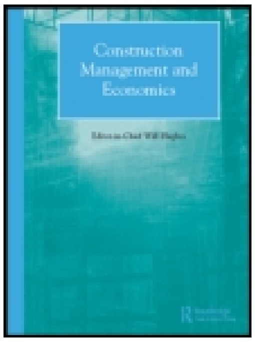

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

The context of innovation management in construction firms

Andreas Hartmann

To cite this article: Andreas Hartmann (2006) The context of innovation management in construction firms, Construction Management and Economics, 24:6, 567-578, DOI: 10.1080/01446190600790629

To link to this article: https://doi.org/10.1080/01446190600790629

Published online: 18 Aug 2006.

Construction Management and Economics (June 2006) **24**, 567–578

The context of innovation management in construction firms

ANDREAS HARTMANN*

Department of Construction Management and Engineering, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

Received 16 October 2004; accepted 16 June 2005

Conscious management of innovation in construction firms is becoming more and more a necessity. However, the possibilities and ways to successfully put an innovative idea into practice depend on a range of contingencies. A framework of innovation management was devised to structure the context variables of construction innovation. Furthermore, an analytical approach was developed to enable researchers as well as construction managers to detect those variables which should be considered for managing construction innovation. The application of the approach to the case of a Swiss contractor revealed dependency on client and location, procurement form, innovation acceptance of the client and regulation degree as significant variables of the external environment. Service offer, knowledge strength, cooperative behaviour, financial strength and time needs were identified as critical variables of the internal environment. The implications are that the management of construction firms should advocate innovative ideas explicitly, make conscious strategic decisions about the direction of the firm's innovation activity and provide methodical and hierarchical support during the innovation process. Establishing internal innovation brokers and using portfolio-based project checkpoints are supportive measures in this regard.

Keywords: Innovation management, context variables, construction firm

Introduction

The construction industry has been dominated by structural change in recent years, which has confronted many firms with the need to make crucial strategic decisions (Pries and Janszen, 1995; Sexton and Barrett, 2003b). These decisions relate to both the breadth and depth of the future range of services the firms intend to offer. The trend in construction markets towards customer-oriented integrated solutions requires firms to assess their range of services in an attempt to pinpoint aspects of cost and differentiation, and devise competitive strategies for selected market segments (De Haan *et al.*, 2002; Davies *et al.*, 2003). Within this process of change the strategic importance of innovation is increasing. Slowly but surely, construction firms are recognising the need to manage innovation more consciously (Gann, 2000; Ling, 2003).

The management of innovation comprises all activities which aim at efficient implementation of novel ideas into effective market solutions (Drejer, 2002) and the capitalisation and reinforcement of the capability and willingness of an organisation to innovate (Trommsdorff, 1990). However, there is no one best way to fulfil these activities, 'as industries differ in terms of sources of innovation and the technological and market opportunity' (Tidd, 2001, p. 173). It is largely acknowledged and underpinned by empirical research that effective and efficient management of innovation depends on a range of context variables (Scott and Bruce, 1994; Damanpour, 1996; Tidd *et al.*, 2001; Frambach and Schillewaert, 2002). Thus, in order to be successful in 'managing ideas into good currency' (Van de Ven, 1986, p. 591), a firm has to be aware of its specific circumstances influencing its possibilities to innovate as well as the exploitation and enhancement of these possibilities.

Several studies have already been undertaken to examine enablers of and barriers to construction

* E-mail: a.hartmann@utwente.nl

Construction Management and Economics
ISSN 0144-6193 print/ISSN 1466-433X online © 2006 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/01446190600790629

innovation (for an overview see Bossink, 2004; Blayse and Manley, 2004). Yet, a consistent understanding of innovation management in construction firms is still missing. Limitations of accumulated knowledge can be mainly traced back to the amalgamation of direct and indirect effects of context variables on innovation. Possessing a conscious business and technology strategy, for example, is identified to be supportive for the innovativeness of construction firms (Nam and Tatum, 1992; Atkin, 1999). However, strategic decisions affect a firm's innovation performance by defining the requirements on innovation processes (Sexton and Barrett, 2003b). At the same time, they are shaped by the environment within which the firm is operating (Seaden *et al.*, 2003). Consequently, they mediate the influence of environmental variables such as technological advancement on organisational structures (Miller *et al.*, 1988). That is, organisational innovation refers to the actions, reactions and interactions of, and between, different context variables (Sexton and Barrett, 2003b). Successful management of innovation needs to consider these patterns of interrelated contingencies (Frambach and Schillewaert, 2002). From the contextual point of view of construction firms, research has widely neglected the distinction between context variables that firms are able to influence to ensure a certain innovation performance and context variables that firms have to consider while altering the former. Guidance on how to evaluate the potential of an innovative idea to perform well and, based on that, how to manage innovation is scarce.

The research this paper reports on addressed this knowledge gap. Its aim was threefold. First, the research conceptualised, based on a literature review, contingencies of organisational innovation through a framework of innovation management. The framework distinguishes instrumental and environmental variables. It depicts the interaction of these variables and their relationship to innovation performance. However, due to differing situations of construction firms, it seems to be impossible to provide a generally valid set of context variables. Thus, the second aim was to link the framework with an analytical approach that would guide construction management in detecting environmental variables and stimulate discussion on the expected innovation performance. For construction research, framework and approach offer the opportunity to reveal patterns of relationships among instrumental and environmental variables, and innovation performance. A first step towards consistent models of innovation management in construction firms was part of the third research aim. Here, the analytical approach was applied to the case of a Swiss contractor in order to provide a first set of environmental variables and to draw first implications for the configuration of instrumental variables. The paper is structured according to these three research aims.

