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Innovation and interorganizational cooperation: a synthesis of literature

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Abstract

Purpose – In construction, literature interorganizational cooperation is argued to be an important aspect of construction innovation. From this perspective, several distinct bodies of literature provide relevant insights. In literature on complex product systems (CoPS), it is argued that construction industry is a CoPS industry and that in CoPS industries systems integrators set-up and coordinate interorganizational innovation. Furthermore, various bodies of literature provide information about factors that affect the success of innovation and interorganizational cooperation. The purpose of this paper is to integrate the findings from these bodies of literature.

Design/methodology/approach – To uncover the present state of knowledge about systems integrators, a comprehensive literature review is conducted. Furthermore, the paper analyzes various fields of literature to derive an overview of factors which have been empirically related to the success of innovation and interorganizational cooperation.

Findings – First, this paper structures the current knowledge on the role and characteristics of systems integrators. Subsequently, the paper translates this knowledge to the context of construction industry and discusses the basis for classifying a firm as a systems integrator in construction industry. Furthermore, the paper presents a list of relevant success factors derived from literature on new product development, strategic networks and alliances, open innovation, and construction innovation.

Originality/value – By integrating various bodies of literature, this paper provides a solid base for future theory development on how firms achieve interorganizational innovation in construction industry.

Keywords Innovation, Construction industry, Knowledge management systems, Research work

Paper type Literature review

Introduction

The construction industry is characterized by its highly fragmented supply chain. Knowledge, materials, technologies and skills are dispersed among many different organizations. Many studies have highlighted that the construction industry's fragmentation in combination with poor interorganizational cooperation is hampering innovation (Dulaimi *et al.*, 2002; Egan, 1998; Latham, 1994). Ambitions to enhance innovation in construction industry are part of many reform programmes in various countries (Dorée, 2004; Ang *et al.*, 2004; Flanagan *et al.*, 2001; Barlow, 2000).

Scholars have argued that it is interorganizational cooperation across project boundaries in particular, that is important for innovation in construction (Dewick and Miozzo, 2004; Dorée and Holmen, 2004; Holmen *et al.*, 2005; Miozzo and Dewick, 2004). Researchers suggest that close and stable relations between the various organizations

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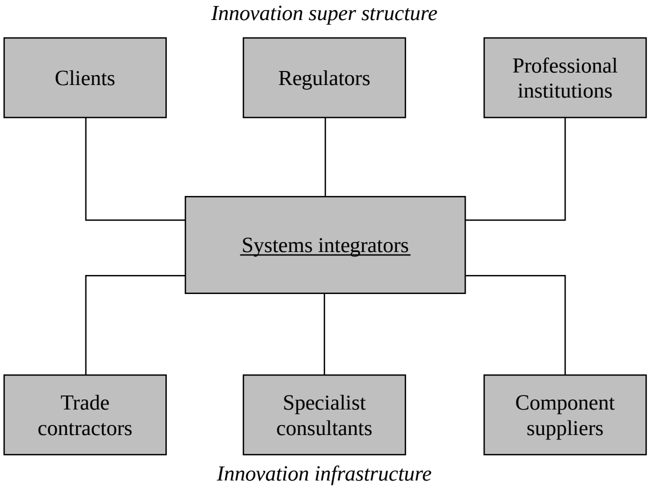
involved in the construction process, such as contractors, architects, engineers, suppliers, clients, research institutes and government bodies, contribute to the development and adoption of innovations. It is argued that close and stable relations facilitate sharing of knowledge and risks.

Based on the argument that interorganizational cooperation is an important factor in construction innovation, an interesting question is: what firms are creating and orchestrating the type of interorganizational cooperation that is needed? From this point of view, literature on complex product systems (CoPS) provides interesting insights. CoPS are products that are customized, made up of many components, based on multiple technologies, and produced in one-off projects or in small batches. Examples include flight simulators, military systems, aircraft engines, chemical plants, buildings and business information networks. Also construction industry can be categorized as a CoPS industry (Hobday, 1996; Winch, 1998; Gann and Salter, 2000; Barlow, 2000). In CoPS literature, scholars focus on a specific type of firm: systems integrators. The concept of systems integrator refers to firms that design and produce CoPS. Systems integrators add value through systems integration: they integrate components, technologies, skills and knowledge from various organizations into a unified system for an individual customer. To do so, systems integrators set-up a strategic network of organizations and coordinate the process of integrating dispersed resources of the network members.

