

Critical ICT-Inhibiting Factors on IBS Production Management Processes in the Malaysia Construction Industry

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Abstract. Industrialized Building System (IBS) is one of the approaches that had been introduced as an alternative to conventional building method where it becomes the new strategy of enhancing the sustainable construction in current industries while spearheading a huge advancement of benefits with green constructions into the existing industries. The IBS approach is actively promoted through several strategies and incentives as an alternative to conventional building methods. Extensive uptakes of modern Information Communication Technology (ICT) applications are able to support the different IBS processes for effective production. However, it is argued that ICT uptake at the organisational level is still in its infancy. This raises the importance to identify critical inhibitors which are inhibiting the effective uptake of ICT in the IBS production management process. Critical inhibitors to ICT uptake were identified through questionnaire survey with the IBS industry stakeholders. The mean index and critical t-values are generated with the use of the quantitative tool, Statistical Package for Social Sciences (SPSS). The top ten priority ranked inhibitors reflect the Cost, People and Process elements to ICT uptake. High costs in acquiring the technologies and resistance to change were some main concerns from the findings.

1. Introduction

Industrialised Building System (IBS) is defined as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site works [1]. The benefits of IBS, also called offsite construction have been widely studied and include reductions in time, defects, health and safety risks, environmental impact, and whole-life cost with a consequent increase in predictability, productivity, whole-life performance and profitability [2, 3, 4, 5, 6].

Simplifying the manufacturing process and making prompt repairs are key priorities of the precast industry. The nature of precast products offers the precast industry a shortened working period and reduces cost competitiveness [7]. Similarity to an advanced and more complex construction technology for instance the modular houses and mass-customisation can only be developed and produced using an extensive and interwoven IT tools [8]. Fewer disputes and better coordination are expected as a consequence of increasing use of ICT solutions.

Appropriate implementation of Information Communication Technology (ICT) will facilitate more effective and *productive* materials management processes. ICT can be a vital and reliable tool to offsite implementation and to integrate design in offsite project. Thus, widespread use of modern Information



Technology (IT) tools will support the different IBS processes by enabling more accurate documents and good conditions for an effective production. Besides that, errors are discovered early and problems in the manufacturing and assembly phases can be avoided [9].

However, [10] indicated low IT adoption and limited technology availability to have generally discouraged Industrialized Building System (IBS) in Malaysia.

2. ICT Uptake in IBS Management Process

More sophisticated solutions of ICT based technologies in IBS processes are emerging, such as wireless communication, bar-coding and Radio Frequency Identification (RFID) for tagging technologies. Today, the European prefabrication industry uses platform-based and system-based mass customisation – especially for the provision of wall and ceiling elements. An almost complete digital chain – using computer integrated manufacturing (CIM) from the very early planning stage through to manufacturing – is state of the art within the timber construction in Switzerland as well, [11]. A report by Construction Research Institute of Malaysia [12] pointed technology as a main support to impact IBS in the future. Findings showed that BIM, a 3D modelling software, is able to resolve many technical difficulties in the precast construction processes. For instance, with the adoption of BIM in the precast concrete industry, engineering cost are reduced, cost of rework due to errors are tremendously reduced, [13]. In addition, it was stated that further improvement of manufacturing technology is a strong solution to tackle the weakness and threats of IBS adoption.

However, the current practice of ICT uptake in the tracking of IBS components in Malaysia is rather uncommon. There is a lack of effective logistics management in the Malaysian construction industry, where technology intervention plays a very critical role [14]. IBS production process needs a sustained improvement and management in order to ensure proper components are developed and handed over at the right time, in the proper order and without damages.

Recent findings on ICT uptake in IBS management process indicate that most of the problems or issues faced were normally solved with human solution or by technical menial methods [15]. ICT applications were not regarded as the best practices in overcoming the IBS components management problems. Thus, this paper aims to identify critical inhibitors which are inhibiting the effective uptake of ICT in the IBS production management process in Malaysia construction industry.

3. Shortcomings of ICT Implementation

Some authors stated [16], that ICT-enabled collaborative working is a prime tool for driving a revolution in construction as it has already worked in the aerospace, shipbuilding, automotive and process industries, although its use is still evolving within construction, which also means the lack of ICT implementation in materials management. He also suggested that despite much R&D done in this area; we have yet to see widespread benefit from its use. This may be due to the fact that 96% of clients use email to exchange project information, whilst only 13% of clients use other ICT based collaboration tools to manage projects [17], [18].

