WWW-SYSTEM USE AND BUSINESS VALUE IN PROJECT NETWORKS

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ABSTRACT

This multiple case study describes the usage and potential business value of www-systems in distributed engineering project (DEP) networks. The study recognizes three different categories of www-system use: 1) "document sharing", where the system is used in centralized document management 2) "collaboration", where the www-system is used actively in stakeholder collaboration and 3) "project-management support", where companies actively utilize the metadata generated by the system in supporting their internal and inter-firm project-management processes. The factors identified as explaining the current system-use category of a company are the company's internal capability, external capability, collaboration capability, and system-use experience derived from projects. However, it is realized that the optimal system-use mode of a company is dependent on its position and respective co-ordination needs in the value network. Regarding the benefits, the results confirm that enhanced strategic benefits take effect after a time lag, during which companies learn to exploit the improved visibility the system provides.

Key words: distributed engineering project (DEP), project networks, document management, www-enabled document management systems

1 INTRODUCTION

Development of the Internet has enabled new innovations with respect to information management and collaboration within companies and business networks. One new and emerging area is that of various network collaboration tools that can be described as web-based information logistics platforms. These tools are developed for distributed environments, where they are expected to rationalize the information flows and communication practises between the various stakeholders.

Altogether, the adoption, use and value of technology solutions based on the Internet is an active research area (Straub et. al, 2002). There is strong pressure to answer the question of whether and how these IT investments create business value (Zhu et. al, 2004). Past research has concentrated on the use and value of IT in companies or, for example, in dyadic business relationships within supply chains (SC). There are fewer studies published on the use of these web-based information systems in distributed business networks. Further, when studying the means of IT value creation, it is not enough to focus on the enabling technologies (the Internet) per se, as IT alone cannot be a source of sustained business value. Instead, sustained value can be derived from firm-specific resources that are enabled or supported by technologies (Christiaanse and Venkatraman, 2002, Subramani, 2004). These resources are developed over time when using, for example, various e-business tools in supplier collaboration. Thus, we need a better understanding of the postadoption variations in the usage and value of (Zhu and Kraemer, 2005).

By addressing these gaps in the literature, this paper explores the postadoption usage and potential business value of one innovative network collaboration tool that is used in distributed engineering projects (DEP). The tool is a www-enabled document management system (later referred as a www-system) that supports centralized document management and supplier collaboration in inter-firm project networks. Traditionally, network companies have used mail, courier services and, in recent years, they have been increasingly using e-mail in exchanging documents and informing each other about matters relating to their current tasks. The www-system enables project stakeholders to access project documents and other material from anywhere in the world with a www-browser.

This paper presents the results of a multiple case study conducted in the Finnish marine and pulp and paper industries. Case companies that use the www-system include various project stakeholders that are classified as: engineering officers, system suppliers, and end customers. The aim of this paper is, first, to understand how various project stakeholders use the www-system in distributed engineering projects (DEP), and, second, how the benefits are realized in different use modes. Further, we are looking for factors that explain the way project stakeholders use the www-system. Through these analyses, we contribute to the debate of how IT creates business value, especially in distributed environments.

The paper is organized as follows: It starts with a brief discussion about the communication challenges in the distributed engineering project environment. Then prior research on IT business value and selected issues related to organisational learning that forms the context to

our study are covered. The paper proceeds with a description of the data and method, and concludes with a discussion of results and the theoretical and practical implications of the study. Finally, suggestions for further research are presented.

2 LITERATURE REVIEW

2.1 Www-systems and distributed engineering projects

Successful management of distributed engineering projects (DEP) requires efficient inter-firm information exchange and communication. This is especially important in the design phases of large, complex engineering projects, as they involve several heterogeneous participants embedded in the process of defining, exchanging and reviewing documents. In a typical distributed industrial machinery and production system delivery project, the partners each have their own distinct role in the flow of documents. As each of the contributors has to share various information and data regarding the project with other project partners, communicating project information efficiently and working on the basis of the latest information is a fundamental prerequisite of success. Companies are under enormous competitive pressures in terms of time, scope and costs. These pressures force companies to search for new ways to collaborate with project network partners in order to streamline and integrate inter-firm processes.

The recent rapid changes in the field of project www-technologies are providing new efficient solutions enabling better management of project information by linking various project stakeholders (Morris and Pinto, 2004). The systems are web-based information logistics platforms developed for the DEP environment, enabling project members to access project documents and other material from anywhere in the world with a www-browser. These tools support centralized document management and supplier collaboration in inter-firm project networks.

There are several studies that recognize the possibilities new collaborative tools could bring for project supply chains. Morris and Pinto highlight the resulting virtual integration of project supply chains providing benefits that accrue from tight coordination, partnering, quick and efficient communication, focus and specialization (ibid.). The reported benefits of the www-enabled document management applications are more effective information transfer (Tam, 1999), easier document access, up-to-date information and reductions in the average review and response cycle time for the benefit of all parties (Zack, 2002). In a Finnish study on the use of new electronic tools in managing multipartner project documentation in the construction industry (Sulankivi et. al, 2002), the major finding was that significant benefits that can be measured in terms of time, money and quality – fundamental project goals – can be gained. Further, on the basis of two project cases, Hameri and Puittinen (2003) argue that the use of www-systems in an integrated distributed engineering environment results in efficiency improvements. Realized benefits include accuracy of delivery, cost control and improved compliance with customer demand. According to the study, www-enabled project business makes it possible to run projects with leaner organizations through better project knowledge management.

