WHICH ARE THE LIMITATIONS OF ICT TOOLS FOR COLLABORATIVE DESIGN WITH SUPPLIERS?

Talas, Yassine (1); Gzara, Lilia (1); Le Dain, Marie-Anne (1); Merminod, Valéry (1); Frank, Alejandro Germán (2)
1: Université Grenoble Alpes, France; 2: Universidade Federal do Rio Grande do Sul, Brazil

Abstract

New Product Development (NPD) is increasingly relying on Information and Communication technologies (ICT) to support collaborative activities conducted by NPD actors. On the other hand, companies growingly integrate suppliers into their NPD process in order to enhance their innovation capability. The purpose of this paper is to explore the limitations of ICTs usage in the context of collaborative design with suppliers. To address this question, we propose to analyze usage drawing upon a functional classification of ICT tools. The framework will allow us to highlight the limitations according to each main functionality supported by ICTs. In this respect, three case studies are conducted with insight at the company level. The results show that for knowledge management and project and resource management functionalities, limitations will differ according to the use or not of a shared tool to collaborate. The study also shows that for cooperative work functionalities, some ICTs incompatibility issues might occur. Our conclusions pointed out some customer-supplier relationship specificities that condition ICT usage, like trust, and power and dependence factors.

Keywords: Collaborative design, Customer supplier collaboration, Technology, Information and Communication Technologies, New product development

Contact:
Yassine Talas
Université Grenoble Alpes
Collaborative Design
France
talas.yassine@gmail.com

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 8: Human Behaviour in Design, Vancouver, Canada, 21.-25.08.2017.

1 INTRODUCTION

Previous research highlighted the central role of ICTs to foster the collaboration within project teams in charge of NPD (Barczak, 2008; Nambisan, 2003). For example, ICTs support capture, storing, retrieving and sharing of project knowledge and information (Pavlou and El Sawy, 2006). Thus, they enhance the knowledge base available to the project teams (Dewett and Jones, 2001) by increasing the reach and richness of knowledge and information (Sambamurthy et al. 2003) and by making their processing faster (Ettlie and Pavlou, 2006). Moreover, ICTs help intensify the socialization of team members by allowing for knowledge networks and communities (Alavi and Leidner, 2001). Through enterprise social networks, actors can locate competencies and expertise or start discussion threads to resolve design issues. On the other hand, project teams are made up of cross-functional actors, and globalization is pushing organizations towards more and more geographically dispersed teams. In these contexts, ICTs are used to improve the coordination of new product development activities (Ozer, 2000) and actors (Pavlou and El Sawy, 2006), through process and/or project management tools. Furthermore, ICTs offer enhanced communication capabilities (Song et al., 2007), and are enablers for synchronous and asynchronous communication among teams' members in NPD (Montoya et al., 2009). ICTs has also the potential of enabling collaborative work in real-time e.g. NPD actors can visualize simultaneously design documents from different locations.

However, previously mentioned research discussing how ICTs facilitate collaboration, didn't distinguish the use of ICTs according to the collaborative situations, namely collaboration among internal actors or with external actors. Indeed, there is a need to collaborate internally across functions because project teams are usually composed of cross-functional actors in order to integrate all the internal expertise needed for the development of the product (Song et al., 1997). But there is also a need to collaborate across the organizational boundaries with suppliers that are critical sources of innovation in NPD (Brem and Tidd, 2012). In fact, integrating suppliers in early phases of development projects is considered as a key factor for competitiveness (Bidault et al., 1998; Handfield et al., 1999). Collaborative design with suppliers ranges from a simple consultation with these latter on design ideas (White box), to a joint development of an outsourced product (Grey box), and finally to making suppliers fully responsible for the design (Black box) (Petersen et al., 2005). Numerous studies have demonstrated the benefits from this collaborative design with suppliers. Companies can gain from the supplier's technology and expertise, reduce the development costs and lead time, and add value to the innovation and quality of products (Handfield et al., 1999; Ragatz et al., 2002).

