THE USE OF INTERORGANISATIONAL ICT IN CONSTRUCTION PROJECTS

A CRITICAL PERSPECTIVE

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Preface

After four years of research at the Department of Construction Management & Engineering (CME) of the University of Twente the only things that are left are writing down this preface and defending my thesis. I write this preface with mixed feelings. On the one hand, I am glad that I am able to close a very busy period. Carrying out PhD research in two days a week seemed hectic sometimes. I look forward to starting to do new things and to spending more time with my family and friends. On the other hand, doing PhD research is a great experience and the freedom you have in doing your own – very nice – job you will never find again.

Many people have supported me over last four years in carrying out this research. Unfortunately I am not able to thank them all personally in this preface. In general, I would like to thank my family and friends and my (former) colleagues from the department of CME, Balance & Result, and Ballast Nedam/ Infra Consult and Engineering for their direct and indirect contributions to this thesis. In particular, I would like to thank several people for making the great opportunity of doing a PhD research possible and for being guides and offering support over the past years.

First of all, I would like to thank my supervisors: Geert Dewulf and Hans Voordijk. Thank you for all the discussions we have had and the comments you made on all the draft versions of this thesis. Geert, your drive to set up new things and to look for new opportunities is special and infectious. Four years ago, you were not happy with me offering to do a PhD research part-time. I am glad that, in the end, you made this opportunity possible. Hans, we have written a lot of papers together. Your enthusiasm and drive to write papers are great. The first papers we wrote together won me over to the idea of starting this PhD research. Geert and Hans, I look forward to our future cooperation.

I would like to thank all those involved in the four field studies and the experts from the United States construction industry. Without all of you sharing your time and experience with me I could not have conducted this research at all. The projects and informants remain anonymous for reasons of confidentiality. In general terms I would like to thank (in alphabetical order) CFE Nederland, Gemeente Breda, Holland Scherm, Imtech Control Systems, Ingenieursbureau Gemeentewerken Rotterdam, KWS, ProRail, RET, Rijkswaterstaat, Strukton Betonbouw, Van Hattum en Blankevoort, and Witteveen+Bos for participating in the field studies. Special thanks go to Bas Scheuierman and Joost Eijkman for conducting two field studies. The discussions, workshops, and 'pizza eating session' we have had were not only useful for both of you but were very helpful for me as well. Thank you for that. I would also like to thank Martin Fischer for the hospitality at Stanford University and for giving me the opportunity to use the network of the Stanford Center for Integrated Facility Management (CIFE) to gain access to companies in the United States.

Twice a year, the User Group reflected on the progress and the preliminary findings of the research and supported me in finding field studies. The user group meetings were always very informative and our discussions helped me a lot. I would like to thank the following persons for their participation in this User Group: André Hartjes (SBR), Cees Buijs (Ingenieusbureau Gemeentewerken Rotterdam), Hans Jongedijk (Bouwdienst Rijkswaterstaat), Hans Wamelink, Henk Samson (both Infocus Management Consultants), Henk Schaap (Gobar adviseurs), Jan Oege Zijlstra (CROW), Jos Heerkens, Daan van Schijndel (both Heijmans), Menno de Jonge (Ballast Nedam), Rob Snijders, and Gerben Koppelman (both ARCADIS). I hope we find ways to keep on cooperating in the future.

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My final words are for those who are dearest to me. Mathijs, you are now 16 Months old. In spite of the busy period, I am still ‘De Papa’ for you. I am very proud of you. Maureen, last year especially has not always been easy. Thank you for your unconditional support. In your opinion you have contributed nothing to this research but, in fact, we have done this research together. With the PhD research completed, we will be able to handle the little one who is joining us soon. I look forward to all the times with you and our family in the years to come.

Enschede, September 2007
Arjen Adriaanse

Summary

In construction projects, many participants from different organisations have to work together. In these projects – to facilitate cooperation and coordination – interorganisational communication is of vital importance. The use of Information and Communication Technology (ICT) can offer many benefits in improving interorganisational communication, cooperation, and coordination in the context of construction projects. Numerous companies have now started to adopt and use interorganisational ICT. However, ICT often has limited added value and fails to meet expectations.

Over the last decades, much research has been conducted on the use of interorganisational ICT in construction projects and on the adoption and use of ICT. However, this research has some major limitations. First, studies which focus on the use of ICT in construction projects do not provide a detailed in-depth understanding of the mechanisms which influence the way actors use ICT in its social and interorganisational context. In addition, they do not analyse the dynamics of the use of ICT over time to explain how and why certain outcomes are realised. Second, existing models that could help to predict ICT adoption and use are criticised for their limited explanatory powers and for their contradictory results across studies. The methodological perspectives that are used in these studies – quantitative, positivist – cause most of these limitations.

To address the limitations, this qualitative research examined the interorganisational use of ICT in construction projects in-depth to understand why ICT is often not used in the intended way and how barriers to the successful use of ICT can be overcome. The successful use of ICT was equated with its intended use; the intended use was defined as the use that is assumed by the organisation(s) that customised the ICT application to a specific construction project. This research concentrated on two main research questions:

1. What are the key mechanisms that influence the way actors use interorganisational ICT and how and why do these mechanisms change over time?
2. What are directions for solutions to the barriers to the successful use of interorganisational ICT in construction projects?

The answer to the first research question provided understanding of how actors (individuals, organisations) use interorganisational ICT over time and why they use ICT in this way. The answer to the second research question provided directions for solutions to barriers and suggestions for change.

The problem of underutilised interorganisational ICT can be analysed from several points of view. Information systems research is often classified in three perspectives: positivist, interpretive, and critical. In this research, we adopted a critical perspective. This perspective was able to provide an in-depth understanding of the use of ICT from the point of view of the actors involved and enabled an analysis to be made of the hidden layers of social reality. In addition, as this perspective tries to transform social situations, it did, therefore, provide suggestions for change.

Alvesson and Deetz (2000) propose guidelines for doing research from a critical perspective. They identify three different tasks that need to be addressed when carrying out critical research: insight production, production of critique, and transformative re-definition. The thesis followed these tasks.

Insight production

Insight production calls for local understanding and interpretations to be made in which empirical material is viewed from a multitude of angles and related to wider economic, social, historical, and political forces. Therefore, an in-depth analysis was conducted into the use of interorganisational ICT and the mechanisms influencing this use. Chapters 2, 3 and 4 focused on the task of 'insight production'.

In *Chapter 2*, the key mechanisms that influenced the way actors used interorganisational ICT over time (i.e., a document management and workflow management application) during the first Dutch field study were determined. As our insights into these mechanisms were inadequate, an explorative approach was used to analyse ICT use in a construction project. Ethnography and the methods and techniques of the grounded theory approach were used to conduct the study. This chapter resulted in the formulation of a theoretical framework which contained four mechanisms (or categories) that determined the way actors use ICT in the construction project:

- *Personal motivation:* the extent to which actors are willing to use interorganisational ICT themselves. Personal motivation influences both the willingness of the actors to use ICT and their willingness to invest resources to overcome barriers to the intended use of ICT.
- *External motivation:* the degree to which actors are forced by other actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest resources to overcome barriers to the intended use of ICT.
- *Knowledge and skills:* the degree to which actors know how to use ICT. When knowledge and skills are limited, the actors themselves are the ones restricting the use of ICT.
- *Acting opportunities:* the extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.

Submechanisms (or subcategories) that influenced the way actors used interorganisational ICT in the construction project were related to these four categories and integrated into a theoretical framework. The framework showed the barriers and drivers to the intended use of interorganisational ICT and could explain the use of ICT during the construction project over time.

Chapter 3 presented the results of the four Dutch field studies. The framework from Chapter 2 was further developed. In the field studies, the use of document management and workflow management applications was analysed. Ethnography and the grounded theory approach were adopted to conduct these studies. This chapter, at a more analytical level than in Chapter 2, revealed the mechanisms (or categories) and submechanisms (or subcategories) influencing the interorganisational use of ICT in these construction projects. This resulted in the formulation of a theoretical model including mechanisms and submechanisms and showed barriers and drivers to the intended use of interorganisational ICT. Fundamental characteristics of construction projects, such as the temporary nature of interorganisational cooperation, the different objectives of the organisations involved, and the production on the construction site caused most of these barriers.

In this same chapter, the theoretical model was related to existing models about the adoption and use of ICT, namely: The Unified Theory of Acceptance and Use of Technology (UTAUT), the Theory of Planned Behaviour (TPB), and the Technology Acceptance Model (TAM). Based on this comparison we added the construct 'intention to use ICT' to our model and depicted some missing elements in existing models. The resulting model was then suggested as being a more comprehensive model than existing ones.

In *Chapter 4*, the robustness of the theoretical model was tested in the context of the interorganisational use of ICT in projects in the United States construction industry. In addition, product modelling applications were added to the research. In this step, interviews with 20 experts from the United States construction industry were conducted. This showed that the mechanisms and submechanisms influencing interorganisational ICT were not different in this context. However, the study also showed differences between document management, workflow management, and product modelling applications at the dimensional level of the mechanisms. For example, product modelling applications appeared to be more difficult to learn and understand because a different way of working and thinking was needed. Two important consequences are that (1) actors need to spent more time learning how to use ICT and (2) actors have more distorted perceptions about the benefits of this interorganisational ICT.

In this chapter, directions for solutions to barriers to the successful use of interorganisational ICT in construction projects were also formulated. These directions were based on the four Dutch field studies (Chapters 2 and 3) and the research conducted in the United States construction industry (Chapter 4). The proposed solutions were then related to the submechanisms of the theoretical model.

Production of critique and transformative re-definition

Production of critique builds upon the task of insight production. Interpretations are deepened by the adoption of a critical social theory. Transformative re-definition aims to develop critical and relevant knowledge to understand and facilitate change. Critical social theory was used to determine the origins of unintended use and to provide suggestions for change.

In *Chapter 5*, several concepts of Habermas' critical social theory (i.e., models of action, concepts of system and lifeworld) were used as a 'lens' to analyse interorganisational use of ICT, and barriers to the intended use of ICT in our four field studies. This provided more in-depth understanding and insight into the way the social system and the technical system interacted, and how and why actors used interorganisational ICT. The analysis showed that Habermas' critical social theory could be used to understand how actors should use interorganisational ICT, how they actually *did* use it, and how they tried to overcome barriers to its intended use. More specifically, our analysis showed that several barriers exist that restrict actors in using the intended models of action or in using these models of action in the intended way. These barriers were related to the mechanisms of our theoretical model. In addition, the concepts of system and lifeworld and the connection between them could be used to analyse structural barriers that influence the mechanisms of our theoretical model. Based on an analysis of the four field studies from the perspective of Habermas' critical social theory, we were able to formulate suggestions for change.

Samenvatting

In bouwprojecten wordt door verschillende organisaties samengewerkt om een bouwobject tot stand te brengen. Communicatie speelt een belangrijke rol om de samenwerking en coördinatie tussen deze partijen te faciliteren. Door ontwikkelingen op het gebied van informatie- en communicatietechnologie (ICT) ontstaan nieuwe mogelijkheden om interorganisationele communicatie, samenwerking en coördinatie te ondersteunen en te verbeteren. Steeds meer organisaties beginnen deze vormen van ICT toe te passen. In de praktijk blijkt deze ICT echter vaak een beperkte toegevoegde waarde te hebben en worden de verwachtingen vaak niet waargemaakt.

Bestaand onderzoek naar het gebruik van interorganisationele ICT in bouwprojecten en onderzoek naar adoptie en gebruik van ICT hebben een tweetal belangrijke beperkingen. Ten eerste wordt in deze onderzoeken geen diepgaand inzicht verkregen in mechanismen die het gebruik van ICT in de interorganisationele context beïnvloeden. De dynamiek in het gebruik van ICT wordt niet onderzocht en onderzoekers zijn slechts in beperkte mate in staat te verklaren waarom ICT uiteindelijk op een bepaalde manier functioneert. Ten tweede worden bestaande modellen over adoptie en gebruik van ICT bekritiseerd vanwege de beperkte verklarende werking en de tegenstrijdige onderzoeksresultaten. De methodologische perspectieven die in deze onderzoeken worden gebruikt – kwalitatief en positivistisch – veroorzaken deze beperkingen in belangrijke mate.

Vanwege deze tekortkomingen wordt in dit kwalitatieve onderzoek het gebruik van interorganisationele ICT in bouwprojecten diepgaand onderzocht om te kunnen verklaren waarom ICT vaak niet op de bedoelde manier wordt gebruikt en hoe barrières tot het succesvolle gebruik van ICT overwonnen kunnen worden. 'Succesvol gebruik' van ICT wordt in dit onderzoek gelijkgesteld aan 'het bedoelde gebruik' van ICT. Het bedoelde gebruik wordt gedefinieerd als het gebruik zoals dat bedoeld is door de organisatie(s) die de inrichting van ICT voor het specifieke bouwproject heeft of hebben bepaald. Het onderzoek richt zich op twee hoofdvragen:

- Wat zijn de belangrijkste mechanismen die de wijze waarop actoren interorganisationele ICT gebruiken beïnvloeden en hoe en waarom veranderen deze mechanismen tijdens de looptijd van het project?
- Wat zijn oplossingsrichtingen voor barrières tot het succesvol gebruik van interorganisationele ICT in bouwprojecten?

Het antwoord op de eerste onderzoeksvraag levert inzicht in de wijze waarop actoren (individuen, organisaties) interorganisationele ICT gebruiken gedurende de loop van het project en waarom ze ICT op deze wijze gebruiken. De tweede vraag levert oplossingsrichtingen voor barrières en suggesties voor verandering om succesvol gebruik van ICT te kunnen realiseren.

De wijze waarop interorganisationele ICT gebruikt wordt, kan op verschillende wijzen onderzocht worden. Onderzoek naar informatie systemen wordt vaak geclassificeerd in drie perspectieven: het positivistische, het interpretatieve en het kritische perspectief. In dit onderzoek wordt het kritische perspectief toegepast. Dit perspectief levert diepgaand inzicht in het gebruik van ICT vanuit het oogpunt van betrokken actoren. Tevens richt dit perspectief zich op een analyse van verborgen lagen van de sociale werkelijkheid om zo de basis van fundamentele veranderingen (d.w.z. verbeteringen) in hun sociale context zichtbaar te maken. Om daadwerkelijk verandering te kunnen realiseren wordt vanuit dit perspectief gestreefd naar het formuleren van suggesties voor verandering. Op deze wijze kunnen fundamentele barrières tot het bedoelde gebruik van ICT opgelost worden.

Alvesson en Deetz (2000) reiken richtlijnen aan voor het uitvoeren van onderzoek vanuit een kritisch perspectief. Zij onderscheiden drie verschillende taken die horen binnen kritisch onderzoek:

inzicht productie, productie van kritiek en veranderinggerichte herdefinitie. Dit onderzoek volgt deze drie taken.

Inzicht productie

'Inzicht productie' vraagt om lokaal inzicht en lokale interpretatie waarbij empirisch materiaal bekeken wordt vanuit verschillende hoeken en gerelateerd wordt aan economische, sociale, historische en politieke invloeden. Om deze taak uit te kunnen voeren is in dit onderzoek een diepgaande analyse uitgevoerd van het gebruik van interorganisationele ICT en de mechanismen die dit gebruik beïnvloeden. De hoofdstukken 2, 3 en 4 richten zich op deze taak.

In *hoofdstuk 2* worden in een veldstudie de belangrijkste mechanismen bepaald die het gebruik van interorganisationele ICT tijdens de looptijd van een Nederlands bouwproject beïnvloeden. In dit project wordt een softwareapplicatie toegepast waarin document management en workflow management functionaliteiten zijn opgenomen. Omdat het inzicht in dergelijke mechanismen nog beperkt was is in deze studie voor een exploratieve aanpak gekozen. De methoden en technieken van etnografisch onderzoek en van de gefundeerde theoriebenadering zijn toegepast om het gebruik van interorganisationele ICT in dit bouwproject diepgaand te analyseren. Deze studie heeft geleid tot een theoretisch raamwerk bestaande uit vier mechanismen (of categorieën) die het ICT gebruik in dit bouwproject beïnvloeden:

- *Persoonlijke motivatie:* de mate waarin actoren interorganisationele ICT zelf willen toepassen. Persoonlijke motivatie beïnvloedt zowel het gebruik van ICT als de mate waarin actoren bereid zijn om middelen te investeren om barrières tot het bedoelde gebruik te overwinnen.
- *Externe motivatie:* de mate waarin actoren gedwongen worden door andere actoren om ICT te gebruiken. Externe motivatie beïnvloedt zowel het gebruik van ICT als de mate waarin actoren bereid zijn om middelen te investeren om barrières tot het bedoelde gebruik te overwinnen.
- *Kennis en vaardigheden:* de mate waarin actoren weten hoe ICT gebruikt moet worden. Wanneer kennis en vaardigheden beperkt zijn, zijn de actoren zelf de beperkende factor tot het gebruik van ICT.
- *Handelingsmogelijkheden:* de mate waarin actoren in staat zijn om ICT op de bedoelde manier te gebruiken. Wanneer de handelingsmogelijkheden beperkt zijn, is ICT niet in staat om het handelen van betrokken actoren te ondersteunen.

Tevens zijn submechanismen (of subcategorieën) benoemd welke bovenstaande mechanismen beïnvloeden. De mechanismen en submechanismen zijn samengevoegd in een theoretisch raamwerk. Hiermee kan inzichtelijk gemaakt worden welke barrières en drijfveren tot het bedoelde gebruik van interorganisationele ICT aanwezig zijn en kan het gebruik van ICT tijdens de loop van het bouwproject verklaard worden.

In *hoofdstuk 3* worden de resultaten van vier Nederlandse veldstudies gepresenteerd. In dit hoofdstuk wordt het theoretische raamwerk uit hoofdstuk 2 verder ontwikkeld. Er zijn aan het project uit hoofdstuk 2 drie andere projecten toegevoegd. In deze bouwprojecten worden document management en workflow management applicaties toegepast. Tijdens de uitvoering van deze studies is gebruik gemaakt van de methoden en technieken van etnografisch onderzoek en van de gefundeerde theoriebenadering. In dit hoofdstuk wordt meer op een analytisch niveau dan in hoofdstuk 2 ingegaan op de mechanismen (of categorieën) en submechanismen (of subcategorieën) die het gebruik van ICT in deze bouwprojecten beïnvloeden. Dit hoofdstuk resulteert in een theoretisch model, bestaande uit mechanismen en submechanismen en toont barrières en drijfveren tot het bedoelde gebruik van interorganisationele ICT. De meeste van deze barrières worden veroorzaakt door karakteristieken van bouwprojecten zoals de tijdelijke samenwerking tussen organisaties, de verschillende belangen van betrokken partijen en de productie op de bouwlocatie.

In dit hoofdstuk wordt het theoretisch model tevens gerelateerd aan bestaande modellen over de adoptie en het gebruik van ICT, namelijk de 'Unified Theory of Acceptance and Use of Technology' (UTAUT), de 'Theory of Planned Behaviour' (TPB) en het 'Technology Acceptance Model' (TAM). Op basis van een confrontatie met deze modellen wordt het element 'intentie tot ICT gebruik' aan het ontwikkelde theoretische model toegevoegd. Tevens blijken er een aantal ontbrekende elementen te zijn binnen de bestaande modellen. Het ontwikkelde theoretische model wordt dan ook gepresenteerd als een meer holistisch model dan bestaande modellen.