2.2 Research on IT business value

The term *IT business value* is commonly used to refer to the organizational performance impacts of IT, including productivity enhancement, profitability improvement, cost reduction, competitive advantage, inventory reduction and other measures of performance. Most studies since the mid-1990s have shown significant positive impacts of IT investments (Devaraj and Kohli, 2003, Kudyba and Diwan, 2002, Brynjolfsson and Hitt, 1996). Soh and Markus (1995) point out that there is a certain threshold level of IT use that needs to be achieved before an impact can be observed. Beyond that level, more use might or might not lead to positive impacts. It depends on whether the use is "appropriate" to the key activities and environment of the firm.

Previous research has theorized IT benefits to SCM. Mukhapadhyay and Kekre (2002) develop and test an integrative framework to couple both the strategic and operational gains of EDI. They show that direct strategic benefits are gained as the implementation of EDI strengthens the business relationship between customers and suppliers. Their study also illustrates that the operational measures of relevant business processes improve at both the supplier and customer ends after implementation. Further, their analysis indicate that significant improvements in process performance leads to enhanced strategic gains, but there is a time lag involved. Zhu and Kramer (2004) analyze e-business value along the same lines. They discuss an e-business value hierarchy where The Internet forms the bottom layer that acts as a platform for information sharing along the value chain. The Internet, with unique characteristics that are open standard, public network, and a global connectivity enables value creation through transaction efficiencies, market expansion, and information sharing and integration that further has a positive impact on firm performance in sales, procurement, and internal operations.

In many cases, IT solutions are becoming commodity-like, but the process of integrating IT into companies' strategic contexts is complex and imperfectly understood. In the information systems (IS) literature, the resource-based view (RBV) has been used to explain how IT business value resides more in the organization's skills to leverage IT than in the technology itself (Ross et. al, 1996, Soh and Markus, 1995, Clemons et. al, 1991). That means that IT business value depends on the extent to which IT is used in the key activities in the firm's value chain (Zhu and Kraemer, 2005). Subramani (2004), who is interested in value creation potential from the supplier's point of view, shows that the benefits are mediated by deployment of relationship-specific investments. His findings are in line with the argument that sustained value can be derived from firm-specific, economically valuable, resources that are enabled or supported by technologies Christiaanse and Venkatraman, 2002.

2.3 Adaptation and learning

Early studies of the influence of technology on organizations (see, e.g., Perrow, 1967, Woodward, 1965) were based on the premise that technology was inflexible and therefore a given, and that the subject of interest was the impact of technology on the organization (Robey and Sales, 1994). A more mature perspective states that, while IT influences

organizations, organizations at the same time influence the design, implementation, and use of the technology to meet their information requirements. The organization-technology relationship is thus a mutually adaptive relationship where both technology and business processes evolve in response to the needs of changing business environments (Poole and DeSanctis, 1990).

Studies of adaptive processes discuss the relation between exploration of new possibilities and exploitation of old certainties (March, 1991, Levinthal and March, 1981). Such actions whose goal is to improve operational efficiencies are considered as exploitation, where as those actions whose goal is to learn about the environment and discover novel ways of creating value or solving problems are considered as exploration (Subramani, 2004). According to March (1991), both exploration and exploitation are essential for organizations and there needs to be an appropriate balance between the two. For example, an over emphasis on exploitation alone may compromise competitive advantages that may be gained through IT investment over time.

In earlier studies of organizational learning, the difference between exploration and exploitation is expressed as distinctions between refinement of an existing technology and invention of a new one (Levinthal and March, 1981). Subramani (2004) offers a slightly different explanation when he conceptualizes exploitation and exploration of EDI in supply chain management (SCM) as two complementary appropriations of the technology. He compares them to automating and informating, which are two broad motives for using information systems.

According to Subramani (ibid.), the goal of IT use for exploitation is to systematically improve and incrementally refine various structured and repetitive tasks related to the transaction-processing activities between suppliers and customers. One example is the implementation of inventory alerts, based on preset triggers to communicate stocking levels of products in warehouses. As a result, there are clearly definable benefits, such as cost reduction and process efficiency.

Conversely, the goal of IT use for exploration is to support non-routine and, in many cases, unstructured tasks. Often these tasks are related to questions about supply chain strategy and the structure of the supply chain. In practice, this means utilizing the broad arrays of information accumulated throughout the system and using it for, for example, improving our understanding of a particular market situation and of the various cause-effect relationships related to a particular business environment. Further, according to Subramani (ibid.), exploration may lead to re-designed business processes for creating new capabilities and for finding novel solutions to current problems.

