Behavioral Economics Perspective in Exploring the Decision Making of Industrialized Building Systems in Malaysia

S. A. S. Zakaria, G. Brewer, and T. Gajendran

Abstract—**The adoption of modern building technology is playing an increasing vital role in the development of construction industry. Therefore, the proliferation of Industrialized Building System (IBS) technology adoption by construction industry has made the study of existing technology adoption theories and decision making models in IBS setting increasingly important. The intention of this paper is to determine the influence of behavioral factors on IBS decision making as perceived by IBS supply chain members in Malaysia. This paper proposes conceptual and theoretical frameworks by investigating the influences of behavioral factors on the decision making of IBS technology adoption. This paper starts with a description of decision making nature as a development towards a grasp of decision making as a process in which a decision maker interacts in the formation of a final choice based on behavioral economics perspectives, particularly with reference to IBS decision making in the Malaysian construction industry. The paper ends with the implications of this conception for behavioral factors influences in IBS decision making.**

***Index Terms*— decision, industrialized building system, behavioral economics**

I. Introduction

IN building technology adoption, barriers to the acceptance of off-site production (OSP) are based around human perceptions grounded in the historical failure of off-site practices to deliver improved performance, technical difficulties (e.g. site specifics, delivery problems, interfacing problems, cost), lack of opportunities for benefiting from economies of scale, and the fragmented structure of the construction supply chain [1]. Although numerous works have demonstrated the possible benefits of adopting OSP to construction projects, yet uptake has been slow [2]. Industrialized Building System (IBS) or off-site production is the focus of many government and private initiatives to increase the productivity of the building projects and construction industry. IBS technology is the mass factory-produced building components off-site, then they are properly assembled and joined on-site to form the final units [3]. It is argued that IBS improves the productivity of construction and also reduces the amount of site labor involved in building operations [4]. A review of past IBS adoption literatures indicated that past studies have focused mainly on technical and managerial problems [5]-[7]. Accordingly, IBS technology policy over these years has focused on better understanding the practice behind the scientific and technical aspects of IBS technology itself [8]. The changes in IBS technology adoption that have taken place in Malaysia will bring significant economic, social and sustainable impacts, from the case of foreign labor dependency [9] to the green technology problems [10]. Due to the nature and extend of these scenarios, decision makers in construction industry have begun to pay more attention to IBS technology adoption and gradually recognizing that IBS decision must be seen as equally important in addressing IBS problems. In order to achieve IBS goals [11], both the scale of IBS adoption decisions, priorities, and values for each decision maker need to be clearly understood. Therefore, based on this argument, this paper is materialized to assess the perception of IBS supply chain members based on their experience and knowledge in relation to the behavioral factors of decision making pertaining the IBS technology adoption of building projects in Malaysia. This paper is also based on an effort to develop a conceptual framework for IBS decision making in construction industry and to determine the influences of behavioral factors on IBS decision making. This paper provides a review of recent work in behavioral economics and technology adoption with the development of IBS decision making models. First, the study will be exploring a series of key behavioral concepts. Next, the study is intended to determine whether IBS decision makers are concerned and influenced by the behavioral factors of IBS decision making.

II. Decision Making Process and Behavioral Economics

A better understanding and utilization of behavioral economics underlying IBS technology adoption can give decision makers a competitive edge in the challenging world of construction industry. The term behavior refers to anything a person does, typically in response to internal and

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external events which can be overt actions that are open to view or convert activities that are not openly shown [12]. Economics and social psychology are heuristics tools for identifying for factors that influence specific behaviors such as values, attitudes, habits, social norms, personal norms, and perceived behavioral control, meanwhile economics focuses on the influences of internal and external factors explaining intentions to act [13]. In general, decision makers' evaluation on an item's value on some dimension is derived from binary comparisons between a small number of choice alternatives available in the working memory [14]. Human preferences in the choice and judgments of financial decision making are relative [15]. In addition, emotional states have powerful effects on how individuals process chance events or evaluate outcome [16]. Feeling states are important modulators of decision making behavior [17]. Therefore, the effect of an internal state change of an individual who subjectively transform probabilities into decision weight and outcomes into values, which depends on the individual aspiration, expectation, and situation [18]. Behavioral economics has now generated a large number of studies showing how descriptive and procedural variables that are psychologically important and actually influence behavior in many settings [19].