In this respect, Ragatz et al. (1999) have identified common and linked information systems to be an important differentiator between most and least successful integration efforts of suppliers into the NPD process. Though, no insight on the mechanisms of actual ICT usage have been studied in the particular situation of collaborative design with suppliers. The little literature streams that have interest in collaborative design e.g. CSCW (Computer Supported Collaborative Design), have focused more on the general context of collaborative work in design rather than investigating specific ICTs usage when suppliers are integrated. Compared to internal usage, one can suppose that mechanisms of ICT usage in collaborative design with suppliers may be different. Indeed, there are some relationship specificities that are particular to inter-organizational collaboration, especially the customer-supplier one in NPD. In fact, confidentiality matters arise when external actors are involved, and the trust between co-development partners plays a significant role in sustaining the collaboration (Seppänen et al., 2007). Another specificity of collaborating with suppliers, is the high likelihood of misunderstandings to occur when knowledge available in one company is translated to the other one (Merminod and Rowe, 2012).

Thus the aim of the paper is to explore ICTs usage in collaborative design with suppliers in NPD. More particularly, the question addressed is: "What are the limitations of ICT tools when supporting collaborative design with suppliers?" In order to answer our research question, the stress will be made on the functionalities offered by these ICTs to support the collaborative activities carried by team members within both parties. First, we draw on a typology of major ICT functionalities to propose a framework aimed at highlighting the limitations of the usage according to each mean functionality. Second, we carry three industrial case studies in order to investigate ICT usage externally. In the next sections, we present the background of our conceptual framework of collaborative ICTs usage. This framework will serve our analysis of the case studies. Then, the methodology used for our research and

the case studies are described. We present afterwards the case study results. Finally, we discuss the results and draw some conclusions and future research avenues.

2 THEORETICAL BACKGROUND

2.1 ICTs functionalities classification to support collaborative activities

In literature, ICT tools for NPD have been classified according to two main criteria: the 'context' of the usage and the functionalities supported. First, some authors have classified ICT tools according to their contextual usage settings. DeSanctis and Gallupe (1987) classified ICTs in a "group size versus dispersion of members" matrix. In their matrix, tools could support teams working in smaller or larger groups who are in the same location or in a dispersed configuration. Similarly, Ellis et al. (1991) also analysed ICTs focusing on the space dimension, but in relation to a time dimension. They proposed a space/time classification in which the interaction supported by ICT could occur in the same or in different locations at the same or at a different time. The time dimension of Ellis et al. (1991) distinguishes synchronous from asynchronous tools. On the other hand, other authors have classified ICTs from a functional point of view (Table 1). These classifications are based on the functionalities offered by ICTs to support collaborative activities. The functionalities identified by the authors can be regrouped in three main classes which refer to three critical activities required by internal or external actors to effectively collaborate in NPD: (1) interactions between actors to solve problems, (2) information and knowledge sharing and (3) coordination of activities. In this regard, Jassawalla et al. (1998) have defined collaboration as the coming together of diverse interests and people to achieve a common purpose, specifically by the means of these three critical activities. As illustrated in Table 1 and explained below, the ICT functionalities model proposed by Pavlou and El Sawy (2006) encompasses and refers to these three critical activities: Interactions are related to their Cooperative Work functionalities, information sharing to the Knowledge Management functionalities and coordination of activities are reflected through the Project and Resource Management functionalities.

Table 1. Functional classifications of ICT tools for NPD (Adapted from Peng et al. (2014))

	Pavlou and El Sawy (2006)		
	Project and Resource Management Systems	**Knowledge Management Systems**	**Cooperative Work Systems**
Rangaswamy and Lilien (1997)	Project Management Team management (workflows)		Team management (communication) Decision making
Nambisan (2003)	Project Management Process Management	Information and knowledge management	Collaboration and Communication
Sambamurthy et al. (2003)	Process management	Knowledge management	Communication
Barczak et al. (2008)	Project management	Information and knowledge management	Communication and collaboration Product development Market research and analysis
Song and Song (2010)			Decision-aiding Communication
Peng et al. (2014)	Project management	Product data and knowledge management	Communication Product design
Pavlou and El Sawy (2006)	**Project Management Resource Management Scheduling and Task assignment**	**Coding, storing and sharing of knowledge Knowledge directories Knowledge network**	**Conveyance Presentation Convergence**