Studying the different roles of IT exploitation and exploration as they relate to structured and unstructured tasks of companies' business environments is expected to improve our awareness of the multiplicity of issues related to the question how IT actually contributes to better business performance. Further, there is a growing recognition among the research community that the impact of IT can be identified through a process-level contribution (Ashworth et. al, 2004, Tallon et. al, 2000). Therefore, it is important to study IT's role in different types of processes related to the collaboration within network members.

2.4 Identified research gaps

The motivation for this study is derived from the above discussion. First of all, on the basis of the literature review, we argue that IT business value creation to business processes is an unsettled issue and should be studied further. Further, it can be concluded that more empirically grounded research is needed to increase awareness of the postadoption use of IT in business processes. Second, the development of various network collaboration tools based on the Internet offer an interesting area for research. Especially as there is not much empirical research studying the use and realized benefits of these systems in boundary-spanning project network settings. Furthermore, the existing research on the use and effects of these systems on different project stakeholders, and on the whole distributed engineering project environment, is rather scarce.

3 RESEARCH DESIGN

In order to increase our perception of www-system use and the mechanisms through which the potential benefits of the system deployment realize, a multiple case study is conducted. This research is enabled by collaborating with a company providing www-systems for the distributed engineering projects. Their system is accessible from anywhere in the world with a www-browser from any workstation connected to the Internet. The global access enables co-operation and virtual project teams to deliver projects in virtual project workspaces; for example, deliverables can be submitted for review and comment, and discussion on deliverables can be carried out online and linked to the actual design documents. Project partners can join in on workspaces on demand without specialized software and they can work on several projects for different clients at the same time. Thus, the system can be used for information management, partner collaboration, information process follow-up, and performance analysis. Figure 1 illustrates the fundamental principle of the system.

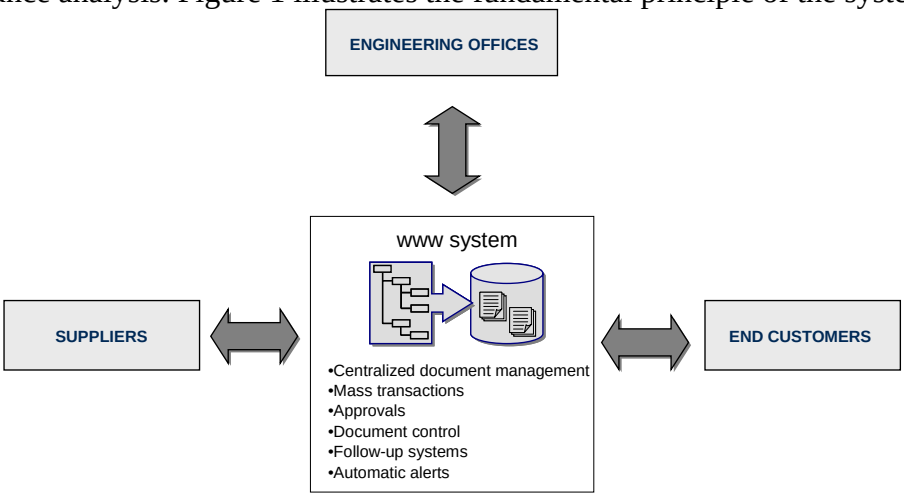

Figure 1. Principle of the www system

A multiple case study research design was chosen to facilitate the collection of context data on the use and effects of the www-system on collaboration within the DEP network

stakeholders. The case-study approach is selected, as little previous empirical research is available on the subject (Eisenhardt, 1989). Research questions of the paper are formulated as follows:

1: How are various project stakeholders using the www-systems in distributed engineering projects?
2: How do the benefits realize in different use modes?
3: What types of factors explain the way project stakeholders use the www-system?

The research is focused on complex project deliveries, which involve various stakeholders and actors contributing to the final deliverable in the form of documents. We selected ten companies in the Finnish marine and pulp and paper industry. The case companies were selected in a manner in which they represented both selected industries and three different positions in the project network, i.e. end customers, engineering offices and system suppliers. Five of the companies operate mainly in the marine industry and five in the pulp and paper industry. However, as can be seen from the Figure 2, some of the companies serve both these sectors. The sample included two end customers, five engineering offices and three systems suppliers.

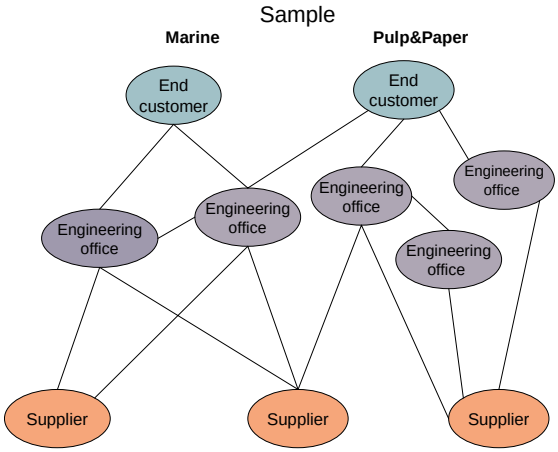

Figure 2. Interviewed companies

The type of documents that our case companies share through the www-system covers all documentation describing the product and project-management process. Examples are drawings, memos, instructions, quality policies, project planes, project follow-up reports and various approval and audit documents. Table 1 presents the basic information related to the www-enabled project document management application use within the sample.