The framework of innovation management

That firms respond differently to different contexts is theoretically and empirically supported by the contingency approach. Since the 1960s a substantial body of research has been conducted aiming to describe the relationship between environment, structure and performance of organisations (e.g. Woodward, 1965; Pugh *et al.*, 1969; Dewar and Hage, 1978; Fry and Slocum, 1984; Miller, 1992; Bhattacharya and Bloch, 2004). In essence, the contingency approach states that for a given context an optimal organisational structure exists (Donaldson, 2001). This argument has been much criticised, especially for its assumption of a deterministic relation between situation and organisational structure. Nevertheless, contingency research could show that context variables define the possibilities of effective and efficient organisational settings or rather determine the boundaries in which strategic choices are possible (Child, 1972; Miles and Snow, 1978). It asserted additionally that 'the understanding of context-structure-performance relationships can only advance by addressing simultaneously the many contingencies, structural alternatives, and performance criteria that must be considered holistically to understand organisation design' (Drazin and Van de Ven, 1985, p. 519).

Based on that, the general literature has already identified a wide range of context variables influencing organisational innovation (for an overview see Souitaris, 1999). From the perspective of innovation management, one set of these variables possesses the character of instruments which are configured to ensure a certain innovation performance. The innovation performance refers to the effectiveness and efficiency of the innovation process (Thom, 1990). It expresses the extent to which an innovative idea solves a problem, becomes accepted on the market, leads to competitive advantages and consumes resources for its realisation (see below). The other set belongs to the internal and external environment of the firm. It represents 'the totality of physical and social factors that are directly taken into consideration in the decision-making behaviour of individuals in the organisation' (Duncan, 1972, p. 314). It defines the window of opportunities for the managerial configuration of the instrumental variables (Tidd, 2001) (Figure 1).

The instrumental variables of innovation management encompass a firm's culture, strategy, structure and processes, which alongside innovation affect the

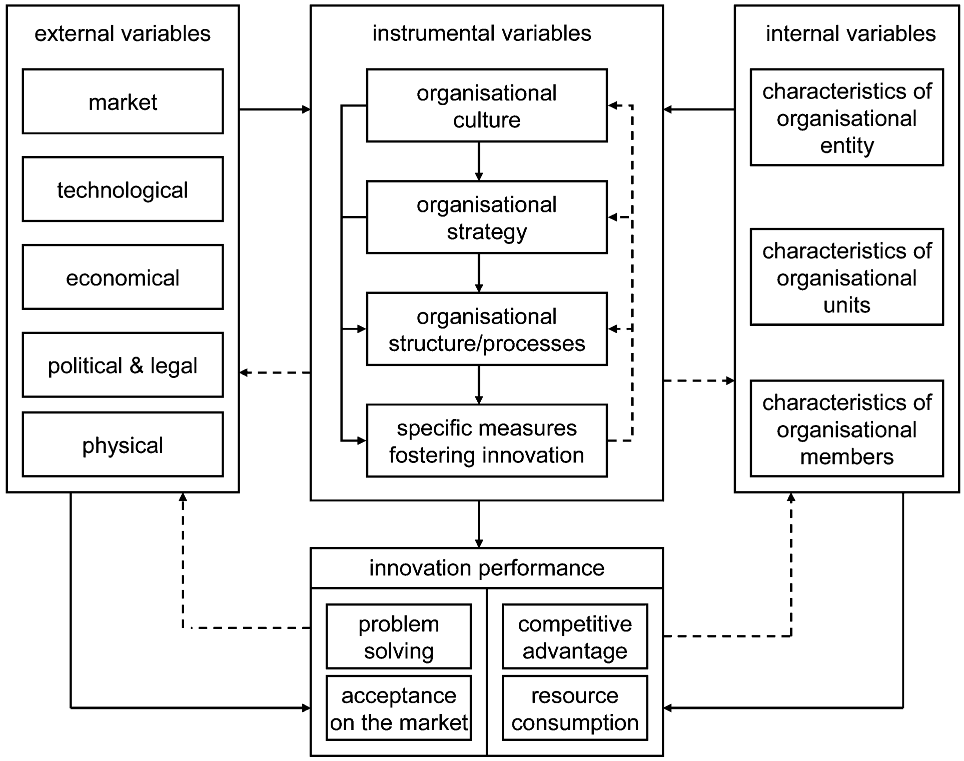

Figure 1 The framework of innovation management

realisation of every kind of task within the firm (Thom, 1990). Organisational culture represents the shared system of values and beliefs which become manifest in the behaviour and actions of organisational members (Martins and Terblanche, 2003). Cultural attributes advantageous for innovation include encouraging and supporting employees to question predominant ways of working, tolerating unsuccessful ideas without punishing innovative employees, accepting conflicts and handling conflicts constructively (Martins and Terblanche, 2003; Blayse and Manley, 2004). Through organisational strategy, business priorities of firms are constituted and expressed in a commonly shared vision and long-term goals. A supportive effect on innovativeness could be found if the development of new markets, technologies or products is part of business strategy (Nam and Tatum, 1992; Swan and Newell, 1995). Through organisational structure and processes tasks, competencies and responsibilities are divided, configured and assigned to organisational units and members. Organisational attributes such as specialisation and function differentiation are seen to be conducive to innovation, whereas formalisation and centralisation inhibit innovative solutions (Damanpour, 1991). Additionally, instrumental variables include specific measures, which are of particular interest either to single phases of the innovation process (e.g. creativity methods for the generation of ideas), to the realisation of a certain kind of innovation (e.g. R&D for product innovations) or to the innovation behaviour in general (e.g. incentive system) (Thom, 1990).

The internal environment comprises variables within the boundaries of the organisation such as characteristics of organisational members (e.g. educational background), units (e.g. intra-unit conflicts) and the organisation as a whole (e.g. kind of services) (Duncan, 1972; Kimberly and Evanisko, 1981). The external environment consists of variables outside the boundaries of an organisation such as market variables (e.g. intensity of competition), technological variables (e.g. technical advancement), economical variables (e.g. private investments), political and legal variables (e.g. regulations), social and cultural variables (e.g. educational level) and physical variables (e.g. climate) (Duncan, 1972). Which environmental variables become relevant for innovation management may strongly differ between firms (Souitaris, 1999; Tidd, 2001).