In *hoofdstuk 4* wordt de robuustheid van het theoretische model getoetst in de context van het gebruik van interorganisationele ICT in Amerikaanse bouwprojecten. Bovendien worden niet alleen document management en workflow management applicaties onderzocht, maar worden tevens product modellering applicaties toegevoegd aan het onderzoek. Tijdens deze studie zijn interviews gehouden met 20 experts uit de Amerikaanse bouwsector. Het onderzoek in deze andere context geeft geen aanleiding tot wijzigingen in het theoretisch model, maar toont wel aan dat document management, workflow management en product modellering applicaties anders gepositioneerd worden binnen de dimensies van mechanismen. Het leren toepassen en doorgronden van product modellering applicaties is bijvoorbeeld lastiger doordat een andere manier van werken en denken nodig is. Dit heeft een tweetal belangrijke consequenties: (1) actoren moeten meer tijd besteden aan het leren gebruiken van deze applicaties en (2) betrokken actoren hebben vaker een vervormd beeld van de voordelen die deze applicaties kunnen bieden.

In dit hoofdstuk worden tevens oplossingsrichtingen geformuleerd voor barrières tot een succesvol gebruik van ICT. Deze oplossingsrichtingen komen voort uit de vier Nederlandse bouwprojecten (zie hoofdstuk 2 en 3) en het onderzoek in de Amerikaanse bouwsector (zie hoofdstuk 4). De oplossingsrichting zijn gekoppeld aan de submechanismen van het theoretische model.

Productie van kritiek en veranderinggerichte herdefinitie

De activiteit 'productie van kritiek' bouwt voort op de 'inzicht productie' activiteit. Binnen deze activiteit worden inzichten verdiept door de toepassing van een kritisch sociale theorie. 'Veranderinggerichte herdefinitie' heeft als doel kritische en relevante kennis te ontwikkelen waarmee verandering begrepen en gefaciliteerd kan worden. Een kritisch sociale theorie wordt gebruikt om een beter zicht te krijgen op de oorsprong van niet bedoeld gebruik en om suggesties voor verandering te ontwikkelen.

In *hoofdstuk 5* worden een aantal concepten uit de kritisch sociale theorie van Habermas (d.w.z. zijn handelingsmodellen en zijn concepten 'systeem' en 'levenswereld') gebruikt als een 'lens' om het gebruik van interorganisationele ICT en barrières tot het bedoelde gebruik in de vier Nederlandse bouwprojecten te analyseren. Dit levert diepgaander inzicht in de wijze waarop het sociale systeem en het technische systeem elkaar wederzijds beïnvloeden en geeft een diepgaandere verklaring waarom actoren ICT op een bepaalde manier gebruiken. De analyse toont de geschiktheid van de kritisch sociale theorie van Habermas aan om te begrijpen hoe actoren ICT eigenlijk zouden moeten gebruiken (d.w.z. hoe het ICT gebruik is bedoeld), hoe zij ICT werkelijk gebruiken en hoe actoren barrières tot het bedoelde gebruik proberen te slechten. Meer specifiek toont de analyse barrières die actoren ervan weerhouden om de bedoelde handelingsmodellen te adopteren of om deze handelingsmodellen op de bedoelde wijze toe te passen. Deze barrières zijn gerelateerd aan de mechanismen van het in dit onderzoek ontwikkelde theoretische model. Bovendien kunnen de 'systeem' en 'levenswereld' concepten en de relatie tussen beiden gebruikt worden om structurele barrières te analyseren die uiteindelijk de mechanismen van het ontwikkelde model beïnvloeden. Op basis van de analyse van de vier Nederlandse bouwprojecten vanuit het perspectief van de kritisch sociale theorie van Habermas zijn suggesties voor verandering geformuleerd.

Table of contents

Chapter 1

Introduction

1.1 The use of interorganisational ICT in construction projects

Construction is a highly fragmented industry compared to other manufacturing industries (Dawood et al., 2002; Weippert et al., 2002). In construction projects, many participants from different organisations have to work together on a temporary basis. Therefore, in these projects – to facilitate cooperation and coordination – interorganisational communication is of vital importance.

Although communication is highly important in construction projects (Dawood et al., 2002; Mohamed and Stewart, 2003; Thorpe and Mead, 2001), the construction industry is confronted with great communication difficulties in sharing information among participants. Often the waste of time and money is the result of inadequate information and communication ("insufficient, inappropriate, inaccurate, inconsistent, late or a combination of them all") (Tam, 1999, p.107). It is expected that the importance of communication between participating organisations is going to increase even more in the future. For example, the increased complexity of construction projects, and the need to achieve faster results will increase the intensity of interorganisational communication (Alshawi and Ingirige, 2003, p.350) In addition, inadequate communication is seen as an important barrier to innovative, more integrated, construction processes (Dawood et al., 2002).

The use of Information and Communication Technology (ICT) can offer many benefits in improving interorganisational communication, cooperation, and coordination in the context of construction projects. ICT that is used for this purpose is defined in this study as 'interorganisational ICT'. Numerous companies have now started to adopt and use interorganisational ICT. However, the use of ICT across organisational boundaries in construction projects is still limited and not as effective and efficient as it could be (e.g., Alshawi and Ingirige, 2003; Andresen et al., 2003; Hjelt and Björk, 2006; Nitithamyong and Skibniewski, 2004; Sulankivi, 2004). Often these applications have added limited value in construction projects and have failed to meet expectations. It seems that the use of ICT between organisations in construction projects is only beneficial under certain conditions. Insights into these conditions may ensure a more predictable, effective, and efficient use of ICT in the future.

From earlier studies focussing on the use of interorganisational ICT in construction projects, we can make the following observations. First, several researchers discuss factors, barriers, or problems that can be related to the use of interorganisational ICT in construction projects (e.g., Alshawi and Ingirige, 2003; Andresen et al., 2003; Anumba and Ruikar, 2002; Björk, 2003; Nitithamyong and Skibniewski, 2004; Nitithamyong and Skibniewski, 2007; Weippert et al., 2002). Although these studies do improve the understanding about the use of ICT, they do not explain how and why these factors influence this use, or how and why factors are interrelated. In addition, these studies do not analyse the dynamics of the use of ICT over time to explain how and why certain outcomes are realised. Second, researchers often concentrate on technological aspects (e.g., required functionalities) or the potential benefits of the use of interorganisational ICT (see Andresen et al., 2003; Hjelt and Björk, 2006; Nitithamyong and Skibniewski, 2004). The few case studies in which the actual use of ICT is analysed (e.g., Andresen et al., 2003; Harty, 2005; Hjelt and Björk, 2006; Howard and Petersen, 2001; O'Brien, 2000; Thorpe and Mead, 2001; Weippert et al., 2002) do not provide a detailed in-depth understanding of the mechanisms influencing the way ICT is used in its social and interorganisational context, and how this use is influenced over time. Therefore, there is a

need for in-depth research on the mechanisms influencing the use of interorganisational ICT in construction projects.

The current situation in which organisations start to adopt and use interorganisational ICT is not unique to the construction industry. Organisations in other industries have invested heavily in *intra*organisational ICT over the last 25 years and increasingly start to expand to *inter*organisational ICT as well (Jasperson et al., 2005). With the use of interorganisational ICT cooperation, coordination, and communication between two or more organisations can be supported by enabling, more integrated working practices (Kumar and van Dissel, 1996; Martins et al., 2004; Montoya-Weiss et al., 2001). However, in today's practice, interorganisational ICT is frequently underutilised (Jasperson et al., 2005). Often ICT has failed to meet expectations because it has not been used in the intended way.

One of the most important requisites for the successful introduction of interorganisational ICT is that it is adopted and used by its potential users. Understanding the mechanisms that influence these aspects is an important step towards improving the value of ICT and, in the end, improving interorganisational cooperation, coordination and communication in the future. Since the seventies, much research has been conducted on the individual adoption and use of ICT. These studies resulted in lists of factors or conditions that influenced these aspects. From the mid-eighties onwards efforts moved to the development and testing of models that could help predict ICT adoption and use (Legris et al., 2003, p.192). Influential models which were used in the information systems literature are - the Theory of Reasoned Action, the Technology Acceptance Model, the extended Technology Acceptance Model, the Motivational Model, the Theory of Planned Behaviour, a model combining the Technology Acceptance Model and the Theory of Planned Behaviour, the Model of PC Utilisation, the Innovation Diffusion Theory, the Social Cognitive Theory, and the Unified Theory of Acceptance and Use of Technology (see Venkatesh et al., 2003 for a recent overview).

Thus, researchers have made significant progress over the last decades in developing models that could help predict ICT adoption and use. However, existing models are criticised for their limited explanatory power and for their contradictory results across studies in the major relationships between constructs (Lee et al., 2003; Legris et al., 2003; Sun and Zhang, 2006). Below we identify several major limitations of former studies. Most of these limitations are caused by the central methodological perspectives which are used in studies examining the adoption and use of ICT: quantitative and positivist perspectives (Sun and Zhang, 2006).

1. *Focus on individually orientated ICT:* most studies focus on simple, individually orientated ICT "as opposed to more complex and sophisticated organisational technologies" (Venkatesh et al., 2003, p.427). Several researchers argue for studies focusing on multi-user systems, team-level acceptance, and more complex technologies (Lee et al., 2003; Legris et al., 2003; Venkatesh and Davis, 2000; Venkatesh et al., 2003). Sun and Zhang (2006) suggest that individual and group technologies influence user acceptance differently.
2. *Limitations in measurement of actual ICT use:* most studies measure the self-reported use instead of actual use (Lee et al., 2003; Legris et al., 2003). These studies assume that self-reported use successfully reflects actual usage (Lee et al., 2003). However, self-reported use may be subject to method bias, which results in distorted findings (ibid.). For example, Mathieson et al. (2001, p.96) suggest that "[a]n individual's recollection of behaviour may reflect recent events more than past events". This means that when subjects are asked to report their use of ICT over the last month they might, in fact, reflect only on the last week. In addition, the questions asked about the use of ICT can be questioned. The use of ICT is usually measured by the frequency and the amount of time using ICT, the actual number of ICT usages, and

the diversity of usage (Lee et al., 2003). However, this might not reflect the use of ICT appropriately. For example, a user may only use interorganisational ICT to a limited extent because nothing needs to be communicated to the other organisation, or a user may use ICT intensively but not as intensively as possible.

3. *Limited focus on dynamics in ICT use over time:* most studies are cross-sectional studies in which variables influencing the use of ICT are measured at a single point in time (Mathieson et al., 2001, p.109; Venkatesh and Davis, 2000, p.199; Venkatesh et al., 2003, p.433). However, these variables may be dominant at different moments in time. For example, studies suggest that perceptions change and subjective norms become less important with increased experience (Karahanna et al., 1999; Mathieson et al., 2001; Venkatesh et al., 2003). This may explain the contradictory results found between different studies (Lee et al., 2003). There is, therefore, a need for studies to be made in which the dynamic nature of the causal mechanisms addressed by the models are captured over time (Venkatesh and Davis, 2000, p.199). Recently researchers have begun to pay attention to temporal changes in users' beliefs and attitudes towards ICT use (e.g., Bhattacherjee and Premkumar, 2004; Bhattacherjee and Sanford, 2006; Kim and Malhotra, 2005; Venkatesh and Morris, 2000; Venkatesh et al., 2003). However, these longitudinal studies are still cross-sectional snapshots and do not explain in-depth how and why constructs change over time.
4. *Lack of in-depth contextual analysis:* a contextual analysis is important in understanding the use of ICT (e.g., Orlikowski and Iacono, 2001) However, many studies use student samples to test the models about ICT adoption and use (Lee et al., 2003; Legris et al., 2003). These samples are not appropriate for reflecting the real working environment. The understanding of the dynamics of adoption and use of ICT – especially in complex contexts – still needs improvement (Sun and Zhang, 2006). The predictive capacity of the models can only be increased if additional organisational and social factors are included (Legris et al., 2003; Sun and Zhang, 2006).

To summarise, former research focussing on the use of interorganisational ICT in construction projects and research focussing on the adoption and use of ICT has its limitations. To address these limitations there is need for qualitative research that provides a detailed in-depth understanding of the key mechanisms influencing the way ICT is used in its social and interorganisational context in construction projects and how this use is influenced over time. A better understanding of these mechanisms and solutions to potential barriers to the successful use of ICT is important in order to achieve the benefits of interorganisational ICT in the future. Combining former quantitative with this qualitative research is a powerful way to build theory (Eisenhardt, 1989; Lee, 1991), and is a natural extension to quantitative information systems research into the adoption and use of ICT carried out in the past (Lee et al., 2003).

1.2 Objectives, research questions and scope

This research examines the interorganisational use of ICT in construction projects in order to understand why this ICT is often not used in the intended way and how barriers to the successful use of ICT can be overcome. Therefore, the first objective of this research is to identify the key mechanisms influencing the interorganisational use of ICT. The second objective is to formulate – based on the key mechanisms – solutions to barriers to the successful use of interorganisational ICT in construction projects.

Researchers often use the words Information Technology (IT), Information and Communication Technology (ICT), and Information Systems (IS) interchangeably. However, there are important differences between these terms (see Benbasat and Zmud, 2003; Galliers, 2003; Hirschheim and Klein, 2003; Iivari, 2003; Myers, 2003; Orlikowski and Iacono, 2001). In this research, IS are

regarded as social systems of which the technological system is just one aspect (Galliers, 2003; Myers, 2003). According to (Lee, 2001, p.iii): *"research in the information systems field examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerge when the two interact"*. An important difference between the technological system and IS is that an IS is specific to an organisational or interorganisational context (Iivari, 2003). Therefore, an IS cannot be bought; only technological systems can be bought. According to Weber (2003, p.vii) the technological system "is simply the platform or resource on which we build information systems".

A technological system is often called IT (or IT artefact), and sometimes the new term ICT that includes communications technology is used (Myers, 2003). In this research the term ICT will be adopted because of the importance of communication in analysing the research object. Interorganisational ICT is used to support communication, coordination and collaboration between participating organisations in construction projects. In this research, the definitions of Hirschheim et al. (1996) and Kumar and Van Dissel (1996) will be used and translated into the context of construction projects to define interorganisational ICT as:

"A technological communication, coordination, and collaboration system that transcends legal enterprise boundaries and manipulates, stores, and disseminates symbols (representations) that have, or are expected to have, relevance and an impact on socially organised human behaviour in construction projects".

Thus, the term ICT is used when we refer to the technological system and the term IS is used to refer to the social system in which ICT is used. This dissertation adopts the position that the use of ICT is a social act (Lamb and Kling, 2003). In this view, interorganisational ICT is able to support *and* constrain social action. In addition, interorganisational ICT is one of the means actors can use to achieve a certain end. Actors are units that have acting capabilities (Dietz, 1999). According to Dietz (1999) these acting units can be persons (or roles of persons), groups of persons, departments, or whole companies depending on the problem at hand. In the context of interorganisational use of ICT we may argue that organisations have the capability to act. However, in the end, organisations always act through persons who act on behalf of the organisations. This dissertation assumes that the way actors act in construction projects is fundamental for the success or failure of interorganisational ICT. A better understanding of the key mechanisms influencing the use of this ICT over time and the implementation of solutions to potential barriers will avoid user rejection and/or the failure of well-designed applications.

This research focuses on the actual use of ICT and does *not* elaborate on the realised benefits and the effects of the use of ICT on the performance of the project. In addition, it elaborates on the main actors in a construction project. These actors are: the client (or owner), the designer (architect and/or engineer), and the contractor. We can distinguish three important lines of interorganisational ICT that can be used between these actors in a construction project:

- *Document management applications:* these applications are used in order to store, organise, and manage a collection of documents within a construction project.
- *Workflow management applications:* these applications are used to manage the flow of information and to monitor and record the progress of tasks in a construction project.
- *Product modelling applications:* these applications (e.g., 3D modelling, 4D modelling, Building Information Modelling applications) are used to make a graphical model (i.e., representation) of a building object. 4D applications add a further dimension (i.e., time) to the 3D application. Product models can store both graphical and non-graphical data.

The successful use of ICT is equated with the intended use of ICT. The intended use will be defined as the use that is assumed by the organisation(s) that customised the ICT application to a specific

construction project. With this use of ICT, the organisation(s) expects to realise certain benefits. A limitation of this definition is that the organisation(s) might have false beliefs about the use of ICT, that is, the intended use might be impracticable.

Based on the discussion above, this research concentrates on two research questions:

1. What are the key mechanisms that influence the way actors use interorganisational ICT and how and why do these mechanisms change over time?
2. What are directions for solutions to the barriers to the successful use of interorganisational ICT in construction projects?

The answer to the first research question will provide an understanding of how actors (individuals, organisations) use interorganisational ICT over time and why they use ICT in this way. This will explain why actors do or do not use ICT in the intended way in certain situations. The answer to the second research question will provide directions for solutions to barriers and suggestions for change. The barriers are related to the mechanisms. Some barriers might be solved in a construction project, others might be very difficult to solve or even impossible to solve.

1.3 User group

A number of scholars have recently argued that information systems research should be more relevant to practice (Applegate and King, 1999; Benbasat and Zmud, 1999; Lee, 1999; Lyytinen, 1999). Benbasat and Zmud (1999) argue that IS research needs to be:

- Interesting: the research addresses problems or challenges that are of concern to professionals;
- Applicable: the research produces knowledge and offers prescriptions that can be utilised by practitioners;
- Current: the research focuses on current technologies and business issues;
- Accessible: the research is written in a way that professionals can understand and enjoy reading.

In order to ensure the practical relevance of the results and to address the dimensions of relevance mentioned above, a 'user group' was formed. The User Group consisted of 9 representatives from the Dutch construction industry. These representatives were chosen based on their involvement in sectoral 'interorganisational ICT initiatives' in the Dutch construction industry or because of their key positions in the main actors' organisations within construction projects (client, designer, contractor). Therefore, this group could reflect on experiences related to the introduction and use of interorganisational ICT and the working practices of the main actors within construction projects.

The User Group met at least twice a year over a time period of 4 years and reflected on the progress of the research, and its preliminary findings. In addition, the User Group helped the researcher to find field studies. This group assisted the researcher in asking questions, in reflecting on (preliminary) mechanisms, and in developing solutions to potential barriers to the successful use of interorganisational ICT. In addition, at the start of the research, the researcher conducted open interviews with each member individually in order to learn about potential mechanisms influencing the use of interorganisational ICT, and drivers and barriers to the successful use of this ICT.

1.4 Research methodology

The problem of underutilised interorganisational ICT can be analysed from several points of view. Information systems research is often classified in three perspectives: positivist, interpretive, and critical[1]. From a *positivist* perspective a communication medium "operates like a conduit that transports meaning from one person to another, as if the meaning were something physical" (Ngwenyama and Lee, 1997, p.149). In this view, ICT is considered a neutral provider of input for decision-making and the decision maker is a passive recipient of this information (Schultze, 2000; Varey, 2002). ICT is perceived as a 'problem solver' that improves decision making and the monitoring of performance, and increases the efficiency and effectiveness of business processes (Cecez-Kecmanovic, 2005; Lyytinen, 1987). From this perspective, researchers try to discover cause-effect relationships or universal causal laws (Cecez-Kecmanovic, 2005, p.21).

The *interpretive* perspective is a reaction to the positivist perspective. Within this perspective, researchers adopt a social action perspective on ICT and include subjective and intersubjective meanings of human beings (Ngwenyama and Lee, 1997; Orlikowski and Robey, 1991). In this view a user of ICT is not merely treated "as a passive receptacle, but as an intelligent being in a shared social context" (Ngwenyama and Lee, 1997, p.150). Consequently, researchers observe social situations and try to explain and understand the use of ICT by understanding in-depth the way actors act in their social context (ibid.).