When it comes to innovation in CoPS industries systems integrators are in a central position (Figure 1). They are at the interface between innovation superstructure and innovation infrastructure (Miller *et al.*, 1995; Winch, 1998). The innovation superstructure consists of clients, regulators and professional institutions. The innovation infrastructure comprises component suppliers, trade contractors and specialist consultants. Owing to this central position, scholars argue that the main role of systems integrators in innovation of CoPS is to meet evolving customer requirements by orchestrating research and development (R&D) activities of the innovation infrastructure (Prencipe, 2003; Brusoni *et al.*, 2001).



Sources: Adapted from Miller *et al.* (1995); Winch (1998)

Figure 1.
Innovation structure in CoPS industries

By deductive reasoning an interesting conclusion can be drawn from CoPS literature. The line of reasoning is as follows:

- In CoPS industries systems integrators set-up and coordinate interorganizational innovation (major premise).
- Construction industry can be categorized as a CoPS industry (minor premise).
- In construction industry systems integrators set-up and coordinate interorganizational innovation (conclusion).

Following this line of reasoning, it would be interesting to identify systems integrators in construction industry and explore how they achieve interorganizational innovation. However, the term systems integrator is not a commonly used term in construction industry. Who are the systems integrators of construction industry? Before a theory can be developed of how systems integrators achieve interorganizational innovation, they need to be identifiable. Therefore, to clear the path to theory development, this paper captures the constituents of the term "systems integrator" by reviewing CoPS literature and subsequently translates them to the context of construction industry.

Furthermore, interorganizational cooperation and innovation are being studied in various fields of research. The accompanying bodies of literature all contain information concerning factors that are critical for achieving success. Together, this information serves as a valuable foundation from which to develop a theory of how systems integrators achieve interorganizational innovation. Since the objective of this paper is to pave the way towards theory development, it also presents an overview of critical factors derived from various relevant bodies of literature.

A classification of firms in CoPS industries

The concept of systems integrator has been used to describe producers of CoPS: producers of flight simulators (Miller *et al.*, 1995), aircraft engines (Brusoni and Prencipe, 2001; Prencipe, 1997), buildings (Winch, 1998), aircraft engine control systems (Brusoni *et al.*, 2001), chemical plants (Brusoni and Prencipe, 2001) and military systems (Hobday *et al.*, 2005). In these industries, both physical and human resources, such as subsystems, components, technologies, skills, information and knowledge are dispersed among various organizations. CoPS producers are positioned at the interface between customers and the supply network. The primary constituent of the term "systems integrator" is systems integration: to bring together dispersed resources and integrate them into a coherent system. However, the term systems integrator comprises more than the act of systems integration. Two other constituents are: contractual responsibility for the functioning of the system, and project-based production (one-offs or small batches). Taken together, these three characteristics define a category of firms that add value through systems integration in project-based industries. These characteristics correspond with the definition of Davies *et al.* (2007):

> In its pure form, a systems integrator is the single prime contractor organization responsible for designing and integrating externally supplied product and service components into a system for an individual customer.

The twofold role of systems integrators
When examining the descriptions of systems integrators' activities (Prencipe, 2003; Hobday *et al.*, 2005; Brusoni *et al.*, 2001) it becomes clear that the role of systems integrator comprises two main tasks:

(1) Systems integrators set-up a network of various organizations. From a strategic viewpoint, they configure the organizational network in terms of members, relationships and division of work. This includes decision making regarding issues such as sourcing (insourcing vs outsourcing) and the type of contractual terms (formal vs informal) to be adopted in relationships.

(2) Systems integrators coordinate the work of the organizations involved in the network. By orchestrating the activities of the network members (such as design, production and R&D) systems integrators guarantee the coherence of the network output.

Two analytical levels of systems integration
Besides, two types of tasks, two different analytical levels of systems integration can be distinguished. The first analytical level concerns the level of production. This level of systems integration has been labelled variously: static systems integration (Brusoni *et al.*, 2001), synchronic systems integration (Prencipe, 2003) and intrageneration systems integration (Hobday *et al.*, 2005). It refers to the role of prime contractors that set-up and coordinate a network of organizations for the design and construction of a CoPS within a predefined time period and financial budget. Systems integration in production networks is aimed at achieving technological and organizational synchronization. Technological synchronization refers to the configuration of components and is related to the overall consistency and functioning of the CoPS. Organizational synchronization refers to the organization of the production process, and is related to the efficiency of the supply chain.