According to the system-theoretical view, which regards organisations as open and complex systems (French and Bell, 1973; Hill *et al.*, 1994), several interrelations between context variables and innovation performance exist (Figure 1). Variables of the internal and external environment open up a firm's potential to innovate and constrain the strategic alternatives for its exploitation (Tidd, 1993). They determine if an innovation will perform well and, thereby, how instrumental variables have to be configured. By choosing a certain innovation strategy, the requirements on organisational structure and processes and the application of supportive measures are defined (Chandler, 1973). The realisation of strategic decisions and organisational measures is guided by a firm's culture regarding innovation, which 'fills the gap between what is formally announced and what actually takes place' (Martins and Terblanche, 2003, p. 65). Consequently, implemented strategy, structure and processes reflect and, simultaneously, shape the value and norms of the firm. Additionally, structure and processes restrict, once established, the formulation of strategies (Miles and Snow, 1978). These recursive relations (broken lines in the framework) indicate the extent to which there is a fit among instrumental variables influencing innovation performance. Recursive relations also exist between instrumental and environmental variables. On the one hand, a conscious influence on the environment, for example on inhibitory variables, may enlarge the innovation potential and the strategic options of a firm (Miles and Snow, 1978). On the other hand, a certain innovation performance may result in dynamic effects which, by altering environmental variables (e.g. intensity and kind of competition), push a whole industry forward (Abernathy and Utterback, 1975).

Given this framework of innovation management, managers of construction firms are confronted with two questions:

- Which environmental variables have to be considered for the configuration of instrumental variables to achieve a certain innovation performance?
- How should instrumental variables be configured if a set of environmental variables is given?

In the following an approach to answer the first question is presented.

The potential of innovative ideas to perform well

It seems obvious that even when focusing on the construction industry, the individual situations of the various firms differ. Construction firms operate in different countries or regions, have different histories, offer varying services, etc. Moreover, organisational members perceive the importance of environmental variables differently. Their assessment of the effectiveness and efficiency of the innovation process may deviate from each other (Frambach and Schillewaert, 2002). What is needed is a common basis upon which construction management is able to decide whether and how an innovative idea is going to be realised. An analytical approach from Michel (1990) was transferred to construction to provide guidance on evaluating the expected performance of an innovative idea. It allows the identification and discussion of those environmental variables that affect possibilities and ways of putting an innovative idea into practice. For the analysis of a firm's internal and external environment, the potential of an innovative idea to perform well is divided into four sub-potentials (Figure 1):

- the potential of problem solving;
- the potential of diffusion;
- the potential of differentiation;
- the potential of implementation.

The potential of problem solving describes the chance of an innovative idea to transform project requirements (e.g. energy consumption) into constructional solutions (e.g. insulation). It refers to the characteristics of an innovation and addresses variables of the external environment of a firm. Previous research showed that problems solved through innovative ideas mostly arise from the divergence of target constructional parameters from the actual state of art (Nam and Tatum, 1989; Mitropoulos and Tatum, 2000). If requirements (e.g. technical) cannot be reached by known solutions, the search for new alternatives is triggered (Tatum, 1984; Slaughter, 2000). Apart from being a reaction to problems, innovative ideas can also proactively contribute to their solution by anticipating project demands and grasping technological opportunities (Nam and Tatum, 1992). However, the potential of an innovative idea to solve an existing or open formulated problem is always connected with uncertainty and the risk of failure (Sexton and Barrett, 2003a).

The potential of diffusion includes the chance of an innovative idea to become accepted on the market. It pays attention to the fact that construction innovations are introduced through inter-organisational networks, which consist of firms of different industries, private as well as governmental organisations temporarily working together in projects (Slaughter, 1998; Gann and Salter, 2000). As recent research has discovered, the commitment of the network parties is mostly needed to successfully adopt innovations (Ling, 2003; Abd El Halim and Haas, 2004; Dewick and Miozzo, 2004). The potential of diffusion links an innovative idea with the attitude of project participants towards this idea and is related to the external environment of a firm.

The potential of differentiation describes the chance of an innovative idea to lead to advantages in competition. It considers that innovations are not ends in themselves and, as supported by empirical studies, the managerial aim to enhance the competitiveness of a firm is a strong impetus for construction innovation (Mitropoulos and Tatum, 2000; Seaden *et al.*, 2003). It connects the innovative idea with the strategic requirements of a firm and is influenced by variables of the internal environment.

The potential of implementation includes the chance of an innovative idea to be transferred into an innovate solution successfully applied in practice. It considers that generating a new idea is a necessary but not sufficient task to complete the innovation process (Sexton and Barrett, 2003b; Abd El Halim and Haas, 2004). The idea has to be developed further into a viable service, product or process. This transformation mostly requires additional in-house resources to be connected with resources from other organisations in a networking process (Slaughter, 1998; Barlow, 1999). The potential of implementation refers to requirements of the innovation process and covers the internal environment of a firm.

Through an intensive discussion, members of a firm's management define and weight the environmental variables expected to have an influence on the four sub-potentials. Thereafter, each member assesses the importance of the identified variables individually. The results of the evaluation are then used to discuss the expected performance of an innovative idea and the alternatives to realising the idea (Michel, 1990).

Environmental variables influencing the innovation potential

Because innovation is inherently uncertain, it is unlikely that all variables are known in advance. Besides providing guidance on the analytical process, research can also orientate practitioners with respect to the most significant variables. Here it is argued that a convincing evaluation of the effectiveness and efficiency of innovation processes requires the simultaneous consideration of external and internal contingencies. In order to make a first step towards consistent patterns of relationships among context variables and innovation performance in construction firms, the potential of a Swiss contractor for realising innovative ideas was analysed. Thus, the aim of the case study was to reveal logical links between environmental variables and innovation performance by answering the following questions:

> Which environmental variables influence the potential of innovative ideas (1) to solve problems; (2) to become accepted on the market; (3) to lead to competitive advantages; and (4) to be developed into an applicable solution?

