PAPERS

The Role of Co-creation in Enhancing Explorative and Exploitative Learning in Project-Based Settings

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ABSTRACT

We study how co-creation practices influence explorative and exploitative learning in five collaborative construction projects with partnering arrangements. Drawing on a longitudinal case study, our findings reveal two different types of explorative learning processes (i.e., adaptation and radical development) and three different exploitative learning processes (i.e., incremental development, knowledge sharing, and innovation diffusion). Furthermore, co-creation practices enhance adaptation, radical development, and incremental development, which are typical intra-project learning processes. Co-creation practices do not, however, enhance knowledge sharing and innovation diffusion across projects. These findings concur with previous insights that the temporary and one-off nature of projects makes inter-project learning problematic.

KEYWORDS: project-based learning; exploration; exploitation; co-creation; collaboration; partnering; construction

Project Management Journal, Vol. 48, No. 4, 22–38

Published online at www.pmi.org/PMJ

INTRODUCTION

The importance of simultaneously facilitating short-term efficiency by exploiting existing knowledge and technologies to make profits today, and long-term innovation by exploring new knowledge and technologies to adapt for future demands, is continuously highlighted in the management literature (e.g., Jansen, Tempelaar, van Den Bosch, & Volberda, 2009; March, 1991; O'Reilly & Tushman, 2013). Most prior research has studied exploration and exploitation on firm and business unit levels, investigating their effects on performance. Research targeting how exploration and exploitation are managed at the project level is less common (Junni, Sarala, Taras, & Tarba, 2013; Turner, Maylor, & Swart, 2015). This is surprising given that project-based organizations (PBOs) consistently struggle with organizational learning challenges (Bakker, Cambré, Korlaar, & Raab, 2011; Chronéer & Backlund, 2015; Scarbrough et al., 2004a). For many PBOs, innovation and explorative intra-project learning are critical aspects of developing and delivering complex and customized products that satisfy evolving customer demands, whereas exploitative inter-project learning is necessary to achieve efficient use of limited project resources (Brady & Davies, 2004; Eriksson & Leiringer, 2015; Turner et al., 2014). However, inherent characteristics such as the uniqueness, autonomy, and short-term focus of each project, and the interdependencies between project actors and their activities make it difficult to manage both explorative and exploitative learning (Davies, Dodgson, & Gann, 2016; Eriksson, 2013; Söderlund, 2008).

In the particular context chosen for this article—construction projects—the above described difficulties are especially prevalent. De-centralization and dispersed modes of working in inter-organizational projects are defining characteristics of the industry (cf. Leiringer, Green, & Raja, 2009). Construction projects are temporary, often highly customized and rarely undertaken within a standard framework. Moreover, clients and end-users are rarely the same, and even large repeat clients have their projects spread across time and space (Winch & Leiringer, 2016). The downside of this arrangement is that the autonomy afforded to individual project teams increases the risk of their becoming disconnected from other projects within the same organization, with detrimental implications for inter-project learning (Bresnen, Edelman, Newell, Scarbrough, & Swan, 2003).

Project learning processes are commonly impeded by temporary and often adversarial relationships that lead to coordination problems on the more complex projects (Bresnen, 2007). In recent years, therefore, collaborative arrangements (mostly termed "partnering") have been increasingly implemented to enhance coordination, joint problem solving, and co-development processes among the project actors (Bygballe, Jahre, & Swärd, 2010; Eriksson, 2015). Prior studies on partnering projects have indicated the positive effects of improved collaboration on efficiency-related aspects such as cost savings, reduction in disputes, shorter construction time, and improved predictability (Crespin-Mazet, Ingemansson, & Linné, 2015; El Asmar, Hanna, & Loh, 2013), as well as innovation-related aspects, such as increased chance of implementing innovations (Bosch-Sijtsema & Postma, 2009; Manley, 2008; Worsnop, Miraglia, & Davies, 2016). Accordingly, it has been suggested that partnering arrangements might serve as engagement platforms that enable clients and contractors to co-create value on construction projects (Jacobsson & Roth, 2014).

While the co-creation concept originates from the service industries and business-to-consumer (B2C) markets (e.g., Payne, Storbacka, & Frow, 2008; Prahalad & Ramaswamy, 2000, 2004a), there is now an increasing interest in connecting co-creation practices and learning processes at the project level in the literature on innovation and new product development (NPD). For example, Mahr, Lievens, and Blazevic (2014) highlight the importance of integrating different actors' knowledge sets and engaging in joint explorative and exploitative learning when co-creating value. Indeed, the core of co-creation is the joint learning processes that involve the integration of these different knowledge sets (Kleinsmann, Buijs, & Valkenburg, 2010). It is on this emerging strand of literature that this article seeks to build in investigating how co-creation practices are related to explorative and exploitative learning within and across construction projects.

The purpose of this article is to investigate if and how project actors engage in co-creation practices, and if and how this influences explorative and exploitative learning in collaborative construction projects. More specifically, we first identify central explorative and exploitative learning processes and how they are interrelated in collaborative construction projects. Second, we investigate if and how the client, designer, and contractor engage in co-creation practices and how this might influence the different learning processes.

We begin with a theory section that discusses the key concepts of explorative and exploitative learning and value co-creation and link this to the construction project context. Subsequently, the method is described and positioned against prior research highlighting the central roles of processes and interactive practices in value co-creation (e.g., Payne et al., 2008; Vargo & Lush, 2004). The empirical investigation involves longitudinal case studies to develop a deeper understanding of *why* and *how* processes emerge and evolve. The findings are structured around the main themes identified through thematic data analysis (Braun & Clarke, 2006), describing five central learning processes and how these are influenced by co-creation practices. Particular importance is given to the origins of, and drivers for, these co-creation practices and their links to particular project challenges. The article ends with conclusions outlining the interrelations among co-creation practices and the different types of learning processes in a project-based industry, namely construction.

Theoretical Background

Explorative and Exploitative Learning

In the organizational learning literature, two main types of learning modes are typically distinguished—exploration and exploitation—following the seminal work of March (1991). Explorative learning involves a distant search for, and assimilation of, new knowledge and technologies to enhance creativity and to achieve innovation and radical development of new solutions. Exploitative learning instead involves a local search for familiar knowledge and technologies to deepen the current knowledge set and achieve incremental development and continual improvement of existing solutions. Accordingly, exploration is generally associated with terms such as: adaptability, flexibility, risk taking, distant search, experimentation, radical development, and long-term orientation. Exploitation, on the other hand, is associated with refinement, control, routinization, local search, efficiency, incremental development, and short-term orientation (Andriopoulos & Lewis, 2010; Junni et al., 2013; March, 1991; O'Reilly & Tushman, 2004).