Like the interpretive perspective, the *critical perspective* is a reaction to the positivist perspective. Although the critical perspective shares some assumptions with the interpretive perspective (e.g., epistemology) these perspectives differ in two important ways. First, critical researchers assume that it is not enough to understand the use of ICT from the point of view of the actors involved. In their view, some actions and situations cannot be explained without a deeper investigation of hidden layers of social reality (Cecez-Kecmanovic, 2005, p.29). The critical perspective tries to identify the restrictive and alienating conditions of the status quo, such as power, domination, conflict, and distorted communication (Cecez-Kecmanovic, 2005; Howcroft and Trauth, 2004; Klein and Myers, 1999; Orlikowski and Baroudi, 1991). Critical theorists use theory to understand the deeper – historical, economical, political, and social – layers of social reality more fully. This theory serves as "a map or guide to social reality" (Cecez-Kecmanovic, 2005, p.29) or as "the 'lens' one uses in observation" (Alvesson and Deetz, 2000, p.37). Second, the focus of the critical perspective is on questioning and trying to transform social situations instead of just understanding them (Cecez-Kecmanovic, 2005; Howcroft and Trauth, 2004; Orlikowski and Baroudi, 1991). Change is one of main challenges of the critical perspective and is, in this respect, different from the other perspectives. Critical researchers try to emancipate actors from – often previously unconscious – constraints and "thereby enhance the opportunities for realizing human potential" (Klein and Myers, 1999, p.69). One other important characteristic of the critical perspective is its sceptical stance

[1] This distinction is based on Chua's (1986) classification of research epistemologies. Another well-known classification scheme – that is very much related to Chua's (1986) scheme – is that of Burrell and Morgan (1979). Their typology of paradigms for the analysis of social theory in general, and organisational theory in particular, is based on two key dimensions. The first dimension contains assumptions about the nature of social science and is called the 'subjective – objective' dimension. The second dimension comprises assumptions about the nature of society and is called the 'regulation – radical change' dimension. The dimensions define four distinct paradigms: functionalist (e.g., positivist), interpretivist, radical humanist (e.g., critical social theory) and radical structuralist. Burrell and Morgan (1979, p.23) define a paradigm as "the commonality of perspective which binds the work of a group of theorists together in such a way that they can be usefully regarded as approaching social theory within the bounds of the same problematic". Theorists within a paradigm share the underlying meta-theoretical 'taken for granted' assumptions. According to Burrel and Morgen (1979) intellectual journeys between paradigms are rare, but possible e.g., see Marx (from radical humanism to radical structuralist) and Silverman (from functionalist to interpretive). We use Chua's (1986) classification scheme because this scheme is often used to classify information systems research.

towards the introduction of ICT (Brooke, 2002, p.51). This perspective does not regard ICT as the ultimate 'problem solver' such as the positivist perspective does.

To date, the positivist perspective has dominated information systems research (Chen and Hirschheim, 2004; Orlikowski and Baroudi, 1991; Richardson and Robinson, 2007). Only limited attention has been paid to the interpretive perspective, and the critical perspective is almost non-existent[2]. Over the last 15 years a small but growing number of researchers have adopted a critical perspective in general and critical social theory[3] in particular to analyse the development and use of ICT (Howcroft and Trauth, 2004; Richardson and Robinson, 2007). Examples are Cecez-Kecmanovic (2001; 2002), Cecez-Kecmanovic and Janson (1999), Hirschheim et al. (1996), Hirschheim and Klein (1994), Janson and Cecez-Kecmanovic (2005), Myers and Young (1997), Ngwenyama and Lee (1997), and Ngwenyama and Lyytinen (1997). However, a lack of empirical studies is a major weakness of critical social theory (Lyytinen, 1992; Howcroft and Trauth, 2004). According to Lyytinen (1992, p.171) in order to make critical social theory a viable research approach "the research should step from elevated critique into the practical research mode". Nowadays, there is still a call for empirical studies to situate the critical perspective as a real alternative to the positivist and the interpretive perspective (Cecez-Kecmanovic, 2005; McGrath, 2005).

Each perspective has its own strengths and weaknesses in different situations (Gioia and Pitre, 1990; Goles and Hirschheim, 2000; Varey, 2002). In our research, we focus on the interorganisational use of ICT and barriers to the intended use of this ICT. We elaborate on why interorganisational ICT has failed to meet expectations and how this situation can be changed. Therefore, we adopt a critical perspective for analysing the use of interorganisational ICT. This perspective is able to provide an in-depth understanding of the use of ICT from the point of view of the actors involved and is able to analyse the hidden layers of social reality. Its sceptical stance towards the introduction of ICT makes this perspective even more useful in explaining why ICT has failed to meet expectations. In addition, this perspective tries to transform social situations and therefore, provides suggestions for change. Hence, in this research a critical perspective will be used to interpret and analyse the use of interorganisational ICT. By using a critical perspective we will identify barriers to the intended use of ICT and ways to overcome these.

Alvesson and Deetz (2000) propose guidelines (i.e., a critical methodology) for doing research from a critical perspective. They identify three different tasks that need to be addressed in order to reach the ultimate goal of change: insight production, production of critique, and transformative re-definition. The three tasks will be briefly discussed below.

The first task, insight production, may be seen as an outcome of successful interpretation (Alvesson and Deetz, 2000). Insight production calls for local understanding, and interpretations in which empirical material is viewed from a multitude of angles and is related to wider economic, social,

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[2] This might be caused by the publication, tenure, and promotion systems in the field (see Chen and Hirschheim, 2004 for a discussion).

[3] Critical social theory has its origin in the Institute of Social Research at the University of Frankfurt, established in 1923. This institute is often referred to as the Frankfurt school (or 'Frankfurter Schule'). The school attacked functionalism for its inability to handle social change and for its narrow focus on instrumental reason (Hirschheim et al., 1996). Critical social theory is a combination of objectivist ontology with subjectivist epistemology. Critical social theory bridges the paradigm boundaries to some extent (Gioia and Pitre, 1990). Critical social theory incorporates some elements of both the positivist (empirical knowledge) and interpretive (hermeneutic knowledge) perspective (Goles and Hirschheim, 2000; Hirschheim and Klein, 1989). Some scholars regard structurationists (Giddens, 1984; 1991) and the later work of Foucault as part of critical social theory (Alvesson and Deetz, 2000; Lyytinen, 1992).

historical, and political forces (Alvesson and Deetz, 2000; Howcroft and Trauth, 2004; Richardson and Howcroft, 2006).

The second task, critique, builds upon insight (Alvesson and Deetz, 2000, p.144). The researcher "deepens insight-oriented interpretations through more critical theoretically-oriented explorations of these interpretations" (ibid., p.151). According to Alvesson and Deetz (2000, p.150) "[c]ritical studies are inclined to pay attention to and interpret 'raw material' for advanced interpretations in terms of power and domination, broadly defined". This means that critical researchers try to challenge taken-for-granted assumptions, beliefs, ideologies and discourses (Richardson, 2005, p.282). In this research, we follow Alvesson and Deetz (2000) with their suggestion not to integrate insight and critique production but to postpone the production of critique first. In separating these tasks researchers are more open in their interpretations of empirical material and avoid a bias towards elitism.

The third task, transformative re-definition, is the natural counterpart to insight and critique (Alvesson and Deetz, 2000, p.144). The aim of this task is to develop critical and relevant knowledge to understand and facilitate change (Richardson, 2005). According to Alvesson and Deetz (2000, p.153) transformative re-definition "aims to support imagination in such a way that a qualitative, different reality is seriously considered". However, they warn that transformative re-definition should not dominate empirical research because these studies tend to be utopian and not appropriate for studies with research ambitions. In this research we will use our analysis and theoretical explorations to point to the origins of unintended use of interorganisational ICT. Based on these origins we are able to provide suggestions for change.

1.5 Thesis outline

The structure of the thesis is described below and is also depicted in Figure 1.1. This thesis follows the tasks of critical research as presented in the former section.

Part 1 is related to the first task in conducting research from a critical perspective: insight production. In this part, the use of interorganisational ICT and the mechanisms influencing this use are analysed in-depth in four Dutch construction projects. In addition, expert interviews are conducted in the United States construction industry. The results of the first task are presented in Chapter 2, 3, and 4. In *Chapter 2*, the key mechanisms that influence the way actors use interorganisational ICT (i.e., a document management and workflow management application) over time during the first Dutch field study are presented. This chapter results in a preliminary theoretical framework, which is able to explain the use of interorganisational ICT in this project. In *Chapter 3*, the results of all four Dutch field studies are presented. In these studies, document management and workflow management applications are used. This chapter shows a refined theoretical model and reveals, at a more analytical level, the mechanisms and submechanisms influencing interorganisational ICT in construction projects. In *Chapter 4*, the theoretical model is further validated and developed in the context of the United States construction industry. In addition, product modelling applications are added to the research. In this chapter, we formulate directions for solutions to barriers to the successful use of interorganisational ICT in construction projects as well. These solutions are based on the four Dutch field studies and the research conducted in the United States construction industry.
Part 2 is related to the second and third tasks of the critical methodology: critique and transformative re-definition. These steps build upon the former task (insight production). The interpretations from Part 1 are deepened through the adoption of a critical social theory. *Chapter 5* shows the results of an application of a critical social theory in the context of the interorganisational use of ICT in construction projects.

Part 3 contains the conclusions, a discussion of the contributions, and recommendations for research and practice.

Chapters 2, 3, 4, and 5 will be presented in the form in which they have been submitted for publication in scientific journals. One consequence is that each chapter can be read independently from the others. However, one other consequence is that parts of these chapters do overlap significantly. In order to eliminate duplication as much as possible, parts of the introductions have been removed from the chapters and included in this chapter (Chapter 1).

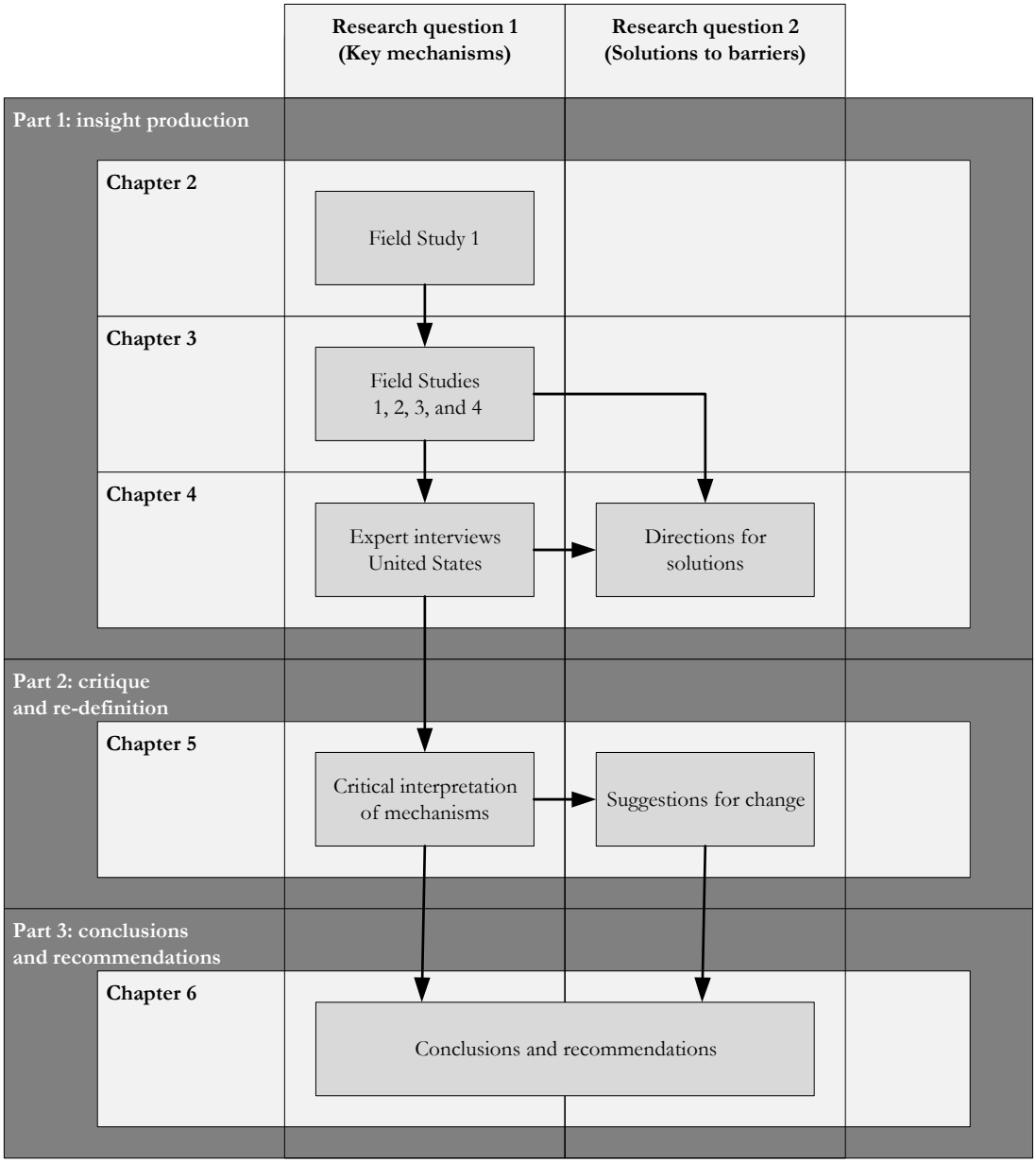

Figure 1.1: Thesis outline

Part 1: insight production

Chapter 2

The use of interorganisational ICT in a Dutch construction project

2.1 Introduction[4]

In this chapter we will focus in-depth on the mechanisms influencing interorganisational use of ICT in a construction project and will develop a preliminary theoretical framework about the use of interorganisational ICT. By identifying and analysing these mechanisms, we try to explain why individuals or organisations are not using ICT in the intended way and how this use changes over time. With these insights, we will explain why ICT has failed to match expectations. In this chapter, we will answer the following research question: what are the key mechanisms that influence the way actors use interorganisational ICT in a construction project and how do these mechanisms change over time?

Since insights into the mechanisms are still inadequate, an explorative inductive approach to develop the theoretical framework is considered appropriate. We use the principles, procedures, and techniques of ethnography and the grounded theory approach to conduct our research. We analyse the use of ICT in its social and interorganisational context in-depth in a construction project.

This chapter is organised as follows. First, the research design of our study is presented. Second, we discuss the research context. Third, the results of our field study are described. The final part presents our conclusions and the implications for research and practice.

2.2 Research design

The research methods followed were that of ethnography and grounded theory. Schultze (2000, p.7) defines ethnography as "an anthropological research method that relies on first-hand observations made by a researcher immersed over an extended period of time in a culture, with which he/she is unfamiliar". Ethnographers are primarily concerned with studying, understanding and providing explanations of human behaviour and action in their social, cultural, and organisational context (Atkinson, 1990; Harvey and Myers, 1995; Myers, 1999; Prasad, 1997). According to Agar (1996, p.131) the ethnographic research method is used "to transfer observations into accounts that group members say are possible interpretations of what is going on". Ethnography was adopted here for three reasons:

1. *To understand human action from an actor's point of view:* an ethnographer 'lives' in the field for a reasonable amount of time to examine situations, meanings, and actions from the point of view of the actors involved (Myers, 1999). This approach enabled the researcher to understand why actors did or did not use interorganisational ICT in the intended way.
2. *To understand what is going on (and often is taken for granted):* combining the long-term presence of the researcher, first-hand impressions, participant observation, and interviews has some important benefits. First, it enables an ethnographer to capture what people say they are doing as well as what they are actually doing (Myers, 1999). Second, it allows him or her to ask more informed questions, and finally, because of an ethnographer's long-term presence, the interviewees feel more open and relaxed in interview situations (Alvesson and Deetz,

[4] An article based on this chapter has been submitted to *Building Research and Information* for publication.

2000, p.199). This gave the researcher a better understanding of what was going on and enabled him to question what practitioners took for granted.

3. *To be able to challenge our assumptions:* an ethnographer tries to answer questions about why actors do not act in ways we think are sensible or rational (Myers, 1999). One of the assumptions was that actors appear to use ICT in a different way than was intended.

Despite these strengths, ethnography is also criticised (Charmaz and Mitchell, 2001). Important potential problems are that (1) the researcher gets overwhelmed by huge amounts of data, and (2) the researcher becomes caught up in details and local understanding (Alvesson and Deetz, 2000; Charmaz and Mitchell, 2001). This often results in low-level description or lists of unfocused categories (Charmaz and Mitchell, 2001, p.161), and the researcher, therefore, is often not able to say anything of wider theoretical significance (Alvesson and Deetz, 2000, p.77).

In order to overcome these two difficulties we combined the method of ethnography with grounded theory. Grounded theory is a qualitative inductive research method that generates theory from data, which is systematically gathered and analysed through the research process (Strauss and Corbin, 1998, p.12). In this approach data collection, analysis, and theory are closely interrelated. Carmaz and Mitchell (2001, p.160) stress that "[u]sing grounded theory methods can streamline fieldwork and move ethnographic research toward theoretical interpretation". Vice versa, ethnography also strengthens the method of grounded theory. It helps "grounded theorists to go deeper in their studied phenomena to understand experience as their subjects live it, not simply talk about it" (ibid., p.161). The method of grounded theory is also useful for this research because of its focus on process, that is, on sequences of evolving action/ interaction and its changes over time, which can be traced back to changes in the conditional context (Strauss and Corbin, 1998). Therefore, in our ethnographic research, we draw on the procedures and techniques of grounded theory to guide our data collection and analysis. The next subsections discuss data collection, data analysis, and the way these are connected.

2.2.1 Data collection

Because of the explorative nature of this research, we decided to select a complex design-bid-build construction project where interorganisational ICT was used between the client, engineering company, and contractor in the construction phase of a construction project. The construction site was located in the city centre of one of the largest cities in the Netherlands. During the construction phase, the engineering company monitored the contractor on behalf of the client. The construction phase of this project started in 2005. The amount tendered for the project was about € 26 million, and the duration of the construction phase was 15 months. The complexity of the project increased the opportunities for looking at not only routine events, but also special, and unexpected events (Schatzman and Strauss, 1973). These events might influence the way actors use interorganisational ICT differently. The ICT application was new to all actors involved.

The researcher did his field research for a 6 months period starting at the moment that ICT was introduced into the project (i.e., four weeks after the contract was awarded to the contractor). For four months, the researcher spent three days a week in the field and a further day each week to analyse the collected data. In the last two months, the researcher collected data more 'from a distance' and spent increasing time on analysis rather than data collection.

The researcher was located at the engineering company. At the start of the project, the engineering company considered that having a 'free' role in this project would be inappropriate. A 'free' role would bring about enormous risks to both the engineering company and the contractor because of the different interests of participating organisations and the risk of spreading confidential information. Within the engineering company, the researcher had no restrictions in data collection.

The researcher had complete access to the ICT application, to all internal meetings within the engineering company, and to the project meetings with the client and the contractor. He could also interview and observe members of the engineering company if he felt there was a need for it.

To capture the views of the members of the other organisations that were involved, the researcher was allowed to interview members of the client and the contractor. The researcher had many informal talks and semi-structured interviews with the contractor's work planner who was responsible for using the ICT application on behalf of the contractor. In addition, participant observation during project meetings with the contractor and the client, and observation of the ICT-behaviour of actors was allowed, which made observation of members of the contractor and the client possible. It is important to note the importance of gaining the confidence and trust of the actors involved. The researcher had to avoid that the people from the contractor and the client might think that what they said would be fed back to the engineering company. The researcher, therefore, spent a lot of time at the start of the research project introducing himself to participants and discussing the confidentiality of the results. After a while, actors became used to the researcher's presence in the field.

During the field study, the researcher collected data using multiple techniques in order to increase the validity of identified constructs (Eisenhardt, 1989). First, he spent most of the time observing participants and informally talking to them. Participant observation took place during the daily routine and in meetings. The researcher took a passive role rather than an active role to minimise the extent of his impact on local practices[5]. In addition, the researcher observed participants' ICT-behaviour to grasp how actors communicated and used ICT. He tried to understand 'what was going on' regarding the use of ICT. Second, the researcher conducted many informal and semi-structured interviews to capture participants' perceptions and understanding. The researcher tried to see the world from the participants' point of view. Without these perceptions and this understanding, it would have been difficult to understand why actors acted in a certain way. Finally, the researcher examined documents. Contract documents describe the arrangements about what people should communicate formally. In addition, the researcher collected and analysed other available documents, such as specifications of the ICT application, minutes of meetings, and letters communicated between the engineering company and the contractor. Documents provided important qualitative information that could be compared with the responses of the interviewees and the observations. The researcher took detailed notes during all data collection activities to capture his impressions and insights.