The search for a net of contingencies and the explorative character of the investigation were the reasons for choosing a single case study. The restricted generalisation of results inherent to single cases was met in three ways.

First, the case study focused on a typical contractor with regard to the firm size, namely Marti, a firm employing approximately 1,000 members of staff. The firm is structured into regional and central business units which act autonomously. Due to historically different developments the services each business unit offers differ. Building construction, maintenance of buildings, road construction and underground engineering are typical services of the regional business units. Tunnelling and engineering services are centrally coordinated. Another characteristic typical for firms like Marti is that services mainly focus on production. However, in recent years Marti has partly moved on the value chain towards an increased integration of design and construction services. In the area of building construction this has already led to an independent business unit.

Second, the investigation was not restricted to a specific innovation. Moreover, on the basis of several examples and general observation about the course of innovation processes within the firm influences on the four potentials were determined.

Third, the data collection was carried out as interplay of personal interviews and group discussions to reconstruct and validate individual experiences. At the beginning the heads of four regional business units were interviewed separately. At two meetings these managers discussed the results of the interviews. Questionnaires sent to six project managers, 12 site managers and 10 foremen working for the four business units delivered supplementary data. At two further meetings the four managers also discussed these results. Additional information was gathered from outside the firm through semi-structured interviews with seven professional clients including three banks, one insurance company, one trading company, one airport company and one university (Girmscheid and Hartmann, 2002). The heads of the construction and real estate departments represented the client organisation. Again the outcomes provided the input for a group discussion of the four managers.

The data were analysed by comparing the results of interviews and group discussions with the four potentials. The focus was on exposing environmental variables that influence innovation performance significantly. In the following the detected variables and their impact on effectiveness and efficiency of innovation processes are presented.

Influences on the potential of solving problems

Two variables of the external environment were found to influence the chance of an innovative idea to transform project requirements into constructional solutions:

- the dependency of constructional tasks on clients;
- the dependency of constructional tasks on locations.

The construction process normally starts when the client makes the decision to build. The dependency of constructional tasks on clients leads to the fact that to a certain extent each constructional task has to be responsive to the specific requirements of a single client. These changing demands may lead to problems that call for an innovative solution or may offer opportunities to propose a solution that meets the demands best. A certain degree of individualisation is also the result of the dependency of constructional tasks on locations. The qualitative and quantitative combination of resources has to be adjusted to the local conditions of the building's place of usage, which in turn can also cause problems to be solved innovatively or can provide opportunities for new solutions. The realised ideas at the investigated contractor showed that the potential of solving problems will be greatest, if:

- a single parameter of the constructional solution can be improved without bigger changes of parameters also necessary to fulfil the requirements of client and location;
- a single parameter of the constructional solution can be improved with changes of parameters not relevant to fulfil the requirements of client and location;
- all parameters of the constructional solutions crucial to fulfil the requirements of client and location can be jointly improved.

The dependency on clients and locations also influences the potential of solving problems through the applicability of an innovative solution to several projects. Here the potential increases with the prospect of using the innovation more or less adapted to the requirements of future constructional tasks. For example, one of the business units of Marti recognised an increasing demand for the maintenance of tunnels. At the same time they got the opportunity to carry out a small tunnel reconstruction. Although they had not been active in this market segment before, they could build on existing knowledge from underground engineering. The success of the first project and the prospect of getting more contracts encouraged them to invest in new and adapted machines. Through continuous learning and growth, the new market segment became a main pillar for this business unit. A cross-project application of innovative solutions can be particularly expected if changes involve single elements of the product or process, such as construction material and equipment. For instance, another business unit of Marti observed abroad the advantages of high-pressure water blasting and started to test machines. They introduced the technology on their home market and developed several tools on their own to apply the machines for different segments such as tunnel, road or building reconstruction. Similar results are obtained by Tatum and Funke (1988), who reported on a specialised contractor developing laser-guided earthmoving equipment, as manufacturers were not interested in investing in this small market. It can be stated that the more an innovation contributes to the final composition of a building or construction process, the more it has to consider specific requirements and, thus, the less it can be directly transferred to other projects. This also means that a comprehensive rationalisation of the building process is restricted. Owing to individual preferences, changing space and weather conditions as well as the need for transportable equipment, a fully automated operation process is hardly realisable. In fact, flexible machines that are applicable for different tasks are preferred. Marti, for instance, introduced flexible, modularly composed units for tunnelling which allow the drilling of blast holes, setting anchors and injecting into hollow spaces.

Influences on the potential of diffusion

For evaluating the potential of an innovative idea to become accepted on the market, three variables of the external environment are found to be relevant:

- the procurement form;
- the innovation acceptance of the client;
- the regulation degree.

The procurement form determines significantly if a project provides incentives for construction firms to innovate and supports commitment between the involved parties. From the perspective of the examined contractor, incentives and commitment arise if the firm can bring in its knowledge at an early stage of the construction process and if creativity is appreciated and rewarded. However, until now existing procurement forms have much prevented a stronger diffusion of innovative ideas. For example, regarding subsequent offers of alternative solutions to the tendering documents, the firm's representatives state that several architects and engineers fear a loss of image in the eyes of the client and, thus, reject alternative tenders. Furthermore, it has to be convincingly proved that the alternative solution has visible advantages in comparison to the first plan, but if the solution is convincing and worked out in detail, there is the danger that the client will look for another firm that will realise the idea for less payment. Some clients take innovative ideas of the contractor for granted. Indicators for the innovation orientation of procurement forms are seen in the number of projects in a market segment carried out on performance rather than solely on price competition, the existence and application of incentive systems (e.g. bonus-malus-system) for efficient constructional solutions or the point in time when the knowledge of subsequent phases is incorporated into the construction process. This is underpinned by findings of Micelli (2000), who emphasises the necessity of procurement forms that 'allow an administration to learn about all the opportunities the markets can provide' (p. 652).

