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UNDERSTANDING THE INNOVATION ADOPTION PROCESS OF CONSTRUCTION CLIENTS

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ABSTRACT

Although the role of clients in stimulating construction innovation seems to be controversial, little has been known about their innovation adoption behaviour. This paper presents first results of an ongoing research project the aim of which is to shed more light on the adoption processes of construction clients. We build up a conceptual framework that describes innovation adoption as a communication process. Furthermore, we highlight and discuss the main findings of a case about the adoption of a temporary construction for the maintenance of a motorway bridge. Thus far we conclude from our findings that a more accelerated diffusion of construction innovation requires that the client has a thorough understanding of the problem an innovation is intended to solve. Furthermore, there must be improved dissemination and availability of information about similar solutions applied in previous projects and, for large-scale structural changes, ideas must be considered either in advance or at an early stage of a project.

Keywords: innovation, adoption, client, construction

1.0 INTRODUCTION

Recent research shows that innovation for construction firms, similarly as for other industries, offers the opportunity to enhance performance, gain higher profits and attain competitive advantages over respective rivals (Ling, 2003; Sexton and Barrett, 2003; Seaden et al., 2003). However, the common perception of construction is that of a not very innovative industry. Indeed, compared to other sectors, construction struggles with a slow diffusion of new products, processes and services (Reichstein et al., 2005). Several studies have aimed at revealing the reasons for this low rate of innovation adoption. The project-based character of construction has been identified as a major barrier to an increased diffusion speed (Pries and Janszen, 1995; Winch, 1998; Gann and Salter, 2000). Although projects allow the directed allocation of resources to meet the specific requirements of clients, their one-off nature leads to discontinuities in the development and transfer of knowledge within and between organisations (Dubois and Gadde, 2002). The project-based character of construction results additionally in a fragmented and decentralized structure of the industry expressed through a great number of small firms from different trades and professions. As soon as an innovative solution exceeds the level of being incremental and becomes systemic, the implementation of such a solution usually requires the involvement and at least the commitment of a range of project parties that possess their own logic, language and interests (Slaughter, 2000; Taylor and Levitt, 2004). Here the role of clients seems to be essential. Construction clients are able to stimulate innovation not only by determining building specifications and demanding higher building and process performance, but also by establishing and controlling the mechanisms that account for the extent of collaboration and communication of project participants (Blayse and Manley, 2004; Dewick and Miozzo, 2004). Moreover, a client's risk sharing, commitment to innovation and leadership in project planning and execution is considered to be vital for the successful implementation of construction innovation (Nam and Tatum, 1997). However, strong client leadership does not necessarily result in innovative projects. Quite contrarily, it is argued that innovative construction projects led by the client are exceptions rather than the norm due to the desire of clients to avoid the risks associated with innovative solutions (Ivory, 2005).

Despite this ambiguous role clients seem to play for the diffusion of innovation in construction, up to now little has been known about their innovation adoption behaviour. More specifically, the process that forms an attitude towards innovation and leads to the decision to implement a new idea has not been investigated in detail. This paper reports on an ongoing research project, the aim of which is to shed more light on that somewhat neglected but important topic. Main questions that the research tries to answer include:

How does the innovation adoption process of construction clients take place?
How can the process be improved so that innovation diffusion in construction is accelerated?

The intention of this paper is to develop a conceptual framework describing the innovation adoption process of construction clients. The focus of the framework is on the first process phases leading to the decision to adopt or not to adopt a new idea. Furthermore, the paper presents the results of a first case study that covers the implementation of a temporary construction for the maintenance of a motorway bridge. Carrying out the case study, analysing and discussing the findings are based on the developed framework.

2.0 THEORETICAL BACKGROUND

Although there is a large body of knowledge on innovation diffusion, investigations on innovation diffusion in construction are scarce. Thus, our theoretical considerations depart from the work of Rogers which has served as basis of many surveys and which has constantly been developed further (Larsen, 2005). Our thoughts are summarised in a

conceptual framework for the first three phases of the innovation adoption process of construction clients, depicted in Figure 1 and explained in the next sections.