The second analytical level of systems integration takes a more long-term view on the cooperative relationships. Besides, production, systems integration is also considered on the level of innovation. It concerns the creation of incremental or radical innovations to meet evolving customer requirements or changing regulatory requirements. This level of systems integration is labelled, respectively, dynamic systems integration (Brusoni *et al.*, 2001), diachronic systems integration (Prencipe, 2003) and intergeneration systems integration (Hobday *et al.*, 2005). It refers to CoPS producers that develop new product families in cooperation with various organizations, such as suppliers, trade contractors, consultants and clients.

Systems integrators in construction industry
The three characteristics that constitute the basis for classifying a firm as a systems integrator can be used to identify systems integrators in construction industry. Taking into account the single point responsibility for the system as a whole, the role of systems integrator manifests itself in a specific set of construction projects: construction projects in which a single firm is contractually responsible for the performance of the structure. In other words, in design-build projects or turn-key projects. Firms that act as single prime contractor in these types of construction projects, and that perform the task of systems integration, can be categorized as systems integrator. At least, if they also meet the third condition: project-based production. However, in most cases, this last condition will be met

when a firm already meets the first two conditions, since construction industry is a typical example of a project-based industry.

This way of classifying firms in construction industry as systems integrators differs from previous literature. Winch (1998) was the first to translate the concept of systems integrator to the organizational actors as we know in construction industry. According to Winch:

> [. . .] the systems integrator role is shared between the principal architect/engineer and the principal contractor. Thus, construction typically has two separate systems integrators – one at the design stage and one at the construction stage.

The authors' share Winch's view that the task of systems integration is often split among these two actors. This is the case in construction projects in which the design-bid-build method of contracting is being used. However, as can be derived from the growing body of literature, the classification of systems integrator comprises more than performing a part of the task of systems integration. Systems integrators perform the complete task of systems integration. They take care of both design and construction of a system. Therefore, the authors' suggest classifying firms that only provide design or construction not as systems integrators. Furthermore, besides the design and construction of a system, some systems integrators also provide additional services, such as maintenance, financing or operational services. Examples of this type of systems integrators include the special purpose vehicles that can be found in PFI projects (Brady *et al.*, 2005).

Since the percentage of construction projects in which one firm is contractually responsible for both design and construction is rising in various countries, such as the UK (Khalfan and Mcdermott, 2006), The Netherlands (Dorée, 2004), and the USA (Pietroforte and Miller, 2002), it is plausible that the percentage of construction projects contracted to a systems integrator is rising. This theoretical deduction follows from the second constituent of the term "systems integrator": contractual responsibility for both design and construction of a system.

Examples from practice

Two examples from The Netherlands show the existence of firms in construction industry that act as a systems integrator and set-up and coordinate interorganizational innovation. Table I lists the characteristics of both examples. We derived the data about the examples through a desk study and interviews with the firms. In both examples the initiative started with the firm having an idea for a new system and the aspiration to put it on the market as a systems integrator. However, in both examples the firms lacked the complete range of resources, skills and knowledge which were needed to develop the idea into a ready-to-market system. Therefore, they started searching for organizations such as component suppliers, trade contractors and specialist consultants that were willing to cooperate. Subsequently, the firm orchestrated the interorganizational innovation process. In other words, the twofold role of systems integrators as displayed in CoPS projects, was also present in both innovation processes (network set-up and network coordination). In both examples, the co-developers also constitute the value chains for the individual projects in which the new systems are adopted.

To typify both innovations, a well-known classification scheme can be used. The innovations can be described as new sets of components that constitute the core of a new family of projects. To achieve innovation, the systems integrators and co-developers jointly

Systems integrator	Description of innovation	Co-developers
Hodes Bouwsystemen	Qbiz®: modular building system for buildings with a high degree of flexibility through the use of new components which are easy to decouple	Supplier of interior wall/ceiling systems Concrete technology consultant Innovation management consultant Steel contractor Electrical/mechanical contractor
Lamikon	Lamikon LongLife®: a system for wooden window frames based on two patents. The focus of the system is on lowering life cycle costs by reducing maintenance costs	Timber suppliers Maintenance contractors Timber Research Institute Supplier of glass Supplier of wood Supplier of coatings Supplier of fasteners Supplier of finishing elements Supplier of building protection products

Table I.
Two examples from practice

developed new components or new ways of linking components together (or a combination of both). This distinction between the novelty of the components of a system and the novelty of the way components are linked together, aligns with the distinction between modular and architectural innovation, as introduced by Henderson and Clark (1990).