Innovative solutions have to be analysed with regard to the added value they offer to the client and their appreciation by the client. The interviewed persons point out that it is difficult to introduce an innovation without a clearly visible added value for the client. Otherwise the client will not be willing to take on additional costs and risks associated with the innovation. An advantage could be lower maintenance costs. For example, one of the interviewed clients accepted a new structural system for a cooling tower which was much more expensive than conventional solutions. But the system promised lower energy costs through which a return of the higher investment could be reached within three years. It could also be found that broad constructional experiences of clients have a positive effect on innovation diffusion. Owing to their repeated construction activity the interviewed clients possess a certain degree of technical and management knowledge, mostly represented through an internal architectural and engineering unit, which allows them to understand the principal mode of functioning of an innovative solution. This is indicated through the ability of clients 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. These results are consistent with a study of Nam and Tatum (1997), which showed a close relationship between the technical competence of clients and their active participation in innovative projects. Moreover, the findings suggest that the attitude of clients towards innovations is also a matter of the innovation behaviour of these clients in their core business. The more clients are innovative in their own business, the more likely it is that they are also open-minded towards construction innovation.

Regulations play an important in role in construction, as they can prevent legal disputes by determining the quality of services to be delivered. At the same time, the binding nature and usage of regulations can hinder the diffusion of innovative solutions that exceed the current state of the art. Technical regulations in particular, due to their hardly manageable variety and lack of transparency, can lead to undifferentiated usage. That can cause heavily detailed specifications that constrain the ability of the firm to find an optimal constructional solution. This supports findings of Gann *et al.* (1998) who state that 'clarity and simplicity is needed in the regulatory process to enable the take-up of good practice and encourage innovation' (p. 293). A positive effect emerges from regulations if they form entry barriers. For example, one of the business units of Marti developed a crusher to pre-process blast furnace slack for road construction. At the beginning no requirements on the production process existed. Thus, it was relatively easy for imitators to get into this business, but once standards were established a further penetration of the market slowed down.

Influences on the potential of differentiation

From the case study results, two variables of the internal environment influencing the potential of an innovative idea to lead to competitive advantages could be extracted:

- the service offer;
- the knowledge strength.

The service offer determines, first of all, the kind of the competitive advantage. The services of Marti confined to the production phase mainly place emphasis on low cost. Thus, innovative ideas aiming at efficient processes such as new construction methods or equipment are strategically most important. Regarding the integration of design and production services, a shift to product uniqueness could be noticed. This is not surprising, as the firm has moved towards the planning phase, which allows a stronger exertion of influence on the building system. Moreover, only the early involvement in the construction process opens up the possibility to comprehensively design and, thus, improve the constructional solution. Especially in conjunction with procurement forms considering the value-added tasks, the chance to influence the parameters of the construction solution sequentially decreases with services of later phases such as production. In this case the chance to differentiate on the basis of innovative solutions remains low. Furthermore, it could be found that new and specific fields of services (e.g. maintenance) offer a wider range of opportunities to differentiate on the basis of new ideas than traditional services (e.g. building construction). Fewer detailed contract specifications due to a lack of experience on the part of the planning institutions are seen as reason for differences. Furthermore, poorly conceived and technically mature developments of suppliers play a role, too.

An innovative solution leads to an advantage in competition if the incorporated knowledge reaches a level that exceeds the current state of the art and can be exclusively used by the innovating firm. Thus, an idea possesses a high potential of differentiation if the firm can already revert to a high level of knowledge for realising the idea and if it is possible to protect the new knowledge against competitors. As contractors like Marti usually offer service and not products, shielding acquired knowledge from imitators is restricted. The interviewed persons state that site production to some extent externalises a firm's knowledge and that they also visit sites of other firms to obtain suggestions for new ideas. Thus, employees with extensive experience gained from previous projects all the more become an important pillar of the firm's performance. In particular, the ability to solve project-related problems increases with a wide spectrum of knowledge which can be newly combined. Consequently, to counteract poaching and the resigning of staff members, professional development programmes are seen to ensure an exclusively usable knowledge. The firm is forced to continuously learn, which corresponds to findings from other studies of project-based industries (e.g. Keegan and Turner, 2001). Although the focus of teaching programmes is on technical subjects, a number of employees from the higher and middle management of Marti take or took part in certificated courses in business administration. Indicators for the knowledge strength are the number of projects acquired through innovative ideas, the number of professional development programmes taken up by employees, the number of experienced senior staff members or the labour turnover rate.

Influences on the potential of implementation

The variables of the internal environment which were found to have an influence on the potential of an idea to be transferred into an innovative solution comprise:

- the cooperative behaviour;
- the financial strength;
- the time needs.

The importance of cooperative behaviour results from the fact that an increasing innovation degree requires knowledge from different sources inside and outside of the firm. Cooperative behaviour means the ability and willingness of a firm's staff members to contribute to the development of an innovative solution and to share knowledge with other participants of the development process. The study results show that, regarding the realisation of new ideas, staff members within a business unit are cooperative. However, as Marti is structured into regional and central business units that act autonomously, sometimes hindrances for collaboration between units arise. In particular, the business unit with the initial idea has to take the risks whereas other units are not willing to bear part of that risk. Besides this, the spatial separation with independent markets restricts the communication between business units to a minimum. Although business units offer the same services and, thus, have similar experiences, the awareness of problems already innovatively solved by other units is mostly lacking. Furthermore, limitations on time and manpower often prevent the selective mobilisation of knowledge in other business units. It could also be found that cooperation with other organisations requires persons with empathy, negotiating skill and self-confidence to balance cultural and structural divergences. These persons are able to build up and maintain credibility and trust towards the other organisation and to confront and solve conflicts. For example, the head of one business unit could overcome hostile and strongly competitive behaviour of local construction firms and form a bidding consortium for a tunnelling project. Moreover, the cooperation won the tender by offering an innovative construction method.