(1) NPD actors need to contribute to the design activity by sharing their expertise to solve problems and create boundary objects. In this regard, project actors interact by communicating and collaborating across time and space. The Cooperative Work Systems (CWS) functionalities introduced by Pavlou and El Sawy (2006) help support these type of team interactions. They integrate all the collaborative work carried for decision making (Rangaswamy and Lilien, 1997; Song and Song, 2010) and over product design (Barczak et al., 2008; Peng et al., 2014). Pavlou and El Sawy (2006) argue that CWS functionalities have the potential of enhancing the collective mind of the group. CWS are associated with three sub-functionalities: conveyance, presentation and convergence. Conveyance functionalities address information exchange behaviours carried to convey data and information (Montoya et al., 2009) e.g. annotations. Presentation feature are functionalities that help actors manipulate the format of their individual contributions and add meaning to existing knowledge e.g. tools for conceptual mapping (Wheeler et al., 1999). Convergence refers to functionalities aimed at the development of shared

meaning among team members with different expertise and cultures (Wheeler et al., 1999). They include all collaborative decision-making and problem-solving activities that could range from idea generation and market analysis to the simulation of product designs.
(2) NPD actors need to share data and information that are necessary to complete the activities and tasks of each actor. In this respect, Knowledge Management Systems (KMS) functionalities support coding and sharing of project and product information and knowledge (Barczak et al., 2008; Nambisan, 2003; Sambamurthy et al., 2003; Peng et al., 2014) as well as the creation of knowledge directories, and knowledge networks or communities (Alavi and Leidner, 2001).
(3) NPD actors need to coordinate efforts to carry out well the assigned tasks. The Project and Resource Management Systems (PRMS) functionalities help development teams synchronize their activities, thus enhancing their coordination (Pavlou and El Sawy, 2006). PRMS support process and workflows management in NPD. PRMS are also concerned with different aspects of project management, such as scheduling, resource allocation and task assignment. In contrast to other authors, Pavlou and El Sawy (2006) regrouped project and resource management functionalities into one main functionality. Even if these two functionalities aren't of the same nature, the tools offered nowadays allow to carry both activities.

2.2 Conceptual framework

Peng et al. (2014) defines ICT usage in NPD as the application of ICT tools within NPD project's strategic and operational activities. Our study seeks to explore the actual ICT usage in a collaborative context with suppliers. We suppose that ICT tools available for NPD actors may not be used the same way in this collaborative situation. Our focus is made on how each functionality is fulfilled by ICTs, since the contribution of ICTs to the collaboration is reflected through the functionalities they support. Even if the tools are available to support specific functionalities, the question is whether these functionalities are more limited when it comes to using them with collaborative design suppliers. Therefore, drawing on Pavlou and El Sawy's (2006) functional typology, we will highlight limitations for each main functionality in the context of collaborative design with suppliers. In this respect, we define limitations in our research as restrictions that limit ICTs contribution to the functionalities.

3 METHODOLOGY

The purpose of this research is to investigate limitations of actual ICT usage to support customer-supplier collaborative activities. A case study approach is the most appropriate methodology to address such an exploratory research question (Yin, 2009). Using case studies will allow us to emphasize the rich, real-world context in which our phenomena occur (Eisenhardt and Graebner, 2007). We performed a qualitative research in the form of interviews with input from three case studies. The three case studies were carried in 3 major industrial companies that are considered leader in their national and/or regional markets (Table 2). Even if the companies come from different industrial sectors, they share similar project characteristics. Their NPD teams are cross-functional and their sizes are mostly comparable. Companies A and B were studied in their roles as customer companies. They all significantly integrate suppliers in their development processes. The focus will be generally made on these suppliers with whom they collaborative in NPD. Company D is a first-tier supplier of automotive industry. The focus will be made on its collaboration with one specific automotive manufacturer. In all three companies, the project teams strongly rely on ICTs to carry their day-to-day collaborative work.

Table 2. Information about the case studies

	Industry	**Main products**	**Role in this research**
Company A	Small appliances	Small Household Equipment	Customer
Company B	Railway	High-speed trains, tramways and metros	Customer
Company C	Automotive	Clipping systems and bonding solutions	Supplier

We should note that the unit of analysis of this research is the company. Data was collected through interviews with the managers responsible for the specification of the ICT tools at each company. The three interviewees have over 15 years' working experience in their respective companies. In order to capture the limitations of ICT usage externally with supplier, we asked them to report mains limitations encountered but also to compare this usage with internal one. Their answers are based on the feedback received from NPD project teams about the ICT tools. Our interviewees are therefore aware of the tools

functionalities and are well positioned to give a reliable overview of the ICT usage both internally and externally. We conducted an individual semi-structured interview for each case. An interview guide was prepared beforehand and the answers of the interviewees were not restricted as they had the opportunity to expand the discussion. The duration of each interview was about 2 hours, and all interviews have been taped and transcribed. The collected data was coded and analysed using the framework analysis presented in the previous section. Other than specific questions concerning the external limitations of the tools, we analysed the transcriptions of the interviews for relative limitations of ICTs usage with suppliers compared to internal usage. We sent reports to all interviewees to have their comments on the collected data.