Due to the fundamentally different natures of the two learning modes, they are considered difficult to manage together, as highlighted in the literature on organizational ambidexterity (e.g., de Visser, de Weerd-Nederhof, Faems, Song, & van Looy, 2010; O'Reilly & Tushman, 2013). A commonly suggested solution at the firm level is to put in place structural and/or sequential separation of exploration and exploitation in different units/periods, along with a centralized integrating mechanism (Jansen et al., 2009; O'Reilly & Tushman, 2004). However, the uniqueness and autonomy of each project mean that such integrating mechanisms are difficult to implement in PBOs, which further complicates combining explorative and exploitative learning at the project level (Söderlund, 2008; Turner et al., 2014; 2015). Instead, it has been argued that intra-project exploration and inter-project exploitation can be facilitated by inter-organizational collaboration (Eriksson, 2013; Scarbrough et al., 2004a, 2004b).

Exploration and Exploitation in Construction

Construction projects are complex and uncertain endeavors that require explorative intra-project learning to handle development and adaptation challenges during project execution (Eriksson, 2013). Furthermore, the systemic nature of construction innovation and technology development requires coordination of many interdependent components and sub-systems. Hence, different actors often need to collaborate in joint development processes (Bosch-Sijtsema, 2009; Ozorhon, 2013). As parts of PBOs, construction projects also benefit from exploitative inter-project learning to achieve efficient use of limited resources (Eriksson & Leiringer, 2015).

In construction, knowledge can be considered context specific, making it difficult to transfer across projects due to competing and varying personal, professional, and organizational interests (Bresnen et al., 2003). Additionally, time constraints and geographical distances between construction sites, coupled with the commercial necessity of keeping a constant workflow, forces project teams to disband before, or upon, completion of projects, making knowledge sharing across projects even more difficult (Bresnen, Goussevskaia, & Swan, 2004). Nonetheless, there is now an emerging literature base that shows that inter-project learning, in terms of sharing and diffusing knowledge and innovations across projects, can be facilitated by collaborative and long-term relationships in which actors achieve improved communication, knowledge integration, and mutual understanding (e.g., Poirier, Forgues, & Staub-French, 2016).

In summary, prior research has highlighted the importance and challenges of managing explorative and exploitative learning within and across projects, and there are studies that indicate that collaboration may enhance both learning modes (Scarbrough et al., 2004a, 2004b; Tiwana, 2008). In construction, however, the relative autonomy and uniqueness of each project and the traditional temporary and adversarial nature of relationships affect the nature and timing of collaborative work, which increases the challenges of intra- and inter-project learning (Davies et al., 2016; Eriksson, 2013).

Co-creation of Value

In conventional value creation processes, suppliers and customers have distinct and separated roles in production and consumption, which enables sequential creation and adds value based on standardization and maximum production efficiency (Prahalad & Ramaswamy, 2004a; Vargo & Lush, 2004). In contrast, co-creation is an interactive practice into which customers and suppliers bring their own unique resources (e.g., competences and technologies) to co-create value reciprocally through integration (Saarijärvi, Kannan, & Kuusela, 2013; Vargo, Maglio, & Archpru Akaka, 2008). Value is here created synchronously and jointly by customers and suppliers in collaboration (Normann & Ramirez, 1993; Prahalad & Ramaswamy, 2004b). Accordingly, co-creation involves a change from supplier-led customization, in which customers tailor their purchases by choosing from many features, to an approach in which customers add their competences and experiences and become co-creators of the customized content (Prahalad & Ramaswamy, 2000).

The literature on value co-creation is diverse and the concept has been studied and operationalized in different ways across research domains. Originating from strategic management (e.g., Normann & Ramirez, 1993; Prahalad & Ramaswamy, 2000), the concept has become strongly linked to service marketing (e.g., Vargo & Lush, 2004), where studies mostly focus on the usage stage and co-creation of value in use (e.g., Vargo et al., 2008). Recently, co-creation has also stimulated increased interest in innovation and new product development literature (e.g., Lau, Tang, & Yam, 2010; Mahr et al., 2014), with focus on how firms can involve customers in co-development work (e.g., Candi, Van den Ende, & Gemser, 2016; Kleinsmann et al., 2010). From a project management perspective, it is notable that the production stage is often left out in these broad literature sets. Therefore, the focus here is on the recent studies that have started to differentiate co-creation practices on the basis of their timing and content, and dividing co-creation practices into different stages such as (1) design/development, (2) production/manufacturing, and (3) delivery/implementation/usage (e.g., Alves, Fernandes, & Raposo, 2016; Saarijärvi et al., 2013; Voorberg, Bekkers, & Tummers, 2015). Most studies focus on only one of these stages, but some span over two or all, such as the study by Payne et al. (2008) who argue that co-creation practices involve an interactive dialogue in each stage of value creation, from product design through delivery.

In the innovation and new product development literature there is an explicit connection between co-creation and learning; specifically, how co-creation involves knowledge integration based on iterative and interactive learning on the parts of both the customer and the supplier (Kleinsmann et al., 2010; Mahr et al., 2014). Even so, findings diverge regarding the benefits of involving customers in co-creation practices. Many argue that customer involvement in co-development is beneficial and results in improved products and/or innovation processes (e.g., Chen, Tsou, & Ching, 2011; Lau et al., 2010), whereas, others conclude that customer involvement has no, or even negative, effects (e.g., Un & Asakawa, 2015). Two issues stick out as having an effect on the outcomes: (1) the type of learning mode and (2) the timing of the co-creation practices. In terms of the type of learning mode, several studies show that customer involvement in co-development is especially important in achieving exploration (e.g., Candi et al., 2016; Lettl, 2007), whereas others have found that tight couplings with the customer enhances exploitation (e.g., Andriopoulos & Lewis, 2009). In terms of the timing of co-creation practices, the common argument is that customers should be involved either early in the design stage to provide input to the co-development work, or at the implementation stage to learn how to use the finalized product. Customer design input in the production stage is commonly portrayed as negatively affecting time and cost performance (Menguc, Auh, & Yannopoulos, 2014; Rönnberg-Sjödin & Eriksson, 2010). Despite differences in approaches and findings, what is clear in the above-mentioned studies is that the timing, nature, and extent of co-creation practices affect different explorative and exploitative learning processes.

Co-creation on Construction Projects

Many construction projects face high complexity and interdependencies among specialized actors and their activities; thus, a wide set of disparate knowledge sets and technologies must be integrated and coordinated for a project to be completed (cf. Cacciatori & Jacobides, 2005). Temporary and adversarial relationships, along with the difficulties in accurately assessing the quality of the end product and its technical complexity, create a significant moral hazard for the client because once the construction work starts, it becomes inconvenient to change contractors (*ibid.*). Consequently, integrating strategies, such as partnering arrangements, are increasingly deployed in attempts to avoid the coordination problems experienced with traditional competitive and disintegrated strategies (Bresnen, 2007; Crespin-Mazet et al., 2015). Partnering is based on collaborative procurement strategies, which enhance joint problem solving and co-development between the client and contractor throughout project execution (Eriksson, 2015). Partnering arrangements are, thereby, based on both formal (e.g., joint project objectives, open books, and mutual incentives) and informal aspects (e.g., trust and commitment) to serve as engagement platforms for co-creation practices (Crespin-Mazet & Gauri, 2007; Jacobsson & Roth, 2014). While there are many examples of partnering arrangements facilitating the engineering of trust and cooperation, there are also many examples of where this has not happened. The fundamental problem is that, in temporary project settings, there is often limited opportunity for the development of deeper, more resilient forms of trust (Bresnen, 2007).