The financial strength influences the potential of implementation through the ability of the firm to take on the arising costs with respect to the risks of realising the innovation. This means not only providing a sufficient amount of financial resources but also ensuring continuous financing. The difficulty of determining financial resources increases in proportion with the degree of innovation, which is frequently connected with unforeseen modifications and adjustments. A lack of financial resources can cause construction delays or qualitative defects, which in turn negatively affect the firm's image. Furthermore, innovative solutions—especially those requiring large investments—should be applied to several projects in order to amortise the expenditures. However, the interviewed persons state that the fluctuant and unpredictable demand in construction can hamper long-term investments. Whether budgets will be available for innovations or invested capital will be returned depends on the future order situation. A positive effect of financial uncertainty on innovation is seen in new leasing and rent models offered by suppliers of construction equipment and, as mentioned before, efforts to develop flexible construction equipment adaptable to various construction tasks.

The study showed that for transferring an idea into an innovative solution, the time needs of the transfer process also play an important role. On the one hand, the time pressure on most construction projects fosters the search for efficient ways of delivering the firm's services. On the other hand, narrowed time frames of construction projects prevent the realisation of roughly formulated ideas. In all project phases there is hardly enough time to collect additional information and generate supplementary knowledge. This restriction is partly due to short periods of time for compiling large-scale offers, shortened time between the contract award and the beginning of the construction work, and plans made too late. It could be observed that ideas are preferably followed up that are either already sufficiently developed to be ready for application or can be brought to this level of maturity using a minimum of additional resources. This is consistent with the research results of Slaughter (1993), who found that 'time and cost pressures during construction may not necessarily produce the "best" solution to any given problem but, rather, instead provide an "adequate" solution' (p. 546). Similarly, Ling (2003) concludes from her findings that tight project schedules may prevent the implementation of innovative solutions.

Implications for the management of innovation

The detected environmental variables have the following implications for the management of innovation or rather the configuration of instrumental variables in construction firms.

Organisational culture

A distinctive innovation culture in construction firms is rare. Yet, the influences on the potential of implementation indicate that innovation has to become a shared value within a firm to be successful. First of all, new ideas should be prevented from getting lost due to the domination of daily business or unclear competencies. Innovative behaviour should be rewarded and opportunities for an intensive information and knowledge exchange between projects and business units should be created. Moreover, a firm's management should communicate the importance of innovative solutions thoroughly, offer employees freedom to become innovative and support innovative employees actively with their hierarchal potential. This also means that employees and business units should not be evaluated merely on the basis of short-term revenues of projects, but also with respect to their contribution to the long-term success of the firm.

Organisational strategy

The influences on the potential of problem solving and differentiation showed that, based on the service and knowledge profile, strategic decisions about a firm's innovation activity should be made deliberately to exhaust the possibilities for competitive advantages. If a firm's services focus on subsystems of a facility (e.g. façade), there is an increased chance that well-directed investments in developing new material, components or equipment will lead to knowledge exclusively used in several projects. Depending on the existing knowledge, construction firms may realise such investments internally or through cooperative arrangements with, for example, suppliers. The strategic importance of single subsystems decreases if services encompass the supply of the whole facility. Here knowledge about how to combine modules of the facility and of the construction process for a specific project gains much more importance. As this knowledge is mainly based on experiences from previous projects, strategies to strengthen learning and knowledge sharing from, within and between projects seem to be most promising for a firm's competitiveness. Again, this may happen internally or in cooperation with, for example, design firms.

Organisational structure and processes

Innovation processes within the examined firm are, first of all, interwoven with the construction process. Thus, time and financial constraints mostly diminish the potential to develop an idea ready for implementation. Here the role of internal service units, such as engineering departments, should be strengthened. These units, mostly already existing, may assist project teams in investigating the feasibility of innovative ideas, elaborating ideas until the added value in contrast to conventional solutions is recognisable, and solving further problems during implementation. In doing so, they support not only the workability of an idea but also the acceptance of the market by providing regulation competence, expertise, application authorisation and references. Besides the project-related provision of specialised knowledge, service units may also grasp and realise potential ideas that promise technical and economical advantages for several construction projects. They should be enlarged to act as internal innovation brokers connecting business units and external partners, spreading information about new developments and providing methodical help.

Specific measure fostering innovation

The results of the case study suggest that successful innovation requires a set of contingencies to be considered. Furthermore, the dynamics of innovation processes make it difficult to comprehensively assess each context variable right at the beginning. Portfolio-based project checkpoints may stimulate and methodically support the discussion concerning the most significant variables. They may help to decide whether and in which way an innovative idea should be introduced. Such a nine-field portfolio to be used during the course of a construction project compares two factors (Figure 2). The first factor is innovation attractiveness, which includes influences on the potential of problem solving and diffusion. The second factor is innovation strength, which includes influences on the potential of differentiation and implementation. By placing an innovative idea into the portfolio, its expected performance can be judged at different project stages (Michel, 1990).

