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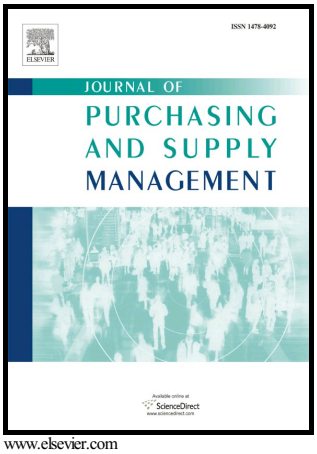

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Organizational interfaces and innovation: The challenge of integrating supplier knowledge in LEGO Systems

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1. Introduction

The dynamics featuring today's business reality makes it necessary for firms to continuously reconsider and modify their products, services and processes. In these ambitions companies have increasingly come to rely on the resources and capabilities of their business partners (von Hippel, 2005; Håkansson et al., 2009; Tushman et al., 2012). The main reason for these conditions is the difficulties for individual firms to keep up with the development within all the technologies on which they depend (Pavitt, 2002; Brunswicker and Vanhaverbeke, 2015).

In such innovative activities the contributions from suppliers are particularly important (Johnsen, 2009; Schiele, 2010; Bengtsson et al., 2013; Luzzini et al., 2015). Previous research shows that successful exploitation of the knowledge of suppliers is contingent on well-functioning inter-firm relationships (Holmström and Roberts, 1998; Hoecht and Trott, 2006; Bäck and Kohtamäki, 2015). For the nurturing of such relationships, Peng et al. (2014, p. 1421) claim that "effective collaboration requires active involvement". In a similar vein, several studies show that extended involvement with suppliers provides substantial advantages in the innovative efforts of buying firms (for example, Lawson et al., 2014; Yan and Dooley, 2014).

At the same time, however, increasing involvement with suppliers is no panacea for innovation. For example, Yan and Nair (2016) argue that high involvement may lead to problems with flexibility and cause coordination issues that can affect innovative performance negatively. Moreover, Ho et al. (2015) conclude that extended relationship involvement is associated with risk and uncertainty. In addition, the combining of internal and external knowledge has shown to be a challenging issue. Problems with realization of objectives in innovative co-development are documented by several researchers (e.g. Dougherty and Takacs, 2004; Hargadon and Bechky, 2006; Garud et al., 2013).

Owing to these contradictory findings, further research is needed on the relationship between the level of customer-supplier involvement and the outcome of this collaboration with regard

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to innovation and renewal. Of particular significance for this relationship are the features of the organizational interfaces between the buying firm and the supplier (Takeishi, 2001; Gadde, 2013). The organizational interface concept is borrowed from organizational theory to address issues regarding coordination and involvement across the boundaries of firms (Adler, 1995). On this basis, the overall objective of the study is to analyse how various forms of customer-supplier involvement in terms of organisational interfaces affect the outcome of collaborative innovation and renewal.

The empirical study regards a process innovation at LEGO Systems – a leading global producer of toy construction kits. Over the years, the packaging lines of the company had been adjusted to various external conditions, resulting in a complex system. To prepare for the future, the firm decided to reconsider their entire packaging philosophy. The aim was to reduce complexity and improve performance through radical renewal of the packaging process. In this effort, suppliers of machinery and packaging materials were involved from the outset of the process in order to encourage novel thinking. These conditions made LEGO's renewal project an interesting empirical context for research on the impact of organizational interfaces on collaboration in innovation processes. A particular advantage of the chosen context is that the buying firm over time applied different interfaces in relation to suppliers, thus enabling analysis of the dynamic features of organizational interfaces.

In the section below, the literature review leading to the specific research question is presented. The paper continues with the methodological considerations and the empirical results. These sections are followed by discussion of the findings, and the conclusions and implications of the study.

2. Literature review

This section begins with an overview of previous research dealing with mobilisation of supplier resources and the problems related to integration of the knowledge resources of the two parties. Then follows a review of the literature on customer-supplier involvement in collaborative innovation. Finally, the features of the organizational interface framing applied in this study is presented, followed by the research question.

2.1 Mobilisation of supplier resources

The increasing significance of supplier contributions to innovation is pointed out in many studies. Chesbrough and Crowther (2006) argue that collaboration with suppliers represents a means to support the innovation effort by accessing external resources that the buying firm may lack. Narasimhan and Narayan (2013) conclude that as organizations become increasingly specialized, their ability to engage suppliers in their innovative efforts is becoming critical. Their argument is that it is imperative for organizations to align internal research and development strategies with knowledge available in supplier firms to secure superior performance. According to Yan et al. (2017), buying firms rely on the competences and resources of their suppliers to become more innovative since these business partners can create value by providing, or bringing awareness of, creative solutions. Finally, Chang (2017, p. 129) claims that companies gain competitive advantage by using "suppliers' resources, skills, capabilities, and especially their design acumen".

The potential benefits residing in supplier involvement in renewal and innovation are well documented (Johnsen, 2009). For example, Ragatz et al. (1997) pointed out major advantages

in terms of reduced costs, improved quality, shortened development times, and access to application of new technology. Petersen et al. (2005) investigated the relationship between supplier involvement and performance in development processes by testing a model of alternative forms of supplier integration. The main finding was that joint goal setting improved both project team effectiveness and overall performance. Furthermore, the authors concluded that the point in time when suppliers become involved is crucial. Their results supported other studies showing that particular benefits are associated with early supplier involvement. In a comprehensive literature review it was concluded that there is "overwhelming evidence to suggest early and extensive supplier involvement as a key explanatory factor for superior new product performance in terms of cost, quality and time to market benefits" (Johnsen, 2009, p. 193). In a similar vein, several authors have encouraged early involvement in order to exploit information and expertise regarding new ideas and new technology (e.g. McIvor and Humphreys, 2004; Gadde et al., 2010). However, utilizing resources from the outside in innovative activities is no guarantee for success since integrating external and internal knowledge is a challenging issue.

2.2 Problems with integration of supplier knowledge

There are several constraints towards successful customer-supplier integration in the processes of innovation and renewal. The purchasing literature reports general tensions with regard to sharing of proprietary information and reluctance of buying firms to accept too much supplier influence on internal operations (e.g. Monckza and Trent, 1997). Wynstra et al. (2001) concluded that managers of supplier involvement processes must take three involvement barriers into consideration. Supplier-related barriers concern the capabilities and resources of the potential partners and their willingness and opportunities to contribute to the renewal efforts of the buying firm. Buyer-related barriers regard the issues brought up above by Monckza and Trent (1997), as well as practices for staffing the collaborative teams, the division of work between the parties, and adequately dealing with the crossed incentive structures among internal functions. Finally, relation-specific barriers may be rooted in insufficient exchange of information with regard to plans and goals. Moreover, lack of trust between the parties can affect collaboration negatively since these complex projects feature risk and uncertainty. Handling such issues require inter-organizational coordination of the customer-supplier involvement (Lakemond et al. 2006; Yan and Dooley, 2014). The former authors concluded that the effectiveness of various coordination regimes is contingent on task dependence, divergence of expectations, and long-term collaborative objectives.