4 RESULTS

In this section, the results of the case studies will be introduced separately and then cross-analysed to show similarities and differences between case studies.

4.1 Single case results

Within the following subsections, the results of each case study will be presented.

4.1.1 Company A

Internally, Company A relies on a Product Lifecycle Management (PLM) tool to manage project and product data. The PLM tool is also used for project management and follow up. The PLM tool offers the possibility of supplier access to specific project work spaces within the internal database. The interviewee reports that this configuration offers more fluid collaboration within a common tool and more efficient document sharing capabilities. It also allows a real-time follow-up of the supplier work progress, since the work is done on the customer's internal tool. Company A has limited such access to few engineering suppliers and has not generalized it to suppliers involved in collaborative design with them that are in charge of design and industrialisation of the delegated product.

Table 3. Company A: Described limitations, their nature and the addressed functionalities

Addressed functionalities	Nature of limitation	Description by the interviewee of the ICT's limitation
PRMS	Unstructured process	"When suppliers have no access to our database, it gets more problematic because there is no process formalization. The collaborative work that we are supposed to carry with our tools is not satisfying at all."
	Lack of process reliability	"There is a lack of PLM reliability because we are not sure the data is necessarily up to date between two process milestones. It leads to big misunderstandings. Moreover, E-mail is the first enemy of our PLM because it is much more convenient. This increases the risk of using PLM only on mandatory milestones of the process."
KMS	Confidentiality issues	"We are used to work with the suppliers having access to our PLM. The collaboration with them go back to years, they know what we expect from them. It is less formalized than with more occasional suppliers. Technically, it is possible to also give access to co-development suppliers, but there are data security related risks… The fear is the confidentiality… It is not a justified fear, it is more cultural than anything else. Moreover, today, the IT has other priorities than this"
	Exchange ponderousness	"The need to exchange better with the other suppliers is persistent, we want to improve it. Today, you have to extract data from the PLM, then send it by other means (we may use FTP servers of the suppliers, but sometimes we are still brought to burn DVDs!), then expect the modifications of the supplier, then receive the modified data by other means, and then you have to return it into the PLM."
		"There are the official company tools that are constrained and ponderous, on the other hand the question is: what do actors really use to manage day-to-day collaboration with suppliers? One example is when some actors shared data through an online video sharing platform! Others share documents using commercial online sharing platforms… There is a risk of confidential data being shared."
		"It happens regularly that people work with wrong document versions when we share by E-mail"
CWS	Incompatibility issues	"The videoconferencing tool is used in practice to collaborate in real-time with suppliers. But it gets more complicated and some functionalities like remote control and screen sharing could disappear when the external actor do not have the same tool, the same version of the tool or the same operating software. Modern tools were not implemented because the IT said: it is ONE tool to collaborate, we will not put in 10 tools…"

The interviewee states that when suppliers have no access to the PLM, the collaboration gets more complicated. He argues that the exchanges in these cases are ponderous. Because of this complexity and ponderousness, team actors get-round the PLM to exchange with suppliers and use other means that are not official company tools to exchange. This leads to risky exchanges that are not mastered by the Information Technology (IT) department. Furthermore, the suppliers have no real-time vision over the general progress of the project, since only spreadsheet files are shared punctually by E-mail. Table 3 highlights the major external limitations of ICTs as described by the interviewee.

4.1.2 Company B

Internally, Company B uses a Computer Aided Design (CAD) authoring tool that is associated to a Product Data Management (PDM) software to manage CAD-files, product and project data. The PDM tool additionally offers workflow and process management capabilities. Similar to Company A, Company B has given access only to few engineering suppliers to their internal PDM database and not to suppliers with whom they collaborate in NPD. The interviewee stresses that no structured process has been defined to harmonize the exchanges with suppliers with whom they collaborate in NPD.