It is clear that the temporary relationships in project-based business-to-business (B2B) contexts make it more challenging to collaborate, share knowledge, and combine resources. Accordingly, there is a difference between how co-creation practices are managed during the design and production stages of construction projects and how the practices are managed in continuous manufacturing industries and consumer services industries. It is therefore relevant to further investigate how project actors engage in co-creation practices, and if and how this influences explorative and exploitative learning on collaborative construction projects. In this empirical context, co-creation could be understood as practices in which different project actors combine and integrate their resources when collaborating to jointly create value in the design and production stages. It is, however, important to point out that even if a construction project can be divided into design and production stages (as we do in this article), these stages are not perfectly separated and distinguishable. To the contrary, design and production are commonly split into sub-stages, and projects consist of many different types of sub-systems, in which the production of one sub-system may be executed before the design of another sub-system.

Research Method

Research Design

Following O'Reilly and Tushman's (2013) call for more exploratory and qualitative in-depth studies on how to achieve exploration and exploitation, we adopted a case study approach to investigate five large construction projects. We sought to apply a replication strategy; hence, only projects with outspoken collaborative arrangements procured by professional clients were selected. This is partly because professional clients with repeat business should, arguably, have the competence to engage in co-creation practices to customize products and processes, and partly because a formal collaborative arrangement can be viewed as an ambition to create a platform for co-creation practices. A second consideration was the size of the projects and available resources. Organizational size affects access to resources (Lau et al., 2010; Un & Asakawa, 2015) and, more specifically, project size affects the amount of activity that a project can incorporate (Candi et al., 2016). This is important, because a lack of resources has been found to hinder simultaneous management of exploration and exploitation in smaller organizational settings (March, 1991; O´Reilly & Tushman, 2013). Therefore, large projects with a contract value of more than 500 million SEK (i.e., >60 million US dollars) were chosen, as they were deemed to provide more opportunities to manage exploration and exploitation through different types of organizational learning processes. As such, the selected cases can be viewed as favorable critical cases (cf. Flyvbjerg, 2006). If co-creation practices are not performed in collaborative projects procured by repeat clients, and different learning processes are not simultaneously managed in large project settings, these practices and processes will be even more scarce and difficult to manage in other types of projects.

We also found it important to investigate a broader range of organizational settings, both to extend the applicability of the emerging theory (Eisenhardt & Graebner, 2007) and to obtain sufficiently rich and comprehensive empirical material, from which to gain insight and illustrate different ways of managing co-creation practices and organizational learning processes in different project settings. Hence, the selection of projects includes the two main construction sectors in Sweden (i.e., building construction and infrastructure construction) (see Table 1).

Projects 1 through 3 were parts of two large infrastructure projects procured by the Swedish Transport Administration

Project	Object Type	Client	Number of Interviews
1	Tunnel, roadwork	Swedish Transport Administration	7
2	Road, overpasses	Swedish Transport Administration	8
3	Road, overpasses	Swedish Transport Administration	6
4	Office building	Commercial real-estate developer	7
5	Industrial premises	Municipality-owned company	8

Table 1: Summary of the five engineering projects.

(STA) in accordance with their internally developed collaboration model. Project 1 belonged to Megaproject A and involved tunneling through bedrock and associated road and concrete lining works. Projects 2 and 3 belonged to Megaproject B and involved highway construction and additional minor access roads and overpasses. The embedded nature of these projects was deemed beneficial for investigating inter-project learning processes. All three infrastructure projects involved civil engineering work, in which the actors faced major geological uncertainties. Projects 4 and 5 were both complex building projects with explicit partnering arrangements. Project 4 involved a large multi-story office building where the client, a real-estate developer, had a signed contract with a specific tenant when the design and construction started. Project 5 involved the construction of industrial premises, which included office areas and extensive and advanced ground work.

Data Collection

Interviews were conducted in three rounds over a four-year period: the first round was conducted during project execution (May 2011–December 2011); the second round was conducted when the projects were more or less completed (May 2012–August 2013); and the third round was conducted one to two years after project completion (April 2013–November 2015). In total, 36 interviews were conducted with the project managers of the client and the contractor and the design managers for each project. In Projects 3 and 5, the client's project manager also served as design manager. In some cases, a respondent was interviewed on three occasions, but due to staff turnover and the transient nature of the construction business, a majority of the respondents were interviewed twice. In Projects 1 and 4, there was a change of the clients' project managers during the production stage, and in Project 5, the contractor's project manager changed as the project came to close out. See Table 2 for more information about the respondents.

The longitudinal data collection process adopted an abductive approach and followed the advice of Alvesson (2011) to be more open, general, and broad in the early stages and more specific and delimited toward the end; hence, each round was more specific in terms of theoretical constructs. Following Andriopoulos and Lewis (2009), all interviews in Round 1 began with questions covering general topics: project description and organization, key actors and their relationships, and prioritized performance criteria. The focus then turned to the development and implementation of new and existing work methods and solutions on the project. The interviews were conducted at the project offices using a semi-structured approach, with open-ended questions loosely informed by the organizational learning literature. In Round 2, the respondents were asked to describe and reflect upon on how their projects had been executed. Here, the questions were focused on how different organizational and managerial practices had influenced project performance and learning processes. In addition, they were asked to describe examples of development work and to elaborate on *why*, *how*, and by *whom* it was undertaken. In Round 3, the respondents were asked specific questions regarding how the parties collaborated and if and how this had influenced the

Type of Actor	Age	Number of Interviews
Client 1A (initial)	33	2
Client 1B (successor)	65	1
Contractor 1	54	2
Designer 1	41	2
Client 2	38	3
Contractor 2	39	3
Designer 2	39	2
Client 3	29	3
Contractor 3	37	3
Client 4A (initial)	35	2
Client 4B (successor)	42	1
Contractor 4	55	2
Designer 4	45	2
Client 5A (parallel)	48	3
Client 5B (parallel)	30	2
Contractor 5A (initial)	44	2
Contractor 5B (successor)	52	1

Table 2: Information about the respondents.

development, implementation, and diffusion of new or improved solutions and work methods. Furthermore, the project outcomes were briefly discussed in retrospect. All three rounds of interviews were recorded digitally.