Driving forces behind ICT usage are varied, as well. In Asia, owners (governments) are more proactive in introducing ICT in project management while in other regions such as North America, the United Kingdom and Australia, drive is usually self- motivated. It is also found that there is a general hesitance towards the use of ICT.

Table 1. Core elements to the differing usage of technologies [19]

CORE ELEMENTS	RANKING OF COUNTRIES ACCORDING TO % AMOUNT OF INFORMATION OBTAINED					
	Rank 1		Rank 2		Rank 3	
	Country	%	Country	%	Country	%
Characteristics	Japan	45.0	Australia	35.8	Malaysia	19.2
Labour	Australia	42.3	Japan	30.6	Malaysia	27.1
Market Share	Malaysia	36.5	Australia	34.5	Japan	29.0
Policies	Malaysia	39.7	Japan	30.5	Australia	29.8
Workers' Union	Australia	48.9	Japan	26.9	Malaysia	24.2
Culture	Japan	36.0	Malaysia	35.7	Australia	28.3

From the findings in **Table 1**, the level of ICT acceptance globally is in a competitive condition, whereas Malaysia is potentially picking up. In relation to that, Malaysia's ICT sector faces funding problems especially at the seed or pioneer level. Implementation of ICT could not further take place as local venture capital firms could not afford the high risk. They instead tend to focus on the need to be profitable within 12 months in order to gain back their seed money in a short period, [20]. Others authors [21] pointed out a few problems that cause the limited benefits of software packages in the construction project level. For instance, lack of software integration [22, 23]; lack of a standardized platform for information exchange [24] and lack of standard processes for construction project management [25].

The shortcomings of ICT uptake in the construction industry bring forth a need to review possible inhibitor elements inhibiting ICT uptake in the industry. Several research publications [26-30] indicate that people, process and technology are the three key elements that need to be considered for successful uptake of technologies. Together, these three elements create business value [30]. However, he further states that "the people, processes, and technology need a leader", just as "an orchestra needs a conductor". The same analogy can be applied to the adoption and uptake of new and innovative technologies within construction companies. The "conductor" in this case is the policy making. To successfully implement and use any new technology it requires policy makers to plan and drive policies and strategies. Policies are "written principles or rules to guide decision-making" [31]. All four elements are considered important for an organisation to effectively employ ICT. A company cannot employ ICT if it satisfies the requirements of just one element and not the others. Hence, all four elements - policy, process, people and technology - need to work hand-in-hand and symbiotically (refer **Figure 1**).

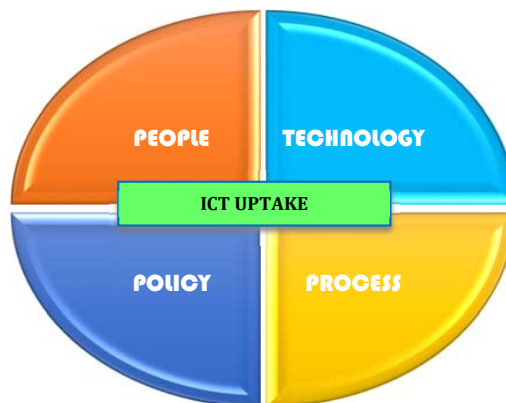


Figure 1. Driver elements for ICT uptake

Taking this into account the ICT uptake model, which has been structured for an organization must have to employ ICT:

- *Policy Makers* that believe in the technology and take strategic measures to drive its adoption, uptake and usage in order to mobilise the industry to implement and benefit from it;
- *Processes* that enable and support the successful adoption of the technology;
- *People* who have adequate skills, understanding of, and belief in, the technology; and finally
- *Technology* applications and infrastructures which are adequate.

The four elements to ICT uptake will form the theoretical basis to identify critical inhibitors to ICT employment on IBS management process.

4. Methodology

This paper applies the method of purposive sampling, where the samples are selected based on the knowledge of a population and the purpose of the study [32]. This is a form of non-probability sampling in which it includes specialist knowledge of the research issue. Apart from the government IBS policy makers, IBS precast manufacturers are the selected respondents which form the biggest population among the other four IBS systems (e.g. IBS formwork, IBS steel systems) in Malaysia.

Out of 41 questionnaires sent, a total of 31 were returned, giving a 76% high response rate from the construction industry, which in general stands at only 25% to 35% [33]. The questionnaire was sent to 33 organizations from the listed companies, whom the majorities are manufacturers under the Registered IBS System Provider (RISP) list in Malaysia. In addition, 8 questionnaires were distributed to the government policy makers who are direct decision makers to the issues pertaining to IBS. The data collection focused on the IBS precast manufacturing process, where ICT applications are more significantly used.