Table 4. Company B: Described limitations, their nature and the addressed functionalities

Addressed functionalities	Nature of limitation	Description by the interviewee of the ICT's limitation
PRMS	Process ponderousness	"We have less and more powerful suppliers… it is hard to impose on a powerful supplier (which is as big as our company) to work in our database according to our own process, and with the same tools as ours…They want to control their own process…"
	Unstructured process	"It's difficult to say how we manage collaboration with suppliers. Depending on the project, on the supplier, it will be different…because no sharing and 'interacting with supplier' process have been decided at the company level. It is a huge gap…"
KMS	Confidentiality issues	"Not me or my team, but the IT security team is reluctant to more generalize the access to our database to suppliers with whom we collaborate in design…"
	Exchange ponderousness	"Except E-mails, there is nothing to answer the specific needs of functions…It is a growing need from project actors. We are really behind in this area, it is still crafty…3D drawings transfer is done with commercial online sharing platforms, electrical and mechanical schemes are shared through E-mail, some heavy files can be shared through FTP servers. "
	Little traceability	"With the actual tools, There is almost no traceability. Everybody does what he can… In contrast to what is done internally…"
CWS	Incompatibility issues	"In general, screen sharing with supplier is slightly used, but it is not a generalized procedure. I remember in one project with a supplier, we didn't have the same videoconferencing tool. It took around 4 weeks to standardize the use of the tool even for videoconferences."

Internally, Company B uses a specific project management software to manage projects and tasks assignments. Suppliers don't have a real-time vision over the project global progress. On the other hand, a videoconferencing tool is available with the same functionalities as in Company A, and showing the same external limitations. Additionally, the current CAD tool doesn't allow satisfying real-time visualization of CAD files. Therefore, the screen sharing functionality of the videoconferencing tool is used instead, either internally or with suppliers. Table 4 highlights the major external limitations of ICTs as described by the interviewee.

4.1.3 Company C

For the Company C, the focus will only be made on the specific tools at the boundary of the collaboration with one automotive manufacturer. Company C relies on three main tools to collaborate with this main customer: A supplier portal developed by the customer, a videoconferencing tool and E-mail. The supplier portal is used to exchange product and project data, the planning of the project, and to manage process milestones. The interviewee reports that it is a satisfying tool to make things official and

structure the collaborative work. Moreover, the collaboration is highly fluid within the tool and both parties have access to the same level of information.

Table 5. Company C: Described limitations, their nature and the addressed functionalities

Addressed functionalities	Nature of limitation	Description by the interviewee of the ICT's limitation
PRMS	Process ponderousness	"At each process milestone, every required document should be uploaded. No matter if the content of the document is finished or not. Generally, documentation is a step ahead of the technical solutions, we are pressured by the milestones on the tool even if the technique is not fixed yet. Sometimes we just put a blank document! This ponderousness decreases the quality of interaction with the supplier, it leads to loss of time, of information and to misunderstandings."
	Feeling of control	"What is meant to avoid problems (the tool), eventually ends up causing them. We spend meetings with customer just discussing when to upload documents… We feel like the tool is only there to keep an eye on us."
KMS	Access rights issues	"People from our side have to save everything back in our internal database. Sometimes, the customer can delete important documents without us knowing... And if 2 or 3 years after, we want to check the document for traceability matters, you don't find it or you don't have the accesses anymore. We cannot prove that we once uploaded them…"
CWS	Incompatibility issues	"Sometimes, because we don't have the same versions of the video-conferencing tool… Or because they use another videoconferencing tool… In this cases, it gets more complicated to use… We are still sometimes forced to use the phone instead…"
		"Our CAD tool is incompatible with theirs… They've just upgraded to a new version, but we can't follow the upgrade because our PDM is incompatible with this new version… This is why real-time visualization and work over CAD files is done via the video-conferencing tool…"

However, three limitations of the shared portal have been mentioned. One is related to the process asymmetry within the tool since the companies don't share the same process. Second limitation, is the supplier feeling that the customer company uses the tool sometimes more for a purpose of control. Third limitation reported is that the customer company holds the right to take back the accesses from the supplier or might delete documents uploaded by the supplier, leading to traceability issues for the supplier. Table 5 highlights the major external limitations of ICTs as described by the interviewee.

4.2 Cross case analysis

In order to show similarities and differences between the three case studies, we will analyse results according to the functionalities (Table 6). Concerning CWS functionalities, the three companies reported some incompatibility issues when using related tools with customer or suppliers. On the other hand, for the PRMS and KMS functionalities, the results show two types of tools that are used to collaborate. First, a shared ICT tool could be used. It could be a tool specifically developed by the customer for the collaboration or just an access given by the customer to the internal tool. As regards the KMS functionalities, thanks to these shared tools, the collaboration with suppliers is more structured and fluid as they allow for better information sharing and traceability. However, when it comes to PRMS functionalities, as reported in the results of Company C, the fear is that such tools become constraining and ponderous from a process standpoint since the customer and the supplier company don't share the same development process. There is also a fear from the supplier side that these tools are sometimes more used to control their work. Second, in some cases there is no formalized shared tool for the PRMS and KMS functionalities. Project teams only rely on internal tools that are satisfying when used internally, but ponderous when used to collaborate with external actors. With respect to PRMS functionalities, there is no real-time visibility from the supplier side on the project progress, which can be considered as a limitation for the collaboration. There is also no structured process to manage the collaboration with the available tools. In relation to KMS functionalities, such configuration complicates sharing of data and comes with little traceability. Moreover, confidentiality matters restrict the usage of these functionalities. Risk of data loss, misunderstandings and loss of time have been reported as more likely to happen when no shared tool is used for the collaboration.

Table 6. Limitations of ICTs usage to support collaboration with the supplier

	Limitations of ICTs usage to support collaboration with the supplier	
	Shared tool for the collaboration	**No shared tool for the collaboration**
Project and Resource Management Systems (PRMS)	Process ponderousness Feeling of control	No real time visibility on project progress Unstructured process Lack of process reliability
Knowledge Management Systems (KMS)	Access rights issues	Exchange ponderousness Confidentiality issues Little traceability
Cooperative Work Systems (CWS)	Incompatibility issues of video-conferencing tool and CAD tool	

5 DISCUSSION AND CONCLUSIONS

The empirical insights point out to some customer-supplier relationship specificities that were discussed in previous inter-organizational NPD or management literature. In the light of the case studies results, these specificities seem to condition the usage of ICTs in the situation of customer-supplier collaborative design. First, trust between partners is one of the most critical factors of success in collaborative design with suppliers (Ragatz et al., 1999; Walter, 2003). It leads to better information sharing, improved communication, and enhanced problem-solving capabilities (Handfield and Bechtel, 2002; Seppänen et al., 2007; Walter, 2003). Company A and B have been reluctant to give access to their internal tool to suppliers with whom they really collaborate in NPD. As a result, the fluidity of the collaboration was decreased. In the case of Company A, the few engineering suppliers that have access to their internal tool share a long and satisfying previous experience with company A and they both have mutual understanding of what they expect from each other (Selnes, 1998). Second, the analysis of ICT usages highlighted the dependence and power relationships between a customer and a supplier company. For example, Company B cannot impose on suppliers with an equal power relationship to use their internal ICT tools, whereas the customer of Company C has imposed on them to use a specific ICT tool for the collaboration. The asymmetric power relation is also illustrated through the feeling of control suppliers might express when using these specific tools. It was the case for Company C, who felt that the tool is used more to control them rather than to solve problems. The adaptive behaviour of Company C to use the tool imposed by the customer could be explained by the relative power of its automotive customer (Brennan and Turnbull, 1999).

Using a tool that is specific to the collaboration or sharing an existing tool with the supplier has proven to facilitate the interactions between project actors. However, there is the question of how to use these common tools for process and for knowledge management when the partners have different development processes. For instance, Company C, while using the tool developed by one of its main customers, are forced to adapt to their process, which leads to loss of time and misunderstandings.

Another consideration is that companies A and B didn't have a formalized procedure that defined how to share and interact with the suppliers using ICTs. Moreover, no structured process within existing tools for managing supplier involvement have been defined. In this regard, van Echtelt (2007) have identified formulating and communicating procedures for managing supplier involvement as a strategic management process for supplier integration in NPD. In our cases, ICT-oriented processes were not in line with the organisational processes. More generally, standard versions of ICTs cannot be tailored by editors to meet one specific company need, and on the other hand companies could sometimes be reluctant to customize their ICT tools due to the cost of it.

Furthermore, our study reveals how strategical management support is critical in collaborative design with suppliers. If supplier involvement in NPD is not a strategical objective for the company, the necessary resources, including investments in ICTs to better collaborate, and the IT department priorities, will not be allocated and mobilized.