Table 1. Basic information on the application use within the sample

End customer	Implementation year	Users inside the company	Users of project personnel (%)	Number of external companies	Number of external users	The share of projects in which the application used (%)
EC1	2004	50	100 %	10	50	20
EC2	2004	30	100 %	5	30	50
Engineering office						
EO1	1998	300	100 %	27	350	100
EO2	1999	200	90 %	10	40	100
EO3	2000	30	15 %	7	20	20
EO4	2001	300	85 %	20	100	20
EO5	1996	2000	40 %	20	100	80
System supplier						
SS1	2004	500	20 %	0	0	60
SS2	1998	400	90 %	0	0	50
SS3	2002	10	10 %	0	0	20

The primary data collection methods used for the study were semi-structured interviews and document analysis. An interview guide was used because it is more comprehensive and systematic for data collection than a conversational interview and more flexible than either the standardized open-ended interview or the closed, fixed response interview. The interview guide covered the following topics: the nature of the company's project business, the use of www-enabled systems, business effects of the www-system and future views on www-system use. The semi-structured interviews were conducted with twelve representatives from the case companies. Among the interviewees there were IT managers, business development managers and project managers; each interviewee had both system-use and implementation experience.

The interview data was analyzed in two successive phases. First, within case analyses, were assessments of how the application was used, how the use had developed over time, and what benefits related to the application use in individual companies could be identified. After analyzing each of the cases separately, the cases were compared with each other to identify potential patterns between companies using the application. The data were analyzed using tables and data displays, as suggested by Miles and Huberman (1994). This approach facilitated an exploration of the key issues within each organisation and an analysis of these issues across companies. As a result of this, we were able to classify the companies into three system-use categories. Further, we searched for explaining factors why certain companies fall into certain use-mode categories. To finalize the cross-case analysis, we linked the extracted mechanisms and identified benefits to the different use-mode categories.

Concerns regarding validity and reliability are particularly important for case-based research [Yin, 1994). External validity reflects how accurately the results represent the phenomenon studied, establishing the generalisability of results. In this study, generalisability, as recommended by Yin(ibid.), has been enhanced by including multiple in-depth cases in the study that represented different industries and different positions in the project network. The second issue in research design quality – reliability – addresses the repeatability of the experiment, and whether replication is possible and will achieve the same results. Pilot interviews were used to refine the research content and procedure before the data collection phase. Additionally, the informants were sent a copy of the interview guide beforehand, so they knew the types of questions and the type of documentation that might be requested. To further corroborate the reliability, a case study database that included a copy of the complete interview guide for each case and detailed summary write-ups of each case was established. Construct validity addresses the establishment of the appropriate operational measures for the concepts studied. One way to deal with construct validity, according to Yin (ibid.), is to

return the case study reports to the informants for verification. Respective company personnel reviewed all ten case descriptions before the cross-case analysis stage. Multiple sources of evidence were used when available; this also enhanced construct validity.

4 RESULTS

The early application adoption during the late 90's was more or less dominated by those engineering offices that were actively involved in the system development with the system provider. The main driving force for the use within the engineering offices was stemming from the experienced operational problems with document management in terms of "*dispersed project documentation taking time to manage*", "*working based on old information leading to extra costs"* and "*tedious document change processes*". More recently, other project network members, such as various system suppliers and even end customers, have also become active users of the www-system. Consequently, different companies in the distributed engineering project network use the system differently.

Our analysis is divided into three aspects. First, we report the findings related to the system use and proceed with the realized benefits related to the different use modes of the system. Then, we present the potential factors that explain how the www-system is being used by project network companies.

4.1 System use

In terms of the extent and different features of the system use, we were able to identify three different categories of the system use and classify the case companies accordingly. The identified use modes are document sharing, collaboration and project-management support. The classification of case companies and the inter-relations of the use modes are presented in Table 2.

Table 2. Use modes and case companies

Use mode	Case companies
document sharing	EC1, SS1, SS3
collaboration	EO3, EO4, EC2, SS2
project management support	EO1, EO2, EO5

Document sharing

The implementation of the www-tool system translates into a new way of managing and sharing documents. By introducing the system, a company modifies its document management processes by placing the documents in a centralized place instead of storing them in a separate company file system. Consequently, instead of storing documents in internal file systems and managing complex information flows between network companies, the system enables the management and sharing of documents from one centralized place

over the web. This change alone enables real-time document visibility for project stakeholders. What this visibility brings about is a change in the manner in which documents are searched and exchanged in inter-firm networks: one can simply log into the system and search for the required information.

However, companies in document-sharing mode are not utilizing the advanced features of the www-tool, but are basically using the system as a passive drawing document warehouse, thereby enhancing document visibility. Communicating by means of documents does not occur through the system, but in traditional ways such as by e-mails and mail. The system then integrates project network companies via centralized document management, but other interactive mechanisms enabled by the system are not utilized.