2.2.2 Data analysis

The researcher used Strauss and Corbin's (1998) analytic coding procedures; he did not conduct these procedures in sequence, but partially in parallel (ibid.). The researcher iterated when carrying out the research. The procedures are discussed below.

First, the researcher started with *open coding*. He coded the data based on a line-by-line analysis of his field notes and categorised this data in concepts. These concepts represented meaningful ideas that had been detected in the data. As soon as the researcher had some clear concepts, he started to group these together in more abstract analytic categories and subcategories specifying the categories. These categories and subcategories had the potential to explain and predict 'what was going on'. The researcher then developed the categories and subcategories' properties and dimensions (i.e., the range along which general properties of a category vary). Second, the researcher linked categories

[5] The roles that an observer takes can be active or passive, open or covert. According to Gold (1958) four field roles can be distinguished: (1) complete participant, (2) participant-as-observer, (3) observer-as-participant, and complete observer. See Gold (1958) for a discussion. In this research, the participant-as-observer role was used.

and subcategories to form a more precise and complete explanation of the way actors used interorganisational ICT in construction projects (i.e., *axial coding*). The researcher looked for answers to questions such as why, when, where, how, and with what consequences an actor used ICT. Finally, the researcher integrated the major categories and subcategories into a larger theoretical framework (i.e., *selective coding*). In addition, he checked the internal logic and consistency and filled out poorly developed categories and subcategories by further theoretical sampling (see below).

An important characteristic of the grounded theory approach is that data analysis occurs in parallel with data collection (Strauss and Corbin, 1998). One of the major techniques used in grounded theory is theoretical sampling. Strauss and Corbin (1998, p.201) define theoretical sampling as "[d]ata gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons,' whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of properties and dimensions".

According to Strauss and Corbin (1998), the data-gathering should be finished at the point of theoretical saturation. At this point, no new information emerges during coding. After 6 months of field study the researcher was convinced that the point of saturation had been reached in this project because the actors were using the ICT application at a level that was stable and not expected to change. At that stage, no new concepts were being derived from the data. After the period in the field, the researcher took several months to go through the data again and to write down the storyline.

After the researcher had finished his storyline, the draft findings were fed back to participants in the field (i.e., contract supervisor, management of engineering company, and work planner). This served several purposes. First, the actors could reflect on the findings. According to them, the findings reflected their opinions and feelings correctly. Second, the actors could reflect on the confidentiality of the results. Only one actor asked the researcher to keep a small descriptive part of the story confidential. Because of the spatial limits of this paper, we will not present the entire storyline, just the condensed results.

2.3 Research context

The web-based ICT application used in this project incorporated document management and workflow management features. The workflow management feature was used to manage the flow of documents and information and to monitor and record the progress of tasks. With the document management feature documents could be stored, organised, and managed in a digital way.

The ICT application was used between the contractor and the engineering company to support their formal communication. Some months after the introduction of ICT, the client gained viewing permissions in the application.

In this project, the engineering company (i.e., one of the contract supervisors) initiated the use of ICT. Before the project was awarded to the contractor, the engineering company developed the application – together with the software vendor and a business consultancy company – based on its customary way of working and the administrative conditions that applied to this project. With the use of the application, the engineering company's internal processes and the interface with the contractor were automated. Therefore, the engineering company specified a set of processes that the engineering company wanted to perform internally and externally with the contractor. The software vendor incorporated these processes in the workflow management feature. Several groups of actors were distinguished in the workflow processes: contract supervisors, supervisors, design managers,

and consultants (see Figure 2.1). These groups had one or several tasks in the workflow processes. The number of people who participated in an actor group is shown in Figure 2.1.

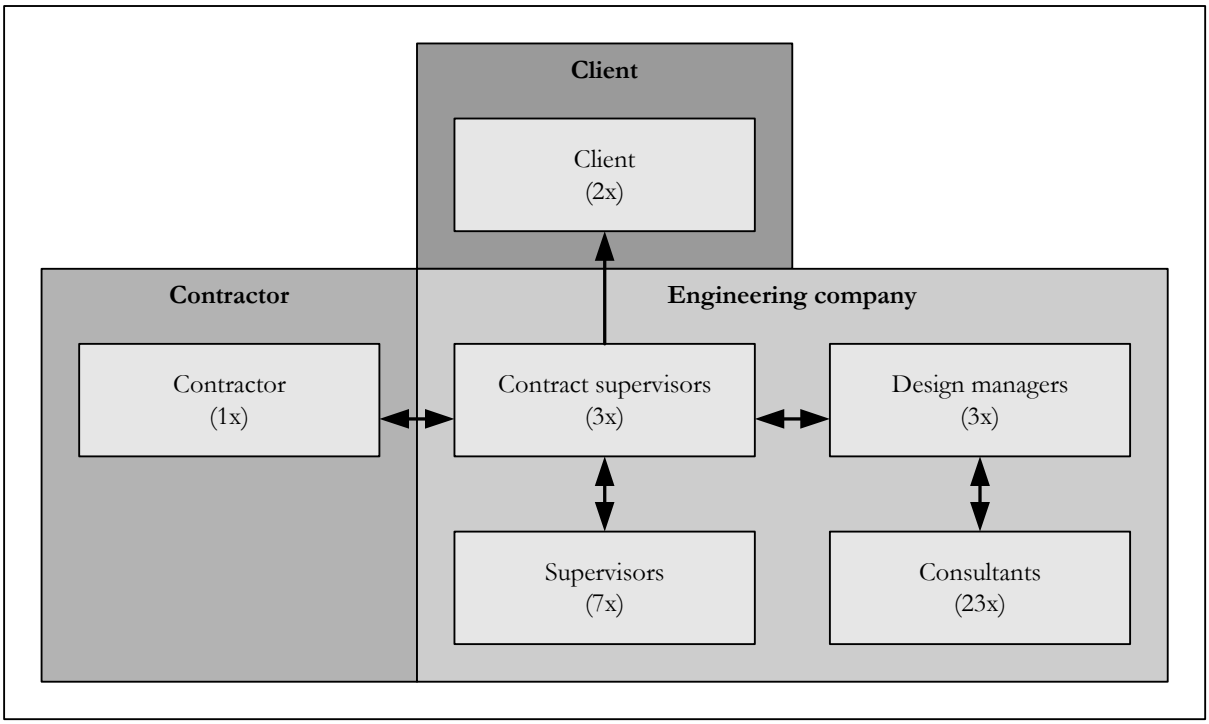

Figure 2.1: Digital workflow processes

The engineering company who introduced interorganisational ICT had clear expectations about its intended use; it would be used for all formal communications between the contractor and the engineering company except for letters, meeting reports, and drawings made by the engineering company which had to be sent by ordinary mail. Some of the documents that the contractor sent to the contract supervisors had to be approved by the contract supervisors themselves, such as instalments, performance statements, deviations, and extra work. Other documents, such as plans, noise measurements, and computations, needed to be assessed by other actors within the engineering company. All documents needed to be stored in the ICT application as well (i.e., in the document management feature).

With this use of ICT, the engineering company assumed that it would realise the following benefits:

- Reduced administration load;
- More structured communication;
- Better process control;
- Better document and information control;
- Faster exchange of information.

According to the engineering company, the contractor should get the following benefits:

- More structured communication;
- Faster response times from the engineering company.

The selected project was a design-bid-build project with the client and the engineering company opting for competitive tendering. The engineering company in the contract mandated the use of ICT to the contractor. The contractor was allowed to use the engineering company's ICT application free of charge. However, the engineering company had not incorporated the contractor's

internal working processes in the application because, at the moment the customisation took place, the contractor had not been selected. The contractor decided not to invest time and money in aligning the application to his own internal working processes and made a work planner responsible for using ICT (see Figure 2.1).

After the contract was awarded to the contractor, it took several weeks to get the application up and running. During these weeks the software vendor offered a 4-hours user training to all potential users of the application. In the meantime, actors used traditional means of communication such as ordinary mail, telephone, fax, and e-mail. None of the potential users had experience with the application.

2.4 Research results

In this section, we will focus on the analytic mechanisms that influence the use of interorganisational ICT. Ethnographers and grounded theorists differ in their treatment of presenting the results of their study. Ethnographic writing focuses on writing entire narratives in which their – often general – categories are embedded. "They may use these categories as a means of organizing their description" (Charmaz and Mitchell, 2001, p.169). Grounded theorists concentrate on writing analytical stories, which are focused on conceptual analysis, and only include "snippets of stories and fragments of experience, rather than entire narratives" (Charmaz and Mitchell, 2001, p.170). Because of our focus on mechanisms that influence the use of ICT we will primarily follow the treatment of grounded theorists in presenting our results. However, being ethnographers, we have to keep in mind that we represent our actors in the writing properly and that we represent what is really happening as fully as possible (Van Loon, 2001, p.280).

Therefore, in the first subsection we describe the way ICT is actually used. To do this, we will focus on *how* ICT is used over time and *how* events and actions influence this use. In the second subsection, we examine mechanisms (i.e., categories and subcategories), which determine the use of ICT in this project (i.e., *why* did actors act as they did). Finally in the third subsection, we present our theoretical framework and illustrate the way this framework is related to the actual use of ICT in this project.

2.4.1 The actual use of ICT over time

In discussing the actual use over time, we distinguish three different episodes. Each transition from one episode to another involves a substantial change in the way that the actors use ICT. In this subsection, we will only present the highlights of each episode without trying to be exhaustive.

Episode 1: Some actors try to use ICT (Weeks 1 – 6)
The actors start the use of ICT from their offices, because until Week 18 (Episode 3) the construction trailer is not available. During this episode and the two other episodes the actors experience a high level of time pressure. The contractor (i.e., work planner) starts to use ICT immediately after it becomes available. However, after some initial attempts in the first weeks (i.e., 5 messages are sent in the right way, several in the wrong way) the contractor stops using ICT and returns to the use of traditional – especially paper-based – means of communication. In this episode, the contractor always uses ordinary mail for sending documents. Thus, messages he[6] sent digitally are also communicated in a paper-based form.

[6] In this thesis, organisations are referred to as he or him. This is not meant to make reference to any specific gender.

After receiving the messages (and the accompanying documents) from the contractor, the contract supervisors forward them internally to different actors within the engineering company by using the ICT application. This results in 29 internal messages being sent, several containing indications of urgency. However, actors within the engineering company often send messages in the wrong way (e.g., documents are not linked to messages and messages are not received because they are not sent in the appropriate way). In order to reduce user problems, an ICT consultant provides user-support to actors within the engineering company several times. At the end of this episode, a design manager and several supervisors have reacted to the contract supervisors by using the ICT application. However, the contract supervisors only react in a paper-based form, in meetings, or informally to the contractor.

Episode 2: Actors start to use ICT in a structural way (Weeks 7 – 12)
The contract supervisors realise that they have to intervene in the use of ICT otherwise it will be difficult to eliminate the backlog. This episode, therefore, starts with a clear statement being made in several meetings by the contract supervisors to both the contractor and the actors of the engineering company that everyone has to use ICT (*"From now on, we use ICT"*; *"If you [the contractor] don't communicate instalments by ICT we will not pay you"*; *"The use of ICT is a contractual obligation"*).

After this intervention, the contractor starts to use ICT for communicating documents to the contract supervisors. In this episode, the contractor communicates 122 messages. However, the contractor does not always use ICT, or does not always use ICT in the way that was intended by the engineering company:

- The contractor uses ICT only when he does not need to scan documents. Often documents are received in a paper-based form from subcontractors or suppliers, or handwritten notes are made on documents.
- The contractor always communicates twice by using ordinary mail and by using ICT. The only exceptions to this rule are deviations.
- The contractor starts communicating just the first signed page of a document to the engineering company instead of the entire document. The contractor's project leader signs the first page of a document before it is sent to the contract supervisors.

The contract supervisors arrange an instruction session for the contractor to increase the contractor's understanding of the application. The software consultant provides user-support. In addition, the software consultant makes some small changes in the application based on the contractors' and engineering company's experiences.

The contract supervisors start to use ICT to react digitally to messages. In this episode, the contract supervisors communicate 76 messages to the contractor. However, the contract supervisors do not use ICT to approve any deviations. These are discussed in separate meetings.

Within the engineering company, actors use ICT almost in the intended way. They always react digitally to messages. However, in their responses, the contract supervisors and other actors within the engineering company often refer to documents that are communicated in a paper-based form (e.g. drawings), informal agreements, or meetings. Thus, not all information is entered in the application.

The contract supervisors want to extend the scope of the application. They propose that the contractor should communicate the drawings and letters digitally too. However, the contractor rejects this proposal.

Episode 3: Actors approximate the intended use (Weeks 13 – 27)
At the start of this episode the contractor acquires a bulk scanner, which enables him to digitalise documents easily. In addition, at a meeting the contract supervisors and the contractor make clear agreements about the use of ICT *("All documents prescribed in the contract have to be communicated by ICT only"*).

Therefore, the contractor starts to use ICT in the intended way (i.e., only ICT is used; see research context). The only exceptions are:

- Drawings that need to be assessed by the contract supervisors;
- Drawings and schedules larger than A3;
- Documents in which colour is used;
- Drawings and computations that need to be assessed by government agencies after they are communicated to the engineering company;
- Financial consequences of deviations.

In addition, the contractor communicates instalments by using ICT and sometimes by using paper-based documents as well. In this episode, the contractor communicates 492 messages to the contract supervisors.

The contract supervisors and other actors within the engineering company use ICT in the same way as they did in Episode 2. The contract supervisors use ICT to communicate 207 messages to the contractor. However, the contract supervisors do not approve deviations and extra work by using ICT; they approve them instead in separate meetings.

Two remarkable events take place in this episode. First, in Week 16, the client gains access to the ICT application. However, the client does not use it. Second, in Week 18, the construction trailer becomes available to project participants and the contractor, the contract supervisors and the supervisors move straight into it, but only in week 22, does the Internet connection become available to the contractor. In the meantime, the contractor communicates important information from his office instead of the construction trailer.

2.4.2 The mechanisms influencing the use of ICT

Based on our field study, we are able to distinguish four categories influencing the use of ICT: (1) personal motivation (willingness to act), (2) external motivation (forced to act), (3) knowledge and skills (knowing how to act), and (4) opportunities to act. These four categories and the subcategories influencing these categories are described in detail in this subsection. With these categories and subcategories, the use of ICT in the different episodes described in the previous subsection will be explained. The categories and subcategories can be drivers or barriers to the intended use of ICT. In this discussion, we refer to the structural use of ICT that takes place in each episode and avoid giving anecdotal evidence. Sometimes anecdotal evidence is used to illustrate the structural use of ICT.

1. Personal motivation
Personal motivation refers to the extent to which actors are willing to use interorganisational ICT themselves. Personal motivation influences both the willingness of the actors to use ICT and their willingness to invest resources to overcome barriers to the intended use of ICT.

We distinguish two subcategories influencing personal motivation:

a) *Perceived benefits and disadvantages of ICT use:* the extent to which actors perceive the use of ICT as benefiting and/or disadvantaging them. When actors perceive that there are many

benefits (and no, or only a few, disadvantages) this will influence personal motivation positively. On the other hand, many perceived disadvantages will influence personal motivation negatively. This subcategory can be a driver and a barrier to the use of ICT.

b) *Perceived time pressure:* the extent to which actors perceive that they have to act quickly when using, or considering the use of, ICT. A high level of perceived time pressure can moderate personal motivation because of the highly perceived benefits of the use of ICT. However, a low level of perceived time pressure does not result in a high level of personal motivation to use ICT per se. This subcategory can only be a barrier to the use of ICT.

The subcategories influencing the personal motivation to use ICT will be discussed in greater detail below.

1a) Perceived benefits and disadvantages of ICT use

Our field study revealed that each actor perceives the benefits and disadvantages of ICT differently, which results in a different use of ICT. Therefore, we will discuss this subcategory from various points of view.

Contractor

At the start of Episode 1, the contactor is sceptical about the use of ICT. This scepticism is caused by the limited alignment of the application with his working practices in general and the alignment with his quality management system in particular. For example, the work planner questions: *"How can we organise our document control with this application?"*. In addition, the contractor's project leader mentions: *"I used to sign all the documents before they were communicated to the contract supervisors. Now, how do I know that the right documents are being communicated?"*. Because of this scepticism, the contractor adopts an attitude of caution. The contractor tries to minimise his use of ICT and does not try to overcome the barriers to its intended use. He tries to work according to his customary – paper-based – working practices as much as possible. The work planner says about the contractor's attitude towards these practices: *"That is the way we are used to working in every project. We work that way all over the world"*. However, this scepticism is not only caused by the potential disadvantages of the use of ICT. The fact that the contract supervisors do not use ICT to respond towards the contractor in Episode 1 strengthens this scepticism as well: *"What are the benefits of using ICT when the contract supervisors are not responding?"*.

When the contractor starts to use the application in Episode 2, he perceives several benefits and disadvantages in its use. The contractor does not see any benefits in using ICT for communicating documents that the engineering company has to approve. Often these documents are not available digitally to the contractor. In Episode 2, the contractor only has a normal rather than a bulk scanner available; as a result, the scanning of documents costs a lot of time compared to paper-based communication (some documents are about 70 pages thick). So, in Episode 2, the contractor tries to minimise his scanning activities. He does not use ICT for communicating documents that need to be scanned or he communicates only the first signed page of a document digitally. However, the situation is different with deviations. When the contractor uses ICT for sending deviations, he can communicate them much faster than in the traditional – paper-based – form, especially as long as participants are not yet located in the construction trailer. In the contractor's view, it is very important to record and communicate deviations as soon as possible. In addition, he does not have to keep a separate statement of sent deviations anymore. Because of these benefits, the contractor starts to send deviations immediately at the start of Episode 2.

Unfamiliarity with the application causes the contractor's sceptical stance towards interorganisational ICT in an important way during Episodes 1 and 2. According to the work planner and the contractor's project leader, before the start of the project the contractor had no idea about what the

application entailed. Therefore, it was difficult to assess what the costs and benefits of the use of the application would be. The contractor decided not to include the use of the application in the bid. As a result, he does not want to invest money to align the application with his working practices. He maintains the use of his traditional – paper-based – practices internally. In addition, the contractor does not want to invest time and money to use ICT to communicate drawings and letters as proposed by the contract supervisors in Episode 2. When the engineering company communicates drawings digitally to the contractor, the contractor instead of the engineering company has to plot these drawings if the contractor wants to use them on-site. The contractor has not included the costs of purchasing a plotter and cartridges, and the time spent on printing drawings, in his bid. The same applies to letters: the contractor has to spend extra time digitalising letters. Because these digital practices are not specified in the contract, the contractor is able to refuse the engineering company's proposal. On the other hand, using ICT to send documents is a contractual obligation, the contractor, therefore, has no other choice than to purchase a bulk scanner in order to reduce the time spent on his scanning activities.

For several reasons the perceived benefits and disadvantages are not fixed over time. First, the way actors (themselves and others) use ICT influences their perception of the benefits and disadvantages. For example, it is not until Episode 2 that the contract supervisors start to respond to the messages that the contractor communicates digitally. This stimulates the contractor to use ICT in Episode 2. Second, several barriers are overcome over the course of time (e.g., the software vendor improves the application based on user experiences, the understanding about the application increases, and peripheral equipment becomes available). A contract supervisor says about improvements in the application: *"It is important that the contractor sees the benefits of the application. Therefore, we spent time and money in improving the application for the contractor".*

Contract supervisors
The ICT application is developed based on the engineering company's working practices and priorities. Therefore, the engineering company could attain many benefits from the use of ICT. When we focus our attention on the contract supervisors, we see that contract supervisors experience benefits especially when they are distributing documents to actors within the engineering company and to the contractor. Distribution by ICT instead of regular internal mail is faster and saves a lot of paperwork. Therefore, when actors start to use ICT in Episodes 2 and 3, the contract supervisors ask the contractor to send all the documents and drawings that need to be distributed to the design managers by using ICT. However, in relation to drawings the contract supervisors themselves assess these benefits as lacking. They prefer to receive these in a paper-based form because then they do not have to plot or print these.

