16. Technology, Innovation and Supply Chain Management

Competitive / Original research paper

Pioneers, Followers and Interaction Networks in New Technology Adoption

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ABSTRACT

Organisation attitudes and individual roles have critical input to the technology adoption process. This paper is the first attempt to investigate construction technology adoption based on organisation attitude, structure and interaction networks. This study investigates how different roles interact to make adoption decisions. A semi-structured interview protocol is developed and used to collect rich data from seventeen pre-selected interviewees. The qualitative data is analysed using thematic analysis techniques. The quantitative data is analysed using the analytic hierarchical process (AHP). The analysis found three distinctions based on the attitude of organisations to new technology, their structure and the interaction networks inside the organisations that have an effect on the technology adoption process.

Keywords: Organisation attitudes, Technology adoption, Decision making, Marketing.

INTRODUCTION

When an organisation decides whether or not to adopt a new technology individuals from a variety of

roles will have critical input. Rogers (2010) has made a deep study of the individuals involved in new

technology adoption, but not for the construction industry. Several studies have identified the

importance of various roles in technology adoption in construction, such as top management

(Mitropoulos & Tatum, 1999, 2000), project managers (Mitropoulos & Tatum, 1999) and users

(Brewer & Gajendran, 2012; Johnson & Clayton, 1998). However, the interaction between these roles

has not been investigated to understand how the interaction and communication between individuals

within a construction company (internal), and with other companies (external) can affect the adoption

process. This paper is the first attempt to investigate adopters' interactions at three scales: (a) industry

level; (b) organisation level; (c) individual level.

Predicting the diffusion of new technology at the industry level requires understanding of the attitudes

that different organisations have toward new technologies. Rogers (2010) has shown that in the area

of information systems organisations can be categorised as: innovators, early adopters, early majority,

late majority, and laggards. Most existing studies in construction use this categorisation without

examining its applicability to construction (Potbhare, Syal, & Korkmaz, 2009). Moore (Leite,

Akcamete, Akinci, Atasoy, & Kiziltas, 2011) showed that there are a chasm between early adopters ("visionaries") and the majority ("pragmatists") in information technologies. However, the applicability of this categorisation and the presence of this chasm have not been investigated in regard to construction technologies.

For an organisation many factors such as its structure, type of business, expertise, and vision can affect technology adoption (Geroski, 2000). Most existing research into different attitudes toward adopting new construction technologies have used large scale questionnaire surveys and so have been limited to examining the effects of organisation size (Nikas, Poulymenakou, & Kriaris, 2007) or type of business (e.g. contractor, client, and consultant) (Rahman, 2013). However, such highly structured questionnaires are unable to investigate the processes that the organisations utilise in making technology decisions and how individuals in different roles participate in these processes. Therefore, there is a need for an exploratory study to investigate the effect of organisational structure on technology adoption attitudes and processes.

Individuals and managers have a significant role in technology adoption decisions (Couchman, Zutshi, Wilkin, Warren, & Sohal, 2011; Hossain & Quaddus, 2011; Roxas, Battisti, & Deakins, 2010). Several studies (Brewer & Gajendran, 2012; Mitropoulos & Tatum, 2000; Peansupap & Walker, 2005) have paid attention to the role of particular individuals (i.e. users, and top managers) as drivers in technology adoption in construction. However, the focus of the research about top managers has been on how it is necessary for them to foster the right environment to enable a new technology to be accepted by the individuals in an organisation after the decision to adopt that technology has been made, rather than the role of the top managers in actually deciding to adopt that technology. For example, Nikas et al. (2007) highlights the important role that top management has in planning the introduction of new information systems over a period of years, obtaining technical consultants, and ensuring that personnel attend training and seminars. The questions arise of which organisation roles are involved in the adoption process from managerial level to operational level, and how do they interact?

The purpose of this study is to explore possible patterns of potential adopter behaviour and also the interaction between the individuals both within the potentially adopting organisation and with

individuals from other organisations, such as vendors. In addition, the paper presents how different

roles within the internal hierarchy of the adopting organisation are involved.