Collaboration

In the design phase of a large and complex project, one essential feature is the active inter-firm communication and interaction on documents. In our sample, there are companies that are actively using the different collaborative features of the system. There is a clear distinction between this system-use mode and "document-sharing" mode, as companies in collaboration mode are interactively communicating by means of documents through the system and not by traditional means such as separate mails. Therefore, documents are not only stored and downloaded from the system, but active communication about documents takes place through the system. For example, documents are shaped, reviewed, commented upon on-line, revisited and approved by utilizing the system. Further, the automated document change alerts are in use and utilized. Automated document change alerts are control agents that inform the relevant system users by e-mail as changes to documents are made. This ensures that the system users are able to trust the system with respect to latest information; it also ensures they are able to react immediately to changes and that they remain all the time aware of the state of the documents.

Collaboration requires both internal and inter-firm depiction of document management processes and the linking of documents to the followed processes. This was one of the distinctive features within the companies in this mode, in contrast to the companies in document-sharing mode as well. Companies that had advanced to this system-use mode acknowledged it was necessary to define and communicate the document management processes at the beginning of a project in order to make this enhanced inter-firm process collaboration successful. Furthermore, as the application use stabilizes, system features can be utilized in shaping the actual project processes both at inter-company level and inside a company. As an engineering office representative stated:

> "*The application features have been utilized in shaping the document management processes in the long run. These are also naturally affected by the way the system is used. Further, with the system it is much more straightforward to control that the agreed process paths and modes of operation are truly followed.*"

Project-management support

Finally, we identified companies that use the metadata generated by the system use in supporting their internal and inter-firm project-management processes. By definition, *metadata* means data that may describe how, when and by whom the document was created and received, and how it was modified. This data can be used to monitor and analyze the performance of an individual project partner as well as the entire project.

Through using the system, the companies have then gained utilizable formal inter-firm communication data in a systemized form that was not previously available. Firstly, the information in this form can be exploited in project process streamlining and optimization by recognizing the possible project document management bottlenecks in terms of, for example, document change and revision loops; the data gained can be used to streamline the processes involved. Secondly, metadata can be utilized in actual project progress follow-up. Companies are, for example, using their share of approved documents as an anticipative measure to control projects as far as being on time is concerned, and for comparing the realized document exchange against the baseline timetable.

Naturally, for a company to fully benefit from metadata use in project-management support, other companies in the project network must show a commitment and willingness to use the www-system as well. The three engineering offices in the project-management support mode each reported that they have been constantly and systematically looking for better and novel ways of utilizing the www-system. Consequently, they have not been satisfied with what has seemed evident in terms of system use, but have been continuously trying and testing new ideas. One example is the ability to use metadata generated by the www-system for project process improvement. An open attitude and learning by trying were necessary to ensuring that companies could benefit from the improved visibility the system provided.

4.2 Benefits of system use

The benefits brought by system use were also analyzed. First, the interviewees were requested to select the five most important benefits in the order of significance from a pre-structured list. Nine out of the ten case companies ranked “project documents are available centrally and globally” as the most important benefit of the system. Other important benefits identified were the comprehensive control of project documents, easier and more visible collaboration with suppliers and customers, fast communication on changes and change management of documents and more easily found and better organized documents.

Next, the benefits brought by the system were analyzed at a more detailed level, as the interviewees evaluated the impacts of the system in terms of financial and operational measures, project processes, information flow and collaboration on the network. The results of these evaluations are provided in Appendix 1. What is most notable from this analysis is that the system was seen as affecting each of the listed factors positively. The most important benefit was seen to be information-flow efficiency related especially to improvements in real-time information, systematic information sharing and time used in searching for

information. In addition to this, the project process improvements were also evaluated to be significant.

Further, the interviewees were requested to freely depict the different mechanisms through which different benefits actually materialise. On the basis of all the information gained, cross-case analysis was conducted in order to link the extracted mechanisms and identified benefits to the different system-use mode categories. Table 3 presents the benefits and the mechanisms through which they realize in different use-mode categories.

Table 3. Benefits in different use modes

	Mechanisms	**Benefits**
Document sharing	Electronic documents are shared in a centralized place over the web.	Decreased project communication and administrative costs as use of traditional communication channels diminishes and documents are in an electronic format.
	Documents are stored in a joint application enabling inter-firm document visibility.	Information flow benefits: real-time information and decreased time use in searching for information
	Changes in the way documents are searched and exchanged, as one is able to view documents and search for the information in the system.	Process streamlining, as there is no need to request documents from other project stakeholders.
Collaboration	Active communication, review, shaping, revisiting and approval of documents through the application.	More speed and systematicy of information sharing enhancing, also awareness of what other project teams are doing. The visibility of communication patterns and the fact that each inter-firm transaction is "recorded" in the system changes the way people act and "forces" one to follow the guided procedures. Design outsourcing to new subcontractors is enabled i.e. the system enables concurrent engineering. This in turn enhances network flexibility and decreases lead times.
	Automatic alerts about statuses and document changes.	Improved efficiency in reacting and controlling design changes contributing also to the decreased number of errors during a project and decreased hazzling costs.
	Active inter-firm collaboration mode requires one to define and communicate the document structures, folders and management processes at the beginning of a project i.e. document management processes are depicted and documents linked to the processes.	Systematic project document management processes improving efficiency and decreasing hazzling costs.
Project	Metadata information generated by the system use is utilized in project process streamlining and optimization.	Data enabling improved inter-firm business process integration e.g. communication matrix analyses. Learning to utilize the streamlining possibilities enhances processes.
	Metadata information generated by the system use is utilized in project management control and measurement.	Follow-up of project state e.g. x% of documents as a baseline for future project planning, recognition of communication bottle-necks improving planning accuracy and lead times.