Some important potential benefits of the use of ICT are not experienced in practice. One of the potential benefits is improved document control. However, the contract supervisors hardly ever use ICT to retrieve documents. Contract supervisors complain about the difficulties in obtaining an overview of communications and documents in the application. In addition, they perceive reading from the screen as being less comfortable than reading paper-based documents. The contract supervisors refer to the possibility of leafing through paper-based documents and of writing down some comments as well. As a result, contract supervisors do not see any benefit in using ICT for document control. Therefore, the contract supervisors print final documents and put them into paper-based files. When the contract supervisors have to retrieve documents, they look in these files.

In addition, some potential benefits are disadvantages as well. The contract supervisors perceive important benefits in being transparent towards the client. Therefore, the engineering company gives the client viewing permissions in the application. As a result, the client can have easier and better access to project information and communication than in traditional projects where such an

application is not used. However, giving this transparency to the client is a huge change compared to traditional situations. Transparency can be a threat to the engineering company too. A design manager mentions: *"When the number of external parties having access to the application increases, the risks increase as well"*. Therefore, the contract supervisors limit the scope of the application to the contractor and the engineering company until the application functions well (see Episode 3). A contract supervisor says about transparency and the way actors react to it: *"Now they all sit in a fish bowl,"* and *"People are afraid to bring data into the application"*.

Client
The client sees no reason to use ICT. He receives the information he needs from the contract supervisors (client: *"That is the advantage of being the client"*). In addition, he does not want to know everything that is happening in the project. Therefore, the client does not use ICT.

We can summarise by saying that the perceived benefits and disadvantages are distributed unevenly across the actors involved. In addition, each actor perceives different benefits and disadvantages when using ICT and its specific functionalities. In this project, the application is developed from the perspective of the engineering company. Therefore, it is the engineering company in particular which benefits from the use of ICT. In the tender stage, the contractor assessed the costs of the use of the application based on a limited understanding of it. This results in resistance to investing in ICT and peripheral equipment after the contract is awarded. The perceived benefits and disadvantages change over time because (1) (other) actors change the way they use ICT, and (2) barriers to the intended use of ICT are overcome.

1b) Perceived time pressure
In a hectic context, the personal motivation to use new ICT and to overcome barriers to the intended use of ICT will be low. In these situations actors tend to communicate as they normally do (e.g., using telephone, fax, e-mail, or mail) although they might see important benefits in using ICT. This mechanism applies to both the engineering company and the contractor. Time pressure influences personal motivation in two ways.

First, because of a high level of time pressure, other priorities prevail in Episode 1. The engineering company focuses on the conditions that need to be secured in order for the contractor to make a start. In turn, the contractor concentrates on making plans, and purchasing, for example, materials and equipment. Actors mention difficulties in using ICT in this hectic context:

- Contractor's project leader: *"We tried to use ICT. Because of time pressure, we stopped using it. We have so much to do. (…) You don't have time to start using it"*.
- A contract supervisor: *"It is so extremely hectic. I don't look in the application. I am very busy solving problems quickly. (…) If I have to solve problems quickly then I don't use ICT. We will correct this later on"*.

The contractor and the contract supervisors do not invest the time needed to learn how to use the new application. They do not really use ICT in Episode 1.

Second, when time pressure is high, actors try to prevent risk. Actors are used to traditional means of communication and trust these means because they are proven ways of working (contract supervisor: *"Communicating by ordinary mail always worked"*). After ICT is introduced actors have less confidence in the application, and the way it is used by others, than in traditional – paper-based, or informal – means of communication. Actors question, for example, if a message is sent or not, if the application is used in the proper way, or if the other actors look into the application. The general feeling that actors are experiencing is that one cannot allow any delays to occur. In Episodes 1 and 2, actors within the engineering company make several mistakes when using ICT. This results in

much delay, which actors experience as very annoying in situations when there is a high level of time pressure. As a result, actors tend to start communicating traditionally (i.e., in a paper-based form or informally) again. In addition, the contractor does not get a response to communicated messages and documents in Episode 1. To be certain that information reaches actors within the engineering company the contractor (also) communicates paper-based documents by ordinary mail. A design manager says: *"The contractor communicates in a paper-based form or informally to us to arrange things quickly"*. This sometimes results in discussions about sent documents and about the latest version of documents.

The same mechanism emerges when unforeseen situations occur. In these situations, actors often communicate informally in order to make decisions quickly. Actors need to communicate in a more structured way than they used to do to use ICT in the intended way and to attain the expected benefits (e.g., more structured communication, better information and process control). This seems to be difficult when there is a high level of time pressure. The contractor's project leader mentions the importance of informal communication when time is scarce: *"At the end of a discussion you know what you have to do. When do you get a response to messages communicated with the ICT application?"*. However, informal decisions need to be formalised as well. The work planner says: *"Sometimes agreements are confirmed. We use e-mail or minutes of meetings to do that"*.

The large financial interests that the participating organisations are experiencing increase the perceived time pressure. For example, if the engineering company has not approved certain documents, the contractor cannot start. A contract supervisor states: *"When you're sitting behind your computer and you do not know exactly how to use the application, you try to arrange things without ICT"*. Another contract supervisor says: *"We need to decide fast. One day of delay means extra equipment costs of 20.000 Euro*".

Although time pressure does not decrease in Episode 3, the use of ICT reaches a stable – almost intended – level. Both the engineering company and the contractor get used to each other, to the application, and to the new way of working. Actors know how they have to use ICT and incorporate ICT into their daily routines. Sometimes actors (both contractor and engineering company) communicate first in a paper-based form or informally and then send messages by using ICT later on to arrange things quickly. According to a design manager, it often takes days before the contractor's message reaches the consultants. Therefore, actors discuss issues in advance before they communicate formally. In these situations, actors refer to the paper-based documents, informal agreements, or meetings in their messages. In addition, the contractor sometimes sends important documents in a paper-based form as well to be sure that information reaches the other person quickly.

We can summarise by saying that perceived time pressure influences personal motivation to use ICT in two ways: (1) combined with the time investment needed to learn how to use ICT, and (2) combined with the perceived risks of using ICT. In this project, time pressure is very high which results in low personal motivation to use ICT after its introduction. However, after a while actors get used to each other, to the ICT application and to the new way of working. Therefore, actors incorporate ICT into their daily routines. Only sometimes, especially in unforeseen situations and when communication has a high level of importance, do actors use informal or paper-based means of communication too.

2. External motivation

External motivation refers to the degree to which actors are forced by *other* actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest time and money to overcome barriers to the intended use of ICT.

Two subcategories influence external motivation:

a) *Availability of contractual arrangements about ICT use:* the extent to which actors are forced to use ICT or other means of communication because this is mandated in the contract. When ICT is prescribed, external motivation is present. When ICT is not mandated no external motivation to use ICT exists. A mandate of only other means of communication is even a barrier to the use of ICT.
b) *Presence of a requesting actor:* the extent to which another actor requests certain action(s) (e.g. use of ICT, or non-use of ICT) to take place and the extent that this request impacts on actors. When actors are asked to use ICT and this request has an impact on them, external motivation is present; if this request is absent or if it does not have impact then no external motivation exists. Another actor who requests acting in another way than using ICT might even be a barrier to the use of ICT if this request impacts on actors.

2a) Availability of contractual arrangements about ICT use

In this project, the engineering company prescribed the use of ICT for the contractor in the contract. This appeared to be an important safeguard for the use of ICT. In a meeting at the end of Episode 2, the importance of the contractual arrangements becomes clear. In that meeting, a contract supervisor asks the contractor to communicate all documents *only* by using ICT. The contractor's work planner answers: *"Only all documents mentioned in the specifications"*. This remark is logical because the contractor has no positive personal motivation to use ICT.

However, contractual arrangements only, do not guarantee the intended use of ICT (see Episode 1). First, it is important that the contractor is kept to the terms of the contract as well. At the start of Episode 2, the contract supervisors are very clear in their communication towards the contractor: *"From now on, we use ICT"* and *"The use of ICT is a contractual obligation"*. At that moment, the contractor realises he has no other choice than to use ICT. Second, the engineering company mandated both digital and traditional – paper-based – working practices in the contract. Therefore, the contractor wants to communicate traditionally as well as digitally until the formal agreement is made that documents are communicated only by using ICT (see above).

The engineering company can strengthen the effects of contractual arrangements by linking payments to ICT use. This mechanism was present, for example, with the instalments. The contractor wants to be paid for finished products as soon as possible (work planner: *"The most important thing is that our instalments are being paid."*). At the start of Episode 2, the contract supervisors are clear about the way the contractor has to communicate instalments: *"If you [the contractor] don't communicate instalments by ICT we will not pay you"*. Therefore, in Episode 2 the contractor spends time and money communicating instalments to the engineering company digitally and in the intended way (contract supervisor: *"When it's about money they [the contractor] will use ICT and will overcome problems themselves as soon as they can"*.). In this situation, external motivation is connected to the personal motivation to use ICT (i.e., payments). This is an important driver to the use of ICT.

However, several actors question if this contractual pressure is always useful. They fear a negative atmosphere:

- Contract supervisor: *"When the working climate comes under pressure you sometimes have to be compliant"*.
- Work planner: *"In the long run, parties do not want to make a maximum effort when you continuously keep them to the contract. It is important to build credits and to create goodwill"*.

We can summarise by saying that actors can be in the position to mandate the use of ICT and that this can be an important external motivation to use ICT. However, three comments could be made

about this statement. First, mandating on its own does not guarantee the use of ICT. Keeping an actor to the contract is important as well. Second, keeping an actor constantly to the contract can be harsh. Actors suggest that it is important to be compliant sometimes. Finally, linking the use of ICT to incentives (e.g., payments) has a positive effect on the motivation to use ICT.

2b) Presence of a requesting actor
The second subcategory influencing the external motivation is 'presence of a requesting actor'. In our field study this mechanism appeared in two ways.

First, requesting actors in management positions can have an important impact. At the start of the project, the management of the contractor's company does not encourage the use of ICT. Other priorities prevail. Therefore, the contractor's work planner is not externally motivated to use ICT. However, at the start of Episode 2, the instructions of the contractor's project leader are clear to participants of his organisation: *"We are going to use ICT"*. In the project leader's view, the use of ICT is a contractual obligation for the contractor and the contract supervisors are clear about its use. This stimulates the use of ICT. The same mechanism appears within the engineering company: the contract supervisors are clear towards the engineering company's project participants: *"From now on, we use ICT"*. This influenced these participants' use of ICT in an important way.

Second, the client, or in this project, representatives of the client (i.e., the contract supervisors) can ask the contractor to use ICT. Although the engineering company mandates the use of ICT, based on the interviews and observations, we can conclude that a representative of the client asking that ICT be used can – to a certain extent – influence the way the contractor uses ICT too. Sometimes a contractor wants to create goodwill or improve his reputation. Therefore, despite disadvantages and the absence of contractual prescriptions he will use ICT. A works foreman of a subcontractor states: *"It is your client. He requests it. You want to make a positive impression. Friday afternoon everyone has to go home with a good feeling"*. The work planner says about the use of ICT: *"In the end it is of the utmost importance that the engineering company is satisfied. When it lies within my reach to satisfy the engineering company I even want to spend more time on ICT. (…) It is important to create goodwill"*.

There are, however, boundaries to the extent to which actors are prepared to conform their actions to other actors' requests. The work planner states about these requests: *"When you have to do much more work than was mentioned in the specifications we won't do it even if the engineering company is requesting it"*.

We can summarise by saying that another actor requesting ICT use can be – to a certain extent – an important external motivation. Some actors are in the position to request ICT use (e.g., management, client).

3. Knowledge and skills
The knowledge and skills to use ICT refer to the degree actors know how to use ICT. When knowledge and skills are limited, the actors themselves are the ones restricting the use of ICT.

Two subcategories influence knowledge and skills:

a) *Clarity of procedural agreements*[7]*:* the extent to which actors know how to act concerning the ICT application (e.g., what information has to be communicated to whom, and in what form and at what time). This clarity can be high or limited, resulting in enough or a restricting amount of knowledge and skills to use ICT.

[7] In chapter 3, this definition will be changed based on the results of the other field studies. In using the method of grounded theory the categories and subcategories evolve over time.

b) *Clarity about the operation of ICT:* the extent to which actors know how to operate the application. This clarity can be high or low resulting in enough or a restricting amount of knowledge and skills to use ICT.

These subcategories can only be a barrier to the intended use of ICT.

3a) Clarity of procedural agreements
In this project, clear procedural agreements evolve slowly. In Episode 2, both the contractor and participants from the engineering company repeatedly ask for clear agreements to be made about the way the contractor has to communicate. In Episode 3, the agreements are clear resulting in the stable use of ICT. Participants comment that they should have invested more time at the start of the project in order to make clear procedural arrangements at an earlier stage. The clarity of agreements is influenced in two ways.

First, the actors' understanding about the new application influences the clarity of agreements. Both the engineering company's and the contractor's understanding is only limited at first and evolves over time. Therefore, it is difficult for them to make clear procedural agreements at the start of the project. In addition, the contract is not completely clear about the way ICT has to be used. The engineering company prescribed the use of ICT only in general terms based on its limited understanding. Moreover, the engineering company described both digital and traditional – paper-based – working practices in the contract to create a safeguard in case the ICT malfunctioned. Therefore, for the contractor it is difficult to decide how to use ICT exactly. The contractor decides to communicate both in a paper-based and in a digital way (Episode 2) until the use of only digital means of communication is formalised in a meeting (start of Episode 3).

Second, motivation (especially personal but also external) to make clear agreements influences the clarity of agreements. When this motivation is high, actors will repeatedly ask for clear agreements or try to formulate arrangements themselves. For example, the contractor has to use ICT to submit instalments or he will not be paid. The contractor asks repeatedly for clarity about the way he needs to communicate instalments to the contract supervisors in Episode 2. Only after a while (and after some attempts in which the contractor communicates instalments in a dissatisfactory way) do clear arrangements emerge.

However, actors can also benefit from unclear arrangements. When arrangements are unclear, actors can start to use ICT in a way that is most favourable to them or they can stop using it. For example, in Episode 2, the contractor uses ICT for communicating only the first page of a document when documents are not available digitally or he does not use ICT at all.

We can summarise by saying that the clarity of procedural agreements is influenced by: (1) the level of understanding of the application, and (2) the motivation (especially personal but also external) to make clear agreements.

3b) Clarity about the operation of ICT
The second subcategory, 'clarity about the operation of ICT' is influenced in two ways.

First, user support influences this clarity. Because the application is new, actors have to learn how to operate it. Before actors start using ICT, the engineering company arranges a training session and distributes a user manual to actors. According to the actors, the instruction course was too short to learn how to use the application. In Episodes 1 and 2, situations regularly occur in which actors (especially within the engineering company but sometimes also the contractor) do not know how to operate ICT in a precise manner. For example, actors do not link documents to messages, and they

send messages in the wrong way. In order to solve these user problems, the contract supervisors arrange several sessions in which the ICT consultant provides user support (i.e., to participants of the engineering company in Episode 1; to the contractor in Episode 2). In addition, actors sometimes call the software consultant if they have questions about the way they need to operate ICT. Actors are very positive about this support because it increases their understanding about the application in an important way. Because of this support and because actors are beginning to have some experience with the application in Episode 3 actors have the ability to operate ICT in the intended way.

Second, the user-friendliness of the application is important in determining clarity about the operation of ICT. A complex application is used in which much functionality is incorporated. According to all the actors, this results in the low user-friendliness of ICT. The application is difficult to learn in a short period of time. According to the work planner, high user-friendliness reduces user resistance. A contract supervisor mentions that everybody must be able to learn to use interorganisational ICT quickly. Therefore, user-friendliness is very important.

We can summarise by saying that clarity about the operation of ICT is influenced by: (1) user support, and (2) the user-friendliness of the application.

4. Acting opportunities

Acting opportunities refer to the extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.

Two subcategories influence the acting opportunities:

a) *Alignment between ICT and working practices:* the extent to which ICT fits in with actors' working practices in the project and their organisation(s). This alignment can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way.
b) *Availability of technical means:* the extent to which technological aspects restrict actors in using ICT in the intended way. This availability of technical means can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way.

These subcategories can only be barriers to the use of ICT.

4a) Alignment between ICT and working practices

People and organisations have their standard working practices. The introduction of ICT has consequences for these practices. When the working practices and the ICT application are not aligned actors face difficulties in using the application. Examples are:

- *The approval process of deviations:* actors are used to following two stages in the approval process. First, the contractor submits a deviation, which the contract supervisors approve or reject based on technical grounds (i.e., the necessity of the deviation). Second, the contractor submits the financial consequences of the deviation, which the contract supervisors might approve or reject. The result of the latter approval is extra work. These two stages are very important to the actors involved and they do not want to change this process. In the ICT application, the distinction between these two stages is not made. Therefore, the contract supervisors can approve deviations in the application only when these are financially approved. The software vendor suggests that deviations can be 'temporarily rejected' when deviations are technically accepted or that the contractor uses ICT only to submit deviations after these are technically approved. However, this process is not satisfactory to the actors involved. In this project, many unforeseen situations take place

and in these situations, the contractor has to act quickly. The contractor wants to report deviations as soon as possible and perceives important benefits in using ICT for this. The contractor wants and needs technical approval before he can begin to carry out his activities. Because the software vendor is not able to change the workflow process in a satisfactory way, the workflow process is only used to submit deviations that need to be technically approved. Actors discuss and approve deviations in meetings, and the contractor submits the financial consequences in a paper-based form. A contract supervisor says: *"The process in the application is not right. We haven't done anything with deviations in the application"*.

- *Document control:* the contractor wants to comply with (the ISO requirements for) his internal quality management system. Important for the contractor are, for example: (1) the approval of documents by an authorised person (e.g., the project leader) before they are communicated to the engineering company, and (2) appropriate revision control. In the contractor's view, the application is not able to support his quality management system. After the contract is awarded the contractor has limited personal motivation to adapt the ICT application to his working practices and vice versa. The work planner says: *"In this stage of the project we did not have any idea what the ICT application entailed. We did not suspect that the application was going to be used so intensively. We thought that we could use the application in parallel with our customary processes. (…) Moreover, in this stage, the application did not have high priority, and we had a sceptical stance towards it"*. Therefore, the contractor decides to minimise the impact of ICT on his working practices as much as possible. When the contractor receives digital information from the contract supervisors, the contractor first prints this information and then communicates it internally in a paper-based form. In addition, when the contractor sends documents to the contract supervisors he signs and scans paper-based documents first. By using ICT in this way, the contractor can still comply with (the requirements for) his quality management system. However, the benefits of the application are very low to him as well.
- *Communication with public agencies:* several drawings and computations need to be assessed by public agencies. The contract supervisors need to communicate these signed and stamped to the agencies. Actors are not able to change this. Therefore, the contractor has to communicate drawings and computations that are signed and stamped (i.e., in a paper-based form; see Episode 3) to the contract supervisors. ICT is not able to support this process.

From the examples it follows that the alignment between ICT and working practices is influenced in three ways: (1) by the motivation to invest resources to align ICT with working practices (see example 2), (2) by the perceived opportunities of changing working practices (see all examples), and (3) by the perceived opportunities of changing the ICT application (see example 1 and 3).

4b) Availability of technical means

Technical means restrict actors in their use of ICT in several ways.