Based on the above literatures, developing better decision making skills, even on technical and technology based problems may involve other factors, including more diversified and practical perspectives with attentions to the surrounding of changing and uncertain environment. Thus, behavioral economics is rapidly developing, interdisciplinary areas that draw heavily on research and perspectives from behavioral science, industrial engineering, and economics itself as shown in Table I.

TABLE I
INTERDISCIPLINARY AREAS IN DECISION MAKING

Area of Study	Decision Nature	Contextual Stressors	IBS Decision Perspectives
Behavioral Science	human factors, human technology interaction	changing public awareness.	
Industrial Engineering	management and organization	changing competencies level, the pace of technological change.	stakeholders and supply chain members' opinion and perspectives.
Economics	decision theory and behavioral economics.	financial pressures, changing market conditions, changing policies.	

Although behavioral decision making research is concerned with how people make choices, behavioral decision making is predicted by individual differences in sensitivity for rewards but not based on impulsive personality traits [20]. In economic psychology, the combination of behavioral economics and decision making promotes good interdisciplinary studies in order to explore whether decision makers have made the right economic choices based on the reasons of having made a decision, their personal beliefs and risk preferences [21]. Identical to individual decision making, firms' behavior can be observed, managed, and measured [22]. From construction management perspectives, understanding scientific facts and managerial theories are not enough [23]. Rather, decision makers in construction industry should also know why factors other than technical advancement on technology and managerial perspectives have merit in IBS decision making.

III. DECISION MAKING OF IBS SUPPLY CHAIN

In construction industry, IBS supply chain is the management of the current IBS delivery process with the transformation from on-site to off-site activities, so that each process of project execution and implementation must be strategized to reduce risks and bring maximum value [24]. Construction supply chain coordinates inter-organizations decision making and supply chain members such as supplier, designer, general contractor, sub-contractor, and clients or owner typically create a decision as a set of possible solutions with the consideration of decision making variables such as environment, cost, time, quality, and safety [25]. Supply chain is an emerging concept in construction industry as individuals and groups work together within a multidisciplinary environment in designing, developing and producing products with common goals aligned with project organization, even if the most important decisions are made during design process [26].

Supply chain management involves the planning and control of the flow of supply chain to speed time to market, reduce inventory levels, lower overall costs, and enhance customer service and satisfaction to meet customer's demand efficiently [27]. In ensuring profitability and competitiveness, supply chain management should be linked to business process to capture synergy of inter and intra company management with the integration of managerial components and behavioral components such as management methods, power, and leadership structure, risk and reward structure, and culture and attitude that are less tangible and difficult to access [28]. Each IBS supply chain members simultaneously plays several roles and this multiplicity of roles affect the ways in which conceptual decision making framework is constructed. Therefore, there is a need for IBS supply chain members to look beyond IBS decision per se [29] and to consider the conceptual decision frame and the behavioral context of IBS technology adoption.

In exploring and understanding IBS decision making from a behavioral approach, a decision making perspective is established which illustrates the ways in which decision makers are like some others and also how they are different from others too or to which people are compared in terms of as an individual in a firm or as a team member in a building project as presented in Table II.

TABLE II
DECISION MAKING PERSPECTIVES

Decision Making Perspectives:	IBS Decision Makers: Individual in a firm	Team members in a project
Entity	construction stakeholders	supply chain members
Nature	individual norms	group norms
Focus	person centered	group variables centered

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Analysis	personal traits	Individual differences in a project
Aims	to develop an understanding of mind or mental activities in IBS decisions	to establish general decision criteria on the IBS technology adoption
Predictions	based on firms ground rules	based on assessment about cause-and-effect relationship
View	judgment within individual	judgment across or between individuals

Based on Table II, by seeking to gain greater insights into the IBS decision making process of both individuals, firms, and construction projects, the study of behavioral economics has important implications for a number of subject and policy areas including the study of constructability, sustainability, labor economics, and ergonomics directed toward undertaking globalization challenges.

IV. Framework of Behavioral Factors in IBS Decision

Appropriate decision processes need not always be analytically complex, but instead depend on the characteristics of the external socio economy context, the decision makers and the decision problem itself. In order to decide on building technology adoptions, the decision makers of construction industry generally depend on external and internal information such as competition, technical development, price movements, policy changes, and other changes within the industry. One way to understand this complex set up interactions between decision making, IBS technology adoption, and the influence of behavioral factors is to describe them in terms of a conceptual decision framework as illustrated by Fig. 1.

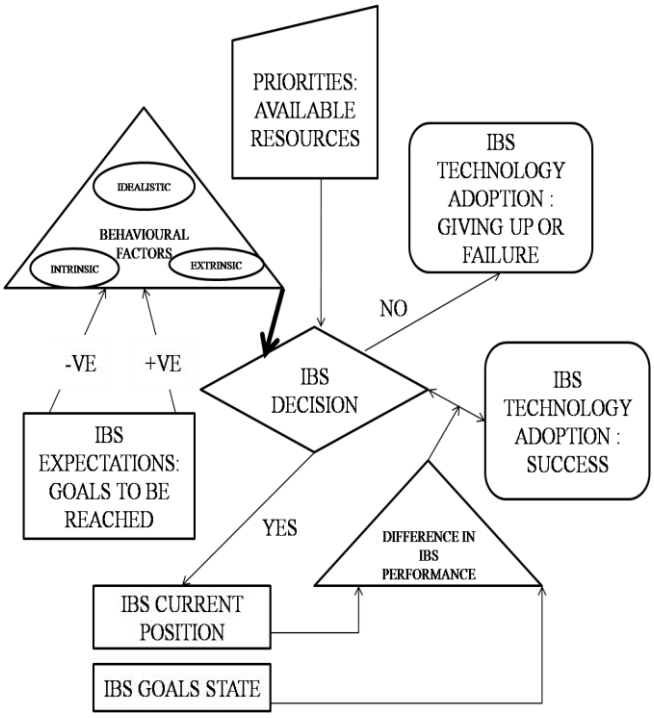

Fig. 1. Conceptual Framework of IBS Decision Making Based on Behavioral Influences

The conceptual decision framework based on decision perspective composes of factors which a decision maker conveys to understand on a particular IBS technology adoption. In Fig. 1, the first part in the centre is IBS decision box. IBS decision is an action response to a discrepancy between IBS current position and the expected or required goal state. However, IBS technology adoption is an option. Decision makers can lead to take action to reduce the discrepancy of IBS technology performance, or to remain with the conventional building method, which implies failure to reach the required or expected IBS state or adoption. This is an important part of IBS decision making process.

Idealistic factor is an idealistic notion of decision making which implies the ultimate decision based on significant factors that the individual values most such as goals achievement, heuristics, and risk considerations; whereas extrinsic factor shapes decision making based on external elements through decision makers' perception, the conformity of firm's needs, and values, leadership style, learning context and previous experience; and intrinsic factor reflects self-thought which recognize decision making as it really is, which is due to the inspiration of personal bias, personal needs and wants, personal values, attitudes, and feelings or emotions [30].

IBS decision making is considerably broader than this in scope as this study is designed to explore the contribution of behavioral factors to IBS decision making process and its impact on building technology choice. A research framework is developed to illustrate decision or choice as the outcome of interactions between behavioral variables, decision maker variables and project variables in IBS decision making process as illustrated by Fig. 2.

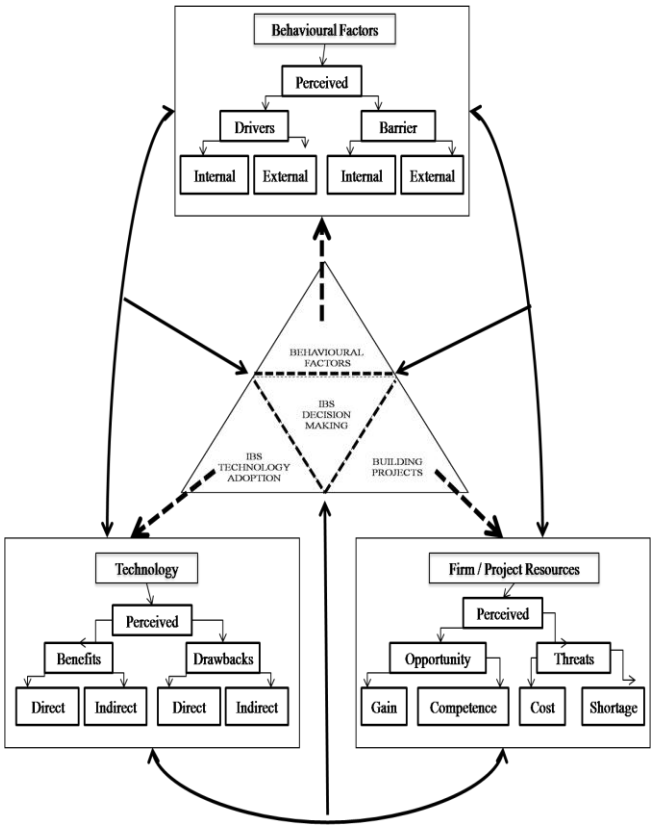

Fig. 2. Technology-firm-behavior framework in IBS Decision Making

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Fig. 2 describes decision making process to provide context for IBS decision and the results of this choice feeding forward to influence future IBS decisions. Fig. 2 also encompasses IBS technology adoption variability in building projects, individual, and group decision makers unit, the impacts of behavioral factors and the choice of building technology. It also incorporates some underlying decision making processes related to the behavioral elements, as well as the defined characteristics, roles, and values of the IBS decision makers. This framework, which is also known as technology-firm-behavior framework which represents the focus of this study enables the attempt to identify what aspects of behavior, what types of IBS decision makers and what types of decisions pertaining IBS technology adoptions. As it is true in other branches of economics, problems with construction industry is characterized by optimal choice and describing actual choice [31]. The solution to this problem is to retain the normative status of choice optimization in decision making and at the same time to develop explicitly descriptive models of decision making based on the behavioral perspective of IBS technology adoption in building construction.

V. Research Methodology

The focus of this study is to analyze the perception of IBS supply chain members on decisions made about IBS technology adoption in building projects. The differences in thoughts and conceptualization that emerge among IBS supply chain members affects their perceptions of behavioral factors in their decision making on IBS technology adoption. This study aims to answer this research question: how strongly we believe that behavioral factors impacted IBS decision making?. Thus, this study has two objectives: 1) to determine behavioral factors that have influences on IBS decision making as perceived by IBS supply chain members and 2) to identify the most significant behavioral factors that have influences on IBS decision making as perceived by IBS supply chain members. The target questionnaire respondents were focused on IBS supply chain members within the Malaysian construction industry based on a purposive sampling. A purposive sampling or judgment sampling involves selecting elements in the sample for a specific purpose as they represent the target population, but they are not necessarily representative [32]. In order to obtain perception towards the behavioral influences on IBS decision making, 27 respondents were identified in this study constituting IBS the supply chain members of three IBS building projects. For each project, these respondents include a/an architect, quantity surveyor, contractor, civil engineer, consultant, developer, project manager, and IBS manufacturer. The structuring of the questionnaire was developed and supported by a review of related literatures on the elements of the research framework. The questionnaires are based on Likert's scale of five ordinal measures of agreement. Ordinal scale 1 to 5 was used in ascending order to show the degree of agreement for the collected data from the questionnaires. The assessment and the opinion of IBS technology adoption are based on the IBS supply chain members' judgments and the decision making process of IBS technology adoption is encapsulated within the perception, subjectivity, and behavioral influences of those who conduct evaluation, prospect, and finally make a decision, based on what they believe is the most important or significant of a given IBS building project.

VI. Results and Discussions

The collected data from the questionnaires were analyzed via the frequency analysis and the index average analysis. The index average was established to figure out the importance level of each behavioral element as represented by the relative importance index (RII) using this formula: Index Average = (Σ *ai* X *xi*)/ Σ *xi*, where *ai* = constant, weighing factor and *xi* = variables representing respondents' frequency of response. The gathered data on the results of respondents were expressed in the figure according the standings of the score of average index. In the discussion of the results, Table 3 presents the results of behavioral factors influence as perceived by IBS supply chain members.

TABLE 3
Ranking of Perceived Behavioral Factors in Ibs Decision Making

Perceived behavioral factors in IBS decision making	Frequency of Respondents Score					Average Index	RII Rank
	1	2	3	4	5		
Idealistic factor: goals achievement	0	0	3	12	12	4.33	1
Extrinsic factor: previous experience	0	0	4	11	12	4.30	2
Intrinsic factor: attitudes	0	0	4	12	11	4.26	3
Extrinsic factor: learning context	0	0	6	11	10	4.15	4
Intrinsic factor: personal needs and wants	0	1	7	6	13	4.15	5
Idealistic factor: heuristics	0	0	3	17	7	4.15	6
Idealistic factor : goals achievements	0	0	6	11	10	4.15	7
Intrinsic factor: personal values	0	0	7	10	10	4.11	8
Extrinsic factor: conformity of firm's needs and values	0	2	7	6	12	4.04	9
Intrinsic factor: feeling and emotions.	0	2	10	8	7	3.74	10

Table 3 shows the results of the questionnaire which seeks to determine the influence of perceived behavioral factors in IBS decision making among IBS supply chain members in the Malaysian construction industry. The relative importance index (RII) is used to rank the different behavioral factors in order to determine their major influences on IBS decision making. The respondents were asked to provide their opinions based on the statements of selected extrinsic, intrinsic, and idealistic factors as perceived by them in deciding on IBS technology. Goals achievement as one of the studied intrinsic factors was ranked by respondents as the major factor that would influence IBS decision making. Intrinsic factor on goals achievement in this case is on the decision to adopt IBS technology based on the possible improvements in quality of life at construction sites. The second rank is the extrinsic factor of the experience of other team members when deciding on IBS technology adoption in

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building projects. The third rank is the intrinsic factor on attitude that is related to the motivation to discover more about IBS technology to enhance its adoption. The fourth, fifth, sixth, and seventh ranks have the same average index of 4.15. They refer to the influence of learning context, personal needs, information processing, and goals achievements as perceived by the respondents in deciding on IBS technology. These influences are also related to the satisfaction, believe, and experience that are achieved from the benefits and positive consequences of IBS adoption in building projects. Besides this, a statement on the personal values of decision makers in terms of their passion for innovation is also an important influence in IBS technology adoption as it was ranked by IBS supply chain members at the eighth position of RII rank. Although it is at the second last of the RII rank, the conformity of firm's needs and values in terms of the future perception of others regarding the career performance of decision makers also has influences on the decision of IBS technology adoption. When comes to the intrinsic factor of feeling and emotions, this factor was ranked by IBS supply chain members at the last place of RII rank which reflects that the element of feelings and emotions are the least influencer in IBS decision making. The survey results signify that most of the IBS supply chain members were responsive to the behavioral factors of IBS decision making. They also perceived some of these factors such as IBS goals achievement, previous experience with IBS projects, and decision makers' attitudes should be considered in deciding on IBS adoption. Given the importance of wide spread adoption for the success of IBS and the *much–slower-than-expected* growth in IBS adoption, there is certainly a need to understand more about what factors are important in the IBS adoption decisions of the Malaysian construction industry [33].

IBS decision making should be understood as a dynamic process that takes place by considering technology adoption, technology in-depth knowledge and processes that the construction business requires. Decision making of IBS technology adoption at the supply chain level may be the most commercial significance in the short term but it is important to recognize the variability of psychology decision making that exist among IBS supply chain members. Another key feature of behavioral economics is "framing" and the view that decisions or preferences are heavily influenced by the ways in which a choice is presented.

Research of IBS decision making with the consideration of behavioral factors offers important assistance in understanding technology adoption based on these ways:

1) First, this study offers insights that cannot easily be required with a purely theoretical decision research.
2) Second, IBS decision making in this study was particularly conducted among IBS supply chain members.
3) Third, from the applied viewpoint, this study is a foundation for understanding technology adoption decisions.
4) Fourth, from a basic viewpoint, this study provides expectation for results that generalize beyond the quantitative viewpoints.

VII. Conclusion

Behavioral economics in this study seeks to provide decision analysis with a more practical and rational psychological foundation by examining the ways in which various aspects of individual and behavioral factors influence IBS decision making. Besides the evidences and results from the perception study of IBS decision making, this paper has provided a review of evidence with IBS decision making models that behavioral factors should be considered in IBS technology adoption. This study also represents an attempt to examine a perception based IBS adoption model that was theoretically grounded in a technology-firm-behavior framework. This study will be used to further confirm the usefulness of technology-firm-behavior framework for studying IBS adoption in construction industry. Thus, behavioral economics can be applied in technical research on human and social cognitive to better understand technology adoption decisions, particularly IBS technology.

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