The study is the first attempt to recognise that there are different groups of companies which may

follow similar processes. This paper helps to fill a gap in the literature of organisations attitude and

behaviour, individuals' roles within organisations and their interaction toward adopting a new

technology. The originality of this paper lies in its contrast of the behaviour of organisations in

adopting new construction technology with the more researched case of organisations adopting

information technology, and in its exposition of the different interaction networks that arise in

differently structured organisations. The result of the paper would assist vendors to understand how

to effectively communicate with potential adopters based on their individuals' role, organisation type,

and competitive environment. Contractors can use the presented network to modify their current

practice.

In this paper, first, the literature of technology adoption is reviewed. Second, a novel framework

considering both customer and vendors is presented. Third, the exploratory research method used for

collecting and analysing data is presented. Fourth, the results of the study are presented, which show

that three distinctions are important for understanding adopter behaviour: pioneer vs. follower,

corporation vs. family business, and managers vs. operators.

TECHNOLOGY ADOPTION

The importance of individuals, organisations and networks in construction innovation has been

investigated (Blayse & Manley, 2004). "Innovation is the actual use of a nontrivial change and

improvement in a process, product or system that is novel to the institution developing the change"

(Slaughter, 1998). These studies tend to cover administration innovations, such as quality systems

(Kale & Arditi, 2010), environmental management systems (Qi, Shen, Zeng, & Jorge, 2010;

Vermeulen & Hovens, 2006), and safety systems (Baxendale & Jones, 2000).

A great deal of research has been carried out in the area of adoption of Information Technology (IT)

in construction. These studies examine how the perception of individuals will influence their

acceptance of new ITs, and the role of top management as a driver for acceptance of ITs (Peansupap

& Walker, 2005). However, there is a gap in the literature regarding the process of construction technology adoption and the roles that individuals play in this process, both within the adopting organisation and without. This section of the paper reviews two main approaches, key concepts and proposes a framework as a basis for the investigation of individual roles in construction technology adoption.

PROPOSED FRAMEWORK

Adoption of technology is defined as the steps taken in the process through which the adopter passes to reach a decision to accept or reject a new technology (Rogers, 2010). This paper covers adoption players at three levels (i.e. industry, organisation, and individual) involving all actions in the adoption process from seeking a possible solution to implementation of the technology into daily construction operations, in which both participants – vendors and customers – exchange information in order to move toward the adoption decision.

This paper assumes that the technology adoption process contains three phases: conceptualisation of solution, adoption decision, and implementation. The various roles that individuals fulfil at each phase are presented. In addition the impacts of external organisations, such as vendors and competitors are included because the dyadic relationship and the interaction of both sides of the adoption – customer and vendor – are believed to be significant in the technology transfer (Bemelmans, Voordijk, Vos, & Buter, 2012; Holt & Edwards, 2012).

RESEARCH METHOD

In order to explore the variety of procedures used by adopters and their characteristics in construction, the semi-structured interview (SSI) technique was chosen (Bryman, 2012). The SSI systematically investigates the process by recruiting preselected interviewees who are experienced and involved in adoption at their company. The data obtained through the interviews is analysed using thematic analysis. Each interviewee discussed the framework in light of a technology adoption case from their organisation. Eleven interviewees were selected at four technology exhibitions held between 2011 and 2013 in order to obtain a representative sample for initial interviews, and six interviewees were

recruited based on recommendations of previous interviewees to cover gaps in the sample. This

method was adopted because the interview aim was elicitation of facts rather than individual behavior

(Schultze & Avital, 2011). In total 17 interviewees were enlisted as itemised in Table 1.

Insert Table 1 about here

The SSI technique was used in order to give the interviewees the maximum flexibility to discuss who

makes decisions at their organisation, rather than to be limited to preselected guesses of the

researcher. The roles, positions and arrangements are not necessarily standard in different

construction companies. Interviewees from customer organisations were asked about the arrangement

of roles involved in the adoption process in their organisation.

The interviews were transcribed and entered into Nvivo, a software program that facilitates thematic

analysis. Thematic Analysis was used to collect passages about the roles that different participants in

the adoption process played. Next, the analytical hierarchical process (AHP) was used to weigh up the

importance of each role in the adoption process. The interviewees from vendor organisations were

asked about any differences in their customers in regards to the adoption process and their specific

characteristics or preferences in order to explore any possible patterns of adopters.