Data Analysis

The empirical data were analyzed using an exploratory thematic analysis procedure inspired by Braun and Clarke (2006) and Spiggle (1994). Data analysis followed a four-stage iterative approach involving repeated rounds of reading and categorizing of the data. Stage 1 involved line-by-line open coding while listening to the recordings and reading the transcriptions and field notes from each interview. We, thereby, identified a long list of initial codes related to the three aggregate dimensions of exploration, exploitation, and co-creation from the data within each case. In Stage 2, we searched for links among the first-order codes within each case, which facilitated grouping them together into second-level categories and third-level themes (Braun & Clarke, 2006; Spiggle, 1994). A core aspect of this stage was that we allowed concepts and relationships to emerge from the data, rather than being guided by an explicit and detailed theoretical framework. In Stage 3, we conducted cross-case analysis, looking for similar concepts and relationships across cases, comparing the categories and themes produced in the second stage. We conceptualized and labeled these themes by capturing the content on a higher level of abstraction and by referring to existing literature that described similar concepts (Spiggle, 1994). In the final stage, we drew on existing studies on organizational learning and co-creation to refine our labels. The themes were refined through repeated investigations both of patterns of commonality and of atypical examples, and were repeatedly compared with the literature in order to achieve congruence in terminology.

The thematic analysis identified five key learning themes, each describing a different type of explorative or exploitative learning process that the project actors engaged in, either individually or in co-creation. Exploration occurred in terms of: (1) *adaptation*, which involved dealing with changes derived from different sources of uncertainty related to ground conditions, poor tendering documents, client requirements in the early stages, and late end-user involvement; and (2) *radical development*, which involved either process or product development. Exploitation occurred in terms of: (3) *incremental development,* which involved continual improvement of existing knowledge and technologies; (4) *knowledge sharing* across projects through post-project review meetings and lessons-learned sessions; and (5) *innovation diffusion* across projects and organizations. These five learning themes form the overarching frame of the empirical findings presented in the next section. In addition, the thematic analysis identified four themes related to the co-creation dimension: (1) co-creation during the design stage, (2) co-creation during the production stage, (3) barriers to co-creation, and (4) drivers for co-creation. See the Appendix at the end of the article for additional details on codes and themes.

Findings and Analysis

Adaptation: Dealing With Uncertainty

In all five projects, substantial changes of existing plans and routines in terms of adaptations to dealing with unpredictable or changing circumstances were major parts of daily work. Adaptation is related to explorative learning in the sense that it involves challenging change efforts that require new solutions to either production processes or the end product. Project participants were proud of being able to resolve any problems that occurred, and adaptation processes were deemed to have saved some of the projects from failure. The empirical findings identify four main categories of adaptation processes. These categories are related to dealing with challenges stemming from uncertain ground conditions, poor tendering documents, uncertain client requirements in the early stages, and late end-user involvement.

Dealing With Uncertain Ground Conditions

All projects that included extensive civil engineering work (i.e., Projects 1, 2, 3, and 5) faced challenges stemming from uncertain ground conditions, in terms of issues with the ground water and geotechnical challenges of working in rock and clay. These difficult ground conditions, which were especially apparent in work involving tunneling, piling, and excavation, led to significant adaptation during production, because work plans and routines had to be changed. For example, Project 5 experienced major problems caused by groundwater when excavating the bottom of the shaft for a fuel bunker 15 meters (approximately 50 feet) below ground level. The original design using a ‘cut and cover’ procedure caused a severe inflow of contaminated groundwater, which exceeded the capacity of the pumping equipment. The escalating and chaotic situation was managed by the client and the contractor who combined their competences to jointly devise a new solution: *“During the excavation, we encountered an unforeseen problem with the groundwater flow. We were afraid that we would drain the whole city. In true partnering spirit the contractor suggested that we would investigate whether a diaphragm wall could be an option, which is relatively new as a permanent structure in Sweden. At that point we had great collaboration” (Client 5B).*

Dealing With Poor Tendering Documents

Another critical antecedent of adaptation processes in the projects was the poor quality of the clients’ original designs, plans, and tendering documents. The low-level quality of these initial documents and plans meant that the parties routinely needed to develop and re-negotiate new plans, solutions, and drawings because errors were revealed during the production stage. This type of adaptation challenge was visible in all five projects, but was especially severe in Project 2 where, among other things, the initial plans and solutions for temporary traffic were defective and impossible to execute. The initial project scope and contract sum grew by 34% and, halfway through the project, 600 change orders had been implemented. To manage these challenging adaptations, the client and contractor combined their knowledge to jointly develop alternative solutions acceptable to both parties: "*When I got involved in the project, we soon found that it was impossible to build in accordance to the tendering documents. We had to change everything. We have shown a remarkable capacity to work together, to change things for the better" (Client 2).* Contractor 2 pinpoints the importance of joint creativity during these adaptation processes: *"Both we and the client were forced to think outside the box due to all the changes we faced. The client was often involved and contributed with ideas when we discussed alternative solutions. There was a degree of creativity involved, forced upon us by the poor design."*

Dealing With Uncertain Client Requirements in the Early Stages

If client requirements are uncertain and ill-defined in the early project stages, there may be numerous changes and additions to the initial plans and thereby significant creep in scope. In our set of cases, these problems were more apparent in building construction than in infrastructure projects. This is by no means surprising, given that the requirements of tenants are rarely set in the early stages of commercial building projects. Hence, as the client gets a better overview of what is wanted and required, changes and modifications become necessary (Cacciatori & Jacobides, 2005).

Project 4 had change orders of 20% of the initial project cost, mostly due to adaptations initiated by the client, who simply did not know what they wanted until the actual tenants were confirmed. Change orders were particularly prevalent toward the end of the production stage: "*We were in a great hurry to deliver a building according to the requirements that were set two and a half years prior. But the customer's customer only had a six-month foresight regarding their internal tenants who were to use the building. Once the tenants were finally confirmed, they wanted to transform the building to fit their current business. To manage all that was, in the end, really hard" (Contractor 4).* The adaptation processes resulting from these uncertain client requirements were ordered by the client without offering any assistance to the contractor: "*As the design manager, I was involved in the project for an unusually long period. Mainly, this was due to the amount of late change orders that required changes to the design up until the very end of the project. Even afterwards, the client wished to demolish and rebuild several spaces, but the contractor put a very high price tag on it with the message that they did not want to do this work" (Designer 4).*

In Project 5, the contract cost increased by 110%, mostly due to the client demanding significant additions, such as an additional office floor and an adjacent pumping station. It should be noted, however, that the client had anticipated such changes, and adaptation was explicitly stated as a success criterion at the beginning of the project. Yet, despite the stated early project intentions, in the midst of production, managing these changes of original plans and solutions was very challenging for all parties involved, especially the contractor. Ultimately, the need for adaptation became overwhelming and created pressures on resources and time, which had negative consequences on both the relationships in general and the co-creation practices in particular: "*The collaborative process has deteriorated from how I perceived it in the beginning. However, it is only natural that as the project budget and schedule become increasingly tight and strained, it will affect the relationships" (Client 5B).*

Dealing With Late End-User Involvement

In line with prior studies on innovation and new product development projects that highlight the importance of end-user involvement (e.g., Chen et al., 2011; Lau et al., 2010), our findings show that end-user involvement facilitated customization and value co-creation in the two building construction projects. Embracing end-users into the design work does, however, increase the risk of scope creep, since their expectations typically crystallize into more concrete specifications as the design process starts to generate solutions that can be assessed (Grabher, 2004). In Project 5, the end-users (i.e., representatives of those who were to move into the finished premises) were not formally part of the project organization; nonetheless, they were intensively involved in providing ideas and design input, particularly in the production stage. This resulted in a customized building that satisfied many of their requirements and desires. Moreover, their late design input caused adaptation challenges in terms of problematic changes to the original solutions, plans, and routines: "*One reason for the numerous changes is that the end-user group has been active up until the end of the project. They saw an opportunity through the partnering arrangement to continuously add stuff. This should, of course, have been done during the design stage. Now it became a pain as it happened during the production stage" (Client 5A).* This is in line with prior studies that have highlighted the importance of involving end-users early in the design stage, as this allows for the design to be frozen sufficiently early to not delay production planning (Eriksson, 2015, Menguc et al., 2014).