The literature on organizational design and management brings up other problems with the ability of organizations to identify, evaluate, and utilize external knowledge (e.g. Cohen and Levinthal, 1990; West and Bogers, 2014). Katz and Allen (1982) analysed the role of the 'not-invented-here' syndrome as a severe obstacle for utilization of external knowledge when existing practices are ingrained in an organization and taken for granted. Such features shape potential resistance and negative attitudes from organizational members towards ideas conceived outside the firm. Organizations are thus to a varying extent able to absorb external knowledge and enhance organizational learning from supplier collaboration. Divergence from established patterns is weeded out in the interpretation of events (Weick, 1995). Moreover, these characteristics keep deviating ideas at bay, thus reinforcing the not-invented-here syndrome (Birkinshaw and Ridderstråle, 1999; Hussinger and Wastyn, 2016). For these reasons customer-supplier relationships and the involvement of the parties come to the fore.

2.3 Relationship involvement

The significant role of the features of the relationship between the buying firm and the supplier in collaborative development has been discussed extensively in the literature. It is possible to distinguish between two major streams of research with regard to such collaboration. The first one takes the point of departure in the distribution of the responsibility of the two parties and the associated consequences for relationship involvement. Asanuma et al. (1989) differentiated between standardized exchange ('marketed goods') and six types of exchange based on solutions that were primarily designed by either the buying firm or the supplier. Petersen et al. (2005) presented a framework derived from previous research including four categories: lack of involvement, white box involvement (the buying firm is responsible, the supplier is consulted), grey box (including some forms of joint responsibility), and black box, where design is primarily supplier-driven, but based on performance specifications from the buying firm.

The second stream of research on collaborative innovation is focused on the mechanisms for coordination between the buying firm and the supplier. Lakemond et al. (2006) identified three forms of collaboration: project integration coordination, direct ad-hoc coordination, and disconnected coordination (where each party is responsible for its respective assignments). Fliess and Becker (2006) conducted a chronological review of the literature in the field and derived three major forms of collaboration mechanisms: contract development, coordinated development, and joint development. These types differed with regard to form of cooperation, degree of innovativeness, know-how required, and clarity of specifications.

Le Dain et al. (2010) combined elements of the responsibility and coordination streams of research by developing a supplier integration matrix involving three main types of collaboration. First, 'traditional subcontracting', based on 'coordinated development', involved features of what Petersen et al. (2005) labelled 'no involvement' and 'grey box'. Second, 'delegated design' associated with 'strategic co-design' showed similarities with 'black box design' in the framing of Petersen et al. (2005). Finally, 'critical co-design' represented a more advanced form of the grey box approach in Petersen et al. (2005). The two axes in the matrix developed by Le Dain et al. (2005) represented the degree of supplier autonomy and the development risk.

Finally, Sobrero and Roberts (2002) identified four types of supplier collaboration where the organization of the interfaces between the parties is central. In 'traditional subcontracting' the buying firm is the dominant actor. 'Integrated subcontracting' involves collaboration related to elements featuring strong interdependencies. This form of collaboration is also customer dominated and provides suppliers with limited freedom. Collaboration based on 'advanced subcontracting' includes elements featuring limited dependence which increases the degrees of freedom of the supplier. Finally, in 'black box' collaboration the supplier takes all the responsibility for design of the solution.

The above framings of supplier collaboration have one thing in common: they tend to identify either the buying firm or the supplier as directing and controlling the collaborative process. However, recent research shows that in many cases the integration between two parties is so all-encompassing that it is difficult to make this distinction (Ford et al, 2011; Inemek and Mathyssens, 2013). Therefore, in addition to the above framings there is a need for concepts describing more intense and interactive collaboration than 'joint development' (Fliess and Becker, 2006), 'grey box' coordination (Petersen et al., 2005) and 'critical co-design' (Le Dain et al., (2010). The framework applied in this study was developed for analysis of

resource interfaces with suppliers (Araujo et al., 1999). Such interfirm interfaces specify the level of adaptations among the partners, as well as guiding norms for their interaction, and stipulate expectations of inter-partner involvement (Twigg, 2002). In their study of resource interfaces with suppliers, Araujo et al. (1999) applied four types of interfaces, reflecting various interaction patterns and drivers of involvement.

2.4 Organizational interfaces

The framework of Araujo et al. (1999) was developed in a study of the interfaces between a supplier of steel and its customers. The study showed that the buying firms utilized the resources of the supplier in quite different ways. The main rational for selecting their framework in this study was the notion of an interactive interface. The three other resource interfaces were labelled standardized, specified and translation. In this section we describe the four interfaces and illustrate how they relate to the concepts discussed in section 2.3.

Standardized interfaces involve what is normally identified as arm's-length relationships. The supplier provides a standardized assortment of products and/or services from which the buying firm can choose. This type of interface shares the features of 'marketed goods' (Asanuma et al., 1989). In this form of business exchange there is no, or very little, involvement between the two parties. The supplier does not need to know about the context of the customer, nor does the buying firm require knowledge of the procedures of the supplier. In fact, one particular role of the arm's-length interface is to ensure that the two parties remain adverse in order to maintain some element of rivalry (Aitken and Patton, 2017). For these reasons, standardized interfaces are not considered relevant for collaborative innovation and renewal and will not be discussed further.

In many situations, a buying firm will prefer a solution that is somehow customized and adapted to the features of the context where it will be used. The least complex option in that respect is when the buying firm prescribes the features of what is exchanged and/or how it should be manufactured and delivered. Araujo et al. (1999) define these conditions as a *'specified' interface*, typically represented by traditional subcontracting. In this situation the supplier is used as an extension of the facilities of the buying firm, with the role to supply parts manufactured according to specification. Information regarding the exchange is normally transferred to the supplier in the form of blueprints and detailed directions, or follows de facto standards. Specified interfaces correspond closely to 'white box' (Petersen et al., 2005), 'traditional subcontracting' (Le Dain et al., 2010), and 'integrated subcontracting' (Sobrero and Roberts, 2002).

A third type of interface is to hand when the buying firm's direction is based on the functionality of what is exchanged, rather than its detailed features. This may include prescriptions based on ideas, but also include rough "drawings on a napkin", provided by the buying firm. This interface, demanding more interaction than the previous ones, is labelled *'translation'* since it requires the supplier to translate the functional characteristics in order to be able to design and produce what the customer needs. Translation interfaces have similar features as three of the categories discussed above: 'black box' (Petersen et al., 2005), 'delegated design' (Le Dain et al., 2010), and 'advanced subcontracting' (Sobrero and Roberts, 2002). Such interfaces provide the supplier with important degrees of freedom with regard to the best way of meeting the demands of the buying firm, thus enabling improvements of both productivity and innovation. On the other hand, translation interfaces

impose significant challenges, as functionality is "sticky" and thus hard to transfer across organizational contexts (von Hippel, 1994; Carlile, 2002; Khamseh et al., 2017).