- *Accessibility of the application:* in Episode 1, one of the contract supervisors is often on-site. There is no Internet connection and computer available on-site. As a result, the contract supervisor does not use the ICT application. He does not use ICT from another location (i.e., this personal motivation is not present). In Episode 3, the construction trailer becomes available on the construction site but the Internet connection in the construction trailer is not yet available to the contractor. It takes about 3 months to arrange a secure Internet connection in the construction trailer and the contractor did not arrange this connection in time. Only several weeks after the contractor moves into the trailer is the Internet connection set up. In the meantime, the contractor communicates important information from his office because he is motivated to use ICT.
- *The application itself and its functionalities:* in Episodes 1 and 2, the client does not have viewing permissions in the application. Therefore, he is not able to use ICT. In addition, actors face

difficulties in keeping an overview of the communications and documents in the application. Therefore, they limit their use of ICT (see 'Perceived benefits and disadvantages of ICT use').

- *Availability of peripherals:* until a bulk scanner becomes available (at the start of Episode 3), the contractor uses ICT in as limited a way as possible. First, the contractor does not know he needs such a scanner. When the contractor has purchased a bulk scanner, it is easy for him to digitalise documents. However, the bulk scanner has its limitations too. It is not a colour bulk scanner and the scanner can only scan small documents. Because of these limitations, the contractor continues to send colour documents and drawings and schedules that are larger than A3 in a paper-based form. The work planner says: *"A colour bulk scanner is too expensive"*. Thus, the contractor does not want to overcome the barrier completely.

From the examples above it follows that the availability of technical means is influenced in three ways: (1) by the motivation to overcome barriers in the technical means (see examples 1 and 3), (2) by restrictions in the technical means (see example 2), and (3) by the level of understanding about technical needs (see Internet connection, bulk scanner in examples 1 and 3).

2.4.3 Towards a theoretical framework

In the previous subsection, several categories and subcategories as well as the relationships between categories and subcategories were presented. Figure 2.2 summarises these findings.

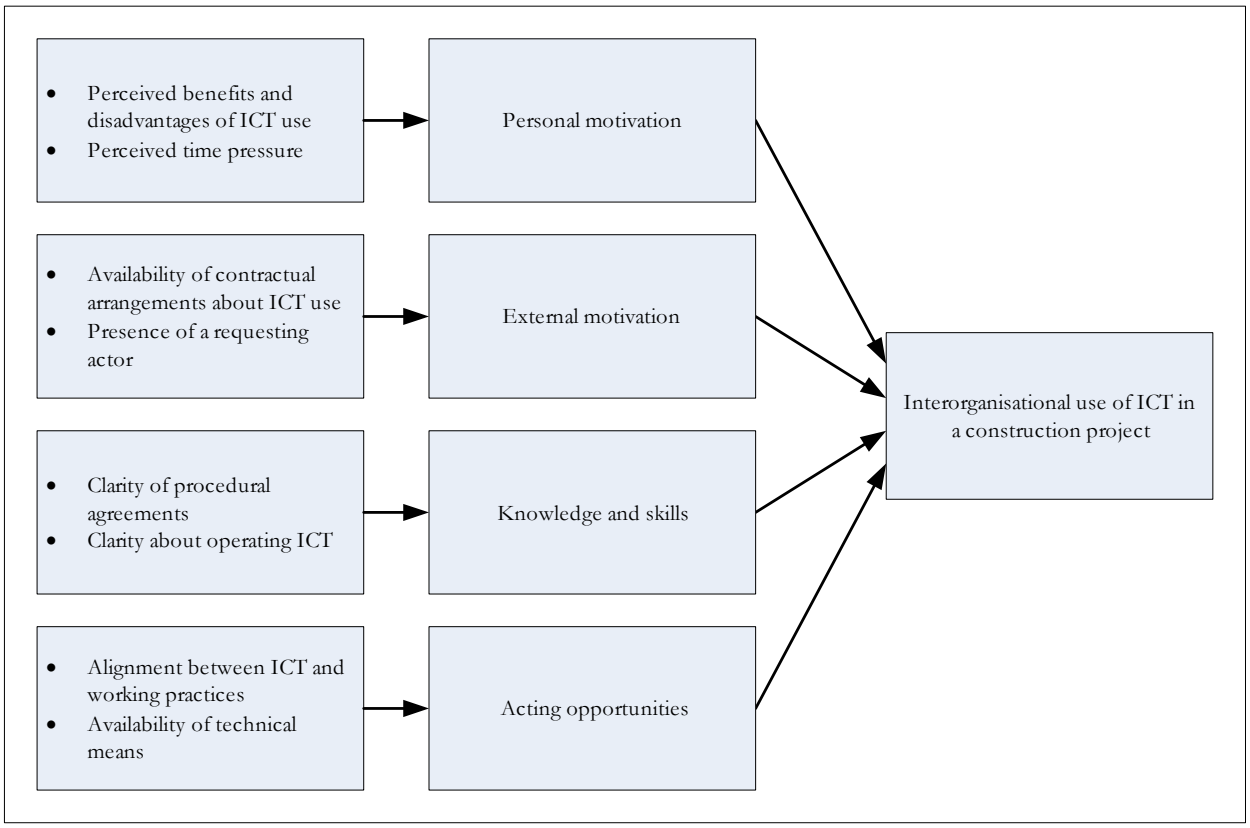

Figure 2.2: Theoretical framework

The subcategories have the potential to explain the way the client (CL), contract supervisors (CS), and contractor (CO) use the ICT application during the three episodes. Sometimes a subcategory is a driver (D) and sometimes a barrier (B) to the intended use of ICT. In previous subsections, the relationships between the way actors use ICT in different episodes and the dominant subcategories that influence this use have already been discussed. These relationships are summarised in Table 2.1.

	Episode 1 (Weeks 1 – 6)			Episode 2 (Weeks 7 – 12)			Episode 3 (Weeks 13 – 27)		
	CL	**EC**	**CO**	**CL**	**EC**	**CO**	**CL**	**EC**	**CO**
Personal motivation									
Perceived benefits and disadvantages of ICT use			B		D	D/B	B	D/B	D/B
Perceived time pressure		B	B		B	B		(B)	(B)
External motivation									
Availability of contractual arrangements			(D)/B			D/B			D
Presence of a requesting actor					D	D		D	D
Knowledge and skills									
Clarity of procedural agreements						B			
Clarity about the operation of ICT		B	B						
Acting opportunities									
Alignment between ICT and working practices					B	B		B	B
Availability of technical means	B	B		B		B		B	B

Table 2.1: Relationship between episodes, actors, and subcategories

From Table 2.1, it follows that in Episode 1, only barriers are present. Contractual arrangements are not a driver because the contractor is not kept to the terms of the contract. The main drivers to the transition to Episode 2 are the contractual arrangements (i.e., the contactor is kept to the terms of the contract) and the presence of requesting actors. Therefore, actors start to use ICT. When using ICT actors are confronted with several barriers. Drivers are needed to overcome barriers to the intended use of ICT. By the end of Episode 2, most of the barriers have been overcome or are not that important anymore (i.e., perceived time pressure); however, some barriers still keep actors from using ICT in the intended way in Episode 3.

2.5 Conclusions and implications for research and practice

We discussed the mechanisms that influence the way in which actors use interorganisational ICT over time in a construction project. Because at the start of this study the insights into these mechanisms were limited, an explorative approach was used to conduct an in-depth analysis of ICT use in a construction project. We used ethnography and the grounded theory approach to conduct this research. Our research resulted in the formulation of a theoretical framework that consists of four categories which determine the way actors use ICT in construction projects: (1) personal motivation (willingness to act), (2) external motivation (forced to act), (3) knowledge and skills (knowing how to act), and (4) opportunities to act. We related the subcategories influencing the way actors use interorganisational ICT in construction projects to these four categories and integrated them into our theoretical framework. With this framework the use of ICT over time in a construction project can be explained.

To date, little is known about the mechanisms that determine the use of interorganisational ICT in the context of construction projects and how this use is influenced over time. The main contribution of this research is that it presents a holistic framework that is able to explain the use of interorganisational ICT over time in a construction project. The interplay between barriers and drivers does not only explain the use of ICT but also the efforts made to invest time and money to overcome barriers to the intended use of ICT. This framework underlines the importance of 'people' issues and the need for a focus on an individualistic actor to understand the use of ICT in the context of construction projects (e.g., Andresen et al., 2003; Hjelt and Björk, 2006; Howard and Petersen, 2001; O'Brien, 2000; Thorpe and Mead, 2001; Weippert et al., 2002). In addition, our

research underscores Harty's (2005, p.521) claim that research needs to focus "on the mechanisms through which established roles, distinct disciplines, and traditional cultures contest and negotiate with and over new technologies or new ways of working". We found that the way ICT is developed and used and the way the application and its use change over time are dependent on these contestations and negotiations.

This chapter can be seen as a first step towards understanding mechanisms that determine the use of interorganisational ICT over time. In the next chapters, the categories and subcategories need to be densified in greater detail and the subcategories need to be conceptualised. In addition, their properties and dimensions, and the relationships between categories and subcategories need to be developed in greater detail. Based on our field study and the technique of theoretical sampling we suggest that subsequent research should examine projects in which:

- The use of ICT is not mandated in the contract.
- Participating organisations develop the application together.
- The construction trailer is available as soon as ICT is introduced. This could make the adoption of ICT more difficult because it is easier to communicate informally or in a paper-based form in this situation.
- Other procurement methods are used (e.g., design-build, partnering).
- Other types of interorganisational ICT applications are used (e.g., product modelling applications).

In addition, connecting grounded theory to existing theory is an important step in developing a more substantive theory (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998). An important direction for further research is relating our theoretical framework to theories about the adoption and use of ICT. Important candidates for this study are the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM). TPB is a general theory of human behaviour (see e.g., Ajzen, 1991) that is often applied to the adoption and use of ICT (Mathieson, 1991; Mathieson et al., 2001; Taylor and Todd, 1995). TAM is considered to be the most influential and commonly employed theory about user acceptance of ICT (Davis, 1989; Davis et al., 1989; Lee et al., 2003).

The theoretical framework has relevance for practice as well. It can help project managers and/or people responsible for implementing interorganisational ICT to identify the technical *and* nontechnical risks of introducing and using ICT in construction projects. Based on this risk analysis, they can formulate and implement measures to overcome these risks or choose to limit the scope of the application (e.g., limit the scope to only some organisations or to only some communication processes). In addition, the framework can be used as an analytical tool to evaluate the status quo use of an underutilised application in a construction project and to formulate and implement improvements based on this analysis.

Chapter 3

The use of interorganisational ICT: four Dutch field studies

3.1 Introduction[8]

Since the seventies, much research has been conducted on the adoption and use of ICT. These studies resulted in lists of factors or conditions that influenced these aspects. From the mid-eighties onwards efforts moved to the development and testing of models that could help predict ICT adoption and use (Legris et al., 2003, p.192). However, existing models are criticised for their limited explanatory power and for their contradictory results across studies in the major relationships between constructs (e.g., Lee et al., 2003; Legris et al., 2003; Sun and Zhang, 2006). Most of these limitations were caused by the central methodological perspectives which were used in studies examining the adoption and use of ICT: the quantitative perspective and the positivist perspective (Sun and Zhang, 2006).

To address these limitations we have conducted a qualitative study from an interpretive perspective[9]. Combining former quantitative research with this qualitative research is a powerful way to build theory (Eisenhardt, 1989; Lee, 1991). In our qualitative research, we focus in-depth on mechanisms that influence the actual use of interorganisational ICT in its social and interorganisational context. By identifying and analysing these mechanisms, we try to explain why individuals and organisations are not using ICT in the intended way over time. We use the principles, procedures and techniques of ethnography and the grounded theory approach to conduct our research. The use of ICT is analysed in its social and interorganisational context in-depth in four construction projects. In this chapter, we will answer the following research question: what are the key mechanisms that influence the way actors use interorganisational ICT and how and why do these mechanisms change over time?

In the previous chapter, the in-depth results of the first field study are presented and the resulting theoretical framework consisting of categories and subcategories is described. In this chapter the results of the four field studies will be presented in a more condensed fashion and the focus sharpens on developing the categories and subcategories more fully, and examining the relationships between these categories and subcategories. This results in a theoretical model that will be related to existing theoretical models about the adoption and use of ICT.

The chapter unfolds as follows. First, the research design of our study is presented. Second, we discuss the results of each of our field studies. Third, based on a cross-field study analysis, we present mechanisms influencing the use of ICT over time. Fourth, we compare our model with prior ICT adoption and use models and reflect on the research method and the limitations of our study. The final part presents our conclusions and the implications for research and practice.

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[8] An article based on this chapter has been submitted to a scientific Information Systems journal for publication. Because this chapter is the submitted version, parts of the research design of this chapter do overlap significantly with Chapter 2.

[9] The first task of the critical methodology is 'insight production'. According to Alvesson and Deetz (2000) the interpretative repertoire is useful to fulfil this task. This chapter only focuses on insight production.

3.2 Research design

To cope with the limitations of former studies conducted on the adoption and use of ICT, we carried out a qualitative study in which the methods of ethnography and grounded theory were followed. Schultze (2000, p.7) defines ethnography as "an anthropological research method that relies on first-hand observations made by a researcher immersed over an extended period of time in a culture, with which he/she is unfamiliar". Ethnographers are primarily concerned with studying, understanding and providing explanations of human behaviour and action in their social, cultural and organisational context (Atkinson, 1990; Harvey and Myers, 1995; Myers, 1999; Prasad, 1997). According to Agar (1996, p.131) the ethnographic research method is used "to transfer observations into accounts that group members say are possible interpretations of what is going on". Ethnography was adopted here for three reasons:

1. *To understand human action from an actor's point of view:* an ethnographer 'lives' in the field for a reasonable amount of time to examine situations, meanings, and actions from the point of view of the actors involved (Myers, 1999). This approach enabled the researcher to understand why actors did or did not use interorganisational ICT in the intended way.
2. *To understand what is going on (and often is taken for granted):* combining the long-term presence of the researcher, first-hand impressions, participant observation, and interviews has some important benefits. First, it enables an ethnographer to capture what people say they are doing as well as what they are actually doing (Myers, 1999). Second, it allows him or her to ask more informed questions, and finally, because of an ethnographer's long-term presence, the interviewees feel more open and relaxed in interview situations (Alvesson and Deetz, 2000, p.199). This gave the researcher a better understanding of what was going on and enabled him to question what practitioners took for granted.
3. *To be able to challenge our assumptions:* an ethnographer tries to answer questions about why actors do not act in ways we think are sensible or rational (Myers, 1999). One of the assumptions was that actors appear to use ICT in a different way than was intended.

Despite these strengths, ethnography is also criticised (Charmaz and Mitchell, 2001). Important potential problems are that (1) a researcher gets overwhelmed by huge amounts of data, and (2) a researcher becomes caught up in details and local understanding (Alvesson and Deetz, 2000; Charmaz and Mitchell, 2001). This often results in low-level description or lists of unfocused categories (Charmaz and Mitchell, 2001, p.161), and a researcher, therefore, is often not able to say anything of wider theoretical significance (Alvesson and Deetz, 2000, p.77).

In order to overcome these two difficulties we combined the method of ethnography with grounded theory. Grounded theory is a qualitative inductive[10] research method that generates theory from

[10] The primary objective of grounded theory is inductive theory building. However, this method also advocates the deductive testing of concepts, categories, and relationships that follow from the data. Therefore, this method is sometimes viewed as being abductive (Kelle, 2005).

Anselm Strauss and Barney Glaser developed grounded theory in the 1960s. Important publications about grounded theory are Glaser and Strauss (1967), Glaser (1978), Strauss and Corbin (1990), Glaser (1992), and Strauss and Corbin (1998). Grounded theory has its origins in the Chicago School of Sociology. This school challenged functionalism and the grand functionalist theories that dominated sociological thought. The Chicago School stressed the need for another methodology for studying social phenomena and human behaviour based on the symbolic interactionism tradition of social psychology and sociology (Eaves, 2001; Kendall, 1999). See Eaves (2001) for a discussion about symbolic interactionism. Since Strauss and Corbin (1990), a controversy has existed between their approach and that of Glaser. This controversy revolves around the use of axial coding and, in particular, the use of the 'coding paradigm'. Glaser (1992) criticises Strauss and Corbin (1990), among other things, for their "full conceptual description". According to Glaser (1992), this is against the principle of the emergence of theoretical categories, because the paradigm "forces" the data. In Glaser's view, the researcher needs to be open-minded during the research process. In fact, Strauss

data, which is systematically gathered and analysed through the research process (Strauss and Corbin, 1998, p.12). In this approach data collection, analysis, and theory are closely interrelated. Carmaz and Mitchell (2001, p.160) stress that "[u]sing grounded theory methods can streamline fieldwork and move ethnographic research toward theoretical interpretation". Vice versa, ethnography also strengthens the method of grounded theory. It helps "grounded theorists to go deeper in their studied phenomena to understand experience as their subjects live it, not simply talk about it" (ibid., p.161). The method of grounded theory is also useful for this research because of its focus on process, that is, on sequences of evolving action/ interaction and its changes over time, which can be traced back to changes in the conditional context (Strauss and Corbin, 1998). Therefore, in our ethnographic research, we draw on the procedures and techniques of grounded theory to guide our data collection and analysis. The next subsections discuss data collection, data analysis, and the way these are connected.

Note that ethnographers and grounded theorists differ in their treatment of presenting the results of their study. Ethnographic writing focuses on writing entire narratives in which their – often general – categories are embedded. "They may use these categories as a means of organizing their description" (Charmaz and Mitchell, 2001, p.169). Grounded theorists concentrate on writing analytical stories, which are focused on conceptual analysis, and only include "snippets of stories and fragments of experience, rather than entire narratives" (Charmaz and Mitchell, 2001, p.170). Because of our focus on mechanisms that influence the use of ICT we will primarily follow the treatment of grounded theorists in presenting our results. However, being ethnographers, we have to keep in mind that we represent our actors in the writing properly and that we represent what is really happening as fully as possible (Van Loon, 2001, p.280).

3.2.1 Field site selection and background

We use a multiple field study approach. With this approach we are able to compare findings across field studies and to look at the data in many divergent ways (Eisenhardt, 1989; Eisenhardt, 1991). This increases the likelihood of building an accurate and reliable theory. In addition, we use multiple investigators (i.e., the main researcher, and two other researchers) which, according to Eisenhardt (1989, p.538), improves the creative potential of the study because the researchers often have complementary insights and different perspectives. In addition, the use of multiple investigators increases confidence in the findings because of convergent perceptions. According to Eisenhardt (1989, p.538) "investigators who have not met the informants and have not become immersed in case details may bring a very different and possibly more objective eye to the evidence". Each field study was assigned to one researcher. The last two field studies were carried out partly in parallel. During these field studies, the main researcher who conducted the first two field studies and the other two researchers shared their draft findings monthly to learn from each other's perspectives, to share interpretations, and to correct errors. In addition, following the method of grounded theory, these sessions were used for asking questions and making comparisons between field studies. This increased our understanding and guided further research activities.

An important characteristic of the grounded theory approach is that data analysis occurs in parallel with data collection (Strauss and Corbin, 1998). One of the major techniques used in grounded theory is theoretical sampling. Strauss and Corbin (1998, p.201) define theoretical sampling as "[d]ata gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons,' whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of properties and dimensions". Therefore, in using the technique of theoretical sampling, we are not treating field

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and Corbin reject the pure inductive position. We will follow Strauss and Corbin's (1998) approach because their guidelines are useful for conducting our research. However, we have to be careful not to impose concepts on the data.

studies independently of each other. Based on our already analysed field sites and evolving theory we make choices in selecting other field sites. In our study, we selected four field sites based on their differences and similarities. The main characteristics of the field studies are summarised in Table 3.1.