Overview and Discussion of Adaptation Processes

It should be noted that adaptation, as well as dealing with uncertainty, are inherent in projects that have a high degree of customization and site-specific production and, therefore, central to how project-based industries work (DeFillippi & Sydow, 2016). The four processes we have identified above are representative examples of the root causes of this uncertainty. Of importance here is that, although adaptation is something that most practitioners take great pride in being able to achieve, it is mainly something negative, at least in relation to pre-determined project objectives. Undesirable changes to original plans disturb and delay the production stage and are a leading contributor to rework (Love, Edwards, & Smith, 2016).

It was apparent from all five projects that co-creation practices are central to adaptation processes, in the sense of combining competences and experiences in joint work efforts to find new solutions that are acceptable for all key actors. In particular, the integration of the complementary competences and experiences of different actors speeds up the process of proposing and implementing new, feasible solutions. Contractor 2 illustrated the importance of a competent client to enable co-creation when managing adaptation: "*When we ran into problems, we handled them jointly; we were flexible and found solutions together. The cooperation was based on staff in the client organization being highly competent. You have to be equally competent; otherwise there will be no good dialogue.*" There is, however, a distinct difference between our context and the more generalist literature on co-creation in terms of the separation of the design and production stages. In our context, co-creation during production does not involve co-production in the form of the client helping the contractor with manufacturing and assembly activities. Instead, it involves joint problem-solving activities to design and develop viable solutions to deal with sudden and unforeseen adaptation challenges during the production stage. As the examples from Projects 4 and 5 show, this is not always the case and there are instances when the adaptation processes are pushed on to the supply side. Hence, co-creation in our project setting is more likely to materialize under circumstances in which the project actors face adaptation challenges forced upon them by external factors, rather than when the adaptations are initiated by one of the actors (e.g., derived from uncertain client requirements).

It is also worth noting that in the organizational learning literature, adaptation is a core aspect of explorative learning related to long-term adaptability to changing environmental circumstances (Andriopoulos & Lewis, 2010). Contrastingly, in our project-based setting, adaptation is mostly short-term and reactive. If these reactive adaptation processes become the overarching focus, it has repercussions for the aspirations of more proactive and value-adding developments. This finding is perhaps best illustrated by another example from Project 5 in which the many unforeseen change orders resulted in cost and time pressures that hindered innovation work. Additionally, the client had initial expectations of joint incremental development through co-creation practices, but these hopes were soon dashed when the focus shifted to the management of change orders and adaptations. "*The schedule is so tight that there is no time for incremental developments. We hoped that we could do more in the spirit of partnering, where we together with the contractor fine-tune plans and solutions to become even better and more efficient. But we have had such a shortage of time and resources that when the first proposed solution has been developed, we have used it immediately; there is no time for any improvement dialogue" (Client 5B).* Ultimately, uncertain environments lead to excessive adaptation, which in turn results in chaotic organization and difficulties in retaining control and continuity. Accordingly, the stressful and urgent nature of reactive adaptations creates negative effects that go beyond the direct costs of the resources spent on handling them.

Radical Development

Notwithstanding the arguments made earlier regarding how reactive adaptation affects proactive development, a core aspect of exploration is radical development (de Visser et al., 2010; Lin & McDonough III, 2011). In the projects, radical development involved new working methods to improve the production processes (i.e., process development) and new technical solutions, components, or sub-systems to improve the end product (i.e., product development).

Process Development

There were many examples of process development in the projects related to finding new production methods or using new technology in production processes. Indeed, the respondents all agreed that process development had higher priority than product development, as summarized by Contractor 3: "*It is important to find new ways of working, to find new ways to build old things.*"

In Project 1, the project actors had an explicit focus on development work and contractual incentives for finding ways to cut costs, which resulted in several process innovations. Early in the design stage, the client and designer jointly developed a production approach in which blasted rock and stone were kept as reinforcement materials for road construction. This novel production solution saved a lot of work and had, according to the respondents, never been used in a Swedish road tunnel before. This was not an isolated case, because project actors often combined their competences and undertook much development work together through co-creation practices in joint design meetings in which the client, designer, and contractor discussed design solutions. The contractor initiated some development processes; for example, standardizing and prefabricating the extractor fan foundations rather than adopting the normal procedure of casting them *in situ*. This innovation would not have been possible without the diverse knowledge sets of all three actors: *"We have assisted the contractor in their innovation efforts, for example when they suggested that we should go for a prefab solution for the fan foundation that hangs from the tunnel ceiling. This has never been done before. We assisted and served as an advisor to the client in the decision process on this" (Designer 1).*

In Project 2, the contractor and designer combined their technical competences and experiences to co-develop an innovative bridge solution that saved time and money during production by reducing the amount of onsite concrete work. The collaborators removed an entire foundation structure to simplify the production of the bridge. Although the client project manager was not actively involved in this particular development, he accepted the new solution on the basis of trust and sharing in the economic savings from it.

Product Development

There were some examples of product innovations in the five projects, although the actors focused more on developing their production processes. In Project 1, the contractor designed wall linings in the tunnel consisting of a new application of prefabricated concrete elements that protect the tunnel from groundwater leakage. This was a novel solution that, according to the respondents, had never previously been used in Sweden. This part of the project was separated into a design–build contract, in which the actors did not have joint design meetings. As a result, this particular development process did not involve co-creation practices to the same extent as other developments on the project. The solution was developed separately by the contractor's specialists in Germany and initially required subsequent correction and adaptation, since the design of the ceiling was not in accordance with the client's expectations. Lack of communication and difficulty in assessing this complex solution resulted in differing expectations and views on what was required: "*We submitted a proposal for a new interior lining to the client, which they approved. Then, as we started assembling the solution they said it couldn't look like that. Apparently, they had not reviewed our proposal thoroughly enough. When they saw how it looked in reality it was not as they expected. How could we know what they had expected" (Contractor 1)?* This example illustrates the difficulties for contractors in performing product development in-house without client involvement due to the customized, non-standardized, and uncertain nature of the project environment.