Finally, *'interactive' interfaces* build on open-ended dialogue between the parties regarding the best way to exploit their combined resources. In such interfaces, they together derive the specification of what to exchange. In this way, the joint decisions can take into account their total set of capabilities. Moreover, through the knowledge of the contexts on both sides of the dyad, the consequences for other firms can be considered, for example in relation to the buying firm's customers and other suppliers and the supplier's suppliers and other customers. In our view, no other categorization takes this broad perspective, although grey box coordination and critical co-design share some features of interactive interfaces. In a more recent paper, Araujo et al. (2016) supplements the original interface framework with two concepts for analysis of interaction processes: interactive capacity and interactive capability. The interactive capacity regards the amount of time and other resources that firms devote to interaction. The interactive capability relates to the skills and knowledge of how to interact with business partners.

The type of interface applied in a relationship impacts directly on the way the supplier's resources can be activated and accessed by the buying firm (Håkansson et al., 2009). In terms of potential benefits, the interactive interfaces represent the best opportunities for mutual involvement. At the same time they are the most resource-demanding ones, as there are many potential solutions and few barriers for exploring a wide array of possibilities. As pointed out in studies of early supplier involvement in new product development, a multitude of opportunities for involvement is not necessarily reducing development efforts and does not always lead to acceleration of project cycle time (Eisenhardt and Tabrizi, 1995).

2.5 Research question

The starting point of our explorative research project is that the outcome of collaborative innovation and renewal is affected by the type of interface applied. Specified, translation, and interactive interfaces represent different levels of relationship involvement. Furthermore, each interface provides the buying firm with particular opportunities for accessing supplier knowledge to support innovation and renewal. However, the literature review showed also that the interfaces are associated with their specific problems for collaborative development.

On this basis, the following research question is formulated:
In what ways do specified, translation, and interactive interfaces impact on the outcome of collaborative innovation and renewal?
Furthermore, particular focus is directed to analysis of the consequences of the interfaces for the integration of the knowledge resources of the two parties.

3. Research method

3.1 Case study and data collection

The LEGO packaging case is a real-time processual study, which unfolded over time. Rather than going through an ex-ante selection process for finding a representative research object, the packaging narrative was discovered during data collection for another study in the company (Andersen et al., 2013). In this way, it was the case that selected the researchers, rather than researchers selecting the case. Similar conditions have been expressed in relation

to other studies discussing the process of "casing" (e.g. Ragin, 1992; Dubois and Gadde, 2014). The features of the complex packaging project fitted nicely with the researchers' interest in issues related to the impact on collaborative innovation of various organizational arrangements.

In general, case studies are recommended for research involving complex systems and events that are unique and where broad research issues are dealt with (Normann, 1980; Eisenhardt, 1989). This approach enables studies of contemporary phenomena in their contexts, which is critical to the understanding of dynamics in social contexts (Halinen and Törnroos, 2005). Moreover, qualitative case studies provide depth, detail and richness of data, thus being suitable for analysis of problems in settings with unclear boundaries (Dubois and Araujo, 2004). The packaging system is a critical resource for companies in various settings. Therefore, this case provides an opportunity for insight and learning in a broader perspective as discussed by Flyvbjerg (2006) and Hagel and Brown (2013).

Data were obtained through several sources. The research project was initiated through the 'informal' information obtained through the interviews in relation to the ongoing research project at LEGO. Once the current study was started, this general information was supplemented with interviews directed toward the specific aim of this study. These formal interviews were supplemented with several follow-up conversations over the phone and clarifying e-mail correspondence. Altogether, the paper is based on 10 formal interviews with various stakeholders in LEGO Systems in Billund, and in LEGO's subsidiary in Kladno (in the Czech Republic) over a period of seven years (2008-15). As a backdrop, other interviews have indirectly informed the authors about the company context. Table 1 provides an overview of interviews conducted with regard to functions, departments, location and time of the interview.

Function	*Department*	*Location*	*Time of interview*
Head of unit	Concept factory	Billund	September 2008
Project manager	Manufacturing	Copenhagen	March 2009
Project manager	Manufacturing	Billund	October 2009
Specialist	Packaging and logistics	Århus	February 2010
Head of unit	Concept factory	Billund	September 2010
Project manager	Product and marketing development	Billund	March 2012
Head of unit	Operations	Billund	December 2013
Packaging director	R&D	Billund	October 2014
Head of production	R&D	Kladno	March 2015
Head of production	R&D	Kladno	March 2015

Table 1: Interviews conducted for the current study

In addition, several other contacts have been made via email or telephone conversation. Purchasing managers were only indirectly involved as influencers in the process, which also explains their absence from the list of interviewees. Moreover, in combination with the interviews, several site visits were conducted. The interviews were transcribed and cross-analysed for their narrative content, in order to build an interpretation of the process and detailing the events by developing a thick and holistic description of the case (Stake, 2005). In the traditions of hermeneutic research, we followed the advice by Kvale and Brinkman (2009) and focused on the conversational qualities of the interview and used the data

transcript as an aid in the process of developing an understanding of the underlying meaning, rather than as the subject matter of the interview.

As Kvale and Brinkman (2009) point out, interview transcripts too often are perceived as 'objective' data, although they are co-produced outcome of a dialogue between interviewer and interviewee, where the foreknowledge of the interviewer impacts the line of questioning. In contrast to viewing data from interviews as objective statements and quotes that accurately reflect the interior mind-set of the person interviewed, insights gained from interviews should be seen as stepping stones towards unfolding of the possible interpretation. Therefore, meaning coding has been used – mainly in order to create meaning condensation in the tradition of phenomenology (Giorgi, 1975). Meaning codes represent a condensation of the conversation revolving around a specific and identifiable theme (Lee, 1999). Meaning codes have been tested against the global meaning of the text (the interview and its purpose and the interviewee's life world) and other interviews (against those conducted and as inspiration for further interviews), internal data, and utterances in conversations.

3.2 Research process

As illustrated in Table 1 we did interviews and followed the LEGO project from 2008 to 2015. During this longitudinal study we relied on the systematic combining approach discussed in Dubois and Gadde (2002), and Kovacs and Spens (2005). This research strategy is based on a systematic movement between theory and data, where theoretical framing and reframing inspired the search for new data and new data likewise opened up for the search for adjusting theoretical perspectives.

In this paper, we describe the development of the packaging project in terms of three steps where different organizational interfaces were applied – starting with the interactive ones, followed by translation and specified interfaces. During the evolvement of the empirical reality we analysed the case in various ways, with different frameworks, following systematic combining principles. In the beginning, attention was directed toward the basic organizational set-up for supplier collaboration. In Andersen et al. (2013) this initial arrangement in the packaging project was compared with the approach applied in another LEGO-project. In this research step the outcome of the organizational arrangements were not studied.

The second step was initiated when LEGO decided to modify its approach by applying a translation interface. In an unpublished seminar paper, we explored the reasons for this change and the effects for innovation outcome of the two types of relationship involvement. In that paper, the analysis focused on the organizational principles discussed in Andersen et al. (2013) and the barriers towards supplier integration presented in the framing of the current study. The organizational interface framework had not yet been identified as a relevant framing. However, LEGO modified its approach a second time and introduced what we have identified as specified interfaces. It was only when this happened we realized the opportunities to apply the framework developed by Araujo et al. (1999, 2016). The particular benefit of the LEGO case in its present version is that the company over time has been engaged in all the three types of supplier interfaces presented in section 2.4.