Conclusion

The research this paper has reported on provided conceptual help for construction firms and construction research to determine and discuss most relevant context variables of construction innovation. It built up

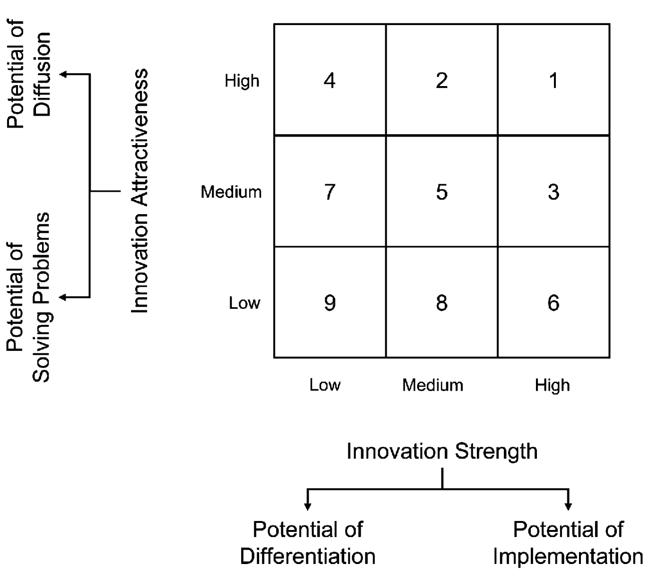

Figure 2 Portfolio used to evaluate innovation performance

a framework of innovation management depicting the relationships between innovation performance and environmental and instrumental variables. In order to evaluate whether an innovative idea performs well, an approach to analyse the context-related potential of putting innovative ideas into practice was developed. The approach differentiates between four potentials of realising innovation in construction: the potential of solving problems, the potential of diffusion, the potential of differentiation and the potential of implementation. By applying the approach to the case of a Swiss contractor, a first set of most significant environmental variables could be obtained. Variables of the external environment include dependency on client and location, procurement form, innovation acceptance of the client, and regulation degree as significant variables of the external environment. Variables of the internal environment include service offer, knowledge strength, cooperative behaviour, financial strength, and time needs. Based on that, major implications for the configuration of instrumental variables are that the management of construction firms should advocate innovative ideas explicitly, make conscious strategic decisions about the direction of the firm's innovation activity and provide methodical and hierarchical support during the innovation process. Enlarging existing service units to act as innovation brokers and using portfolio-based project checkpoints would support innovation management in construction firms.

As the results are based on a single case study, more research is needed to prove the significance of the observed variables and to potentially add further ones. Additionally, future research should provide a deeper insight into the configuration of instrumental variables depending on certain sets of environmental variables. Generally, adequate measures should strengthen the facilitating effects and reduce the inhibitory effects of the variables. Here, the extent to which a firm's environment can be actively influenced varies. Internal variables are more adjustable than external ones. Furthermore, attention should be paid to the intermediary effects of innovation characteristics such as novelty or complexity. For implementing an innovative solution especially with a high degree of novelty it seems, for example, helpful to choose a project with an experienced and innovative client and to involve this client in the innovation process from the beginning (Nam and Tatum, 1997; Slaughter, 2000).

Acknowledgement

The research was funded by the Innovation Promotion Agency (CIT) Switzerland.

References

Abd El Halim, O. and Haas, R. (2004) Process and case illustration of construction innovation. *Journal of Construction Engineering and Management*, **130**(4), 570–5.

Abernathy, W. and Utterback, J. (1975) A dynamic model of process and product innovation. *OMEGA*, **6**, 639–56.

Atkin, B. (1999) Innovation in the construction sector, Paper for the European Council for Construction Research, Development and Innovation (ECCREDI).

Barlow, J. (1999) From craft production to mass customisation: innovation requirements for the UK housebuilding industry. *Housing Studies*, **14**(1), 23–42.

Barlow, J. (2000) Innovation and learning in complex offshore construction projects. *Research Policy*, **29**, 973–89.

Bhattacharya, M. and Bloch, H. (2004) Determinants of innovation. *Small Business Economics*, **22**, 155–62.

Blayse, A. and Manley, K. (2004) Key influences on construction innovation. *Construction Innovation*, **4**, 143–54.

Bossink, B. (2004) Managing drivers of innovation in construction networks. *Construction Engineering and Management*, **130**(3), 337–45.

Chandler, A. (1973) *Strategy and Structure*, The MIT Press, Cambridge.

Child, J. (1972) Organizational structure, environment and performance: the role of strategic choice. *Sociology*, **6**(1), 1–22.

Damanpour, F. (1991) Organizational innovation: a meta-analysis of effects of determinants and moderators. *The Academy of Management Journal*, **34**(3), 555–90.

Damanpour, F. (1996) Organizational complexity and innovation: developing and testing multiple contingency models. *Management Science*, **42**(5), 693–716.

Davies, A., Brady, T. and Tang, P. (2003) *Delivering Integrated Solutions*, SPRU, University of Sussex, Brighton.

De Haan, J., Voordijk, H. and Joosten, G.-J. (2002) Market strategies and core capabilities in the building industry. *Construction Management and Economics*, **20**(2), 109–18.

Dewar, R. and Hage, J. (1978) Size, technology, complexity and structural differentiation: toward a conceptual synthesis. *Administrative Science Quarterly*, **23**(1), 111–36.

Dewick, P. and Miozzo, M. (2004) Networks and innovation: sustainable technologies in Scottish social housing. *R&D Management*, **34**(3), 323–39.

Donaldson, L. (2001) *The Contingency Theory of Organizations*, Sage Publications, Thousand Oaks, CA.

Drazin, R. and Van de Ven, A. (1985) Alternative forms of fit in contingency theory. *Administrative Science Quarterly*, **30**(4), 514–39.

Drejer, A. (2002) Situations for innovation management: towards a contingency model. *European Journal of Innovation Management*, **5**(1), 4–17.

Duncan, R. (1972) Characteristics of organizational environments and perceived environmental uncertainty. *Administrative Science Quarterly*, **3**(17), 313–27.

Frambach, R. and Schillewaert, N. (2002) Organizational innovation adoption: a multi-level framework of determinants and opportunities for future research. *Journal of Business Research*, **55**, 163–76.

French, W. and Bell, C. (1973) *Organizational Development: Behavioral Science Interventions for Organization Improvement*, Prentice Hall, Englewood Cliffs, NJ.