Both examples illustrate the existence of firms in construction industry that act as a systems integrator and perform a central role in interorganizational innovation. However, it is not clear what factors are critical in achieving such interorganizational innovation. Theory is needed to bridge this gap. The next section provides a solid base for such theory development.

Understanding interorganizational innovation

Four different but related fields of literature provide relevant insights with regard to interorganizational innovation, literature on:

(1) New product development (Montoyaweiss and Calantone, 1994; Brown and Eisenhardt, 1995; Cooper and Kleinschmidt, 1995; Song and Parry, 1997; Henard and Szymanski, 2001; Griffin and Page, 1996).

(2) Strategic networks and alliances (Zollo *et al.*, 2002; Lorenzoni and Badenfuller, 1995; Gulati, 1998; Gerwin, 2004; Dhanaraj and Parkhe, 2006; Ahuja, 2000; Powell *et al.*, 1996; Gulati *et al.*, 2000; Thorelli, 1986; Lavie, 2006; Dyer and Singh, 1998; Das and Teng, 2000).

(3) Open innovation (Fetterhoff and Voelkel, 2006; Chesbrough, 2003; Chesbrough and Crowther, 2006; Laursen and Salter, 2006; Dodgson *et al.*, 2006).

(4) Construction innovation (Bossink, 2002; Xiao and David, 2002; Dewick and Miozzo, 2004; Dorée and Holmen, 2004; Miozzo and Dewick, 2004; Holmen *et al.*, 2005; Pries and Janszen, 1995; Dubois and Gadde, 2002; Nam and Tatum, 1997; Blayse and Manley, 2004; Bossink, 2004b; Pries and Dorée, 2005; Kulatunga *et al.*, 2006; Blindenbach-Driessen and van Den Ende, 2006; Hartmann, 2006; Veenstra *et al.*, 2006).

First, literature on new product development provides insight in factors that are critical for the success of new products (Brown and Eisenhardt, 1995; Montoyaweiss and Calantone, 1994). The dependent variable in this field of literature is close to interorganizational innovation. The difference is that the focus is on new product development within a single organization, instead of the development of a new system by a network of several organizations.

Second, literature on strategic networks and alliances provides insight in the factors that are critical for the performance of networks of cooperating organizations. However, the organizational networks that are being studied in this stream of research are not necessarily aimed at the deliberate creation of innovations (Gulati, 1998). Only part of the literature in this field is solely concerned with innovation networks. In this subset of literature, scholars argue that little is known about how new product development is successfully coordinated in strategic networks and alliances (Dhanaraj and Parkhe, 2006; Gerwin, 2004).

Literature on open innovation can be regarded as complementary to the literature focusing on innovation in strategic networks and alliances. Scholars argue that firms in various industries are currently shifting to an "open innovation" model, a more open strategy towards innovation (Chesbrough, 2003; Laursen and Salter, 2006). Firms try to create customer value through active search for new technologies and ideas outside of the firm, but also through cooperation with suppliers and competitors. Literature on open innovation is of interest because it provides insight in the process of interorganizational cooperation in innovation.

Finally, in literature on construction innovation researchers describe the characteristics of the process of innovation in construction industry and discuss how specific industry characteristics affect this process (Blayse and Manley, 2004). These insights are helpful for understanding the context in which systems integrators operate. Furthermore, researchers discuss factors that are critical for innovation.

Table II shows an overview of dependent variables and accompanying critical factors, as reported in the four fields of literature (sources are papers providing an extensive literature review or papers presenting findings from empirical research). Besides, the dependent variables also the indicators are mentioned which are used to measure the various dependent variables. As the dependent variables in the other fields of literature are closely related to interorganizational innovation, it is possible that the factors play a role for systems integrators to achieve interorganizational innovation. In Table II the factors have been assigned to one of the two main tasks of systems integrators: network set-up and network coordination.