In conclusion, the main contribution of this study was to highlight some of the limitations of ICT tools according to the main functionalities they support when used in collaborative design with suppliers. Kraemer and King (1988) consider ICT tool as a package that combines the ICT tool, the organization and its users. They support that any failure in one part of the package would limit the expected benefits of the tool. Consistent with it, our study reveals that ICT limitations are related to the tool itself and the

organisation and procedures that support its usage. The 'users' aspect hasn't been explored in this study as the unit of analysis was the company.
To expand this exploratory study, next steps of our research will be carried at the project level and will include investigating other ICTs usage limitations and determinants of usage in collaborative design with suppliers. The focus will be made on a specific industrial sector and a specific type of collaboration. The upcoming case studies will be carried with multiple informants from the project teams within an extended sample of companies, which will enhance our construct validity.

REFERENCES

Alavi, M., and Leidner, D.E. (2001). "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues", *MIS Quarterly*, Vol. 25 No. 1, pp. 107–136. https://dx.doi.org/10.2307/3250961.

Barczak, G., Hultink, E.J. and Sultan, F. (2008), "Antecedents and consequences of information Technology Usage in NPD: A comparison of Dutch and U.S. companies", *Journal of Product Innovation Management*, Vol. 25 No. 6, pp. 620–631. https://doi.org/10.1111/j.1540-5885.2008.00326.x

Bidault, F., Despres, C. and Butler, C. (1998), *Leveraged Innovation: Unlocking the Innovation Potential of Strategic Supply*, MacMillan Business, London. https://doi.org/10.1057/9780230377820

Brem, A. and Tidd, J. (2012), *Perspectives on Supplier Innovation: Theories Concepts and Empirical Insights on Open Innovation and the Integration of Suppliers*, Imperial College Press, London.

Brennan, R. and Turnbull, P.W. (1999), "Adaptive behavior in buyer-supplier relationships", *Industrial Marketing Management*, Vol. 28 No. 5, pp. 481–495. https://doi.org/10.1016/s0019-8501(99)00057-7

DeSanctis, G. and Gallupe, R. (1987), "A foundation for the study of group decision support systems", *Management Science*, Vol. 33 No. 5, pp. 589–609. https://doi.org/10.1287/mnsc.33.5.589

Dewett, T. and Jones, G. (2001), "The Role of Information Technology in the Organization: A Review, Model, and Assessment", *Journal of Management*, Vol. 27 No. 3, pp. 313–346.

Durmusoglu, S.S., Calantone, R.J. and Sambamurthy, V. (2006), "Is more information technology better for new product development?" *Journal of Product & Brand Management*, Vol. 15 No. 7, pp. 435–441.

van Echtelt, F.E.A., Wynstra, F. and van Weele, A. (2007), "Strategic and operational management of supplier involvement in new product development: A contingency perspective", *IEEE Transactions on Engineering Management*, Vol. 54 No. 4, pp. 644–661. https://doi.org/10.1109/tem.2007.906858

Ellis, C.A., Gibbs, S.J. and Rein, G.L. (1991), "Groupware: some issues and experiences", *Communications of the ACM*, Vol. 34 No. 1, pp. 39–58. https://doi.org/10.1145/99977.99987

Ettlie, J.E. and Pavlou, P.A. (2006), "Technology-based new product development partnerships", *Decision Sciences*, Vol. 37 No. 2, pp. 117–147. https://doi.org/10.1111/j.1540-5915.2006.00119.x

Handfield, R.B. and Bechtel, C. (2002), "The role of trust and relationship structure in improving supply chain responsiveness", *Industrial Marketing Management*, Vol. 31 No. 4, pp. 367–382.

Handfield, R.B., Ragatz, G.L., Petersen, K.J. and Monczka, R.M. (1999), "Involving suppliers in new product development", *California Management Review*, Vol. 42 No. 1, pp. 59–82. http://doi.org/10.2307/41166019

Jassawalla, A.R. and Sashittal, H.C. (1998), "An examination of collaboration in high-technology new product development processes", *Journal of Product Innovation Management*, Vol. 15 No. 3, pp. 237–254.

Kraemer, K. L., and King, J. L. (1988), "Computer-based systems for cooperative work and group decision making", *ACM Computing Surveys (CSUR)*, Vol. 20 No. 2, pp. 115-146.