FINDINGS AND DISCUSSION

Interview transcripts were broken down into concepts to develop themes. Each theme was examined

for meaningfulness. Meaningful themes were found that corresponded to different roles within or

outside the organisation and to organisation attitudes, structures and behaviours.

Emerged Themes

Three major themes were found in regard to adopters' attitude and behaviours. The structure of these

themes is shown in Figure 1.

Insert Figure 1 about here

Pioneers and Followers

Codes related to attitude towards new technology were collected, and two distinct attitudes appeared. These two attitudes were labelled pioneers and followers. Pioneers take the attitude that new technology provides an opportunity to gain a competitive advantage and so should be embraced. Followers are much more concerned about the risks arising from new technology and so want to see that a technology has been proven before they will adopt it. Pioneers are looking for new solutions to do the job safer and faster. Common terminology that they use is that they are looking for a "step change" in doing the job. Pioneers have some similarities with the category of "visionaries" for information system (IS) customers introduced by Moore (Leite et al., 2011). A plant manager (who is responsible for a tunnel boring machinery including the associated above ground earth moving trucks etc.) described criteria for selecting a TBS: "For a tunnel boring system it would be looking at step change in the current way that we do the work underground … A step change is a big shift away from the normal way to a new way, significant change."

Followers wait for a technology to be proven in use by others. Unlike the "chasm" discussed in Moore (Leite et al., 2011), where pragmatists only look to other pragmatists like themselves and ignore the visionaries, followers in construction are happy to imitate pioneers if they see a successful result for adoption. Followers, do not want to be the first in adopting a new technology. A director of a crane manufacturer complains: "To try and open the door for new equipment is a long process. No one wants to be first. They just don't want to be the first person. So, it takes you a while to open the door. Then you sell one, and then slowly you build up."

This paper uses the terms pioneer and follower instead of visionary and pragmatist because followers are willing to give weight to the experience of pioneers whereas "it is painfully obvious that visionaries, as a group, make a very poor reference base for pragmatists" Moore (Leite et al., 2011, p. 43). The construction industry is very project based and so when looking for a reference to see if a technology is proven, the criteria are about the nature of the respective projects, rather than characteristics of the organisations running them.

Pioneers tend to perform more detailed analyses than followers. When talking about equipment hire companies a director of a crane manufacturer claims the first company to purchase a crane will

carefully calculate the cost and required hire rate for making a return on the investment, while "The other guy, he sees them buying and using this style of a crane now… . 'He's got one of them, he must be making money. I am going to buy one.' They don't do any investigation. They don't. They just know he's got one and he is hiring it out, and if they get one, they can hire it out too. … They want to follow the leader".

Discussions with vendors revealed that often if a customer had already bought a technology from a particular vendor, then they preferred to buy the next technology from the same vendor. Sometimes if their previous vendor does not offer the same technology yet, then the customer might wait until the new technology is offered by the vendor they trust. A director of a crane distribution company: "At the end he gets his [technology X] because that is what he really wanted, even though the [technology Y] was a better crane. ... The [technology Y] would done what he wanted to do.. The [technology Y] would have given the reliability which he would have got from the [technology X]. What the [technology Y] did not give him was the fuzzy feeling. It did not [make] him warm and confident, because he already has the [technology x]! … So, it is not just the specification, it is a case of who's he dealing with. What [technology] does he know. … People do not like change."

Corporation vs Family Businesses

In order to discern any pattern at the organisation level, codes related to organisation behaviour toward adoption were collected. From interviews with vendors it was found that they categorised customers into two groups, which they general referred to as corporations and family businesses. Each customer interviewed agreed that they did in fact fit into one of these groups and it was observed that the behaviour of the interviewed customers did indeed match the behaviour that vendors associated with the group that each customer self-identified with. Corporations are more methodical in carrying out a formal purchase procedure involving a relatively large number of employee roles. Construction family businesses still follow a purchase procedure, but it is more flexible, and only involves one or two individuals, including the owner.