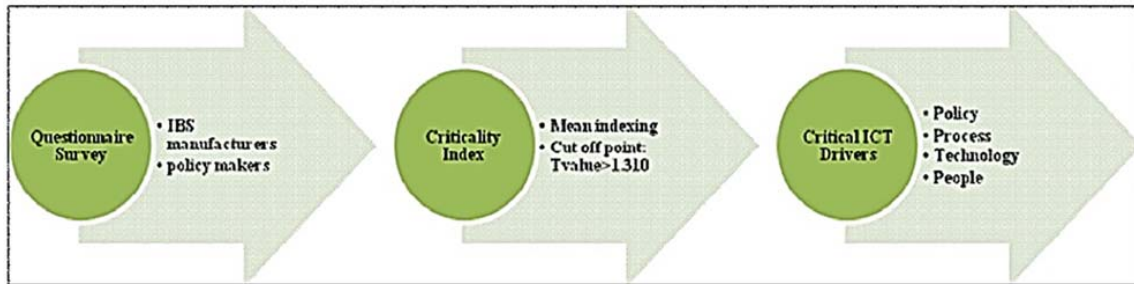


Figure 2. Flowchart of research methodology.

Referring to **Figure 2**, the IBS manufacturers and government policy makers were asked to rate the inhibitors to ICT uptake in IBS process management from Insignificant to Very Significant range. In order to identify the critical rating from all the sub-components of the ICT inhibitors, the mean is fixed at scale '3.5' since ratings above '3' represent 'moderate significant', '4' represent 'significant' and '5' represent 'very significant'. The rankings for the ICT uptake inhibitors can be obtained by calculating the critical value of the variables.

$$\bar{x} = \frac{1(n1) + 2(n2) + 3(n3) + 4(n4) + 5(n5)}{(n1 + n2 + n3 + n4 + n5)} \quad (1)$$

The null hypothesis ($H_0: \mu_1 < \mu_0$) against the alternative hypothesis ($H_1: \mu_1 > \mu_0$) were tested, where μ_1 represents the mean of the survey sample population, and μ_0 represents the critical rating above 3.5. The decision rule was to reject H_0 when the result of the observed t-values (t_o) (Eq. (2)) was larger than the critical t-value (t_c) (Eq. (3)) as shown in Eq. (4). The criticality of ICT inhibitors in this study was examined using Eqs. (3) and (4).

$$t_o = \frac{\bar{x} - \mu_0}{SD / \sqrt{n}} \quad (2)$$

$$t_c = t(n - 1, \alpha) \quad (3)$$

$$t_o > t_c \quad (4)$$

The critical t-value, $t(30, 0.10) = 1.310$ with confidence interval 90% ($\alpha = 0.10$) was set in this study. T-test analysis was employed to rule out the ICT inhibitor components which carry the mean value lesser than 3.5. ICT uptake inhibitor with t-values that are greater than the critical t-value of 1.310 will be shortlisted as the critical inhibitor to ICT uptake. Similar studies which applied mean indexing and t-tests are [34] which rated the criticality index for the importance of the sustainability-related cost components and [35] using mean indexing to discuss the importance of evaluation elements for customer satisfaction in project management. Apart from that, t-test analysis has been used in past research in identifying the relative important indicators [36, 37]. The critical inhibitors to ICT uptake are identified from the four driver elements in **Figure 1**.

5. Critical Inhibitors to ICT Employment on IBS Production Management Processes

The overall rates of the respondents are combined in the following tables for ease of reference and to facilitate interpretation. The following sections contain only the salient information to avoid information ‘congestion’ and the use of many large tables in the main text. Table shows the overall rating for the ICT implementation inhibitors amongst all industry stakeholders; the IBS Manufacturers and Government Policy Makers. (Note: * t-value which is higher than the cut off t-value (1.310) indicating the significance of the indicators). All six critical ICT inhibitors are summarised in **Table 2**.