The research process described is illustrated in Figure 1, providing a simplistic overview of the systematic combining process and how it links to the casing process and the meaning condensation discussed in 3.1. The overview is simplistic in the sense that it tries to impose

some degree of linearity to a process which is oscillating in reality. This figure is a further development of the systematic combining procedure presented by Kovacs and Spens (2005).

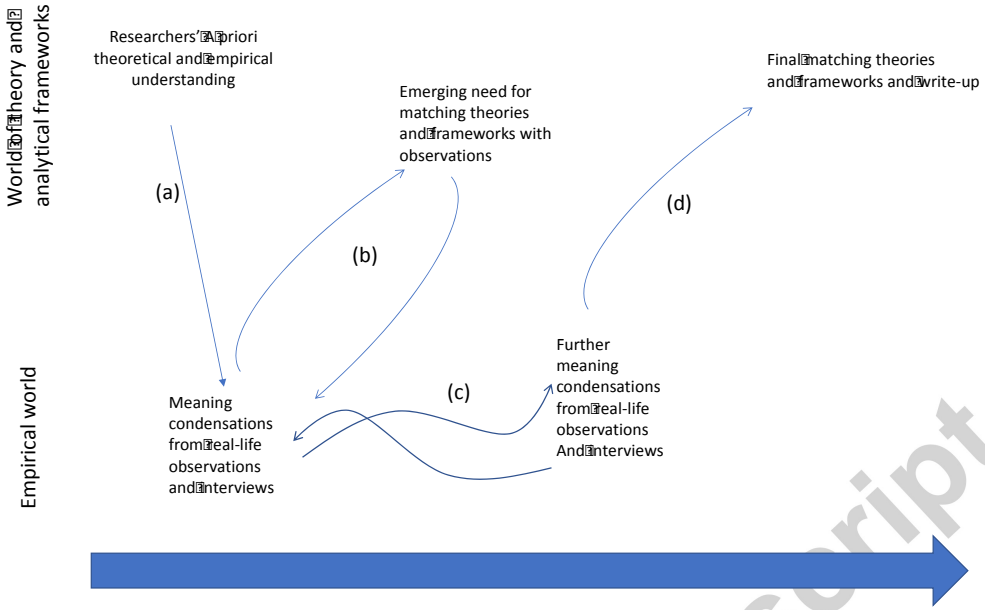

Figure 1: The systematic combining process (inspired by Kovacs and Spens, 2005)

In the present context, our starting point (a) is within an ongoing case study. Interesting side stories and puzzles derived from that study, in combination with theoretical interest in organizational interfaces, trigger a pursuit into the empirical world in the form of interviews and re-reading of available materials. From this point, meaning condensation arises through the combining of existing and new information and the matching with additional theoretical perspectives (b). Insights from systematic combining inform researchers to look for additional material in the manner of snowball sampling as suggested by Miles et al (2014). Meaning condensation from these interviews informs further matching in the theoretical world, but influences also the meaning condensations of prior interviews, as additional interviews corroborate what previously was observed, or suddenly brings attention to something said in a previous interview (c). Finally, as the researchers reach some degree of maturity, implying that no substantial novelty is gained with respect to the nature of the case, they engage in a final matching and write-up phase (d).

Furthermore, besides taking an insider's view to the unfolding events, we have been able to check our understanding of the process as it evolves from an external perspective. Given LEGOs prominence in the business press, a continuous stream of information is publically available from industry magazines and other open sources regarding new developments in their supply and packaging practices. Web searches on involved suppliers, newspaper clips and insights from general case studies on LEGO's development have been used as backdrop material. Finally, generous access has been given to internal LEGO documents in terms of PMs, brochures, strategic plans and minutes from meetings.

In general, LEGO has been open and transparent with respect to providing information about both the more and less successful progress of the project and their collaboration with suppliers. This gives reason to believe that – although interviews with the supplier side are

missing – the interviews have provided a balanced insight into the events studied and described. Also, it can be seen as a limitation, that the purchasing department has not been directly involved in the questioning. There are two reasons why this might be less of an issue in the present case. First, purchasing views are present – albeit indirectly – as the project manager was placed here before he was pointed out as project manager. Secondly, since the task of buying a new pre-packaging equipment is both unique, development-oriented and broad in scope, purchasing's "voice" in the process is one of many.

4. The empirical inquiry

4.1 Project background

LEGO is the world leading producer of construction toys and a globally well-known brand. The signature product is the LEGO building brick, which is the core component in the building set comprised of a step-by-step building instruction and corresponding set of bricks. These elements are all packaged in a cardboard box, serving to display the construction that can be built, as well as a container for the set. The packaging system is a strategic resource for several reasons. The boxes serve an important role for ensuring accuracy and speed in the production of a LEGO set. The box, richly decorated, is also an integral part of the customer experience and for showcasing in retail stores. Moreover, the perceived quality of a LEGO building set is contingent on deliveries of complete sets which also put strong quality demands on the packaging system.

Over the years, LEGO had gradually added bits and pieces to their packaging systems to make them perform in accordance with changing demands. The result was a messy global packaging system of high complexity, containing several generations of machinery. Moreover, packaging lines were ageing as no new investments had been made in the packaging equipment for some time, due to an economic crisis. As sales were growing considerably over the following years, significant investments in increased capacity were needed. An attempt to outsource parts of their production to a contract manufacturer showed that LEGO's demands were beyond the current industry standard and that considerable efforts were required to involve external actors in such projects.

The packaging system represents a strategic bottleneck for LEGO. Sales of toys are highly seasonal (80% of the retail sales appear in December) and category sales are highly unpredictable. Therefore, LEGO must be able to ramp up production fast from time to time to meet demand changes. These features require packaging lines that can produce large volumes with short notice, as well as flexibility to handle swift changes. So far the piecemeal approach had worked, but caused considerable uncertainty and supply delays. The ambition with the project was to rethink the whole packaging philosophy and bring in new ideas from the outside and in these efforts LEGO started to search for input from suppliers. In our presentation, we have divided the case narrative into five phases. Phases one, three and five each describes a dominant type of interface: interactive, translation and specified, while two and four are intermediate phases.

4.2 Phase 1 – Interactive interface

LEGO needed to find and engage suppliers willing and able to participate in the innovation contest. From the beginning, the basic idea was that creative inputs were needed from external suppliers to escape the established way of thinking. The dialogue with competent

suppliers had to be moved beyond existing beliefs within LEGO and possible generic packaging solutions of suppliers. A project manager was appointed, who reported to a steering committee including senior people from top management, finance, sales, design and purchasing. The initial job was to further mature the ideas already developed in LEGO and align the critical internal stakeholders' expectations, visions and wants to a new packaging system.