Fry, L. and Slocum, J. (1984) Technology, structure and work group effectiveness: a test of a contingency model. *Academy of Management Journal*, **27**(2), 221–46.

Gann, D. (2000) *Building Innovation: Complex Constructs in a Changing World*, Thomas Telford, London.

Gann, D. and Salter, A. (2000) Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research Policy*, **29**, 955–72.

Gann, D., Wang, Y. and Hawkins, R. (1998) Do regulations encourage innovation? The case of energy efficiency in housing. *Building Research and Information*, **26**(4), 280–96.

Girmscheid, G. and Hartmann, A. (2002) Innovation in construction—the view of the client, in Uwakweh, B. and Minkarah, I. (eds) *Proceedings of the 10th International Symposium for CIB W55 and W65 Working Commissions: Construction Innovation & Global Competitiveness*, CIB, Cincinnati, OH, pp. 29–43.

Hill, W., Fehlbaum, R. and Ulrich, P. (1994) *Organisationslehre 1*, 5th edn, Paul Haupt, Bern.

Keegan, A. and Turner, J. (2001) Quantity versus quality in project-based learning practises. *Management Learning*, **32**(1), 77–98.

Kimberly, J. and Evanisko, M. (1981) Organizational innovation: the influence of individual, organizational and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Journal*, **24**(4), 689–713.

Ling, F. (2003) Managing the implementation of construction innovations. *Construction Management and Economics*, **21**(6), 635–49.

Martins, E. and Terblanche, F. (2003) Building organisational culture that stimulates creativity and innovation. *European Journal of Innovation Management*, **6**(1), 64–74.

Micelli, E. (2000) Mobilizing the skills of specialist firms to reduce costs and enhance performance in the European construction industry: two case studies. *Construction Management and Economics*, **18**, 651–56.

Michel, K. (1990) *Technologie im strategischen Management: Ein Portfolie-Ansatz zur integrierten Technologie und Marktplanung*, 2nd edn, Erich Schmidt, Berlin.

Miller, D. (1992) Environmental fit versus internal fit. *Organization Science*, **3**(2), 159–78.

Miller, D., Droge, C. and Toulouse, J.-M. (1988) Strategic process and content as mediators between organizational context and structure. *Academy of Management Journal*, **31**(3), 544–69.

Miles, R. and Snow, C. (1978) *Organizational Strategy, Structure and Process*, McGraw-Hill, New York.

Mitropoulos, P. and Tatum, C. (2000) Forces driving adoption of new information technologies. *Journal of Construction Engineering and Management*, **126**(5), 340–8.

Nam, C. and Tatum, C. (1989) Toward understanding of product innovation process in construction. *Journal of Construction Engineering and Management*, **115**(4), 517–34.

Nam, C. and Tatum, C. (1992) Strategies for technology push: lessons from construction innovations. *Journal* *of Construction Engineering and Management*, **118**(3), 507–25.

Nam, C. and Tatum, C. (1997) Leaders and champions for construction innovation. *Construction Management and Economics*, **15**(3), 259–70.

Pries, F. and Janszen, F. (1995) Innovation in the construction industry: the dominant role of the environment. *Construction Management and Economics*, **13**(1), 43–51.

Pugh, D., Hickson, D., Hinings, C. and Turner, C. (1969) The context of organization structure. *Administrative Science Quarterly*, **14**(1), 91–114.

Scott, S. and Bruce, R. (1994) Determinants of innovative behaviour: a path model of individual innovation in the workplace. *Academy of Management Journal*, **37**(3), 580–607.

Seaden, G., Guolla, M., Doutriaux, J. and Nash, J. (2003) Strategic decisions and innovation in construction firms. *Construction Management and Economics*, **21**(6), 603–12.

Sexton, M. and Barrett, P. (2003a) A literature synthesis of innovation in small construction firms: insights, ambiguities and questions. *Construction Management and Economics*, **21**(6), 613–22.

Sexton, M. and Barrett, P. (2003b) Appropriate innovation in small construction firms. *Construction Management and Economics*, **21**(6), 623–33.

Slaughter, S. (1993) Builders as source of construction innovation. *Journal of Construction Engineering and Management*, **119**(3), 532–49.

Slaughter, S. (1998) Models of construction innovation. *Journal of Construction Engineering and Management*, **124**(3), 226–31.

Slaughter, S. (2000) Implementation of construction innovations. *Building Research & Information*, **28**(1), 2–17.

Souitaris, V. (1999) Research on the determinants of technological innovation: a contingency approach. *International Journal of Innovation Management*, **3**(3), 287–305.

Swan, J. and Newell, S. (1995) The role of professional associations in technology diffusion. *Organization Studies*, **16**(5), 847–74.

Tatum, C. (1984) What prompts construction innovation? *Journal of Construction Engineering and Management*, **110**(3), 311–23.

Tatum, C. and Funke, A. (1988) Partially automated grading: construction process innovation. *Journal of Construction Engineering and Management*, **114**(1), 19–35.

Thom, N. (1990) Innovation management in small and medium-sized firms. *Management International Review*, **30**(2), 181–93.

Tidd, J. (1993) Technological innovation: organisational linkages and strategic degrees of freedom. *Technology Analysis and Strategic Management*, **5**(3), 273–85.

Tidd, J. (2001) Innovation management in context: environment, organization and performance. *International Journal of Management Review*, **3**(3), 169–83.

Tidd, J., Bessant, J. and Pavitt, K. (2001) *Managing Innovation: Integrating Technological, Market and Organizational Change*, Wiley, Chichester.

Trommsdorff, V. (1990) *Innovationsmanagement in kleinen und mittleren Unternehmen*, Franz Vahlen, Munich.

Van de Ven, A. (1986) Central problems in the management of innovation. *Management Science*, **32**(5), 590–607.

Woodward, J. (1965) *Industrial Organization: Theory and Practice*, Oxford University Press, Oxford.