In Project 4, a new type of hybrid façade solution was jointly developed by the client, tenant, contractor, and designer, which included meeting the tenant's requirement of a glass façade and the client's requirement of a concrete frame. The tenant and the client were satisfied with this compromise of a hybrid solution and the co-creation practices it was based on. The designer and the contractor both saw potential for this unique solution to be used in future projects and invested central organizational development funds in designing and developing it. Despite this, and in contrast to the other two parties, they were not satisfied with the co-creation practices involved: *"We worked with the facade for far too long before we were told what it should look like. We set up mock-ups, and the [tenant's] architect inspected these several times. But then he went directly to the tenant and talked with them rather than with us. It was a process where we felt we were close to be being circumvented" (Designer 4).*

Overview and Discussion of Radical Development Processes

In four out of five projects, radical process and product developments were achieved through co-creation practices, in which the actors contributed with their complementary competences and experiences. In these cases, the clients engaged in the design stage in order to help develop customized products. This is very much in line with findings in the new product development and co-creation literature in that collaboration enhances explorative learning and innovation (e.g., Chen et al., 2011; de Visser et al., 2010; Shenhar, Holzmann, Melamed, & Zhao, 2016).

In a project-based industry, such as construction, the extent to which such co-creation can take place is directly dependent on the right contractual conditions having been put in place. We have argued that collaborative partnering arrangements are one such favorable context, as they facilitate and put in place mutual benefits and contractual incentives for project actors to engage in joint development (El Asmar, 2013; Jacobsson & Roth, 2014). Even so, findings from Project 3 illustrate that the mere existence of such arrangements might not be enough. It was clear that, although the client was well aware of the importance of a creative contractor in the beginning of the project, many innovative solutions suggested by the contractor were turned down due to a lack of trust and the absence of explicit contractual incentives: *"We often received suggestions for alternative or novel solutions [from the contractor], but we seldom saw any benefits for us. We felt that the contractor earned too much from these new solutions while we got nothing. In retrospect, maybe we should have let the contractor carry out more of these changes and accept that they had earned this extra money. But at that time, we felt a bit cheated" (Client 3).* Contractor 3 verified the lack of trust and the negative consequences it had on development work: "*The degree of trust was low. They probably thought we somehow tried to snatch money from them improperly. We had our meetings and they told us they didn't trust us.*" What this shows is that formal partnering agreements are no guarantee that co-creation practices will ensue. Both formal contractual mechanisms (e.g., mutual incentives) and informal aspects (e.g., trust and commitment) are needed. Yet, even if they are in place, there might still be tensions between the need for the development of trust and the commercial realities that prompt contractual partners to act in more traditional and adversarial ways. In such instances co-creation practices will clearly suffer.

Incremental Development

Incremental development is a core aspect of exploitation (Andriopoulos & Lewis, 2010; de Visser et al., 2010). It is not surprising, therefore, that many of our respondents stated that small adjustments and continual improvements of existing knowledge and technologies are important; indeed, they are often more important than radical developments. However, they also saw how continual improvements were often neglected, partly due to time pressures and partly due to heavily institutionalized practices that are not easily changed. Consequently, in the five projects there were examples of incremental development and fine-tuning, but ultimately many existing solutions were reused without further development.

In Project 1 the client aimed for robust, tried, and tested solutions, minimizing unnecessary risks, but also pinpointed the importance of continual improvement: "*Fine tuning the small things in life, is more important than radical developments.*" The design manager mentioned a few incremental developments they were involved in, working together with the contractor in joint design meetings to refine existing solutions. One example of this was to improve the working environment of mining workers by providing sufficient space so they would not need to splice the drill steel in front of the drilling machine. Despite the client's outspoken wish for fine-tuning, however, the design manager believed that there was a lack of continual improvement: "*We are bad at fine-tuning and incremental development, we often do as we always have done.*"

In Project 3, the actors formulated mutual objectives for the project, one of which was to identify and develop ten improvements that would generate increased efficiency for both parties; thus, the client encouraged the contractor to come up with improvements. Even so, they did not reflect on their own part in this work and instead opted for a predominantly monitoring role: *"We have said to the contractor: find all the adjustments and simplifications you can that have the same quality [as the original design], then we will decide on how we share the profits. That will be a win–win situation."* Not having specified how to share the profit in advance, however, stifled most attempts at joint development.

In Project 4 there was a lack of co-creation practices for incremental development due to weak contractual incentives for the client to engage in cost reduction. In contrast to most other partnering arrangements, the client on this project had created a highly beneficial situation: the client would get paid by the tenant for any additional costs, whereas the contractor had to pay the costs that were above the initial price, which according to the contractor and designer, diminished joint incremental development: "*There was a guaranteed maximum price, which is not suitable in a partnering contract. The client has not been committed to aiding us in cutting costs. We have tried to find cheaper solutions that will benefit both actors, but the client's attitude has been that: no, it is there [in the design], so it should be included" (Designer 4).*

Overview and Discussion of Incremental Development Processes

In innovation research, there is a clear link between incremental development and the exploitation of existing knowledge and technologies (e.g., de Visser et al., 2010; Lin & McDonough III, 2011). It is also commonly claimed that collaboration can enhance such incremental developments (e.g., Andriopoulos & Lewis, 2009). On the contrary, we found that exploitation involves reusing tried and tested technical solutions and work methods as they are, without any development efforts in the front end. Two main reasons for this lack of development stand out. First, the deeply institutionalized belief in the tried and tested and the related skepticism among many clients toward insufficiently tested solutions. Second, as shown in the examples from Projects 3 and 4, the lack of mutual benefits hinders co-creation practices in incremental development processes. Indeed, co-creation in incremental development seemingly requires mutual incentives, so that both parties can benefit from the collaborative development work. Hence, the arrangements used in the new product development environment might not lend themselves immediately to the project-based nature of the construction industry, where the complex and systemic nature of technical solutions and temporary relationships work against the establishment of mutual incentives for collaborative incremental development work.

Knowledge Sharing Between Projects

Another learning process related to exploitation readily identifiable in the studied projects is knowledge sharing between projects. As previously noted, prior research has found that inter-project learning in terms of knowledge sharing between projects is difficult for project-based organizations (Bakker et al., 2011; Brady & Davies, 2004; Bresnen et al., 2003). This was also evidently clear in our five projects, as the interviewees all struggled with the two main, formal mechanisms that had been put in place to facilitate it: post-project reviews and lessons-learned sessions.