The ultimate aim with the redesign was to develop a modular packaging platform, with two automatic line sizes, building on existing market standards for packaging, able to cater for global variation in technical capabilities of machine operators. LEGO representatives visited several international technology fairs for packaging machinery in order to identify and meet with prospective suppliers. From the start it was agreed internally (and communicated to suppliers), that cost did not rank among the top issues on which suppliers would be assessed. In the evaluation of innovation partners LEGO relied on their experience of potential suppliers' capabilities. Several internal departments were involved in these processes, including coordinators specialising in cross-functional arrangements.

The intention was to entice those suppliers, who would see the project as an interesting challenge to showcase and stretch their knowledge. The project leader visited these suppliers, and presented the project scope. This part of the process was fairly open-ended and LEGO did not know exactly what they were looking for, but tried to keep an open mind. The project manager soon learned that gaining access beyond the sales personnel to the supplier's development resources was a real challenge. The suppliers' sales managers frequently operated as gate keepers in the process and were rather unwilling to pass on the unconventional bidding material to their organization. However, after some time, the project manager found ways to present his case so that sales managers agreed to help him in contacts with critical back-office resources, which could better evaluate and grasp the complexity of LEGO's problem. Although the task was unknown to suppliers and they were asked to stretch outside their normal routines, it was possible to find a sufficient number of suppliers willing to become involved. These ten suppliers were interested in engaging in a further dialogue to learn from an industrial lead user. Suppliers were obviously also financially motivated since a refurbishment of LEGO's global packaging lines would mean an order amounting at 30-40 million Euro.

Suppliers individually visited LEGO to give the team an impression of the initial ideas of how they planned to solve the task and on this basis exchange ideas and ask questions to LEGO specialists. After the presentations, the LEGO packaging team selected the five suppliers they thought were the best prospects of becoming turnkey suppliers. These suppliers then had three months to develop and prepare their ideas, including several iterations with the project team. During the preparation, they should receive LEGO for an update visit and also prepare a visit for LEGO at a customer currently using a solution from the supplier. At the end of the time period, suppliers should present their ideas for the packaging team. In addition to these planned meetings, members of the LEGO team were in ongoing communication with the supplier organizations and provided additional information in terms of supplements and briefs. The final presentation was a bounded task, where suppliers described their responses to the assignment and provided calculations of costs and set-up time.

On the basis of the supplier presentations and their learning during the process, the LEGO team realized that no single supplier's solution would be able to satisfy the needs of the

company. But they also concluded that the creative conceptualizations of individual suppliers could be pieced together and comprise a truly novel packaging system. Therefore, the intention was to appoint one supplier to coordinate and prototype this joint solution in collaboration with LEGO. Finally, the system was planned to be rolled out in the global LEGO production system, after plant managers in different countries had commented the proposal.

However, in the end the testing process never materialized due to internal disagreements in the LEGO steering committee that had been changed three times during the process. The immediate cause of this outcome was that the suggested solution was highly automated and technically advanced and, consequently, very costly. Moreover, the new packaging system would create a lock-in situation for this strategic resource for a considerable time period, with respect to capacity, but also with regard to the physical location of the packaging activities. An even more deep-rooted cause was some uncertainty with regard to the future strategic boundary-setting between external and internal supply of packaging equipment and technologies.

4.3 Phase 2 – Internal recovery

Hence, the outcome of Phase 1 was that LEGO decided to postpone the decision to buy new packaging equipment and instead focus on re-internalizing manufacturing in order to stabilize production flows. LEGOs sales were growing fast, and there were great concerns with respect to "rocking the boat". As it was, the packaging system could handle increased capacity, but with considerable delay and restrictions in relation to variability. The decision to postpone investments in a new packaging system came as a big surprise to the members of the project team. Despite the progress made, top management was not ready to implement the concept, but instead stalled the entire project. Regarding the development and renewal process, this second phase did not contribute much. One of the managers interviewed characterized the phase as a "one year vacuum". The main attention was directed to stabilizing of processes before new attempts were to be made. Furthermore, LEGO reconsidered what type of organizational interface to aim for in the third phase.

4.4 Phase 3 – Translation interface

In step with LEGO's continued business success, the packaging problems continued and grew in magnitude. Again, these issues gained the attention from top management, who foresaw problems with their main customers and the risks of opening a gateway for competitors if they were unable to increase the responsiveness and flexibility of the production system. The packaging system was an important Achilles Heel in this respect and required improvements. In this phase, a new team was formed with different mandate, since much conceptual work had already been done. The new project should not be a fully automated solution but rather include and build upon some of the existing pre-packaging machinery that had been re-internalized by LEGO. On the basis of the experiences, a new team re-started the search for a solution.

In this phase the team was organized in a different way. In the first phase, the team was organizationally anchored in the Billund HQ organization, with participation from the senior members in the top management team of LEGO. The new team was managed from the Hungarian contract manufacturer plant, which was also used as the test site for building a pilot production line. The project manager heading this new team was hired in to LEGO with

the take-over of the Hungarian plant. He was asked to organize a new team, with the purpose of building a new semi-automatic packaging line, which would serve the intentions formulated by the previous team, but also build on existing machinery and utilize LEGOs global presence.

The project manager involved the production managers from the other global packaging sites directly in the team. Rather than taking other internal stakeholders on board, he served as a liaison to representatives of the quality, marketing, and decoration departments in the Billund Headquarters. He also contacted the German supplier suggested as coordinator by the team in phase 1. However, when this supplier learned, that LEGO was backing down from their previous concept and wanted to go for more manually oriented solutions, they withdrew from the project. Therefore, the search for new supplier input began and the manager repeated the process of gaining inputs and consent from various LEGO departments by organizing a workshop and visiting several of the internal stakeholders. The production managers from the global production sites had only been involved late in the previous project. Now they were among the first to comment on the modified project and were keen to come up with ideas for building a semi-automatic production line, more similar to the equipment they were already familiar with and the resource context they operated in. Their suggestions revolved around solutions, which could utilize unskilled and temporary labour more effectively than the system suggested in the first phase. These conditions functioned as an important input for involving suppliers in the new process. As the project commenced, based on the modified concept, new suppliers were involved, with strict mandate to work with improving the existing system.

Twenty potential vendors were considered in the process and at the end a German packaging supplier was appointed as system integrator. Their task was a highly complex issue since LEGO was "looking for something special" (interview). The supplier claimed that they had understood what was required. Some problems appeared but the supplier assured that "we will come up with solutions". However, they did not succeed in the first round, and now "all the trouble started". Since the project organization was stressed by milestones from Billund they became increasingly worried because of large variation in the output. Supplier representatives continued to assure that they would be able to handle the problems, but at the end they showed incapable of managing the situation. In hindsight, the project manager concluded that they "should have said NO" to the tough milestones declared by Billund HQ. There was not sufficient time to work through the design issues carefully enough. There was an obvious problem with time because of the challenge to combine the new design of the line with new construction of boxes – at the same time. This situation made the problems partly self-generated by LEGO. The features of the boxes are "extremely important" for the system to work efficiently and fully in line with packaging requirements in the food industry (interview).

