1	1	1	1	7
3.	USG	1	1	1	1	1	1	1	1	1	1	10
4.	IC	0	1	0	1	0	1	1	1	1	1	7
5.	TLI	0	1	0	0	1	1	1	1	1	0	6
6.	IIP	0	0	0	0	1	1	1	1	1	0	5
7.	LD	0	0	0	0	1	0	1	1	1	0	4
8.	LSP	0	0	0	0	1	0	0	1	1	0	3
9.	RC	0	0	0	0	1	0	0	0	1	0	2
10	WGE	0	1	1	0	1	1	1	1	1	1	8
	De .P.	2	6	2	3	9	7	8	9	10	5	

4.4 Level Partition

From the final reachability matrix, reachability and final antecedent set for each factor are found. The element for which the reachability and intersection sets are same are the top-level element in the ISM hierarchy. After the identification of top level element, it is separated out from the other elements and the process continues for next level of elements. Reachability set, antecedent set, intersection set along with different level for elements have been shown below in table V to table XI.

Table 5. Iteration I

S.No.	Reachability set	Antecedent set	Intersection set	Iteration / Levels
1.	9	1,2,3,4,5,6,7,8,9,10	9	I
2.	5,8,9	1,2,3,5,6,7,8,9,10	5,8,9	
3.	5,7,8	1,2,3,5,6,7,10	5,7	
4.	6,7,8,9	1,2,3,4,5,6,10	6	
5.	6,7,2,10	1,2,3,4,10	2,10	
6.	2,10,1	1,3	1	
7.	2,10,3	3,10	3	
8.	2,10, 4	1,3,4	4	

9.	1,2,3,4,5,6,7,8,9,10	3	3	
10.	2,3,5,6,7,8,9,10	3,10	3,10	
11.	2,4,5,6,7,8,9,10	1,4	4	

Table 6. Iteration II

S.N o.	Reachability set	Antecedent set	Intersection set	Iteration/ Levels
2.	5,8	1,2,3,5,6,7,8,10	5,8	II
3.	5,7,8	1,2,3,5,6,7,10	5,7	
4.	6,7,8	1,2,3,4,5,6,10	6	
5.	6,7,2,10	1,2,3,4,10	2,10	
6.	2,10,1	1,3	1	
7.	2,10,3	3,10	3	
8.	2,10, 4	1,3,4	4	
9.	1,2,3,4,5,6,7,8,10	3	3	
10.	2,3,5,6,7,8,10	3,10	3,10	
11.	2,4,5,6,7,8,10	1,4	4	

Table 7. Iteration III

S.No.	Reachability set	Antecedent set	Intersection set	Iteration/ Levels
3.	7	1,2,3,6,7,10	7	III
4.	6,7	1,2,3,4,6,10	6	
5.	6,7,2,10	1,2,3,4,10	2,10	
6.	2,10,1	1,3	1	
7.	2,10,3	3,10	3	
8.	2,10, 4	1,3,4	4	
9.	1,2,3,4,6,7,10	3	3	
10.	2,3,6,7,10	3,10	3,10	
11.	2,4,6,7,10	1,4	4	

Table 8. Iteration IV

S.No.	Reachability set	Antecedent set	Intersection set	Iteration / Levels
4.	6	1,2,3,4,6,10	6	IV
5.	6,2,10	1,2,3,4,10	2,10	
6.	2,10,1	1,3	1	
7.	2,10,3	3,10	3	
8.	2,10, 4	1,3,4	4	
9.	1,2,3,4,6,10	3	3	
10.	2,3,6,10	3,10	3,10	
11.	2,4,6,10	1,4	4	

Table 9. Iteration V

S.No.	Reachability set	Antecedent set	Intersection set	Iteration/ Levels
5.	2,10	1,2,3,4,10	2,10	V
6.	2,10,1	1,3	1	
7.	2,10,3	3,10	3	
8.	2,10, 4	1,3,4	4	
9.	1,2,3,4,10	3	3	
10.	2,3,10	3,10	3,10	
11.	2,4,10	1,4	4	

Table 10. Iteration VI

S.No .	Reachability set	Antecedent set	Intersection set	Iteration / Levels
6.	1	1,3	1	VI
7.	3	3	3	
8.	4	1,3,4	4	
9.	1,3,4	3	3	
10.	3	3	3	
11.	4	1,4	4	

Table 11. Iteration VII

S.No .	Reachability set	Antecedent set	Intersection set	Iteration / Levels
6.	1	1,3	1	VII
7.	3	3	3	
9.	1,3	3	3	
10.	3	3	3	

Table 12. Iteration VIII

S.No.	Reachability set	Antecedent set	Intersection set	Iteration/ Levels
7.	3	3	3	VIII
9.	3	3	3	
10.	3	3	3	

4.5 Classification of factors

The critical success factors described earlier are classified in to four clusters viz. autonomous factor, dependent factors, linkage factors and independent factors (mentioned in Table 13 below). As it can be seen that there is no autonomous criteria . Criteria USG , LK , RGE and IC are drivers . Criteria such as LS and TLI are linkage criteria whereas IIP , LD , LSP and RC are dependent criteria.

Table 13 . Driving Power & Dominance Diagram

D R I V I N G P O W E R	10		US G								
	9		LK A						Linkage		
	8		Drivers			W G E					
	7			I C			L S				
	6								TL I		
	5							H P			
	4		Autonomous					L D	Depende nt		
	3								LS P		
	2									R C	
	1										
		1	2	3	4	5	6	7	8	9	10

Dependence

4.6 ISM The Diagram

The diagram presenting the hierarchy of the various barriers is shown in figure below

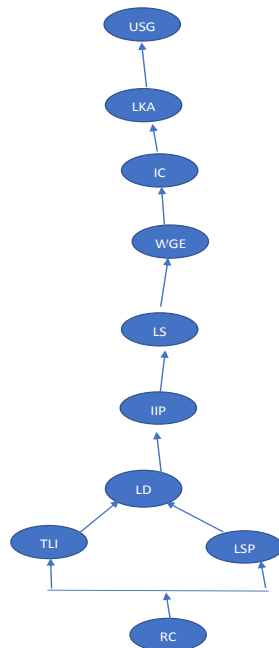


Figure 4.5 : Diagram for barriers to BIM in developing countries

5. CONCLUSIONS

This study focuses on presenting the inter-relationship amongst the various barriers to implementation of BIM in developing countries with the help of Interpretive Structural Modeling methodology.

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