	Field Study 1	**Field Study 2**	**Field Study 3**	**Field Study 4**
Tender sum	26 m Euro	42 m Euro	56 m Euro	1.6 m Euro
Duration contract	15 months	22 months	24 months	32 months
Contract type	Design-bid-build	Design-bid-build	Design-build	Design-build
Used features	Document management, workflow management	Document management, workflow management	Workflow management	Document management, workflow management
Organisations using ICT	Client, contractor, engineering company	Client, contractor, engineering company	Client, contractor	Client, contractor, engineering company, subcontractor
Organisation initiating ICT use	Engineering company	Engineering company (Same organisation as in Field Study 1)	Client	Client
Organisation paying for ICT (customisation, application, training, support)	Engineering company (For own processes and interface with contractor)	Engineering company (For own processes and interface with contractor)	Client	Client; contractor, engineering company pay for modifications (9 months after the introduction of ICT)
ICT use mandated in contract	Yes, for contractor	Yes, for contractor	No	No
Organisations involved in customisation of ICT	Engineering company	Engineering company (A copy of the application used in Field Study 1)	Client, contractor	Client, contractor in initial development; all organisations in implementing modifications
Timing of introduction of ICT	4 weeks after contract is awarded	4 weeks after contract is awarded	1 year after contract is awarded	3 months after contract is awarded
Start of ethnographic research	When actors start to use ICT	When actors move to the construction trailer (9 weeks after start of use of ICT)	When actors start to use ICT	7 months after start of use of ICT; 7 weeks before modifications are implemented

Table 3.1: Characteristics of Field Studies

The field sites share the fact that they are construction projects. Construction projects are temporary cooperations between organisations in which coordination and communication are of vital importance. Together these organisations have to realise a construction object such as a railway, bridge or building. The use of ICT can offer many benefits in this context and companies have now started to use interorganisational ICT. However, the use of ICT across organisational boundaries in construction projects is still limited and not as effective as it could be (e.g., Alshawi and Ingirige, 2003; Andresen et al., 2003; Hjelt and Björk, 2006; Nitithamyong and Skibniewski, 2004; Sulankivi, 2004). Therefore, we consider construction projects as an interesting research object.

Moreover, in the selected construction projects an ICT application is used to support parts of the formal communication between the client, the contractor, and the engineering company (i.e., the main actors in a construction project). Only in Field Study 4, the subcontractor is added to this configuration. The ICT applications used in the projects incorporate document management and/or workflow management features. The workflow management feature is used to manage the flow of documents and information and to monitor and record the progress of tasks. With the document management feature documents can be stored, organised, and managed in a digital way. Using these features the cooperation, coordination, and communication between organisations in a construction project can be facilitated. In all the field studies, the application is new to the actors involved.

We have chosen the field studies because of their differences as well. These differences "allowed useful contrasts to be made during data analysis, which challenged and elaborated the emerging concepts" (Orlikowski, 1993, p.312). The field studies and the decisions made to select them are discussed further below.

Field Study 1
The first field study was a complex traditional design-bid-build[11] construction project in the city centre of one of the largest cities in the Netherlands. During the construction phase, the engineering company monitored the contractor on behalf of the client. The engineering company initiated the use of the web-based ICT application. Before the project was awarded to the contractor, the engineering company customised the application together with the software vendor and an external business consultancy company. The engineering company in the contract mandated the use of ICT for the contractor. The ICT application was implemented 4 weeks after the contract was awarded to the contractor.

We chose to start with this field site because of the complexity of the project. This increased the chance to observe not only routine events, but also special, and unexpected events (Schatzman and Strauss, 1973) which might influence the way actors use interorganisational ICT differently. This allowed the researcher to generate as many concepts as possible.

Field Study 2
In the same way as the first field study, the second was a complex traditional design-bid-build construction project in the city centre of one of the largest cities in the Netherlands. The application used in this project was a copy of the application used in Field Study 1. The engineering company also initiated and mandated the use of ICT. The web-based ICT application was introduced 4 weeks after the contract was awarded to the contractor.

This field site was chosen for two reasons. First, in this project a copy of the application used in Field Study 1 was implemented. No development activities had taken place to adjust the application to this project. However, the participants involved in this project were not those of Field Study 1. This allowed the researcher to study the behaviour of different people using the same application as the one used in Field Study 1. Second, in this project the construction trailer became available more quickly after the contract was awarded than it was in Field Study 1. Therefore, adoption of the application is expected to be more difficult because, for people located together in the construction trailer, it is easier and faster to communicate informally or exchange documents personally than by

[11] Within a traditional design-bid-build project, design and construction are strictly separated. The client is responsible for the design and specifies which activities have to be executed by the contractor. In this project the client had appointed an engineering company for the design. Only when the design was substantially completed did the client start the tendering procedure. The tender was based on drawings and specifications. In the selected project, the client opted for competitive tendering. In competitive tendering, tenders are invited from any contractor and, in general, the lowest tender is accepted. After the tendering procure is finished the construction phase of the projects starts. The contractor is responsible for the construction.

using the ICT application that is new to them. This insight followed from Field Study 1. Therefore, the researcher started his ethnographic research at the time that the construction trailer became available, 9 weeks after the actors started to use ICT. The researcher did some data collection (i.e., observation during the user training and conducting several interviews) before he started his ethnographic research because he wanted to capture the impressions of the actors involved before, and immediately after, the application was introduced.

Field Study 3

The third field study is a design-build[12] project doubling the size of a railroad track. The client initiated the use of ICT. The ICT application was used between the client and the contractor to support just a small part of their formal communications. Only the workflow management feature of the application was used in this project. The client had not mandated the use of the application in the contract but asked the contractor to use ICT. After the project was awarded to the contractor, the client and contractor customised the application together – supported by the software vendor and an external business consultancy company. The ICT application was introduced about a year after the contract was awarded to the contractor.

The researcher chose this field site for four reasons. First, participating organisations (i.e., client and contractor) developed the application together. In Field Studies 1 and 2, the engineering company developed the application with the ICT vendor only. This cooperative development could influence the characteristics of the application and the actors' attitude towards ICT in important ways. Second, unlike Field Studies 1 and 2, the use of ICT was not mandated in the contract. In the two former field studies, this mandate appeared to be very influential in the way actors used ICT. Third, in this project a design-build approach was used (unlike Field Studies 1 and 2) rather than a design-bid-build approach. In design-build projects, the client and contractor have to communicate differently because of a different allocation of responsibilities. This could influence the way actors adopt the application because client and contractor have to communicate less intensively. Finally, the ICT application was introduced about a year after the contract was awarded. Therefore, actors were familiar with using other means of communication in this project. This could make it more difficult for the actors involved to adopt the ICT application.

Field Study 4

The fourth field study is a small design-build construction project. The client initiated the use of ICT. The web-based ICT application was used between the client, the engineering company, the contractor, and the subcontractor to support their formal communications. The client had not mandated the use of the application in the contract but asked the other organisations to use ICT. After the project was awarded to the contractor, the client and contractor customised the application together – together with the software vendor and an external business consultancy company. The engineering company and subcontractor were not involved in customising the application. The ICT application was introduced three months after the contract was awarded to the contractor. After about 9 months experience, the contractor and engineering company replaced their applications with new ones.

This project shared many characteristics with Field Study 3. However, the researcher chose this project for two main reasons. First, the size of the project was much smaller than the other field studies. Therefore, the intensity of communication between organisations was expected to be small. From the other field studies if followed that the intensity of communication affected the adoption and use of interorganisational ICT. Second, we were interested in the way actors adopted the

[12] Within a design-build project, one organisation (i.e. the contractor) is responsible for both design and construction.

modifications in the application and the way the adoption and use of ICT is influenced by the actors' former experiences with the application in this project.

3.2.2 Data collection

In each field study, the researcher did his field research for a 5 to 6 months period. The first months the researcher spent an average of three days a week in the field and a further day each week to analyse the collected data. In the last months, the researcher collected data more 'from a distance' and spent increasing time on analysis rather than data collection.

In each field study, the researcher was located at the organisation initiating the use of ICT (i.e., engineering company in Field Studies 1 and 2, client in Field Study 3) or one of the organisations initiating the modification of the application (the contractor in Field Study 4). The researchers were not located at the other participating organisations. This would bring about enormous risks to these organisations because of the different interests they had and the risk of spreading confidential information. Within the organisation in which each of the researchers was located, the researcher was quickly accepted as a member of the team and had no restrictions in data collection. The researcher had complete access to the ICT application, to all internal meetings within that company and to the project meetings with the other organisations. He could also interview or observe members of this organisation if he felt there was a need for it. The researcher's close proximity to key members of this organisation provided many opportunities for close contact (e.g., time spent together over coffee and lunch, staying on after 5 p.m. when the telephones have stopped ringing, arriving early, travelling together) (Gummesson, 2000, p.48). This appeared to be very useful for collecting important data.

To capture the views of the members of the other organisations that were involved, each researcher was allowed to interview key members of them. In addition, participant observation during project meetings in which these organisations participated, and observation of the ICT-behaviour of these actors was allowed which made observation of the members of all the organisations possible. It is important to note the importance of gaining the confidence and trust of the actors involved. The researchers had to make sure that people did not think that what they said to him would be fed back to the other organisations. They, therefore, spent a lot of time at the start of the research project introducing themselves to participants and discussing the confidentiality of the results. After a while, actors became used to the researchers' presence in the field.

During the field studies, each researcher collected data using various techniques. First, they spent most of the time observing participants and informally talking to them. Participant observation took place during the daily routine and in meetings. The researchers took a passive role rather than an active role to minimise the extent of his impact on local practices[13]. In addition, the researchers observed participants' ICT-behaviour to grasp how actors communicated and used ICT. They tried to understand 'what was going on' regarding the use of ICT. Second, the researchers conducted many informal and semi-structured interviews to capture participants' perceptions and understanding. The researchers tried to see the world from the participants' point of view. Without these perceptions and this understanding, it would have been difficult to understand why actors acted in a certain way. Finally, the researchers examined documents. Contract documents describe the arrangements about what people should communicate formally. In addition, the researchers collected and analysed other available documents, such as specifications of the ICT application, minutes of meetings, and letters communicated between organisations. Documents provided

[13] The roles that an observer takes can be active or passive, open or covert. According to Gold (1958) four field roles can be distinguished: (1) complete participant, (2) participant-as-observer, (3) observer-as-participant, and complete observer. See Gold (1958) for a discussion. In this research, the participant-as-observer role was used.

important qualitative information that could be compared with the responses of the interviewees and the observations made. The researchers took detailed notes during all data collection activities to capture their impression and insights.

3.2.3 Data analysis

The researchers used Strauss and Corbin's (1998) analytic coding procedures; they did not conduct these procedures in sequence, but partially in parallel (ibid.). The researchers iterated when carrying out the research. The procedures are discussed below.

First, the researchers started with *open coding*. They coded the data based on a line-by-line analysis of field notes and categorised this data in concepts. These concepts represented meaningful ideas that had been detected in the data. As soon as the researchers had some clear concepts, they started to group these together in more abstract analytic categories and subcategories specifying the categories. These categories and subcategories had the potential to explain and predict 'what was going on'. The researchers then developed the categories and subcategories' properties and dimensions (i.e., the range along which general properties of a category vary). Second, the researchers linked categories and subcategories to form a more precise and complete explanation of the way actors used interorganisational ICT (i.e., *axial coding*). The researchers looked for answers to questions such as why, when, where, how, and with what consequences an actor used ICT. Finally, the researchers integrated the major categories and subcategories into a larger theoretical model (i.e., *selective coding*). In addition, they checked the internal logic and consistency and filled out poorly developed categories and subcategories by further theoretical sampling. Although we followed these procedures partially in parallel, our approach became more targeted as the research proceeded. We focused on the first two steps in Field Study 1, and moved our focus to the latter two steps in the other 3 field studies because of the emerging concepts, (sub)categories, and theory. In doing so "[t]he initial concepts thus emerged in one organisational context and were then contrasted, elaborated, and qualified in the other" (Orlikowski, 1993, p.312). The results of former field studies were a starting point for beginning the latter field studies. The constant comparative analysis method (see also Orlikowski, 1993; Strauss and Corbin, 1998) was used to constantly compare and contrast findings between field studies.

According to Strauss and Corbin (1998), the data-gathering should be finished at the point of theoretical saturation. At this point, no new information emerges during coding. After 5 to 6 months of research the researchers were convinced that the point of saturation had been reached because the actors were using the ICT application at a level that was stable and no new concepts were being derived from the data. After the time spent in the field, the researchers took several months to go through the data again and to write down the storyline for each field study.

After each researcher had finished the storyline of his field study, the draft findings where fed back to the key participants in the field. This served two purposes. First, the actors could reflect on the findings. Second, the actors could reflect on the confidentiality of the results. Only one actor asked the researcher to keep a small descriptive part of the story confidential. Because of the spatial limits of this chapter, we will not present the entire storyline of each field study in-depth in the next section but just the condensed results.

3.3 Within field study analysis: the actual use of ICT over time

We studied the field sites over an extended period of time and documented the dynamics of interorganisational ICT use focusing on how ICT is used over time, why actors used ICT this way, and how events and actions influenced this use. In each field study, we identified several episodes. By episode we refer to "a set of events that stand apart from others, thus signifying the end of one sequence of activities and the beginning of another" (Newman and Robey, 1992, p.253). Each transition from one episode to another involves a substantial change in the way actors use ICT. In each field study, we will describe the use of ICT from the moment ICT is implemented in the project. However, the researchers did not always start their ethnographic research at that particular moment which means that in some field studies the researcher reconstructed the first part of the field study.

Below we present the findings of each field study. Because of space limitations, we will only present the highlights of each episode without trying to be exhaustive. We will also only focus on the interaction between organisations and will not elaborate on the intraorganisational use of ICT in the field studies. Several issues will be discussed more in-depth in Section 3.4 (the cross-field study analysis).

3.3.1 Field Study 1

Prologue

One of the engineering company's contract supervisors initiated the use of interorganisational ICT. He assumed that there would be important benefits in reduced administration time and costs, more structured communication, better process control, better document and information control, and faster exchange of information. *Before* the project was awarded to the contractor, the engineering company customised the application – together with the software vendor and a business consultancy company – based on its customary way of working and the administrative conditions that applied to this project. With the use of the application, the engineering company's internal processes and the interface with the contractor were automated. The engineering company specified the set of processes that this company intended to perform internally and externally to the contractor in the project. The software vendor incorporated these processes into the workflow management feature. Several groups of actors were identified in the engineering company's internal workflow processes which had one or more tasks to perform in the workflow processes. Because we focused on the interorganisational use of ICT we simplified this situation and identified only the contract supervisors and other actors within this organisation. The number of potential users is shown in Figure 3.1.

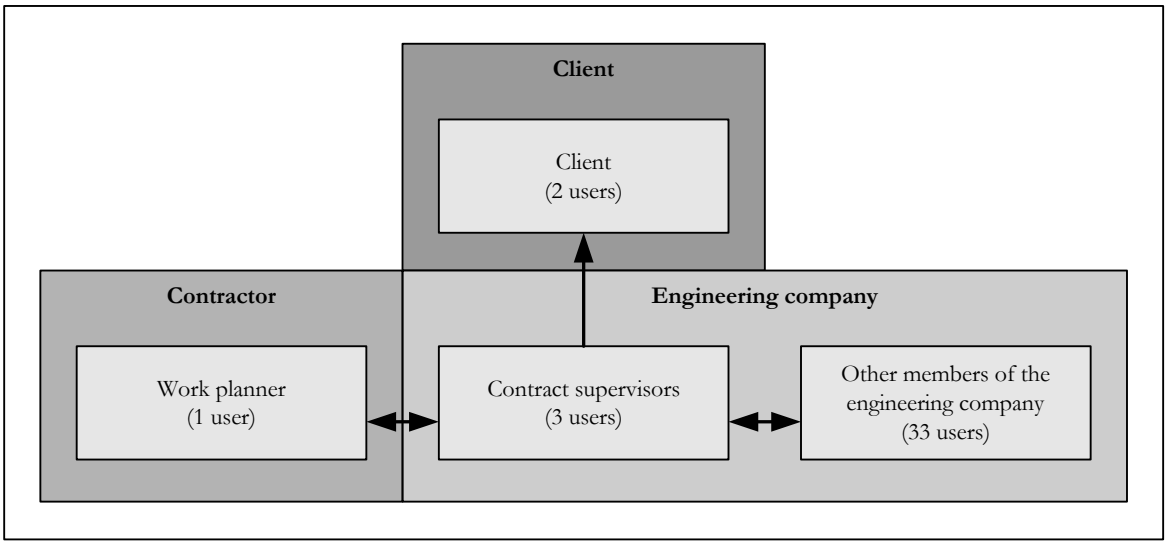

Figure 3.1: Simplified digital workflow processes of Field Study 1

Before actors started to use ICT, the engineering company who introduced it into this project had clear expectations about its intended use: *The application would be used for all formal communications between the contractor and the engineering company except for letters, meeting reports and drawings made by the engineering company, which have to be sent by ordinary mail. Digital communication would replace paper-based communications. The client would have viewing permissions in the application.* Some of the documents that the contractor sends to the contract supervisors have to be approved by the contract supervisors themselves, such as instalments, deviations, and extra work. Other documents, such as plans, noise measurements, and computations, need to be assessed by other actors within the engineering company. All the documents need to be stored in the ICT application as well (i.e., in the document management feature).

In the contract between them, the engineering company mandated the use of ICT for the contractor. In the contract, both the traditional paper-based communication processes as well as the digital communication processes were prescribed in order to create a safeguard in case the ICT application malfunctioned. It was also stipulated in the contract that when information is communicated in both paper-based and digital form then the digital communication takes precedence.

The contractor was allowed to use the engineering company's ICT application free of charge. However, the engineering company had not incorporated the contractor's internal working processes in the application (see Figure 3.1). The application was completely new to the contractor. After the contract was awarded the contractor was allowed to customise the application to his own working practices at his own expenses. He decided not to invest time and money in this customisation and made a work planner responsible for using ICT on behalf of the contractor. The contractor would communicate documents internally in the traditional – paper-based – way.

It took several weeks after the contract was awarded to the contractor to get the application up and running. During this time, the software vendor offered a 4-hours user training course to all potential users of the application and provided a user manual. In the meantime, actors used traditional means of communication such as ordinary mail, telephone, fax, and e-mail. None of the potential users had experience with the application. Bellow – and in the other field studies – the first episode starts at the moment ICT is up and running and actors can start using ICT.

Episode 1: Some actors try to use ICT (Weeks 1 – 6)[14]

The actors start the use of ICT from their offices, because until Week 18 (Episode 3) the construction trailer is not available. In addition, during this episode and the two other episodes the actors experience a high level of time pressure. The actors have to start using ICT in the context of this high level of time pressure.

The contractor (i.e., work planner) starts to use ICT immediately after it becomes available. However, after some initial attempts in the first weeks the contractor stops using ICT and returns to the use of the traditional – especially paper-based – means of communication. Other priorities prevail. This is mainly caused by time pressure, the contractor's scepticism about the application's abilities to support his quality management system (especially appropriate revision control and approval processes), and - to a limited extend – because of the opacity about the operation of ICT. However, this scepticism is also caused by the lack of response from the engineering company (see below). The work planner says: *"What are the benefits of using ICT when the contract supervisors do not respond?"* During this episode, the contractor always uses ordinary mail for sending documents to make sure that information reaches the engineering company. Thus, messages that the contractor sends digitally are also communicated in a paper-based form.

After receiving the messages (and the accompanying digital documents) from the contractor, the contract supervisors forward these internally to different actors within the engineering company. This results in 29 internal messages being sent, several containing indications of urgency. However, actors within the engineering company often send messages in the wrong way (e.g., documents are not linked to messages and messages are not received because they are not sent in the appropriate way). In order to reduce user problems, a software consultant provides user-support to actors within the engineering company on several occasions. By the end of this episode, actors within the engineering company have reacted digitally to the contract supervisors. However, the contract supervisors only react in a paper-based form, in meetings, or informally to the contractor. This is mainly caused by the high level of time pressure, opacity about the operation of ICT, and the fact that one contract supervisor is often located on the job-site where a Internet connection and computer are not yet available.