The formal procedure followed by corporations typically increases the influence of technical personnel. The result of such influence can improve solution conceptualisation. A managing director

of a manufacture notes: "you normally find that the construction company is a higher calibre client. But the other guy [family business], all he knows is that he wants a crane. You ask him questions he can't give you an answer. Construction Companies [corporation], he wants a crane too, but he can tell you everything you want." Family businesses usually have informal or flexible procedures. This flexibility causes the adoption process to be less complex, and usually the adoption process is faster than for corporations, because less people are involved. For example, a sales manager described their offering of a new technology for road rail excavator and maintenance. A director of a family business purchased it immediately after seeing the technology at an exhibition. It took two years of meetings and negotiation before a corporation purchased the same technology. Another sales manager, this time for a crane company explained that family businesses often make their decision in days, and then they order a machine by a simple email or call phone. However, when a corporation makes a decision, it may take weeks, months or even years for the agreement to be signed.

Corporations tend to be construction companies and hence are very project oriented, whereas family businesses tend to be equipment hirers or subcontractors and so their purchases are more likely to be based on perceived market need (i.e. overall activity in the local construction industry).

Insert Table 2 about here

The interviewees were asked to rate the importance of five factors on the purchase decision. Results are shown in Figure 2. The solid line represents the average of interviewees that were customers that were corporations or vendors who only sold to corporations. Similarly the dotted line similarly represents family businesses. The results reveal that family businesses rate vendor attributes (e.g. after sales services, trust, etc.) and technology characteristics as much more important than project attributes or industry standards, whereas corporations rate project attributes and industry standards as more important than vendor attributes. This is consistent with the project orientation of corporations and the ability of corporations to deal with the risk of poor vendor support better more easily than family businesses.

Insert Figure 2 about here

Adopter Roles within Organisation

In order to analyse the roles of individuals in the adoption process and identify key persons, interviewees were asked to compare the importance of different roles in the adoption decision making process. As organisations do not have the same structure, a proposed hierarchical framework including company (i.e. head office), project, and operational (i.e. construction operator) levels were the basis of interviews. Within each level it was assumed that there were three sub levels. Any sub levels not involved in a particular interviewee's organisation were rated as zero.

Insert Figure 3 about here

Figure **3** shows the importance weighting for each level and role, both locally (i.e. within a sublevel) and globally. A normalised analysis (Figure 4) shows that the project level usually has the most input on the adoption process and the company level has the least input. This finding is different to previous studies which mostly focused on the user and operator levels (i.e. their perception of usefulness and ease of use) to predict information technology adoption (Venkatesh & Bala, 2008). Inconsistency for the analysis is 0.03 which is excellent (should be less than 0.1).

Insert Figure 4 about here

While AHP shows that the largest input into technology adoption decision making happens at the project level it is desirable to understand the network between the different roles involved. In order to map this network were asked about the different roles and thematic analysis was again applied. Figure 5 shows the different networks found in different types of organisations.

Company level. For family businesses this level has the most input into decisions regarding technology adoption, including the final say, as represented by an outlined circle at level 1 in Figure 5. For corporations, the role of managers at company level is to set the company policy in regard to technology purchases. They normally delegate purchase decisions down the hierarchy depending upon the expenditure level. In addition, they are usually more interested in vendor selection rather than model selection. A plant manager describes: "Top managers and board of directors usually have an impact on the decision on which vendor is being used, because there are so little vendors, a very small handful. There is previous relationship between these top managers and vendors. So there is

traditionally quite an input on which vendor to take, because of good relations and good support in the past. They might not necessarily relate to the actual technical detail at the time, but since it is the one big ticket purchase on such a site you will have top managers and board of directors being very interested on the choice."

Project level. The project level tends to be the most important decision making level for corporations. Usually the project manager will make the final decision. The project manager is held accountable for the entire project. Project managers are expected to have the capability of managing the risk of technology selection and are paid accordingly. Allowing someone else to make this decision would give the project manager an excuse for project failure and this is something corporations wish to avoid. To enable this more personnel at the project level will be involved, as shown in Figure 5.