It is evident that, within each of the categories, the system use brings direct operational benefits in terms of time, costs and quality. These, in turn, are enabled by improvements within information flow management, collaboration processes and actual project processes that are enhanced as a company advances from one-use mode category to the next.

Regarding the effects on the financial and operational measures in the document-sharing mode, especially the impacts on project "hazzling" and communication costs can be seen as significant.

> *"The typical hazzling is dramatically reduced as information no longer has to be searched from diverse places. Furthermore the project engineers are now constantly aware that the information they use is the latest one."*

The communication costs are substantially reduced as the need for printing papers and postal services declines with the use of electronic approval methods. According to a cost analysis of one of the engineering offices, the printing and print paper costs were reduced by 30% after the application was implemented.

Of special importance are the possibilities that the collaboration mode offers in relation to design outsourcing and concurrent engineering: the possibility of reshaping and revisiting documents on-line, for example, enables increased design outsourcing and parallel designing on the part of engineering offices; this, in turn, decreases the lead times and enhances the flexibility of the project network. These benefits are further strengthened in the project-management-support mode. The system, then, stands as a tool that enables engineering offices to make efficient use of external resources in the design phase. As the companies gain true insight into each other's design process phases and the paralleling of different phases, their being able to more efficiently harness concurrent engineering methods becomes a possibility.

True design process visibility also provides remarkably better inter-company collaboration possibilities, which, in turn, results in time and cost savings. We conclude that, through these mechanisms, the collective capability of the total project network is enhanced by the elimination of inefficiencies and improvements in value. This, in turn, brings competitive advantage to the network utilizing the system.

4.3 Factors explaining the use modes

As can be seen from our use mode and benefit analysis, case companies use the same system differently and respectively the benefits realize differently for them. To summarize, within the document-sharing mode, there are two system suppliers and one end customer, in collaboration-mode, two engineering offices, one system supplier and one end customer, and in project-management-support mode, three engineering offices.

Engineering offices were the first users of the system. Among them, the use mode development followed the learning curve of the company: as companies grew used to document sharing, they gradually realized the other exploitation possibilities the system

enabled in their context and were able to move from the document-sharing mode, for example, to the collaboration mode. This is illustrated in the comment from a representative of a large marine contracting company:

> *"First, we needed a document management system, since we did not have it. Later, after using it, we understood that what we had was also a project collaboration tool that suited our environment."*

A factor that rather obviously explains the current use-mode category of a sample company is the company's system-adoption capability. For the meaning of *system-adoption capability*, we refer to the definition provided by Rogers (1995) as he states that the ability to adopt relates to the skills with which a system user is able to modify the system to fit the situation, and, at the same time, alter organizational structures and communication practices accordingly. In our case setting, the identified skills related to the successful adoption capability of a www-system are the following:

- company's internal capability
- external capability
- collaboration capability, and
- system-use experience from projects.

Here, *internal capability* refers to the way a company embraces IT and is motivated to implement the system. There was a company EO3, for example, whose design engineers were not even used to using electronic documents regularly, their attitudes towards new IT tools being more or less hostile. Obviously, implementing the system into this kind of environment requires both time and extensive internal efforts aimed at, among other things, cultural change.

External capability relates to the use of external process consultants supporting the system implementation and new document management process definitions. We refer not only to the financial resources needed to buy services from experts, but also organizational skills to collaborate with service providers. The representative from SS1 stated:

> *"They [process consultants] have supported and helped us enormously. Without their systematic and disciplined approach we would not be here today. Their support in quickly orientating our company personnel to the system use has been really valuable."*

Collaboration capability refers to the company's ability to link up with the company's project network partners in using the system, an area in which some companies had experienced problems. Conversely, collaboration capability also relates to a situation in which one company in the network requires another to adopt the system for use. Further, one important identified aspect of collaboration capability relates to the ability to facilitate process changes among project network partners.

Finally, *system-use experience* relates to the actual system-use time and its quality accumulated for a company from distributed engineering projects: a company that has been utilizing the system in a number of projects is likely to be in a more advanced use-mode category.

The companies currently in the document-sharing category expressed their intent to move to the active collaboration mode in the future. This way, the document-sharing use mode can be viewed as a transitional stage from which a company proceeds to the next level as system-use experience accumulates. However, contrary to that, the shift from the collaboration mode to the project-management support mode is not an obvious and natural development step for all companies. Our results indicate that only the companies with more co-ordination needs, such as those with engineering offices, actually move to the project-management support mode. However, there is a trend towards centralizing project deliveries to only a few suppliers. Thus, networks that system suppliers have to manage will widen, and therefore project-management support features of the tool will be important for them as well.