Post-Project Reviews

In all five projects, post-project review meetings with key project actors were held with the aims of discussing experiences and learning from good and bad practices for the benefit of subsequent projects. Several respondents, however, highlighted that these reviews were problematic. The client in Project 2, for example, did not find it very useful: *"We had a review meeting and I wrote a final report to* *my superiors. Afterwards, I probably took the report to my summer house and used it to light the fire in the fireplace. I think each project participant gained experience and knowledge from the project, but that we would be able to create an overall shared experience, no, I don't think so."*

In a similar vein, the contractor in Project 5 found these reviews, in general, to be too shallow and that the actors were not trying to engage in sufficiently deep discussions of their experiences: *"It is not easy, this experience feedback we have after each project. We do it, but it is often rather shallow. There is never really any depth. I've been to a number of such meetings, but it is very much just scratching at the surface" (Contractor 5B).*

Continuous Lessons-Learned Meetings

In line with a few prior studies pinpointing the value of continuous lessons learned rather than post-project reviews (e.g., Chronéer & Backlund, 2015; Scarbrough et al., 2004b), some respondents argued that post-project review meetings are problematic, because it is too late to discuss experiences when the project is finished and people have moved on. The contractor in Project 1 was clear about this and suggested that lessons-learned sessions should be arranged regularly throughout project duration. *"Actually it would be good with some kind of session after each project stage. For example, when you are finished with the tunneling we could have a lessons-learned session just for that—discussing what has worked well and less well. You could have such meetings as different stages are finished."* As it turned out, the client in Project 1 had tried to put this into practice, but just not very effectively. As Projects 1, 2, and 3 were parts of megaprojects, attempts were made to achieve continuous knowledge sharing across the different sub-projects to capture good and bad experiences, which were worth imitating or avoiding. On Megaproject A, Client 1 felt that these forums were arranged too infrequently: *"I'll be a bit self-critical. We did not have enough coordination meetings, we should have arranged more knowledge sharing sessions among the sub-projects and the mega-project manager."* On Megaproject B, the client provided extra resources in order to facilitate inter-project learning and had a specially appointed person responsible for coordinating such meetings: *"To share the experience among us in the various projects, we have a technology coordinator who holds technical meetings every two weeks. I think he has had about 157 meetings since the project started" (Client 3).*

Overview and Discussion of Knowledge-Sharing Processes

It has long been customary in project-based industries to conduct post-project reviews and lessons-learned sessions to try to learn from good and bad experiences and feed this knowledge into the design and production stages of subsequent projects (Bakker et al., 2011; Scarbrough et al., 2004a). In line with prior studies, we found that these knowledge-sharing processes are problematic, mainly due to the temporary and one-off nature of construction projects (Eriksson & Leiringer, 2015). Nonetheless, our findings divert from what is commonly claimed in terms of knowledge sharing in the organizational learning literature. Continuous knowledge sharing across functional units and organizations is less problematic in the manufacturing industry, where work is undertaken through continuous and standardized processes and by partners collaborating in supply chain management activities over extended periods of time. In the construction industry, and many other project-based industries, the commercial realities are very different. The industry is characterized by a highly fragmented and temporary delivery structure, in which a myriad of loosely coupled organizations, often deliver to lowest cost agendas, driven on by competitive tendering, in markets where even the large repeat clients would have their projects spread across time and space. In this context, there is a stronger focus on temporary projects than on continuous processes (Chronéer & Backlund, 2015). Hence, the idea of co-creation facilitating inter-project learning for long-term benefits will likely need to be set aside for other more pressing short-term commercial concerns, even in projects where the emphasis is on collaboration.

Innovation Diffusion Across Projects and Organizations

Given the difficulties experienced in knowledge sharing across projects, it is not surprising that the respondents also claimed that exploitation of the new solutions developed on the projects, in terms of innovation diffusion, had turned out to be very challenging. This is also in line with the findings from a plethora of prior studies on innovation in the construction industry (e.g., Bosch-Sijtsema & Postma, 2009; Manley, 2008; Ozorhon, 2013). Nevertheless, a few of the aforementioned radical and incremental innovations developed in the five projects were diffused to other projects or within the organizations participating in the development work. Some solutions that were developed within Projects 1, 2, and 3 were diffused by the clients to other sub-projects in Megaprojects A and B. For example, the solution of reusing blasted rock and stone as reinforcement material in the road construction in Project 1 was applied to another sub-project in Megaproject A, in which the rock quality was sufficiently high for re-use as reinforcement.

In Megaproject B, the innovative bridge solution, which was developed by the contractor and designer in Project 2, was adopted by the client when procuring the next sub-project. Of note here is that this type of client-led innovation diffusion can be very beneficial for the client but not necessarily for the contractor and designer who invested resources in the development work: "*When the client produced the tendering documents for the subsequent project we saw that all of a sudden there was a* *blurry cloud of revisions, indicating that solutions had been changed. So, it was very obvious that after we had presented the new [bridge] solution, it showed up in documents for the next stage. That felt flattering, but okay, then we have burnt that card [laughing]" (Designer 2).*

Many respondents also highlighted the challenge of diffusing project-specific innovations. In simple terms, they did not know if or when they would encounter similar project conditions; hence, they were uncertain if these innovative solutions could be applied elsewhere. This was especially apparent in the civil engineering projects, where varying ground conditions and geological circumstances mean that projects have a degree of uniqueness: *"In our industry, projects don't repeat themselves so often. It is not certain that a new solution is applicable in the next project. It is built elsewhere under other circumstances with other people, other suppliers, etc. We are like a traveling circus putting up our tent in various places. There is a new audience and new actors every time we get together and new circumstances for us when we put up our tent" (Contractor 1).* Due to the difficulties of diffusing innovations and the risk of competitors copying them, several contractors and designers were of the opinion that investments in radical development mostly have to payoff on the project at hand.

Overview and Discussion of Innovation Diffusion Processes

Several studies have shown that inter-project learning is enhanced by long-term relationships over a series of projects (Scarbrough et al., 2004b) and by a centralized integrating mechanism that can assimilate and transfer knowledge from one project where intra-project learning takes place to other parts of the project portfolio (Brady & Davies, 2004; Eriksson & Leiringer, 2015). This is not, however, easy to achieve in construction. In contrast to manufacturing industries, where investments in innovation processes are often initiated by centralized decisions and considered of strategic importance, innovation in the construction industry is mostly conducted in, and financed through, regular construction projects (Eriksson, 2013). This, along with the lack of long-term contracts, has repercussions for innovation diffusion since innovations tend to be developed and customized for the project conditions at hand, rather than for the purpose of being diffused across many projects. This, in turn, results in hesitation to invest in innovation processes. In temporary intra-project collaborative arrangements, the lack of long-term contracts means that there is no platform for co-creation practices regarding inter-project learning processes, such as innovation diffusion. Hence, the symbiotic and interdependent nature of explorative development and exploitative diffusion processes is especially problematic in this empirical setting. A convincing case could be made that megaprojects, consisting of several sequential projects, can rectify one aspect of this problem if a centralized learning mechanism is put in place in the client organization to facilitate innovation diffusion across the different client teams. However, unless the project is particularly large, or several projects are offered, this does little to justify the contractors' innovation investments.

Conclusions

Although the importance of knowledge integration and learning processes have been emphasized in prior co-creation research (e.g., Payne et al., 2008; Vargo & Lush, 2004), there is a lack of studies explicitly investigating how explorative and exploitative learning are managed when buyers and suppliers co-create value. Similarly, although some studies suggest that collaboration enhances exploration and exploitation (e.g., Scarbrough et al., 2004a; Tiwana, 2008), there is a lack of research on how co-creation influences explorative and exploitative learning. We address these literature gaps by cross-fertilizing the literature on organizational learning and co-creation in our study of how co-creation practices influence explorative and exploitative learning in collaborative construction projects.