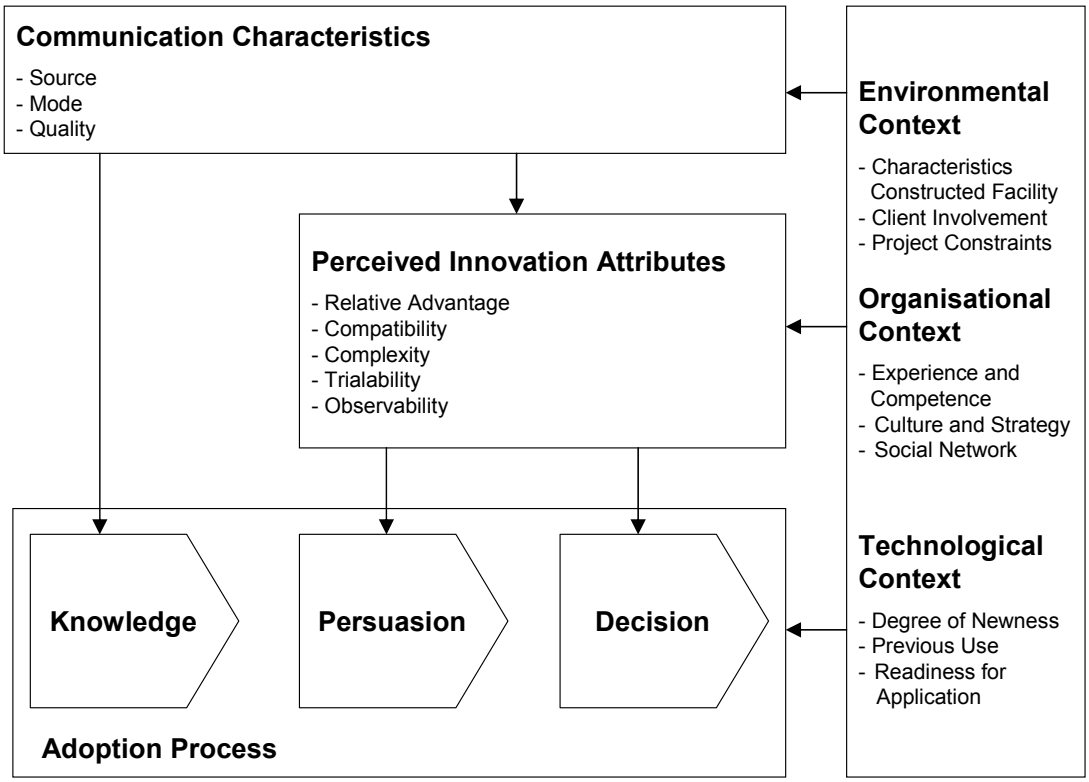

Figure 1: Conceptual framework of the innovation adoption process of construction clients

2.1 COMMUNICATION AND PERCEPTION OF INNOVATION ATTRIBUTES

Rogers (2003) defines diffusion as a process "in which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). The diffusion speed is measured as the number of members of the system who adopt the innovation in a given time period. Thus, diffusion may also be considered as a series of adoptions. Through these processes "an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision" (Rogers, 2003, p. 20). Consequently, five stages may be used to conceptualise the adoption process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation (Rogers, 2003). It should be noted that such conceptualisation simplifies reality to a certain extent. Innovation-related activities normally do not follow a sequential pathway but continue along a nonlinear cycle of feedback and feedforward loops (Tornatzky and Fleischer, 1990). In the following our focus is on the first three phases.

The first step of the adoption process aims at seeking and processing information to reduce the uncertainty about the advantages and disadvantages of an innovation. The likelihood of adoption increases if benefits and values of a new product or service exceed that of alternatives. Thus, the characteristics of information exchange between members of a social system are seen to substantially influence the adoption behaviour of the individual adopter and, consequently, the adoption rate (Nilakanta and Scamell, 1990; Lee et al., 2002). More precisely, the communication characteristics within a social system strongly affect whether a

potential adopter becomes known with an innovation and how this organisation or individual perceives the attributes of the innovative solution (Frambach and Schillewaert, 2002). That is, it can be distinguished between information leading to the awareness that a new idea exists and information explaining function and usage of this idea (Attewell, 1992; Rogers, 2003). The former is a prerequisite for triggering the adoption process or reaching the knowledge stage. Unless potential adopters know about an innovation and its possible benefits, the new idea is unlikely to be implemented. Many studies indicate that the adoption rate grows exponentially as the knowledge of a product increases. This phenomenon is known as the S-curve. A famous study is that of Coleman et al. (1966) in which the adoption of new pharmaceutical products is described. The process of diffusion starts slowly. After some time, more physicians become convinced of the value of the product and start to prescribe the new medicine.

Knowledge about function and usage of an innovation is vital to attain a favourable attitude towards an innovation. Understanding the functional principles of a new idea and the way to use it properly increases the likelihood of adoption, as the adopter is more able to judge the effectiveness of the idea (Attewell, 1992; Rogers, 2003). Consequently, the perception of innovation attributes affects the evaluation of a new idea and the propensity to its adoption. Besides the relative advantage of covering economic and social benefits, Rogers (2003) has extracted four other innovation characteristics that may explain adoption behaviour: compatibility, complexity, trialability and observability. Compatibility refers to the consistency of an innovation with existing values, past experiences, and needs of a potential adopter. The extent to which an innovation is difficult to understand and use is covered by its complexity. Whether an innovation may be experimented is embodied in its trialabilty. Finally, observability is the degree to which the outcomes of an innovation become visible for others.

Communication characteristics that are seen to play a crucial role in raising awareness and developing perception of innovation attributes include the source, the mode and the quality of communication (Mohr and Spekman, 1994; Agarwal and Prasad, 1998; Lee et al., 2002). Main sources of information encompass stakeholders such as clients, suppliers or business partners, independent third parties such as government agencies or research institutions, and personal sources such as friends or near peers (Souitaris, 1999; Lee et al., 2002). Lee et al. (2002) differentiate between two modes of communication: written and oral communication. Written communication uses print media, letters or e-mails, whereas oral communication may occur via telephone or face-to-face (Lee et al., 2002). It is argued that interpersonal contacts and word-of-mouth communication have a greater effect on the development of perceptions, whereas mass media and written information better facilitate the creation of awareness (Agarwal and Prasad, 1998; Lee et al., 2002; Rogers, 2003). We assume that the quality of communication, that is aspects such as the accuracy, timeliness, adequacy and credibility of information (Mohr and Spekman, 1994), also affect the perceived attributes.

2.2 THE CONTEXT OF INNOVATION ADOPTION

Both factors, communication characteristics and perception of innovation attributes, indicate that the adoption process is nested within a specific social context or system. We argue that the adoption behaviour of construction clients may be mainly traced back to the links between context, communication and perception. That is, which sources of information are appropriate or how certain attributes are perceived depend on a range of contextual factors that may be assigned to three context levels: the environment, the organisation and the technology (Tornatzky and Fleischer, 1990). In the following we discuss factors of the different context levels that we expect to strongly influence the attitude of construction clients towards innovation.

On the environmental level we assume that first of all the project-based nature of construction affects client's adoption behaviour. In construction the client normally initiates design and production of a new facility. From this it follows that the adoption process is always connected with the construction process and may be totally embedded within the construction project. That is, the client becomes aware of a new idea during the course of a project, if for example a construction firm suggests an alternative solution. Here the involvement of the client in the construction process seems to be important in order to assure that the client is able to come to a decision by understanding the innovation. If the development process of a new solution starts independently from a specific project or in advance of an upcoming project, the involvement of potential clients may also increase the likelihood of quicker adoption. In this case the client gets first knowledge of an idea before the project is initiated. Also, the persuasion and decision stages may already take place. The implementation, of course, is part of the project, but the project can be explicitly planned with regard to the innovation to be applied.

The link between adoption and construction process suggests that the constraints of a project (e.g. time, budget) affect the adoption process, too. This effect can be conducive (e.g. restricted time requires an innovative solution) or obstructive (e.g. restricted time does not allow to develop an innovative solution).

The market a client is active in may have an additional influence on adoption behaviour. Specifically, we expect the characteristics of the constructed facilities to determine the perception of innovation attributes. A first characteristic is the complexity of a facility. The more a facility consists of different and highly interacting components, the more an innovation may create perturbations throughout the whole system (Slaughter, 1998) and the more a client will face difficulties to understand and evaluate the functioning and effects of such a system change. A second characteristic is the lifespan of a constructed facility. The longer a facility is intended to be used, the more an innovation has to be assessed not only within the installation context, but also over a longer time period (Slaughter, 1998). Then the advantages have to outweigh the probability of modifying and repairing the innovation comprehensively at a later time. This is intensified through the transportability of a constructed facility as the third characteristic. The less a facility can be fabricated and assembled off-site, the less the conditions for implementing an innovation can be controlled (Slaughter, 1998). Moreover, with a low degree of transportability the degree to which an innovation may be tested is also low. A last characteristic that might influence the adoption behaviour of construction clients is social responsibility, which results in a wide range of codes and regulations (Nam and Tatum, 1988). That is, codes and regulations may diminish the advantage of a new idea through time-consuming and cost-intensive activities to prove the reliability of an innovation and to establish new codes and regulations.

On the organisational level we expect experience and competence of the client to have a great effect on communication and perceived innovation attributes. The more a client has carried out construction projects, the more he is able to distinguish different solutions, to formulate specific requirements on the solution, to minimise risks, to apply systematic methods of evaluating solutions or to get access to certain sources of information. Thus, the complexity of an innovation will be lower for an experienced and competent client, who is also better able to judge the relative advantage of the new idea. This is underpinned by findings of Nam and Tatum (1997) who conclude that "the ability to understand the technology usually alleviates the conservative attitude and sometimes even leads to an unusually progressive stance" (p.265). Such clients maintain their competence through different means, including internal construction management groups, internal R&D or design projects, or long-term relationships with the same designer or contractor (Nam and Tatum, 1997). Although such means increase the capacity of clients to obtain and evaluate information and, consequently, result in faster learning, they do not necessarily imply a faster

adoption. It could be found that a greater information capacity also leads to more stringent adoption criteria (Jensen, 1988).

Apart from ability, we assume that willingness to innovate affects the adoption behaviour, too. Construction clients who show a notably innovation-oriented culture and strategy are more likely to come to a favourable innovation decision, as an innovative constructional solution will be more compatible with their existing values and norms. This includes the willingness to learn from the success and failure of past projects. Many reviews take the form of an exercise in 'blame accounting' and in 'trying to cover up mistakes and problems' (Tidd et al. 2005). The preparedness to innovation is also reflected in the social network a client maintains, which may facilitate the spread of information.

On the technological level the influence on communication and perception is most obvious. Depending on the degree of newness, the perceived innovation attributes and the used information sources may differ considerably. According to Slaughter (2000) five categories of innovations with regard to their changes in concept and links to other systems can be distinguished: incremental, architectural, modular, system and radical innovations. We assume that the more a new idea represents a change of existing concepts and system links, the more complexity increases and trialabilty decreases. For example, an incremental innovation is a small improvement in current practice and has no or only small impacts on other parts of the system (Slaughter, 2000). Thus, functioning and usage are easy to understand and the advantages can be mostly demonstrated, as the change is restricted to single component. Directly opposed are system innovations defined as "a set of complementary innovations which work together to provide new attributes or functions" (Slaughter, 2000, p.3). Here the innovation is more difficult to comprehend and its trialability is limited.

Given this, we also assume that with an increased degree of newness, previous usage becomes important for the adoption behaviour of construction clients. The more an innovation was already implemented in projects, the greater its observability and, provided that it was a success, the higher the probability that it will also implemented in future projects.

As mentioned before, project constraints can inhibit the consideration of a new idea. For example, there may not be enough resources available to develop the idea to be ready for application or to test the new solution comprehensively. That is, the more an innovation is ready for implementation, the more likely is its adoption.

3.0 EMPIRICAL RESEARCH

3.1 RESEARCH DESIGN

To study the innovation adoption process a recent major innovative project in the Netherlands has been analysed in-depth. Due to the large number of variables influencing innovation and the impact of situational characteristics we chose a case study approach. The case is part of a multiple case study the results of which will be published at the end of 2006.

We collected data through semi-structured interviews and documentations which report on the innovation application. Interviews were conducted with the firms which developed and the client who applied the new solution. The conceptual framework provided the basis for developing the questions and analysing the data.

3.2 THE CASE "BRIDGE FLYOVER"

The bridge flyover is a temporary bridge used to sustain the traffic during the maintenance of the Rotteviaduct, a bridge on the A20 which is one of the most frequented motorways in the Netherlands. Although temporary bridges have been applied in different projects all over the world, this was the first time that such a construction was implemented in a project in the Netherlands. That is, for both the client, a regional highway department, and the contractor, a medium-sized firm specialised in concrete construction, the solution to span the construction site with a temporary bridge was new.

The solution itself represents a process innovation. By using the bridge flyover, the contractor could renew the bridge joints without any major restraints while the traffic was proceeding. That prevented large and numerous traffic jams. Moreover, the maintenance work could be done continuously during the day, which positively affected the work quality. Due to heavy traffic such work normally requires night work and closing at least some lanes. Consequently only small segments of work can be done, and finishing the work may take a long time. It becomes obvious that the application of a temporary bridge leads to a newly organised maintenance process. Thus, the solution can be also classified as an architectural innovation changing the linking mechanisms of the construction process, but it leaves the single activities nearly unchanged.

Due to his awareness that common ways of carrying out bridge maintenance would not lead to satisfying traffic-wise solutions for the Rotteviaduct, the client started to search for alternatives. As the highway department is part of a public organisation centralised on the national level with its own engineering capacities, an internal expert for bridge joints in this engineering department knew that temporary constructions were applied for similar work in other countries. Thus, the decision was made to tender the project explicitly for a temporary construction. To prepare the tender, an internal project team was composed including the project manager from the regional department, the expert from the engineering department, and experts for traffic and contract issues. The aim was to formulate all the requirements to be fulfilled and yet to incorporate flexibility for the contractor in order to find an optimal solution. Decisive requirements encompassed a maximal permanent load of 200 kg/m^2, the suitability for working loads a normal bridge is designed for, and sufficient work space under the bridge. Particularly the restricted weight of the bridge appeared to be a challenge for manufacturers of steel bridges. The contractor reported that Dutch firms for steel bridges were not able to offer a solution that could meet the needed weight. A partner firm in Switzerland provided the contractor with a suitable solution already adapted for bridge maintenance in Austria. Both the Dutch contractor and the Swiss engineering firm established a joint venture which rented the temporary bridge to the contractor. That is, the contractor expected to apply the bridge in upcoming maintenance projects. The fact that the bridge did not have to be amortised in one project favoured the contractor for the project.

After the tender a detailed plan for applying the temporary bridge was necessary. Here the internal engineering department of the client and the Austrian bridge manufacturer worked closely together. In terms of an iterative process the engineering department concretised the requirements and checked their fulfilment with regard to the constructional solution proposed by the bridge manufacturer. This was essential as some of the design codes for bridge constructions differ in the Netherlands and Austria. Finally, the engineering department took on the role of an internal consultancy for the regional department approving the practicability of the temporary bridge.

3.3 DISCUSSION OF MAIN FINDINGS

The case “Bridge Flyover” explains how variables in our conceptual framework are linked up. An important finding is that, not surprisingly, the persuasion and the decision to adopt the innovation are strongly influenced by the perception about potential advantages of the temporary bridge. However, more interesting are the contextual factors that led to the perception of applying a favourable solution and that specified the ways of communicating these advantages.

On the environmental context level project constraints, especially the traffic situation, prompted the client to look for an unconventional solution. Without such a solution either the bridge lanes would have had to be closed completely for a certain time or the work would have had to be done during the night. The former would have led to unacceptable traffic blocks, the latter to a longer maintenance period with reduced quality and restrictions on noise level. The bridge flyover promised to ensure a constant traffic flow and operations during the day, which simultaneously would allow each joint to be renewed at once. This resulted in shorter construction time, less traffic disturbance and increased joint quality compared to common ways of organising such maintenance work. It becomes apparent that the recognition of a problem which cannot be adequately solved with existing solutions is a strong trigger for the development of an attitude towards innovative ideas.

On the technological context level the usage of similar solutions in other projects was beneficial to the innovation adoption, too. On the one hand that led to knowledge in advance of the project that solutions exist which might be able to meet the project constraints appropriately. On the other hand the technical, contractual and traffic-related considerations directed to the application of such existing solutions eased the tender procedure and formed a positive attitude towards the innovation before the project started. Moreover, during the tender phase technical documents and DVDs of former applications the contractor provided could convince the client to finally adopt the solution. It can be stated that the previous use of similar constructions not only represented the source of the idea but also led to a positive adoption decision by increasing the perceived relative advantages and observability, and decreasing the perceived complexity. The dissemination and availability of appropriate information about previous use of similar solutions contributed substantially to making a favourable adoption decision.

However, another factor of the technological context level slowed down the adoption process: the readiness for application. Due to technical regulations there was no temporary bridge immediately applicable. As a changed structural design was needed and there was no possibility to test this newly designed bridge in advance, at the beginning the regional department was less convinced that a temporary bridge would be practicable.

This effect was partly compensated through a factor of the organisational context level: the access to internal technical expertise which supported the development of the needed confidence. The engineering department not only provided the idea but also formulated requirements and evaluated alternatives. The ease of personal contacts and internal discussions facilitated the comprehension of the solution and reduced the uncertainty about its advantageousness. Moreover, the findings suggest that internal competences fostered the communication quality due to the common organisational and cultural basis on which cooperation and information exchange took place. However, it remains to be seen whether the ongoing reorganisation of public clients and the outsourcing of engineering competences will affect the future innovation behaviour and whether a comparable organisational and cultural context can be established.

Our case study revealed an additional factor of the environmental context which we did not consider in our conceptual framework. The bridge flyover as a process and architectural

innovation shows that the characteristics of the construction process may also determine the adoption behaviour. As the construction process itself took place while the traffic continued, the new way of organising the construction process particularly had to take into account possible impacts on safety, health and well-being of road users as well as construction workers. How road users react to the changed situation and which working conditions are present under the temporary bridge were questions the client was confronted with. Similar to the constructed facility the construction process carries a certain degree of social responsibility, which may demand strict safety or environmental codes or regulations used by the client to assess innovative ideas. That is, the more a constructed facility or the construction process shows social responsibility and the more an idea changes existing structures, the more the idea should be considered in the early phases or in advance of a project in order to provide sufficient resources to meet conditions.

4.0 CONCLUSION

Clients are regarded to play an important role in stimulating construction innovation. This paper reported on an ongoing research project which aims to shed more light on the adoption behaviour of construction clients. The paper built up the conceptual framework that we use to investigate, analyse and discuss different cases of innovation adoption. Furthermore, it presented the main findings of one of these cases.

Thus far we can conclude that the innovation adoption process of construction clients is first of all a communication process. The communication characteristics account for the awareness of an innovation. On the other hand, they affect the perception of innovation attributes, which affects the evaluation of new ideas and the propensity to their adoption. Communication characteristics and perception of innovation attributes are both linked with the context of the adoption process. That is, several factors of the environmental, organisational and technological context determine the way communication takes place and innovation attributes are perceived. Our first case study about the adoption of a temporary bridge identified project constraints, previous use of similar solutions, internal competences and the social responsibility of the construction process as most important contextual factors.

Based on our theoretical and empirical findings, the innovation adoption process of construction clients improves if clients first better recognise and understand the problem an innovative idea is intended to solve, The availability of internal expertise seems to be beneficial for the quality of this communication process. Additionally, the low trialability of construction innovations particularly with higher innovation degrees makes references to similar solutions in previous projects vital. For a more accelerated diffusion, improved spread and availability of information about applied ideas is required. This includes not only technical documentation but also visual material which is especially suitable for forming perceptions about the relative advantage and complexity of the innovation. Furthermore, an early consideration of ideas with considerably structural changes either in advance or at an early stage of a project ensures that safety and environmental conditions can be met. The more general implication of our research is that different adoption strategies are required dependent on the nature of the innovation and the context of the adoption process.

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