Some problems with incorporating the ideas and concepts for cardboard boxes remained. The previous project led to a system that was an important cornerstone in ensuring the flexibility of the more automated system. The idea was that LEGO's packaging flexibility could be greatly improved by implementing a process where decoration could be postponed to the latest time possible. This would make demand patterns better known, which would reduce lead times considerably. However, for several reasons the semi-automatic system was unable to incorporate this idea. The main reason was that the boxes had not been tested on machines – "only on the table" – with subsequent problems. This led to a "bitter dialogue" with the supplier. Some of the problems obviously were created by LEGO as declared above. Also,

supplier representatives agreed that they had not gone through the specifications with enough detail. Furthermore, they had no experience of these materials. Problems skyrocketed since LEGO wanted a running line as soon as possible, given the strongly growing turnover and the resulting pressure on their existing packaging lines.

4.5 Phase 4 – Managing the translation interface

A last attempt was made to handle the situation as the packaging lines were moved from Germany to LEGO's plant in Kladno. People from the supplier were working together with personnel from LEGO. The box was redesigned in cooperation with the cardboard producer. They managed to get some of the formats work, while other formats did not function at all. Both firms worked very hard, but there were severe problems with instability of the equipment. The project was far from target and the problems were still there. At the end the project manager had to go to the steering committee and ask them to say "No Go – No Go with this supplier", since the firm was not capable of solving the problems (some of which were generated by LEGO). The project manager tried his best to come up with something of a gentleman's agreement when the business ended. Such solutions were considered important for maintaining a working relationship with the supplier and avoid bad reputation in the packaging business. The solution was that the supplier was told to bring back home the filling and closing machines. On the other hand, LEGO provided other business in terms of components and sub-systems.

4.6 Phase 5 – Specified interface

A new round of supplier search started, based on a previous list including 25 potential vendors. Again, exhibition visits were a means of locating capable suppliers. This time LEGO did not request a complete packaging line. Instead they decided to work themselves as system integrator, thus employing a specified interface to suppliers. The reason for using this approach was the significant learning point that "it is too difficult for a turnkey supplier to handle this complexity: The machines are complex, the boxes are complex with accompanying complexity of cardboard" (interview). Adding to the complexity is that more than one hundred different boxes are used, involving various materials that behave differently in different contexts. For these reasons, knowledge and competence regarding surrounding processes and the connections to other facilities and their layouts is crucial.

With this mandate, the LEGO team began an active search for a supplier of high-quality and re-useable large cardboard boxes. They found a British supplier, which had developed a useful solution for a locking mechanism, while at the same time providing flexibility with respect to the surfaces to be used for decoration. LEGO also learned that this British supplier had considerable awareness of process conditions and was able to suggest changes regarding suppliers of packaging machinery. Based on these insights, the team managed to improve quality considerably. The manager of the LEGO packaging team therefore decided to invite this supplier to take a more active and permanent role in the team. A significant learning point from the previous project was that design needs time to become appropriate. In this project, six months were spent on the design process, while with the German supplier in phase 3 a complete line had been expected within six months. The project team involved several representatives of LEGO functions, such as marketing, operations, quality, and site managers, in order to achieve a balance between R&D demands and costs. Moreover, suppliers were represented in the team. Also regarding steering committee and reference groups there was a clear striving to include 'all' significant functions and firms.

The main point of departure for the restart was to make minor adjustments of what was available in terms of machines, components, conveyors and other sub-systems. These minor improvements were finished within two months. Both firms tried to find out what adaptations could be made and shared a lot of information. LEGO needed to transfer knowledge and previous experiences to the British supplier. Most things functioned better than expected although some challenges were still to hand.

5. Discussion

During the development process, the supplier interfaces changed from interactive, via translation to specified interfaces. This modification indicates a successive reduction of supplier responsibilities and subsequently increasing control aspirations of the buying firm. The level of innovation and renewal shows decreasing ambition: from a fully automated system to a solution based on adjustments of the existing system. In this section we examine the reasons for these modifications and their consequences. We begin by discussing the innovative opportunities related to the various interface types. This is followed by analysis of the role of organizational arrangements, the problems with integration of supplier resources, and the learning effects observed in the case.

5.1 Interfaces and innovative opportunities

The initial ambition of the focal firm was to develop a really innovative and novel packaging system, by doing things differently. This objective required a new approach that broke away from current beliefs and taken-for-granted assumptions. In these efforts the approach was well in line with findings and recommendations in previous research. Based on the aim to combine internal capabilities with knowledge residing outside the firm boundary, they engaged competent supplier resources that were involved early in the process. The buying firm decided to rely on an interactive interface with this supplier since such a setting is assumed to provide the best opportunities for exploiting others' resources for radical innovation. Moreover, to provide optimal conditions for renewal, the buying firm's people in the project team were decoupled from their normal working procedures and positions. This organizational form was selected in order to stimulate innovative solutions not constrained by established practices. These conditions indeed promoted the evolvement of original ideas and an innovative approach to the packaging problems faced.

Such arrangements are suggested in the literature on 'liminality', where it is claimed that this procedure secures freedom "from the constraints of the social setting that they have left behind" (Wagner et al., 2012, p. 263). With regard to innovative level, the process in the initial phase functioned well. The members in the project team felt liberated from established thinking patterns and behaviour. These organizational conditions strengthened the team spirit and enabled effective combining of the resources of the two parties, in line with findings by Brown and Eisenhardt (1995). In fact, people in the project believed that they were close to develop a truly revolutionary way of reorganizing the packaging system. The interactive interfaces favoured tight connections between the buying firm and the supplier representatives in the project team, thus enabling the development of a highly innovative system. This result is in line with findings by Araujo et al. (1999; 2016) that interactive interfaces represent major reservoirs for innovation and development. However, as described in the empirics, the new solution never materialized, which is discussed in section 5.2 dealing with organizational arrangements.

Translation interfaces are less resource-demanding than interactive interfaces. However, to work adequately, they require supplier capabilities to translate the functional directions from the buying firm to enable design and delivery of solutions that fulfil the requirements in the use context. This study shows that several, and severe, problems can be expected, when these conditions are not to hand, for example owing to complex task characteristics and/or insufficiencies with regard to the competence and skills of the supplier. The buying firm delegated responsibility to the supplier, with limited opportunities to control the operations. In addition, both parties were heavily involved in other operations which resulted in too limited interaction and communication. When problems escalated, the buying firm tried to increase interactivity and enhance control by moving the operations to its own plant. But this was done too late and the collaborative development with this supplier had to be terminated. The reasons for the problems with the translation interface are discussed in 5.3 in the analysis of the barriers towards successful integration of supplier resources.

In the final phase, based on specified interfaces, the complexity of the solution was reduced even further since the project turned towards refinement of the existing system. In this phase, the customer decided to increase the control of the operations by taking on the role as system integrator and applying specified interfaces in relation to suppliers. Since the features of the context of the new solution now were fixed, the uncertainty of the renewal task decreased, which enabled the buying firm to specify more in detail what was required by suppliers. Moreover, the skills and capabilities of the British supplier affected the specifications substantially. This outcome indicates that even specified interfaces benefit from interactivity.