Insert Figure 5 about here

Operational level. As the AHP analysis above revealed, individuals at this level have less input than other levels, and in many projects they are not available at the time of the purchase decision. However, they are involved in the last phase, i.e. the implementation. This contrasts to information technology where the user is more likely to be consulted or has influence on the decision, particularly for rejecting technologies that are not easy to use or efficient. In construction the operator is restricted to asking for upgrades or customisation if it can be justified, and cannot reject the overall system. Operation of the technology can be done by an individual or a sub-contractor.

CONCLUSIONS

The paper has investigated the way that construction organisations adopt technology. The basic attitudes toward technology were uncovered. Pioneers seek out new technology to gain competitive advantage, while followers are more concerned with the risk associated with new technology and so will not adopt new technology until they have seen it in action. However, the construction industry differs from the information technology arena in that followers in the construction industry are much more willing to accept the example of pioneers, whereas the pragmatists in information technology are not so willing to follow the example of visionaries. Another distinction presented in the paper is between the behaviour of contractors organised as corporations and equipment hire companies and

subcontractors organised as family businesses. Corporations tend to have more formal processes and distribute the roles involved with different phases across a larger number of people. The main decision is usually made by top management (the owner) in family businesses, while it is made by project managers in corporations. The findings contribute to the body of knowledge of technology adoption in construction by delineating how the different circumstances and attitudes of the people that have roles in the customer organisation change the way that decisions are made in different organisations. Some of these factors have been identified in other industries, such as the well-known spectrum between early technology adopters and laggards, but in this paper it is made clear how this applies to the construction technology market. Other factors are construction technology market specific such as the way that the project based nature of the construction industry means that these decisions are made at the project level and do not necessarily indicate that the customer organisation is embracing the technology beyond the individual project.
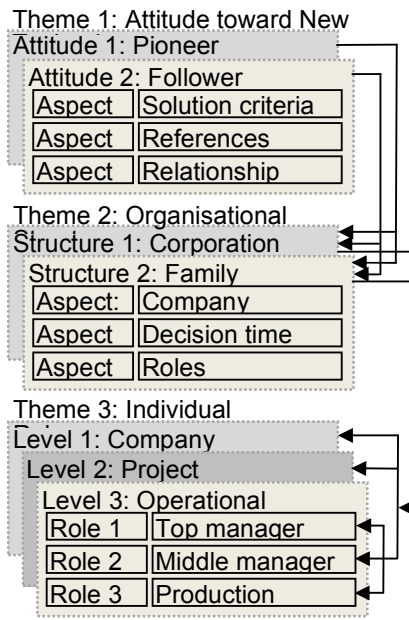
The findings give insight to vendors to understand how construction companies make decisions and the structure of the interaction network in regards to the adoption process. The presented categorisation of companies and interaction network patterns are based on a limited number of case studies. Future research will be focused on verifying the findings of the research with a wider range of companies and technologies. Further studies are needed to investigate which roles are involved in which phases of the adoption process, and to identify the importance of each role in each phase for each company structure.

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Figure 1. Themes from interviews.

Theme 1: Attitude toward New
Attitude 1: Pioneer
Attitude 2: Follower
Aspect	Solution criteria
Aspect	References
Aspect	Relationship

Theme 2: Organisational
Structure 1: Corporation
Structure 2: Family
Aspect:	Company
Aspect	Decision time
Aspect	Roles

Theme 3: Individual
Level 1: Company
Level 2: Project
Level 3: Operational
Role 1	Top manager
Role 2	Middle manager
Role 3	Production

Table 1: Interviewees profile.

No	Experience (years)	Co. revenue ($/yr)	Business	Position [a]	Technology	Price ($ $\times 10^3$)
1	33	500 M	Vendor	SM	Concrete pump	30
					Water pump	800
2	16	12 B	Vendor	SM	Jack hammer	1.0
					Hammer drill	0.5
3	30	75 M	Vendor	MD	Laser level	1-10
					Unmanned aerial vehicle	70
4	20	10 M	Vendor	MD	Screw gun	1.0
					Demolition hammer	0.5
5	22	15 B	Vendor	MD	Tower crane	1,240
6	4	15 B	Vendor	SE	Mobile crane	840
7	43	12 M	Vendor	MD	Mobile crane (250t)	2,800
					Mobile crane (55t)	780
8	14	10 M	Customer	MD	Concrete pump (46m)	1400
					Concrete pump (36m)	900
9	10	100 M	Customer	PL	Blind bore drill	6500
					Concrete pump	90
10	13	100 M	Customer	PM	Formwork	20
					3D point scanner	15
11	7	500 M	Customer	MD	Truck mixer	320
12	25	10 B	Customer	MD	19t Crawler excavator	210
13	30	60 M	Customer	MD	16t Crawler excavator	170
14	40	50M	Vendor	MD	Crawler crane	500
15	30	200M	Customer	PL	Tunnel boring machine	40M
16	20	200M	Customer	PM	Fronted Loader	150M
17	15	50M	Customer	PM	Excavator	150M