Conclusions

Following Schumpeter (1934), innovations can be regarded as "new combinations". This definition of innovation seems particularly appropriate for construction innovation. In construction industry innovations do not only comprise an innovative combination of materials, but, due to the fragmentation of the value chain, also a combination of organizations. This is reflected in the argument in construction literature that interorganizational cooperation is important for achieving construction innovation, in particular interorganizational cooperation across project boundaries. This paper contributes to the extant literature by integrating knowledge from various bodies of literature in which the subject of interorganizational cooperation and

	Network set-up factors	Network coordination factors	Dependent variables & measures
New product development	(Brown and Eisenhardt, 1995) → customer involvement, supplier involvement, gatekeepers, moderate tenure (Montoyaweiss and Calantone, 1994) → marketing synergy, technological synergy, strategy, company resources, protocol	(Brown and Eisenhardt, 1995) → internal/external communication, senior management support, organization of work (Montoyaweiss and Calantone, 1994) → product advantage, proficiency of predevelopment activities, proficiency of market-related activities, proficiency of technological activities, speed to market, costs, financial/business analysis, internal/external communication	(Brown and Eisenhardt, 1995) → success of product development: profits, revenues, market share (Montoyaweiss and Calantone, 1994) → new product performance: profit, sales, payback period, costs, market share (Griffin and Page, 1996) → product development success: customer satisfaction, customer acceptance, market share goals, revenue goals, revenue growth goals, met profit goals, met margin goals, IRR or ROI, competitive advantage, met performance specs, met quality specs
Strategic networks and alliances	(Gulati, 1998) → complementary resources, critical strategic interdependence, partners of known reputation, social embeddedness (Das and Teng, 2000) → resource alignment	(Gulati, 1998) → governance structure, trust between partners, opportunistic behaviour, regular information exchange, long-term commitment (Dhanaraj and Parkhe, 2006) → knowledge mobility, innovation appropriability, network stability	(Gulati, 1998) → alliance performance: survival of alliance, participants' assessment of success (Dhanaraj and Parkhe, 2006) → network innovation output (Das and Teng, 2000) → alliance performance: alliance longevity, alliance profitability, agreed goal achievement
Open innovation	(Chesbrough, 2003) → porosity of firm boundaries	(Laursen and Salter, 2006) → breadth of external search, depth of external search	(Chesbrough, 2003) → firm's innovative success (Laursen and Salter, 2006) → firm's innovative performance: turnover relating to products new to the world market, turnover pertaining to products new to the firm, turnover pertaining to products significantly improved

(*continued*)

Table II.
Factors, dependent variables and measures as reported in the four related fields of literature

	Network set-up factors	Network coordination factors	Dependent variables & measures
Construction innovation	(Blindenbach-Driessen and van Den Ende, 2006) → senior management involvement, team composition, involvement of outside parties (Bossink, 2004b) → environmental pressure, technological capability, boundary spanning (Dewick and Miozzo, 2004; Dorée and Holmen, 2004; Holmen *et al.*, 2005) → tightness of inter-organizational relations (Nam and Tatum, 1997) → owner's involvement, presence of champion, technological competence of leader	(Blindenbach-Driessen and van Den Ende, 2006) → planning of work, activities undertaken (Bossink, 2004a) → leadership style (Bossink, 2004b) → knowledge exchange	(Blindenbach-Driessen and van Den Ende, 2006) → success of innovative projects: on time, within budget, quality, use of service by clients, possibly as part of other services, impact on reputation, learning effects for future innovation activities (Nam and Tatum, 1997; Bossink, 2004b) → construction innovation: project innovativeness (Dewick and Miozzo, 2004) → adoption of new technologies (Dorée and Holmen, 2004; Holmen *et al.*, 2005) → technological innovativeness of projects

Table II.

innovation is addressed. First, we structure the current knowledge on the role and characteristics of systems integrators, of whom it is stated in CoPS literature that they set-up and coordinate interorganizational innovation. Subsequently, the authors' translate this knowledge to the context of construction industry and discuss the basis for classifying a firm as a systems integrator in construction industry. Furthermore, the authors' presented an overview of success factors derived from literature on new product development, strategic networks and alliances, open innovation, and construction innovation. This overview provides a solid base for future theory development on how systems integrators achieve interorganizational innovation in construction industry. Such a theory should be parsimonious (Eisenhardt, 1989; Whetten, 1989) and should also explicate the causal logic that explains why certain factors are of importance (Sutton and Staw, 1995). Since the number of factors in Table II is high, we suggest therefore identifying critical factors by uncovering causal logic during case studies.

Business implications

To study interorganizational innovation in the construction industry is especially relevant due to the current situation in construction industry. In many countries, industry reform programs have been set-up to improve construction industry's performance. One of the goals of these reform programs is to enhance innovation. This paper is especially valuable for those firms in construction industry who seek to create competitive advantage through interorganizational innovation. It provides them with an overview of factors that have been related to interorganizational cooperation and innovation.

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