5.2 The role of organizational arrangements

The most important reason for the failure in the first phase was that the basic idea with the new system had not been anchored in the buying firm's internal organization. The liberation and freedom from the main organization made the project team isolated from the internal stakeholders that later should use the system. While suppliers became involved early in the project, representatives of the global manufacturing division of the buying firm were not included. Therefore, the features of the system were adapted to contexts where advanced technology is readily available and manual labour less common. Thus, the organizational arrangements that were favourable to innovative thinking in the project showed to be counter-productive with regard to maintaining the link to the system's working conditions. Therefore, the required integration between supplier resources and the operative resources of the buying firm never evolved.

In this way, the study illustrates the significance of the organizational arrangements in innovation projects as concluded by Sobrero and Roberts (2002). The authors found that "inter-organizational structuring decisions are significant explanatory variables to understand relational outcome" (p. 159). They pointed out the significance of distinguishing between the institutional definition of legal boundaries between the collaborating firms and the mechanisms for transfer of what is attainable through collaboration. In this study the organizational arrangement in phase 1 successfully spanned the ownership boundary between the parties in the development process, but failed to provide the mechanism for transfer to the operational reality of the buying firm.

The transfer problems identified in this case can be explained by concepts presented by Fong (2003). This model of knowledge creation included processes related to 'knowledge

generation' and 'knowledge integration'. The 'liminality' arrangements in the case were suitable for promoting knowledge generation within the project group in phase 1. At the same time, they represented significant impediments for knowledge integration owing to the isolation from the user context. Similar findings related to approaches based on liminality were reported in a study of information system redesign. In that project the thinking behind the proposed solution "was not extended to the rest of the organization" which set the scene for active resistance (Wagner et al., 2012, p. 261). These conditions illustrate one aspect of the problems with integration of supplier resources, an issue further explored below.

5.3 Problems with integration of external resources

In the translation phase the buying firm modified the organizational arrangements to make sure that the project team remained connected to the main organization. The complexity of the packaging solution was reduced to improve conditions for knowledge integration. Furthermore, the interactive interface was replaced by less demanding connections to the supplier. However, as illustrated in the case description, this translation interface did not function as expected.

The problems observed are clearly related to the three barriers to well-functioning relationship involvement identified by Wynstra et al. (2001). Regarding supplier-related barriers, one problem concerned what Lakemond et al. (2006) referred to as 'task characteristics', involving two aspects: technological novelty and task complexity. First, the supplier in the translation phase lacked experience of the materials that were used, which exemplifies problems related to technological novelty. Second, task complexity was considerable, indicated by the comment of the buyer representative that the translation assignment was too difficult to handle for a single turnkey supplier. Moreover, the supplier was overly optimistic regarding its skills and ability to deal with the evolving problems.

Several barriers related to the buying firm were observed in the translation phase. First, the project team was stressed by the tough time schedules decided by the headquarters. This time pressure made it impossible to devote sufficient time to design and testing. Second, the problems were accentuated by the fact that the buying firm was involved not only in modification of the packaging line, but also in redesign of the boxes. These conditions made it problematic to pay enough attention to the packaging solution. Also the lack of connections to internal operations is an example of this type of barrier. In this respect, Koufteros et al. (2005, p. 123) claim that integration of external knowledge probably would not be realized "in the absence of an internal system that not only advocates it but also facilitates it". Their conclusion is that without such an internal integrated sensory and interpretive system, efforts to integrate supplier knowledge "may be futile". Finally, the support to the supplier at the end of the project appeared too late.

The problems on the two sides of the dyad also created relationship-related barriers. In the translation phase, both parties demonstrated insufficient interactive capacity. As described above, the buying firm was stressed by the tough time frame and the box problems. On the supplier side, the key account manager handled nine other customers, which caused obvious capacity problems. These characteristics of the interactive capacity also resulted in challenges with regard to the interactive capability of the parties. This capability is dependent on the buying firm's internal organizing, "not least how it manages collaboration among internal functions and processes in relation to the interfaces with its suppliers" (Araujo et al., 2016, p. 17). Interactive capability is particularly essential in complex undertakings involving transfer

and interpretation of sticky and tacit information (Kale et al., 2000; Li and Vanhaverbeke, 2009). Drawback related to deficiency in interactive capability appeared in this case since the project required close and intense interaction. Such problems become accentuated in situations where the parties lack "a long history of collaboration" (Schiele, 2006, p. 932), with associated limitations for joint learning.

5.4 Learning effects

The case illustrates some significant learning points with consequences for the collaborative arrangements in the final phase when specified interfaces were applied. Experience gained in the initial phase with interactive interface made the buying firm reconsider the features of the packaging system. The mismatch between the innovative level of the potential solution and its operation in practice was due mainly to the isolation of the project group from the rest of the organisation. In the following phase the organizational arrangements were modified with regard to geographical location, project members, and opportunities to influence the features of the solution. An increasing number of subsidiaries were represented in the process to handle issues related to contextual diversity. In this way, the company adjusted to organizational research pointing out the significant interplay between intra- and inter-company organization (Romano, 2003; Piercy, 2009).

The main learning experience related to the translation interface was that the complexity of the task made it necessary to reduce the responsibility of the main supplier. In principle, the leverage of supplier competence is assumed to be best achieved when the buying firm grants complete freedom to the innovation partner (Sobrero and Roberts, 2002). However, the authors also conclude that these conditions are not valid in situations where there are strong interdependence between the object of the development task and other objects. Owing to such interdependencies the buying firm increased the control of the operations and took on the system integration task by becoming the process owner. Moreover, they were keen on allocating more time to the process than previously, which reduced the pressure for mile-stones, both from the project team and the main organization. In this way they increased the interactive capacity, which was improved even further since the new supplier appointed a key account manager working exclusively with the buying firm.

Finally, learning from previous phases affected also the interactive capability. Regarding the supplier side, the buying firm tried its best to ensure that the supplier was experienced enough and capable of managing its tasks in a better way than the previous one, in line with suggestions by Schiele (2006). On the internal side the conditions were considerably enhanced since the features of the box now were fully decided. In this way the uncertainties regarding the interdependencies between the packaging line and the box were no longer a challenge. All in all, these modifications improved the conditions for interaction and exchange of information. Such well-functioning relationships are prerequisites for integration of supplier competence in situations when "tacit knowledge is embedded in its owner" (Sobrero and Roberts, 2002, p. 176).

The study demonstrated that the specified organizational interface turned out to be effective for the integration of the knowledge resources of the two parties. It begets the question: would the specified interface have worked better than the interactive interface from the beginning? We do not think so. This would assume an independence of the phases and neglect that a trial-and-process process unfolded *between* the phases studied. Without the learning experience gained though the previous phases it would have been difficult to

understand which specification to choose from among the uncountable possibilities for doing so. The context and novelty of the interaction obviously also plays a role in the effectiveness of applying different organizational interfaces ex ante. In cases where organizations already are familiar with each other, effective organizational interfaces may appear more or less by default. However, this also comes with a trade-off: In such cases the organizations deal with someone they already know well, implying also that the degree of novelty and possibility for learning radically new things through interaction is somewhat limited. Thus, we assume the need for a careful balancing between interface design and experimentation is necessary in order to create effective knowledge integration.