[a]: SM: Sales manager, MD: Managing director, SE: Sales engineer, PL: Plant manager.

Table 2: Corporations vs family businesses.

Decision	Corporations	Family Businesses
Approach	Analytical	Flexible / Informal
Decision time	Long time	Short time
Owner role	Not involved	Involved in decisions

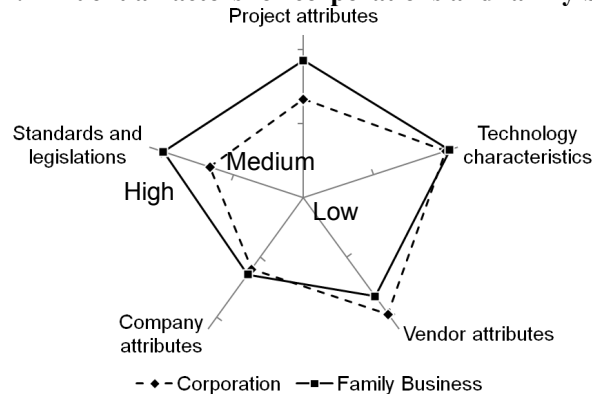**Figure 2: Influential factors for corporations and family business.**

Figure 3: The importance weight of each role. L refers to local weigh, and G refers to global weigh.
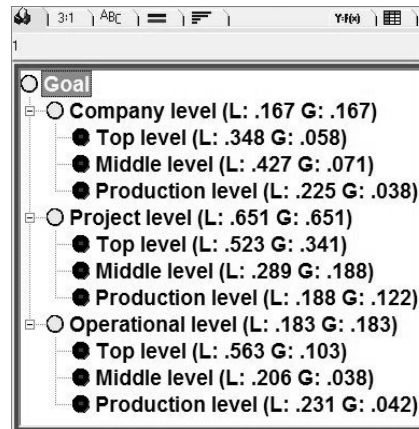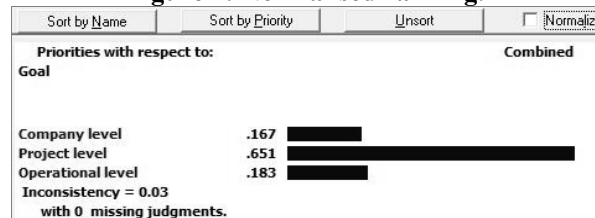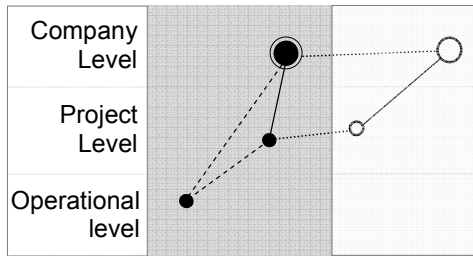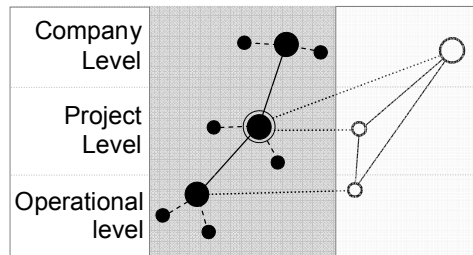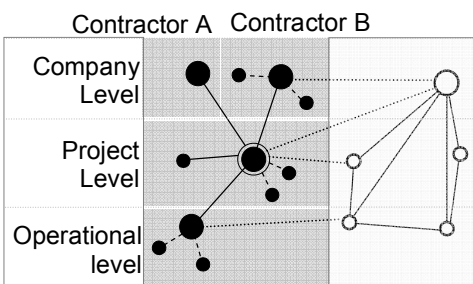

Figure 4: Normalised ranking.