Theoretical Contributions

We contribute to the co-creation literature by showing how clients, design consultants, and contractors engage in co-creation practices to cope with inherent and emerging challenges in the design and production stages of partnering projects, and how this influences explorative and exploitative learning processes. Prior literature has emphasized that co-creation involves a change from customization performed by the supplier, to an approach where customers co-create the customized product along with the supplier (Prahalad & Ramaswamy, 2000). We argue that this change from supplier-led customization to co-creation is especially important in the project-based construction industry. The inherent complexity and uncertainty characterizing many construction projects make it difficult for suppliers to develop customized solutions on their own. Hence, the client needs to be involved in co-creation practices along with designers and contractors to enhance customization.

Recent studies pinpoint the importance of distinguishing between different co-creation stages (e.g., Alves et al., 2016; Saarijärvi et al., 2013; Voorberg et al., 2015). Whereas prior co-creation literature focuses primarily on the design or the usage stage, our findings show that much co-creation takes place in the production stage of construction projects. In particular, this takes the form of the joint design and development of new solutions when sudden and unforeseen circumstances make original plans inappropriate. Our findings also show the additional complexities brought about by the common practice of having some sub-systems produced before the design of other sub-systems, which further highlights the importance of customization during the production stage.

Our findings also contribute to the organizational learning literature by showing that it is not only the two main learning modes (i.e., exploration and exploitation) that compete for scarce resources, as discussed in the ambidexterity literature (e.g., March, 1991; O´Reilly & Tushman, 2013). We have identified five central learning processes within the two main modes that need to be managed in the project setting. Specifically, we show how too much focus on reactive adaptation in some sub-systems crowds out proactive development in others. The drawbacks of adaptations are further compounded by difficulties in diffusing their outcomes. Adaptations are mostly highly customized and tailored to specific time- and space-related circumstances. Such demand for uniqueness limits the scope for reuse and modularity on the product level (Grabher, 2004). Prior research views adaptation in terms of long-term adaptability to changing environmental circumstances of strategic importance (e.g., Andriopoulos & Lewis, 2010; O'Reilly & Tushman, 2004). In contrast, we have found that in construction projects adaptation occurs in the often rather stressful production stage; thus, it is a short-term type of exploration, which is even more difficult to exploit in future projects than radical development. Finally, organizational learning processes require knowledge integration to occur through ongoing social interaction (Kleinsmann et al., 2010; Tiwana, 2008). Yet, our findings show that co-creation practices are more suited to the intra-project learning processes (i.e., adaptation, radical development, and incremental development). Co-creation practices in the inter-project learning processes (i.e., knowledge sharing and innovation diffusion) are more problematic even in projects within the same megaproject.

Managerial Implications

Prior co-creation research has identified the importance of sharing risks, benefits, and responsibilities among customers and suppliers to enhance co-creation practices (Prahalad & Ramaswamy, 2004b). Our study adds to the understanding of these barriers and drivers for co-creation by showing that (1) partners need to trust each other to engage in co-creation practices; (2) all actors need to have sufficient competencies, which can add value in combination with others' competencies; and (3) partners seek to profit from joint development efforts, which influences decisions to spend resources on co-creation practices. An important managerial implication, therefore, is that successful co-creation requires mutual trust, contributing competence among all key actors, and contractual incentives.

Additionally, co-creation practices require cross-functional integration in the supplier firm to reach alignment between the functions that make and deliver the customer promise (Payne et al., 2008). Our findings show that there is also a need for cross-functional integration in the customer organization, so that end-user involvement is not misdirected and ends up hindering value creation. It is, indeed, clear that late end-user involvement during production stages triggers short-sighted and reactive adaptation. The easy solution, which is commonly put forward in the extant literature, is that end-users should be involved early in proactive co-development practices, when their knowledge and experience can provide important input to joint design work (Rönnberg Sjödin & Eriksson, 2010; Menguc et al., 2014). In the project-based environment we have studied, this is a real challenge. End-users typically do not belong to the temporary project organization, but to the permanent line organization that will use the facilities when they are finished (Eriksson, 2015). Much more effort is, therefore, required to take them away from their 'day-job' and involve them in co-creation practices.

Limitations and Future Research

This study has some limitations that also spur suggestions for future research. In line with the co-creation literature, we have focused on co-creation practices between the client and contractor, although we have also included the designer to obtain a fuller understanding of exploration and exploitation during the design stage. Due to the large number of key actors in complex construction projects, and the systemic nature of construction innovation, it would be relevant to investigate wider partnering arrangements, which also include the involvement of subcontractors and material suppliers in innovation processes. Another limitation is that we have studied projects with temporary collaborative arrangements only. Arguably, co-creation practices, knowledge sharing processes, and innovation diffusion processes are heavily affected by the length of the collaborative arrangement. As illustrated by Projects 2 and 3, which were parts of a larger megaproject, knowledge sharing and innovation diffusion can be enhanced by repetition and longer project processes. It would, therefore, be relevant to study strategic partnering arrangements spanning a series of projects to investigate how a long-term perspective affects co-creation practices and intra- and inter-project learning processes.

Acknowledgment

We gratefully acknowledge the financial support received from Ragnar Söderbergs Stiftelse, which made this study possible.

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Appendix: Codes and themes in empirical analysis.

Initial First-Order Codes	Final Codes: Second-Level Categories	Third-Level Themes	Aggregate Dimensions
Handling poor rock quality	Dealing with uncertain ground conditions	Adaptation	Exploration
Handling ground uncertainties			
Handling ground water problems			
Handling change orders due to poor tendering documents	Dealing with poor tendering documents		
Handling change orders due to uncertain client requirements	Dealing with uncertain client requirements in the early stages		
Handling change orders due to unforeseen additional work			
Handling change orders due to late end-user involvement	Dealing with late end-user involvement		
Developing new onsite production methods	Process development	Radical development	
Developing and/or implementing new production IT tools			
Developing new pre-fabrication applications			
Developing new products and/or systems	Product development		
Continual improvements	Incremental development	Incremental development	Exploitation
Finding cost saving simplifications			
Post-project reviews	Knowledge sharing between projects	Knowledge sharing between projects	
Lessons learned sessions			
Diffusing radical developments to other projects and organizations	Innovation diffusion across projects and organizations	Innovation diffusion across projects and organizations	
Diffusing incremental developments to other projects			
Proactive joint development	Co-development	Co-creation in the design stage	Co-creation
Reactive Join-problem solving	Joint-problem solving when dealing with adaptations	Co-creation in the production stage	
Lack of competence hinders co-creation	Barriers to co-creation	Barriers to co-creation	
Lack of contractual incentives hinders co-creation			
Lack of trust hinders co-creation			
Combinative competences drives co-creation	Drivers for co-creation	Drivers for co-creation	
Contractual incentives drives co-creation			
Trust drives co-creation			