Whether a company advances to the project–management-support mode is then moderated and dependent on the company's role in the value network: only the project network companies that have a great need for integration in the project network, and value the process streamlining possibilities or project traceability features the tool offers, advance to the project-management-support mode. Consequently, this also implies that the company's *position in the value network* and respective co-ordination needs have an effect on the use mode of the same IT system in a project network: they determine the optimal level, i.e. the target mode of the system use, for individual companies. Therefore, whether a company is to utilize the system for project-management-support purposes is more a question of a company's value chain position and respective coordination needs.

Figure 3 illustrates the different use-mode categories and the factors that explain a company's shift from one mode to another.

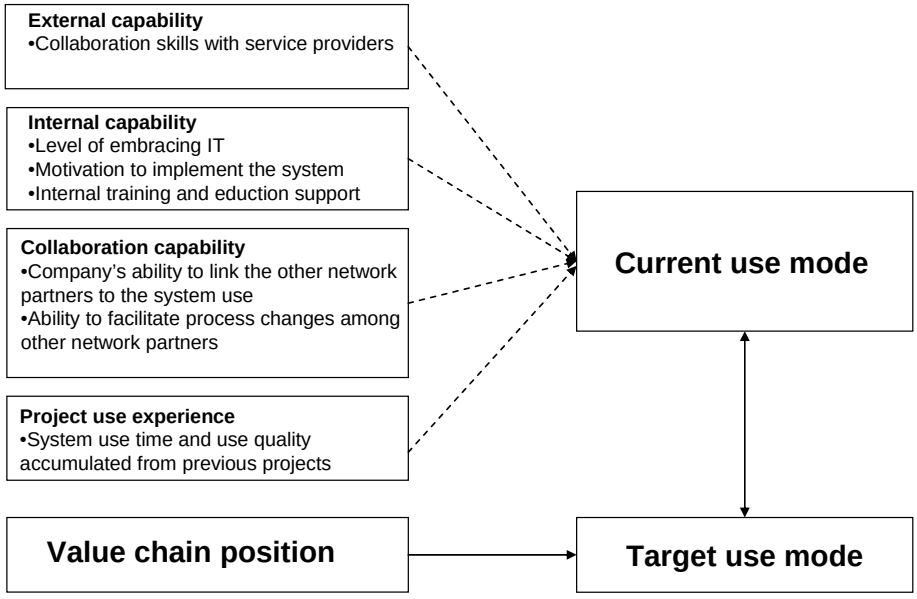

Figure 3. Factors explaining the use modes

5 DISCUSSION

In this paper we have described the use and benefits of a www-system in a distributed network project environment. In distributed engineering projects, we recognized three system-use modes that are “document sharing, “collaboration”, and “project-management support”. Our results highlight the importance of commitment to system use on the part of network members to their developing from a more passive mode, such as document sharing, to a more collaborative usage of the system. Further, the ability to use the more advanced features of the tool to, for example, perform monitoring and bottleneck recognition, requires dedication from the key project network member. The results indicate that certain companies in the network have a more crucial role in getting other network members dedicated to system use. In our case environment, it is most often the role of the engineering officers. At first glance, it looks like they are the ones to benefit from the tool the most, but in the longer run, the competitiveness of the entire project network is enhanced as they become able to provide more value to the end customer through faster project throughput times and improved visibility during the project.

Further analysis of the identified benefits of the system use confirm that the identified benefits can be divided to direct operational, direct strategic and long-term strategic, as is typical of most e-business investments (Mukhodadhyay and Kekre, 2002). Examples of direct operational benefits that come with the system are improved efficiency in reacting to, and controlling, design changes and decreased hazzling costs. Our analysis indicates that, when moving from “document sharing” to “collaboration”, direct operational benefits brought about by the system use are enhanced. There are three reasons for this. First, communication is linked to the documents. Second, automatic alerts make sure that each member is informed about possible changes immediately. Third, active inter-firm collaboration requires that document structures and management processes are discussed and agreed at the beginning of the project. Moving to project-management support and starting to use the metadata generated by the system provides additional ways to improve the document management practices. Now the collaboration requirements between the network members are brought to a more demanding level. A great deal of trust and openness is needed for project network members to discuss the findings related to possible project bottlenecks openly. Here we come to a fundamental problem related to the collaboration practices in general (Smaros, 2005): how to collaborate if the benefits are not distributed evenly according the requested investments?

The www-system use brings also direct strategic benefits as customer service is improved. End customers have an improved visibility to the status of the project through system use. They can at all times compare the progress of the project-to-project plan and be thus informed about the possible delays in the delivery. Another aspect of the improved customer service is the easy access to the project documentation, either during the project or, especially, after completion of the project. However, issues related to the improved customer service did not come up very strongly during the interviews.