Figure 5: Adopter networks.

a) Family business individuals' roles network

b) Corporation individuals' roles network

c) Joint-venture individuals' roles network

Dear Conference Chair,

Thank you for passing on the feedback of the two reviewers. The feedback has been very useful. (It is the most comprehensive feedback that I have received for any work that I have submitted to a conference). We thank the reviewers for these comments, particularly the encouragement to continue researching in this domain and endorsement of the presentation and organisation.

I addressed two main comments, but the other ones would be discussed in the conference as my paper is interactive paper. This is a result of an on-going study and my presentation in the conference would cover all of questions.

Best regards,

Reviewers comment.	Modification made to paper
"Background to the interviewees would have been appreciated"	Table 1 has been given more detail to explain the background of each interviewee (see below)
"I would like to see more information about how people were identified, approached, etc.	Added to Research Method: "Eleven interviewees were selected at four technology exhibitions held between 2011 and 2013 in order to obtain a representative sample for initial interviews, and six interviewees were recruited based on recommendations of previous interviewees to cover gaps in the sample. This method was adopted because the interview aim was elicitation of facts rather than individual behavior (Schultze & Avital, 2011)."
How was the data analysed?	Added to Research Method: "The interviews were transcribed and entered into Nvivo, a software program that facilitates thematic analysis. Thematic Analysis was used to collect passages about the roles that different participants in the adoption process played."
I would also like to see more explanation about how the findings contribute to the study.	Added to Conclusion "The findings contribute to the body of knowledge of technology adoption in construction by delineating how the different circumstances and attitudes of the people that have roles in the customer organisation change the way that decisions are made in different organisations. Some of these factors have been identified in other industries, such as the well-known spectrum between early technology adopters and laggards, but in this paper it is made clear how this applies to the construction technology market. Other factors are construction technology market specific such as the way that the project based nature of the construction industry means that these decisions are made at the project level and do not necessarily indicate that the customer organisation is embracing the technology beyond the individual project."

Table 1. Interviewees profile. (before)

Role	Interviewee Position	Total
Customer	Director	4
General contractors, rail	Project manager	4
work, crane hire	Plant manager	2
Vendor	Director	5
Mobile crane, concrete	Sale manager Sales	1
pump, tools, laser levels	engineer	1

Table 2: Interviewees profile. (after)

a .

No	Experience (years)	Co. revenue ($/yr)	Business	Position [a]	Technology	Price ($ $\times 10^3$)
1	33	500 M	Vendor	SM	Concrete pump	30
					Water pump	800
2	16	12 B	Vendor	SM	Jack hammer	1.0
					Hammer drill	0.5
3	30	75 M	Vendor	MD	Laser level	1-10
					Unmanned aerial vehicle	70
4	20	10 M	Vendor	MD	Screw gun	1.0
					Demolition hammer	0.5
5	22	15 B	Vendor	MD	Tower crane	1,240
6	4	15 B	Vendor	SE	Mobile crane	840
7	43	12 M	Vendor	MD	Mobile crane (250t)	2,800
					Mobile crane (55t)	780
8	14	10 M	Customer	MD	Concrete pump (46m)	1400
					Concrete pump (36m)	900
9	10	100 M	Customer	PL	Blind bore drill	6500
					Concrete pump	90
10	13	100 M	Customer	PM	Formwork	20
					3D point scanner	15
11	7	500 M	Customer	MD	Truck mixer	320
12	25	10 B	Customer	MD	19t Crawler excavator	210
13	30	60 M	Customer	MD	16t Crawler excavator	170
14	40	50M	Vendor	MD	Crawler crane	500
15	30	200M	Customer	PL	Tunnel boring machine	40M
16	20	200M	Customer	PM	Fronted Loader	150M
17	15	50M	Customer	PM	Excavator	150M

SM: Sales manager, MD: Managing director, SE: Sales engineer, PL: Plant manager.