6. Conclusions and implications

6.1 The contributions of the study

The study shows that buying firms need to strive for variety in their interfaces with suppliers. Interfaces score differently with regard to benefits and sacrifices since they connect the resources of the two parties in dissimilar ways. This conclusion is in line with Araujo et al. (1999; 2016) and Lakemond et al. (2006), who argue that no interface type is better in a general way. The choice of interface is contingent on the particular situation and the specific context. The features of the resource interfaces between the two counterparts impact considerably on the prerequisites for collaborative development, as well as the outcome of these processes. The underlying reason is that the features of the interface affect the ways in which the buying firm can activate the resources of the supplier. Therefore, the study confirms previous findings regarding the significance of decisions related to the supplier abilities required (Rosell and Lakemond, 2012), and the level of involvement with suppliers (van Echtelt at al., 2008).

The main contribution of this study is the recognition of the dynamic role of supplier interfaces over time. This finding extends the mainstream perspective that tend to employ a cross-sectional approach. Previous studies have shown (i) how one firm applies various types of interfaces in relation to different customers (for example, Araujo et al., 1999), and (ii) how buying firms rely on specific collaboration forms and integration with various types of suppliers (e.g. Petersen et al., 2005; Le Dain et al., 2010). By taking a longitudinal approach, this study illustrates how the focal firm over time adjusts the type of interface with suppliers through experiential learning, with associated consequences for knowledge generation and knowledge integration. These modifications were required to address problems related to the prevailing interface with regard to organizational arrangements and innovation barriers. These adjustments of interfaces impacted not only on the level of supplier responsibility, but also on the innovation scope, the control ambitions of the buying firm, and the intra- and inter-organizational arrangements.

In this way, the study illustrates the important and somewhat previously overlooked role of the organizational arrangements in the framing and the sequencing of buying firms' interaction with their suppliers. The organizing of the interactive interface in the first phase was beneficial with regard to the development of a highly innovative solution. Isolation of the project group from the current realities of the buying firm as happened was a means of making room for new ideas and blocking for routine thinking and traditional approaches. At the same time, however, this organizational form was a severe hindrance for implementation, since the new solution did not match what was required in the operational reality. Providing optimal conditions for the development of an innovation thus may result in insufficient

connection to the user context. This means that organizational boundaries that are highly appropriate for knowledge generation may be less relevant for knowledge integration. Other researchers have arrived at similar conclusions regarding the significant linkage between internal and external organizing (Romano, 2003; Ellegaard and Koch, 2012). These conditions are illustrated by a quote from Piercy (2009, p. 857) claiming that the important logic is that strategic external relationships "must be mirrored in strategic internal relationships".

Furthermore, the study shows that collaborative innovation efforts feature substantial uncertainty. Significant aspects of this uncertainty, identified also in other studies, relate to the mobilization and the performance of suppliers (Koufteros, 2007; Schiele, 2006), the clarity of the functional specifications (Karlsson et al., 1998), and the required support to suppliers (Andersen and Dreyer, 2009; Beecham and Cordey-Hayes, 1998). As illustrated in the present study, buying firms may handle such uncertainties through increasing control of the innovative efforts. However, this extended control tends to reduce the level of innovativeness because supplier resources will not be fully exploited. Therefore, we agree with Chae et al. (2017) that firms should be careful with imposing too much control. In a similar vein, Brito and Miguel (2017, p. 84) recommend buying firms to relax some of their control features in order to better exploit interfirm interaction "as a source for learning and for the development of new capabilities".

Finally, the interface framework developed by Araujo et al. (1999; 2016) showed to be useful for analysis of collaborative innovation. This framing differs from other categorizations of customer-supplier involvement by the particular emphasis on the parties' mutual engagement in interactive interfaces. Moreover, the notions of interactive capacity and interactive capability enable analysis of both opportunities and shortcomings in the processes of collaborative innovation.

6.2 Managerial implications

The study provides several implications for practice. First, major innovative efforts with suppliers need to be anchored in, and synchronized with, the entire buying organisation in order to provide solutions that are valid for the different problems faced by various internal functions. The organizational arrangement that promoted the development of an innovative solution was not a viable route since the system was impossible to integrate in the existing processes. The lessons learned for both purchasing and general management are the realization that innovative processes have no inherent value if they do not consistently involve and link back to the organizational realities they seek to transform. The role of creativity as a force in this respect is possibly at its strongest, when meeting the resistance of the 'normal way of doing things'. If too much attention is directed to the performance of the development process, severe problems may appear when the solution is to be implemented in the actual operations of the buying firm.

Second, exploitation of supplier resources through well-defined interfaces provides opportunities for successful collaborative development. In these efforts, the buying firm must be prepared to handle several challenges, ensuing from the dynamics of collaboration. Rather than settling for one form of collaborative interface, managers should proactively prepare for ongoing adjustments of organizational interfaces, following the unfolding dynamics of learning, problem-redefinition and problem solving in complex innovation projects. This study shows that technological uncertainty makes it difficult to predict what supplier

capabilities are most relevant. The case also demonstrates that firms tend to underestimate the amount of management effort required to support supplier collaboration. Moreover, the study illustrates the significant issues related to the decision regarding the extent of involvement with suppliers to handle technical and organizational risk and uncertainty.

Third, the notion of buying firms and their suppliers connected through organizational interfaces reinforces managers' attention towards the potential roles and motivations of the organizations they seek to involve, or are being involved with. These conditions require thorough analysis of what type of interface to apply in particular situations. This decision should be based on the task characteristics, the skills, competencies and motivation of the supplier, as well as the interactive capacity and capability of both parties. Moreover, interfaces are enacted in a dynamic context and managers must work diligently to adjust to these features as development processes unfold.

6.3 Limitations and further research

The study provides detailed insight into the relationship between organizational interfaces and the outcome of collaborative innovation in a specific context and from the perspective of the buying organization. One particular limitation of the study is the lack of interviews with suppliers. However, as argued in the methodological section, the openness of the buyer representatives with regard to their own problems in the process increases the reliability of their information about the suppliers. Also, it can be argued, that given the nature of the project, the voice of purchasing was one important voice among several voices. Nevertheless, further research dealing with explicit interaction between customer and supplier is required to increase the knowledge of these collaborative processes. Such studies can challenge and extend the insights presented in this paper in various ways.

In particular we emphasize two directions for further research. Firstly, we encourage studies in other industrial contexts in order to gain deeper insight into the variety of opportunities and challenges. Secondly, this study shows that the buying firm learned from experience and adjusted the features of the interfaces to suppliers. Therefore, further research is required on the dynamics of organizational interfaces. Such studies should investigate the underlying reasons for modifications of organizational interfaces and the consequences for collaborative innovation, especially with regard to the interactive capacity and the interactive capability of organizations.

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Highlights

- How organizational interfaces affect the outcome of collaborative development and renewal
- Transition of organizational interfaces and impact on integration of supplier knowledge in a longitudinal case study
- Interface types affects how buyers can activate the resources of the supplier.
- Core technology transformation processes, enhances need for complex supplier interfaces
- Managers must change organizational interfaces over time for integrating supplier knowledge
- The changing needs of interaction across development projects merits further research