Merminod, V. and Rowe, F. (2012), "How does PLM technology support knowledge transfer and translation in new product development? Transparency and boundary spanners in an international context", *Information and Organization*, Vol. 22 No. 4, pp. 295–322. https://doi.org/10.1016/j.infoandorg.2012.07.002

Montoya, M.M., Massey, A.P., Hung, Y.T.C. and Crisp, C.B. (2009), "Can you hear me now? Communication in virtual product development teams", *Journal of Product Innovation Management*, Vol. 26 No. 2, pp. 139–155. https://doi.org/10.1111/j.1540-5885.2009.00342.x

Nambisan, S. (2003), "Information systems as a reference discipline for new product development", *MIS Quarterly*, Vol. 27 No. 1, pp. 1–18.

Ozer, M. (2000), "Information Technology and New Product Development", *Industrial Marketing Management*, Vol. 29 No. 5, pp. 387–396. https://doi.org/10.1016/s0019-8501(99)00060-7

Pavlou, P.A. and El Sawy, O.A. (2006), "From IT leveraging competence to competitive advantage in turbulent environments: The case of new product development", *Information Systems Research*, Vol. 17 No. 3, pp. 198–227. https://doi.org/10.1287/isre.1060.0094

Peng, D.X., Heim, G.R. and Mallick, D.N. (2014), "Collaborative product development: The effect of project complexity on the use of information technology tools and new product development practices", *Production and Operations Management*, Vol. 23 No. 8, pp. 1421–1438.

Petersen, K.J., Handfield, R.B. and Ragatz, G.L. (2005), "Supplier integration into new product development: Coordinating product, process and supply chain design", *Journal of Operations Management*, Vol. 23 No. 3, pp. 371–388. https://doi.org/10.1016/j.jom.2004.07.009
Ragatz, G.L., Handfield, R.B. and Petersen, K.J. (2002), "Benefits associated with supplier integration into new product development under conditions of technology uncertainty", *Journal of Business Research*, Vol. 55 No. 5, pp. 389–400. https://doi.org/10.1016/s0148-2963(00)00158-2
Ragatz, G.L., Handfield, R.B. and Scannell, T.V. (1999), "Success Factors for Integrating Suppliers into New Product Development", *Journal of Product Innovation Management*, Vol. 14 No. 3, pp. 190–202.
Rangaswamy, A. and Lilien, G. (1997), "Software tools for new product development", *Journal of Marketing Research*, Vol. 34 No. 1, pp. 177–184. https://doi.org/10.2307/3152074
Sambamurthy, V., Bharadwaj, A. and Grover, V. (2003), "Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms", *MIS Quarterly*, Vol. 27 No. 2, pp. 237–263.
Selnes, F. (1998), "Antecedents and Consequences of Trust and Satisfaction in Buyer-Seller Relationships", *European Journal of Marketing*, Vol. 32, No. 3, pp. 305–322. http://doi.org/10.1108/03090569810204580
Seppänen, R., Blomqvist, K. and Sundqvist, S. (2007), "Measuring inter-organizational trust-a critical review of the empirical research in 1990-2003", *Industrial Marketing Management*, Vol. 36 No. 2, pp. 249–265.
Song, X.M., Montoya-Weiss, M.M. and Schmidt, J.B. (1997), "Antecedents and consequences of cross-functional cooperation: a comparison of R&D, manufacturing, and marketing perspectives", *Journal of Product Innovation Management*, Vol. 14 No. 1, pp. 35–47. https://doi.org/10.1111/1540-5885.1410035
Song, L.Z. and Song, M. (2010), "The Role of Information Technologies in Enhancing R&D–Marketing Integration: An Empirical Investigation", *Journal of Product Innovation Management*, Vol. 27 No. 3, pp. 382–401. https://doi.org/10.1111/j.1540-5885.2010.00723.x
Song, M., Berends, H., van der Bij, H. and Weggeman, M. (2007), "The effect of IT and Co-location on knowledge dissemination", *Journal of Product Innovation Management*, Vol. 24 No. 1, pp. 52–68.
Walter, A. (2003), "Relationship-specific factors influencing supplier involvement in customer new product development", *Journal of Business Research*, Vol. 56 No. 9, pp. 721–733.
Wheeler, B.C., Dennis, A. R. and Press, L.I. (1999), "Groupware comes to the Internet: charting a new world", *ACM Sigmis database*, Vol. 30 No. 3-4, pp. 8–21. https://doi.org/10.1145/344241.344242