As discussed in the literature part of the paper, enhanced strategic benefits related to the IT investments arrive with a time lag (Mukhopadhyay and Kekre, 2002). Our case analysis confirms this. The first example is the concurrent engineering approach and paralleling of

different design phases, as the companies have on-time visibility into each other's design processes. It is not possible to enter into concurrent engineering immediately after implementing the www-system to the project network. Project stakeholders need to learn the necessary collaboration practices first. However, once the concurrent engineering approach is established, it should be easy to add, for example, new system suppliers, to the process. Another example of long-term strategic benefits is related to the system feature that enables efficient deployment of external resources, which shortens total lead times and brings noticeable flexibility and responsiveness to the project network. The application thus supports distributed projects by acting as a facilitator of true networking and reducing lead times, one of the key project success measures.

Our results indicate that commitment to www-system use is an important element in explaining why some companies are able to benefit from the system use more than others. Further, both exploitation and exploration skills and attitudes also play an important role in explaining variations in benefits to users of the tool. This seems to be even more important when companies are using the more advanced features of the www-system as they find novel ways to collaborate, identify problems in current practices etc.

The third research question of the paper is about the factors that explain the way project stakeholders use the www-system. Orlikowski and Iacono (2001) affirm that it is important to realize that tools based on technologies such as the Internet and other distributed applications do not provide the same properties in different contexts of use. Within our case sample, we realized that the network company's position in the value chain and respective co-ordination needs define the optimal use mode for a particular company. Engineering offices have more often moved to the third level, "project-management support", as their role in the network requires them to co-ordinate operations. It is mostly in their interest to enhance the process streamlining activities within the project network and thus start using the more advanced features of the www-system. On the contrary, system suppliers that provide independent module solutions to the project have no value added from the move to a more advanced level of system use. They may stay in "document sharing" or, at most, move to "collaboration" mode and use the system more passively as engineering offices. This is because such companies have very simple and straightforward interfaces with other project network members, and co-ordination needs are thus limited. However, due to the trend of centralizing project deliveries to only a few suppliers, the role of a system supplier will change as the networks some of them have to manage become wider and as they are thus expected to utilize the more advanced features of the www-systems as well.

However, our cross-case analysis indicates that companies are not necessarily using the www-system as their value chain position and respective co-ordination needs may require. We identified several factors that seem to have an impact on how an individual network member utilizes the www-system features. These are defined as: the company's internal capability, external capability, collaboration capability, and system-use experience. Further, we argue that investing in these factors is a prerequisite for maximising the benefits the www-system use may provide to project network members. This needs to be further validated, but we believe that even now this is an important finding and offers practical guidelines for managers. Focusing on the identified issues and not forgetting the balance between exploitation and exploration should enable companies to benefit more from the www-system in project network operations.

6 LIMITATIONS AND FURTHER RESEARCH

The study presented in this paper has limitations. The major limitation comes from the research design. The results presented in this paper are based on a snapshot type of case study that did not capture the system-use development, process changes and related learning in the same way that a more longitudinal research approach would probably have been able to. However, the findings of this study present an opportunity to further develop an understanding of the underlying mechanisms of how an Internet-based collaboration tool benefits distributed engineering networks.

In this study, we have focused on the design phase of complex engineering projects. One interesting avenue along which it would be possible to proceed with further research is the impact the www-system use has within the DEP networks overall. It would be interesting to analyse whether the improved visibility provided by the www-system has had an impact on the responsibility distribution among network members. As it seems that the use of this tool enhances concurrent engineering practices, another especially appealing question concerns the possibilities of increasing the level of modularity in projects and the likely impact of doing so on the overall competitiveness of the DEP networks.

Further, in this study we have analyzed networks where task certainty is relatively low in the sense that network members have long-standing business relations with each other, while having relatively standard responsibilities. In further studies, it would be interesting to study the www-system use in a more uncertain environment, where the innovative nature of the product would require more intense collaboration and co-ordination of the individual tasks. It would be especially interesting to see how the value network position impacts the use and potential benefits in a more uncertain environment.

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APPENDIX 1.

Table 4. System effects

Financial and operational measures	*Effect*
Project "hazzle costs"	++
Customer satisfaction	++
Project communication costs	++
New customers	++
Project administrative costs	++
Amount of errors during a project	++
Keeping in schedule	+
Project delivery reliability	+
Project profit	+
Budgeting accuracy	+
Project hit-rate	+
Total project business costs	+
Project lead time	+
Project processes	
Systematic project processes	++
The efficiency of time use	++
Efficiency in reacting to changes	++
Discipline in design changes	++
Fastness of decision making	++
Follow-up of project state through the ratio of completed project documents	+
Recognition of bottle-necks	+
Amount of labour input	+
Information flow	
Fastness of information sharing	+++
Real-time information	+++
Time used in searching information	+++
Systematic information sharing	++
Time used in collecting and sharing information	++
Correctness of information	++
Time used in transferring information from one system to another	+
Collaboration in the network	
The depth of co-operation with project partners	+
Strifes among project partners	+
Awareness of the project team operations in your company	+
The stability of co-operation with project partners	+
Awareness of the project team operations in other companies	+
Comprehension of project stakeholders on joint project goals	+

The interviewees evaluated the system effects on a Likert scale (1-7), 1= strong negative impact, 7= strong positive impact. The averages were coded to the Table 4 in the following way:
Average between 4-5 (+); average between 5-6 (++); average between 6-7 (+++)