Table 2. Overall Rank Order for ICT Implementation Inhibitors by all Industry Stakeholders

	INHIBITORS to ICT Implementation	T-Value	RANK
PROCESS	Conventional process	*1.58	1
	‘Hybrid’ (part electronic and part paper)	-0.105	2
	Risk of technical malfunction	-0.291	3
	Coordination problems	-0.658	4
	Difficult to integrate in existing process	-1.875	5
	Limited technical life cycle	-3.008	6
	Tight project timeframes	-3.251	7
PEOPLE	Resistance to change	*2.299	1
	Conservative attitude of professionals	*1.508	2
	Low technology literacy of the workers	0.28	3
	Decision maker’s lack interest	-1.945	4
	Lack of commitment from management	-2.784	5
TECHNOLOGY	Lack of flexibility of new technologies	-0.124	1
	Incompatibility of the technologies with existing practices and current construction operations	-0.291	2
	The technologies are not easily available locally	-0.945	3
	Hardware incompatibility	-1.087	4
	Poor collaborative tools	-1.249	5
	Complex and difficult technologies to implement	-1.321	6
	IBS processes hampered with conventional methods	-1.405	7
	Software incompatibility	-1.54	8
	Limited wireless access, low speed connection	-1.804	9
	Lack of reliability	-2.047	10
GOVERNMENT POLICY	Type of contract	0.556	1
	Persistence of 2D standards	-0.587	2
	Lack of government incentive	-0.615	3
	Building standards	-0.745	4
	ICT software model ownership	-0.826	5
COST	High costs or substantial financial commitment in acquiring the technologies	*2.855	1
	Cost of specialist software too high	*2.219	2
	High cost for training staff	*1.408	3
	Limited resources available to small and medium-sized firms	0.712	4
	Uncertain economic situation	-0.28	5
	Return on investment too uncertain	-0.794	6

Out of the 34 ICT implementation inhibitors, there are only six inhibitors having t-values above the cut-off point of 1.310. Referring to **Table 3**, there were only six critical ICT implementation inhibitors having t-values above the cut-off point of 1.310. The inhibitors, according to the ascending ranking order are *high costs or substantial financial commitment in acquiring the technologies*; *resistance to change*; *cost of specialist software too high*; *conventional process*; *conservative attitude of professionals* and *high cost for training staff*. Six of these critical ICT implementation inhibitors are under the categories of *Cost*, *People* and *Process*. *Technology* and *Policy* are not seen as critical inhibitors to ICT implementation. However, *Cost* is identified as a critical inhibitor to ICT implementation in the Malaysia construction industry.

Table 3: Critical ICT Implementation Inhibitors for All Industry Stakeholders

RANK	CRITICAL INHIBITORS	ICT IMPLEMENTATION ELEMENTS	T-VALUE (CUT-OFF POINT>1.310)
1	High costs or substantial financial commitment in acquiring the technologies	Costs	2.855
2	Resistance to change	People	2.299
3	Cost of specialist software too high	Costs	2.219
4	Conventional process	Process	1.58
5	Conservative attitude of professionals	People	1.508
6	High cost for training staff	Costs	1.408

Some authors [38] concluded that the number one inhibitor to the implementation of ICT was *ICT investment restrictions due to budget constraints*. Their research finding is in line with the industry IBS stakeholders' opinion that *high cost in acquiring technologies* is the main inhibitor for ICT implementation. Another critical inhibitor in this research is *cost of specialist software too high*. In other study supported that IT systems are too costly that the organizations are unable to afford it, [39]. High cost investment has been one of the most common inhibitor in ICT adoption [40,41,42,43]. Number six critical ICT implementation inhibitor is *high cost for training staff*. Hence, cost is one element that constraints further development of an organisation to greater ICT uptake. The underlying rationale could be caused by the fragmented nature in the construction industry and government not meeting the specific needs in the upgrading of ICT knowledge in the industry. Hence, *Cost* is one very critical inhibitor that should be seriously looked into as three of all six critical inhibitors are under the *Cost* category. Besides that, *People* inhibitor, being one of the top hindrances to ICT implementation has shown the *resistance to change* and *conservative attitude of the professionals*. The construction industry is naturally more cautious towards change and slow to adopt new technology. Authors [44] suggested that people tend to resist change due to their habits acquired over time, which is a primary constraint to ICT diffusion. ICT is hindered from advancing in the IBS process management due to the conventional process that many IBS players still hold on to. ICT will find difficulty to penetrate into processes that are conventional.

6. Conclusion

Communication and systems run more effectively with the adoption of ICT in the construction industry. Thus, there is a need to synchronise the entire supply chain and offer the inquiry functions through the application of ICT, and enable users to promptly acquire information for addressing different future needs. Instant acquisition of management information from the adoption of ICT applications could be a critical element in enhancing industry competitiveness. The result from the criticality index provide the rankings for the ten most critical ICT uptake inhibitors. It is a comprehensive and detailed account of different critical inhibitors to ICT uptake, enabling decision makers and organisational strategists a platform to identify the shortcomings and to further work on development required in adopting ICT. Further research can be executed to incorporate strategies to eliminate the inhibitors to ICT uptake.

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