Episode 2: Actors start to use ICT in a structural way (Weeks 7 – 12)

The contract supervisors realise that they have to intervene in the use of ICT or it will be difficult to eliminate the backlog. This episode, therefore, starts with a clear statement being made in several meetings by the contract supervisors to both the contractor and the actors of the engineering company that everyone has to use ICT (*"From now on, we use ICT"*; *"If you [the contractor] don't communicate instalments by ICT we will not pay you"*; *"The use of ICT is a contractual obligation"*).

As a result of this clarity, the contractor's project leader is clear towards his internal organisation as well: *"We are going to use ICT"*. In the project leader's view, the use of ICT is a contractual obligation for the contractor and the contract supervisors are clear about its use. Therefore, the contractor starts to use ICT for communicating documents to the contract supervisors. During this episode, the contractor communicates 122 messages. The contractor perceives important benefits in using ICT for sending deviations. With the use of ICT he can communicate them much faster than in the traditional – paper-based – form, especially as participants are not yet located in the construction trailer. For the contractor, it is very important to record and communicate deviations as soon as possible. In addition, he does not have to keep a separate statement of the sent deviations anymore. However, with other communications the contractor does not always use ICT in the way that was intended by the engineering company:

[14] The researcher started his ethnographic research in Week 1.

- The contractor uses ICT only when he does not need to scan documents. Often the contractor receives documents in a paper-based form from subcontractors or suppliers, or he makes handwritten notes on documents. The contractor only has a normal rather than bulk scanner available. As a result, the scanning of documents costs a lot of time compared to paper-based communication. Therefore, the contractor minimises his scanning activities. He does not use ICT or he only communicates the first – signed – page of a document digitally instead of the entire document.
- Because of the unclear agreements about how to act, the contractor always communicates by using ordinary mail and ICT. Both the paper-based and digital working practices are mandated in the contract (see Prologue).

The contract supervisors arrange an instruction session for the contractor (i.e., work planner, project secretary) to increase the understanding of the application. The software consultant provides user-support. Therefore, the project secretary is also able to use ICT on behalf of the contractor. In addition, the software consultant makes some small changes in the application based on the contractors' and engineering company's experiences. A contract supervisor says about improvements in the application: *"It is important that the contractor sees the benefits of the application. Therefore, we spent time and money in improving the application for the contractor".*

During this episode, the contract supervisors start to use ICT to react digitally to messages. The contract supervisors communicate 76 messages to the contractor. However, the contract supervisors do not use ICT to approve deviations and extra work, because the workflow process in the application is not satisfactory to the actors involved. Instead they choose to discuss deviations in meetings.

In the engineering company, actors use ICT almost in the intended way. They always react digitally to messages. However, in their responses, the contract supervisors and other actors within the engineering company often refer to documents that are communicated in a paper-based form (e.g. drawings), informal agreements, or meetings. Thus, not all information is entered in the application.

The contract supervisors want to extend the original scope of the application to letters and drawings made by the engineering company. The contractor rejects this proposal because when the engineering company communicates drawings digitally to the contractor, the contractor instead of the engineering company has to plot these drawings if the contractor wants to use them on-site. The contractor has not included the costs of purchasing a plotter and cartridges, nor the time spent on printing drawings, in his bid. The same issue applies to letters: the contractor has to spend extra time digitalising letters. Because these digital practices are not specified in the contract, the contractor is able to refuse the engineering company's proposal.

Episode 3: Actors approximate the intended use (Weeks 13 – 27)
At the start of this episode, the contractor acquires a bulk scanner, which enables him to digitalise documents easily. In addition, at a meeting the contract supervisors and the contractor make clear agreements about the use of ICT *("All documents prescribed in the contract have to be communicated by ICT only"*).

Therefore, the contractor starts to use ICT in the intended way. The only exceptions are:

- Drawings and computations that need to be assessed by the contract supervisors. The contract supervisors prefer to receive these in a paper-based form as this meant that they do not have to plot or print them anymore.
- Drawings and schedules larger than A3 and documents in which colour is used. The contractor is not able to scan these with his bulk scanner.

- Drawings and computations that need to be assessed by government agencies after they are communicated to the engineering company. These need to be signed and stamped first before these are communicated to the agencies.
- Financial consequences of deviations. The workflow process in the application is not able to support this process in an appropriate way.

During this episode, the contractor communicates 492 digital messages to the contract supervisors. The contract supervisors and other actors within the engineering company use ICT in the same way as they did in Episode 2. The contract supervisors use ICT to communicate 207 messages to the contractor.

Two remarkable events take place during this episode. First, in Week 16, the client gains access to the ICT application. However, the client sees no reason to use ICT. He receives the information he needs from the contract supervisors (client: *"That is the advantage of being the client"*). Therefore, he does not use ICT. Second, in Week 18, the construction trailer becomes available to project participants. The contractor and the contract supervisors move straight into the trailer, but only in Week 22 does the Internet connection become available to the contractor. It takes about 3 months to arrange a secure Internet connection in the construction trailer and the contractor did not arrange this connection in time. In the meantime, the contractor communicates important information from his office.

It is important to note that in this final episode time pressure is still high. However, both the engineering company and the contractor get used to each other, to the application, and to the new way of working. Actors know how they have to use ICT and incorporate ICT into their daily routines. Therefore, time pressure is not restricting actors in their use of ICT anymore. Only sometimes actors (both contractor and engineering company) (1) communicate first in a paper-based form or informally and then send messages by using ICT later on to arrange things quickly or (2) send important documents in a paper-based form as well to be sure that information reaches the other person quickly.

3.3.2 Field Study 2

Prologue
The engineering company's project leader had initiated the use of interorganisational ICT in this project. He saw important benefits, especially in increased efficiency in formal communication. The application used in this project was an exact copy of the application used in field study 1 (see Figure 3.2) and was intended to be used in the same way between the contractor and the engineering company. However, in this field study, the client gained access to the application immediately after the application is introduced. The project leader made an ICT assistant (a member of the engineering company) responsible to arrange the implementation and to provide user support. In this project, the engineering company mandated the use of ICT towards the contractor in the contract in the same way as in field study 1.

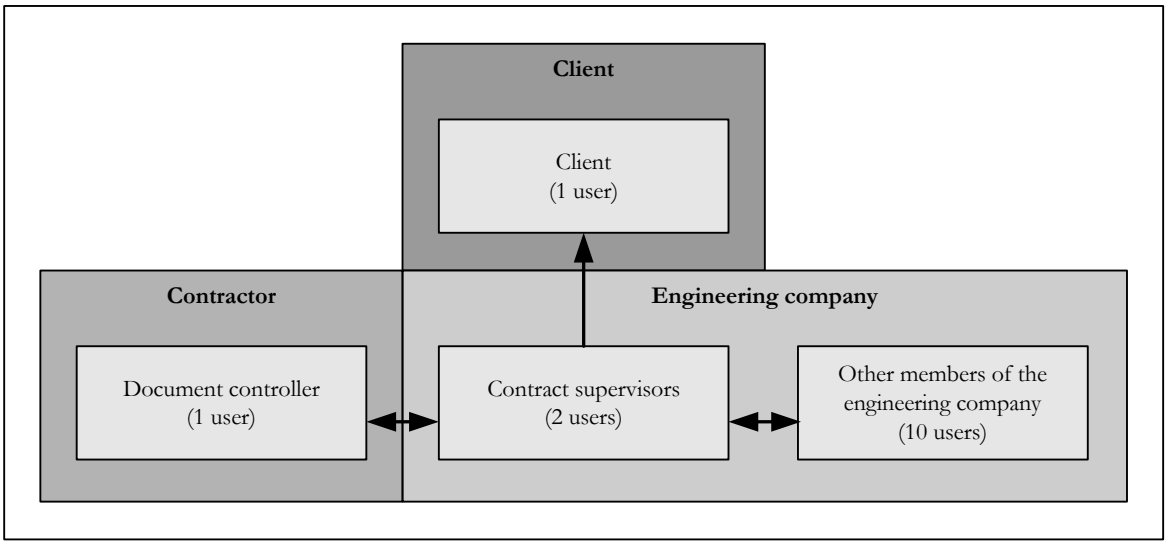

Figure 3.2: Simplified digital workflow processes of Field Study 2

The contractor was allowed to use the engineering company's ICT application free of charge. However, the engineering company had not incorporated the contractor's internal working processes in the application (see Figure 3.2). The contractor had no experience with the application and the application was completely new to him. After the contract was awarded the contractor was allowed to customise the application to his own working practices at his own expenses. He decided not to invest time and money in this customisation and made the document controller responsible for using ICT on behalf of the contractor. The contractor decided to communicate documents internally in the traditional – paper-based – way.

After the contract was awarded the same procedure was used as in field study 1: it took several weeks to get the application up and running, a 4-hours user training was offered, and a user manual was provided. In the meantime, actors used traditional means of communication such as ordinary mail, telephone, fax, and e-mail. Although the engineering company had already used the application in another project, none of the potential users had experiences with this application.

Episode 1: Contractor starts to use ICT (Weeks 1 – 11)[15]

The contractor (i.e., document controller) starts to use ICT immediately after it becomes available. Because the construction trailer is not yet available, the contractor communicates from a construction trailer of another construction project. The contractor communicates mainly deviations and extra work digitally. The contractor perceives important benefits in these digital communications; he wants to submit this information as quickly as possible and ICT is able to quicken this process. Other – more general – important benefits the contractor perceives in using interorganisational ICT are better process control, better document and information control, and faster exchange of information. As a result, the document controller tries to find out how the application needs to be used herself. However, she communicates extra work not in the intended way: the wrong workflow process is used. As will be explained below, during this episode, the contractor has to communicate digital information always paper-based to the contract supervisors as well. Both digital working practices as well as paper-based practices are mandated in the contract. This eliminates most of the contractor's potential efficiency gains. Other documents, such as work plans and instalments, are communicated by ordinary mail because the contractor does not have a bulk scanner in the other construction trailer. In the contractor's view it costs too much time to scan

[15] The researcher started his ethnographic research in Week 10.

all these documents. In addition, the document controller does not know exactly how these documents need to be sent digitally.

The contract supervisors do not use ICT. They communicate in the traditional paper-based way. The application has low priority to them because of the high time pressure they are experiencing in this and the other episodes. In addition, besides some benefits (e.g., better document and process control), they perceive important disadvantages of the use of ICT as well. They like to receive documents paper-based because (1) they can write their comments on these documents, (2) they do not have to print these documents themselves (i.e., they do not like to read from a screen), and (3) they can take documents to meetings easily. In addition, they perceive the use of ICT as an additional workload because issues that are already approved in meetings need to be approved in the application again. In their view, the use of ICT means that they have to carry out extra activities. Therefore, they do not use ICT and thus do not react on the messages communicated by the contractor. They request the contractor to communicate both paper-based and by using the ICT application. They say to the contractor that they will react on the paper-based version until they are located in the construction trailer. The engineering company's project leader and the ICT assistant try to override them to use the application. However, they do not succeed in that.

At the end of this episode, the contractor and contract supervisors move to the construction trailer. However, the contractor faces problems in arranging a secure Internet connection in the trailer. Therefore, the contractor stops using ICT. Although the contract supervisors move to the trailer they still do not use ICT. The contractor is not happy with this situation. The contractor's project leader says in a project meeting: *"We are using ICT whole the time, except the last two weeks because we moved to the trailer. We are shouting in the desert!"* and *"Every hour we invest in the application is a waste of time"*. The contract supervisors tell the contractor's project leader that the ICT assistant will start to react digitally on the contractor's messages and that he will support the contractor in using the application in the appropriate way.

The client does not use ICT in this and the other episodes. He says he does not have time to use the application and he does not perceive benefits in using the application. Therefore, the client receives all information paper-based from the contract supervisors. In addition, ICT is not used internally within the engineering company in this and the other episodes. Main reason is the restricted availability of the engineering company's project leader. The contract supervisors have to communicate documents digitally to the project leader in the application and the project leader has to forward these documents to actors within the engineering company. However, the project leader is only available on this project for two days a week. To avoid delays, the contract supervisors communicate internally directly in the traditional paper-based form. This reduced the value of the application to them.

Episode 2: Engineering company starts to use ICT (Weeks 12 – 13)

Because of problems with arranging a secure Internet connection in the construction trailer, the contractor does not use ICT during this episode and communicates only in paper-based form. It is important to note that the most important benefit to the contractor (i.e., quickening the process of communicating deviations and extra work to the contract supervisors) is eliminated by moving to the construction trailer. The contractor and the contract supervisors are located in the same construction trailer, which makes personal communication and information exchange easier. This factor plus the contractor's bad experience with the application, cause him to have a low motivation regarding ICT use.

During this episode, the ICT assistant starts to react digitally on behalf of the contract supervisors to the deviations and extra work sent by the contractor in Episode 1. Deviations and extra work are

first discussed and settled in paper-based form in meetings. The ICT assistant enters the results of these discussions in the ICT application. However, the ICT assistant is confronted with two problems when trying to do this:

- The workflow process developed in the application to support the submission and approval of deviations and extra work is not able to support the current (and desired) working practices. Actors are used to following at least two stages in this process. First, the contractor submits a deviation, which the contract supervisors approve or reject based on technical grounds (i.e., the necessity of the deviation). Second, the contractor submits the financial consequences of the deviation, which the contract supervisors might approve or reject. The result of the latter approval is extra work. In the ICT application, the distinction between these two stages is not made. Therefore, the contract supervisors can approve deviations in the application only when these are financially approved.
- The contractor used the wrong workflow process for communicating extra work. The contractor is requested to communicate extra work again by using the right workflow process.

The contractor is asking repeatedly for clarity about the way the ICT application should be used. The contractor does not want to think out himself how the application should be used. The document controller says: *"If the engineering company wants us to use ICT, then they also have to provide clarity"*. However, the contract supervisors and the ICT assistant are not able to provide this clarity to the contractor.

Episode 3: Contractor and engineering company try to use ICT (Weeks 14 – 16)
This episode starts with a request being made by one of the contract supervisors that the contractor should use ICT. In his view, the absence of an Internet connection might not be a reason that ICT is not being used. In addition, the use of ICT is a contract obligation. After this request, the contractor arranges a dial-in connection within two days. The contractor starts to communicate deviations and extra work digitally to the engineering company again. All information is communicated in paper-based form as well. The ICT assistant reacts on behalf of the contract supervisors digitally to deviations and extra work after these have been discussed and approved or rejected in meetings.

For several reasons the contractor's attitude towards the use of ICT becomes very negative:

- No efficiency gains are realised because information is always communicated twice (i.e., digitally and paper-based).
- The way ICT needs to be used is still unclear and its use seems to be very illogical.
- ICT is used differently than mandated in the contract.
- The application is not aligned with the contractor's quality management system (e.g., messages are not signed, there are unclear revision controls, the workflow process for deviations and extra work is not appropriate).

The only reason why the document controller (i.e., contractor) uses ICT in this episode is because this use is mandated in the contract. However, the use of ICT causes a lot of frustration and additional work. Therefore, at the end of this episode, the contractor's project leader allows her to stop using ICT until the application functions well and the way it should be used is clear. He writes a letter to the contract supervisors to formalise his decision.

Episode 4: Contractor and engineering company do not use ICT (Weeks 17 – 22)
At the start of this episode, the contract supervisors have a meeting with the ICT assistant, the head of their department, and a contract supervisor from Field Study 1. During this session, the contract supervisors mention their complaints about the application and their time constraints. It appears

that the contract supervisor from Field Study 1 is able to give practical solutions to the problems that the contract supervisors are facing in their project and he points out that the application is also being used in the wrong way sometimes. At the end of this meeting the head of the department decides that the contract supervisor from Field Study 1 will provide support during this project to overcome the problems.

During this episode several meetings take place in which the contract supervisor from Field Study 1 responds to user questions and explains how problems are solved in his project. Participants discuss how the application should be used (e.g., which documents need to be scanned and attached to messages and which documents not, what is the easiest way to use the application, how can the contractor still work according to his own quality management system when using ICT). However, the contract supervisor from Field Study 1 is not able to answer all the questions. It becomes apparent that actors need to make clear agreements about the way the application should be used in *their* own project (e.g., what kind of information do the contract supervisors want to receive digitally). The sessions offer clarification for participants and they start to adopt a more positive attitude towards the application. However, they also question how they could have figured out how to use the application for themselves.

At the end of this episode the application is cleared, changes are made in the workflow process for deviations and extra work, and agreements are made about the way the application is going to be used thereafter. These agreements are in line with the 'intended' use (see Prologue of Field Study 1). Participants want to start again from scratch with an application that is able to support their working practices.

Episode 5: Contractor and engineering company use ICT and traditional means (Weeks 23 – 34)

At the beginning of this episode, the contractor starts using ICT again, initially with deviations, which are most important to the contractor. After a while, other documents that are intended to be communicated digitally also follow (see Prologue for intended use). The contract supervisors are supposed to react digitally to messages because the ICT assistant is not able to assist in this project any longer. However, the contract supervisors do not react for the first 3 weeks. A contract supervisor says: *"I have to invest time to learn to use ICT. We have to use the application. However, we set our priorities differently at the time. (…) We need extra capacity on this project. As long as extra capacity is not arranged, we will not use ICT that much"*. This situation is very annoying for the contractor. The document controller says: *"I invested a lot of time in importing data in the application. That seems to have been a waste of time"*.

After three weeks, the engineering company's team is expanded to include a project assistant. She starts to react digitally to the messages communicated by the contractor. From that moment, the engineering company starts to use ICT at a stable level. However, this does not mean that the contractor and the project assistant communicate in the intended way. Actors communicate digital information in paper-based forms as well. They communicate first in the traditional way and then later on information is communicated digitally. When they need to assess information they use paper-based forms instead of digital documents. This means that a new means of communication is added to the traditional means of communication. Actors choose to communicate in this double fashion for several reasons:

- Deviations and extra work are first discussed and approved in meetings before they are communicated.
- Actors do not want to stop communicating in paper-based forms because of their lack of confidence in the ICT application.

- The application still does not dovetail with the contractor's working practices (especially with his quality management system: e.g., revision controls, fields in messages do not correspond with fields in his standard paper deviation forms). Therefore, the contractor still prefers to use paper-based forms of communication as well.
- The contract supervisors still want to receive documents in paper-based form.

In addition, drawings are communicated in paper-based form because these cannot be scanned and plotted in the construction trailer.

3.3.3 Field Study 3

Prologue
The client's contract manager initiated the use of ICT in this project after the contract was awarded to the contractor. He was particularly convinced of the value of more structured communication between contractor and client. In addition, the client intended to use the application as a new corporate application when it proved to function well in this project. However, the use of ICT had not been mandated towards the contractor in the contract. The contract manager proposed that the contractor would use interorganisational ICT. The contractor's contract manager wanted to use the application as well. He perceived great value in faster response times, and shorter lead time, but he did not want to invest money in the ICT application. Therefore, the client decided to pay for the application, the customisation of the application, and the user support. The contractor was allowed to use the client's application free of charge. He only had to invest time to make the software vendor customise the application to his own working practices. In the end, the ICT application was introduced about one year after the client awarded the contract to the contractor. Before ICT was introduced actors used traditional means of communication such as ordinary mail, telephone, fax, and e-mail or had informal talks. The actors already moved months before ICT was introduced to the construction trailer.

The client had a clear opinion about the intended use of ICT: *The application would be used to support the deviation processes between client and contractor. Digital communication would replace paper-based communications in the construction trailer.* This decision was based on three main arguments. First, the client wanted to use the application only for communication on the job-site. He wanted to use a local server in the construction trailer because of the bad experiences he had had with the use of a web-based application in a former project. In that project the contractor could not access the client's server because of the client's secure corporate network. Second, the client wanted to use the application only to support deviation processes. By limiting the application to only these processes, the client wanted to focus on communication that occurs regularly between client and contractor and therefore he limited the complexity of the application. When the application proves to function well the scope of the application might be expanded to other processes. