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Decision Analysis and Negotiations for Technology Adoption Decision: An Exploratory Study

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ABSTRACT

The construction industry generally takes a conservative attitude towards adopting innovations. Previous research has tended to focus on information technology instead of heavy construction equipment. Also, the 'process' of adopting of new construction technologies by companies remains unexplored until now. In the previous part of the research the initial stages of technology adoption were examined including identification of the range of options available and comparison of the options in order to determine and collect any information that is missing for any of the options. With this in mind, this paper presents the initial investigation into the next part (phase) of the technology adoption process, which is found to involve analysis of the most viable options, involving a demonstration of the technology on the user's site and / or discussion with other technology users, and the making of the final decision. A total of 35 interviews with participants from Australia and 63 from North America were undertaken. Participants from both sides of the process (i.e. customers and vendors) were chosen in order to cross-validate the findings of each group using triangulation. A total of 96 technologies were identified ranging in cost from $0.75M to $45M, including mobile / tower cranes, concrete pumps, and blind bore shaft drills. The analysis revealed that a customer passes through three stages to make the adoption decision from the point where the customer is in the position to short list the number of technology options and vendors. The outcome confirmed the original hypothesis that the adoption process has well-defined stages starting with: a) Information analysis; b) technology evaluation; and c) adoption decision. These three stages are mirrored by vendor activities which respond to potential adopters. The analysis also highlighted the importance of word of mouth, feedback from experienced technology users, and negotiation in the process.

Keywords: Negotiation, Analysis, Technology adoption, Decision making.

INTRODUCTION

Previous studies about innovation and technology adoption provide an abundance of theory and evidence regarding how information technology is adopted at the macro level, and how the decision to adopt proceeds at a micro-level. While the technologies themselves have been studied in the literature, the process of how a construction company makes the decision to adopt these technologies is largely unexplored in construction. Some of the best known studies about technology adoption remain vague about the decision phase of the adoption process and take awareness of the technology and its perceived value as a given (Karahanna, Straub, & Chervany, 1999). In response to this gap in the literature, we present our inductive analysis of how customers and vendors in the construction

industry interact and follow a pathway after their decision to adopt a technology. Our findings provide the empirical foundation upon which we develop an improved Construction Technology Adoption Framework (CTAF).

Several studies have focused on technology selection or prediction of performance for a particular technology such as cranes (Valli, Jeyasehar, & Dhanaraj, 2013) or concreting equipment (Serdar Ulubeyli & Aynur Kazaz, 2009) utilizing quantitative analysis, such as the analytical hierarchy process approach (Shapira & Goldenberg, 2005). For example, S. Ulubeyli and A. Kazaz (2009) suggest that the selection of a new concrete pump is mainly based on distance pumped. In addition, they suggest a selection method considering five different criteria (e.g. selling price, operating cost per day, technical services). However, the result of each of these studies is an algorithm for technology choice based on limited factors or technology features. The unfamiliarity of the technology for a construction company, vendor issues, or dynamic factors such as previous performance of both vendor and technology are often ignored. In addition, such studies assume that the technology selection occurs in a single stage, akin to an impulse purchase (S. Ulubeyli & A. Kazaz, 2009), rather than a multi-stage decision making process, which sometimes takes more than a year in the construction industry, particularly for heavy equipment.

This study presents a model that can be used to systematically analyse the adoption decision stages from the perspective of vendors and customers. The model appeals to innovation researchers by providing a more accurate and detailed summary of the stages of the adoption decision process. It also appeals to innovators, entrepreneurs, and vendors who are interested in facilitating the adoption process and developing their business.

The originality of this paper lies in the examination of the interactions between the customer and the vendor during the adoption decision process after a construction company investigated different available solutions. The literature shows that most studies in this area focus on the introduction of an innovation and its applicability. However, the process that occurs after the investigation phase and before implementation has not been investigated. This paper helps to fill a gap in the literature of construction technology by considering the process a customer passes through to commit to use a particular technology on a construction project. The findings of the paper will assist innovators to

understand the new technology adoption process, and facilitate adoption of their technology. The paper proceeds as follows. First, we present our inductive method by which we explore how the adoption decision process occurs in the construction industry. Second, we present our analysis of interview data, from which we isolate mechanisms by which the process is implemented by customers and vendors. Third, the adoption decision process is presented as the second part of the Construction Technology Adoption Framework (CTAF). Finally this is followed by our conclusions.

RESEARCH METHODOLOGY

In order to test the hypothesis that the industry follows specific decision processes linked to the investigation process and implementation, we employed semi-structured interviews, because of their flexibility in obtaining deep understanding (Bryman, 2012). We collected first-hand data by attending five Australian technology exhibitions or industry gatherings in Sydney, Adelaide, Melbourne, Brisbane and Perth, and cross-validated by attending similar events in the USA. A sample of 98 participants was purposefully selected based on their relevant experience and involvement in the adoption decision process. In order to generalise the technology adoption process across countries and cross-validate the findings, participants were recruited from both Australia and North America, applying the comparative sampling approach (Teddlie & Yu, 2007). A summary of the participants' profiles are provided in **Error! Not a valid bookmark self-reference.**.

Insert Table1 about here

EXPLORING THE PROCESS

This section describes the process used for applying thematic analysis techniques to the transcriptions of the interviews (Roulston, 2001) in order to identify themes representing the stages a customer passes in implementing a new technology.

Create activity nodes

At this point 710 passages that indicated a part of the adoption process or a related activity were assigned into relevant child nodes. Each of these child nodes represented one activity related to a purchase decision. Table 2 lists examples of these nodes and comments extracted from an interview illustrating each one.

Insert Table 2 about here

A further 33 nodes were created related to vendor activities. Three example nodes are listed in Table 3 together with illustrative examples.

Insert Table 3 about here

Identify basic themes

The next step is to identify basic themes and relationships that link the various child nodes. Basic themes are the lowest-order premises evident in the data (Attride-Stirling, 2001). In this case the themes are coherent steps in the overall purchase decision phase. This step involves allocating child nodes to parent nodes and sorting them into identifiable basic themes. Each parent node represents a family of activities with some basic similarity of sequential connection. These parent nodes are connected to each other using the function of "create relationship" in NVivo.

Insert Table 4 about here

Each basic theme is then re-examined to identify if it refers to a specific event or some other meaningful entity. **Error! Reference source not found.** shows examples of the six new parent nodes that were generated using data from 31 customer activity nodes. For example, one of the parent nodes is called "Financial analysis", indicating one of the customers' activities before purchasing the technology. This node has several child nodes, such as "Resell value analysis", "Demonstrate dollar value", and "Cost analysis". Considering their relationships, these child nodes and the relevant parent nodes constitute a basic theme. The resulting basic themes will assist in developing overarching themes that will be used in structuring the adoption decision framework. Table 5 shows examples of the five new parent nodes generated using data from the 32 vendors' activity nodes. All the parent and child nodes represent five basic themes.

Insert Table 5 about here

Develop Candidate themes to develop the adoption decision framework and cross validation

Comparison between the parent nodes generated from the customer interviews with the parent nodes generated from the vendor interviews shows that they are identical. Thus the two groups of interviews cross-validate each other. Each pair of associated parent nodes constitutes a candidate theme

representing related activities in the adoption decision process. A summary of candidate themes and parent nodes is presented in Table 6.

Insert Table 6 about here

Develop the structure of the adoption decision process

In order to increase the accuracy of candidate themes, all relevant passages linked to nodes within the identified themes were reviewed in terms of integrity and criticality. This review is called re-focusing the analysis at the broader level of themes (Braun & Clarke, 2006). The result of the re-focus analysis of themes I and II shows that customers compare short-listed vendors against each other, while analysing each of the vendors and their technologies in terms of financial analysis and support. Therefore, themes I and II should be merged to represent one stage of the process about information analysis. In addition, the activities about references and practical evaluation assist vendors to validate / prove their technology before customers make their final decision. Some participants state that usually only one of them (i.e. reference or evaluation) is needed. For example, a top manager of a global vendor (#cn1) states *"If you have references then a trial is not needed."* Therefore, themes III and IV also should be merged into one overarching theme to cover all activities between analysis and the final decision. The three remaining rationalised overarching themes that can be used for the framework are described in the following sections.

Insert Table 7 about here

To further cross validate the three steps involved in the framework, interviewees were asked to check whether each stage reflected their experience of the technology adoption process. They were directly asked to evaluate each stage of the process by using a Likert scale of high, medium, low, and not applicable. Results are provided in the last column of Table 7. Table 7 shows the number of sources and references that mention each of the three stages of the framework. This shows that all three stages are important for both customers and vendors. These results also cross-validate the findings of the qualitative analysis. Evaluation, including reference and trial, is more prominently in the minds of the

participants than the adoption decision activities such as making the final decision and signing the contract. However, they still tend to rate all three as important. A manager of a global vendor (#cn1) believes that in these stages "If you are not 100% pushing you will not get the order." The interviews show that several factors affect the customers' decision. These factors will be discussed in the next section. This will be followed by a section about the individuals involved in the decision process. All of this will be tied together in the following section where each stage of the purchase decision process will be discussed individually.

SYNTHESIS OF RESULTS FOR FRAMEWORK DEVELOPMENT

Error! Reference source not found. gives an overview of the activities in the decision phase followed by customers and vendors. This section describes each of these stages in detail.

Stage 4 – Analysis

Stage 4 in the framework refers to analysing information collected in the previous stages in order to short list available options or / and collect new specific information to proceed to the decision process. In this stage, the analysis is a comparative analysis based on detailed and technical information, official quotation, labour cost – equipment and financial assessment. They usually develop a matrix for the analysis.

Insert Figure 1 about here

Stage 5 – Evaluation

Stage 5 in the framework refers to evaluating the technology from a practical perspective. In this stage customers want to make sure that the technology will suit their job and conditions. In addition, customers are concerned about the capability of vendors in terms of aftersales services. The main activities during this stage are to communicate with referees, and/or rent, lease, or trial in order to evaluate both the technology and vendors' capability. As a vendor describes:

"*They [customers] want references. If you convince them up to the analysis [Stage 4], then to place an order with you mostly they said ok, [...] Can you show us a reference, which is similar to our plant? If you can show them something similar, sure, you have your order. If you cannot show them,*

then you have to maybe do a trial. The trial is not needed if you have the references. The references are very, very important. Very high! Only the trial is important if you have no reference. You do not need both, you only need one." (31.19 #cn1)

Stage 6 – Decision

Stage 6 in the framework refers to decision to commit to the technology use. The interview shows that the two previous stages, called 'analysis' and 'evaluation' are the basis of the decision. For example, a customer describes that "*evaluation is the most critical [stage]. The sale comes later; it comes automatically*" (#cx55). Another customer weights the stages and indicates that evaluation (Stage 5) is more important than the decision itself in the adoption process.

CONCLUSION

The purpose of this paper was to develop a deep understanding of how customers make the decision for adopting a new technology and how vendors support them in this decision process. This paper systematically tests the hypothesis that the industry follows specific decision processes linked to the previous process (i.e. investigation) and the next process (i.e. implementation).

Through the analysis of 98 semi-structured interviews with experts in Australia and North America, it was found that a customer passes through three distinct stages to commit to adopting a new construction technology. The outcome confirms the original hypothesis that the adoption process has well-defined stages starting with: a) analysis, b) evaluation, and c) decision. These three stages are mirrored by vendor activities which respond to potential adopters by offering: a) specific information about their technology, b) trial and references list, and c) offer the technology (e.g. offer contract and sale). This finding was validated by data triangulation between the results of customer and vendor activities during the adoption decision process.

This study departs from previous studies that have focused on the customer's intention to use a specific technology at a particular stage. In addition, this study investigates vendors' activities that might contribute to the process, which have been overlooked in previous research. The findings of this paper fill a gap insofar as it provides a deeper understanding of the technology adoption decision process. The research also contributes to the body of knowledge of construction technology adoption

by developing a systematic framework illustrating the adoption decision as a three-stage process rather than a single stage.

The original contributions of the findings of this paper lie in its careful collection and analysis of two different samples (Australia and North America) from both customers and vendors to establish a scientifically sound understanding of the last stages of adopting new technology. The testing of the prepared hypotheses led to three key observations: (1) the middle adoption phase consists of three stages; (2) each stage comprises unique activities; and (3) the process stages of the decision makers (customers) are paralleled by clearly identifiable stages taken by vendors.

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Table 1 A summary of technology exhibition participants' profiles

Item	Description	Vendors	Customers	Total
Region (Interviewees' business base)	Australia	9	26	35
	North America	30	33	63
Size (based on the number of employees)	Small (4-19)	4	20	23
	Medium (20-199)	14	22	39
	Large (>200)	14	24	27
Interviewees' experience (years)	<5	3	0	3
	6-10	8	5	13
	11-30	18	32	50
	>30	8	24	32
Total		39	59	98

Table 2 Customer quotes assigned to appropriate nodes

Child node	Selected comments
Short listing	We typically shortlist vendors... (10.00 #cn14)
Criteria based analysis	We went through after weighing up that criteria, I did the purchase. (10.00 #cn25)
Resell value analysis	One reason that you pick a [brand A] over a [brand B] piece of equipment is the resell. You can sell [brand A]once you get 5000 hours at a much higher rate than you can sell a [brand B].(3.04 #cx41)

Table 3 Vendor quotes assigned to appropriate nodes

Child node	Selected comments
Short list	Customers get three quotes. That is the rule. Then they delete the

	cheapest one. The technical manager considered two of three. (47.30 #cn1)
Finance Lease / hire	There is a lot of options going here. Do I lease it? How am I going to pay for it? How am I going lease it? How am I going to hire it? How am I going to pay for it – with cash or go to a bank loan. (37.17 #cn8)

Table 4 Allocating child nodes to parent nodes using customers' comments

Child node	Parent node
Short listing	1. Comparative analysis
Criteria based analysis	
Narrow down	
Market	
Resell value analysis	2. Financial analysis
Demonstrate dollar value	
Risk analysis	
ROI analysis	
Financial arrangement	
Cost analysis	

Table 5 Allocating child nodes to parent nodes using vendors' comments

Child node	Parent node
Short list	1. Competitive advantages
Technical information	demonstration
Quotes	2. Analysis support
Finance	
Cost proof	

Justification
Proposal
Spare parts
Answering customers' team questions
Current customer
Evidence of money saving

Table 6 Candidate themes covering the adoption decision phase combining customer and vendor comments

Parent nodes	Candidate theme	Source	Reference
1. Comparative analysis (C)	I Comparative analysis	15	20
1. Demonstration of competitive advantage (V)			
2. Financial analysis (C)	II General analysis	34	56
3. Implementation analysis (C)			
2. Analysis support (V)			
4. Collect assessment results of previous practices (C)	III References	21	32
3. Reference list (V)			
5. Practical evaluation (C)	IV Practical evaluation	68	156
4. Trial and evaluation support (V)			
6. Purchase decision (C)	V Decision	20	36
5. Discussion, communication and contract (V)			

Note: [1]C refers to customers' parent node and [2]V refers to vendors' parent node. The 'Source' column represents the number of interviews where the parent node was discussed. The 'Reference' column refers to the number of times that the parent node was discussed in these interviews.

Table 7. Stages 4 to 6 of the adoption decision process

Stage	Source	Reference	% of times ranked "high"
Stage 4. Analysis	40	133	59.1
Stage 5. Evaluation	69	320	60.2
Stage 6. Decision	48	152	59.1

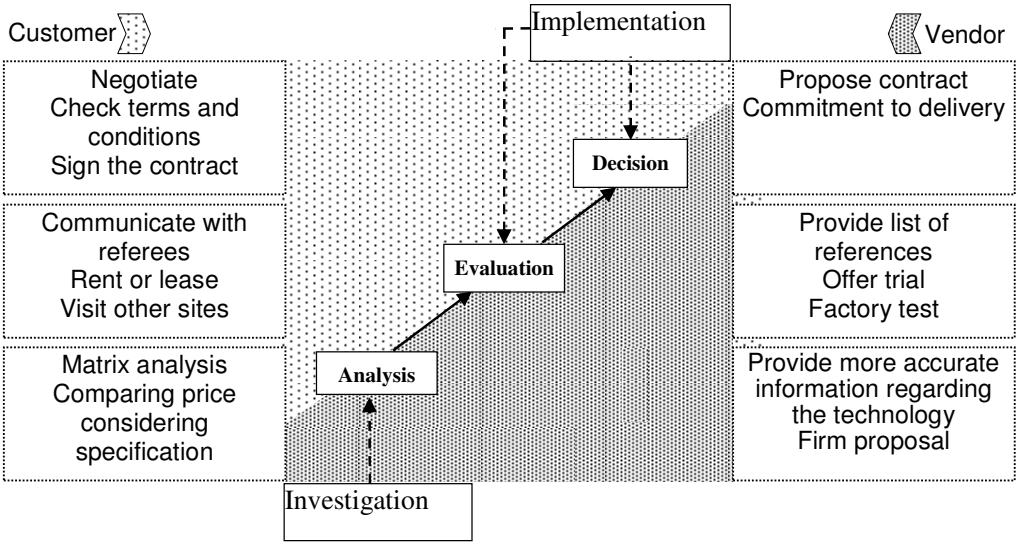

Figure 1 Decision Framework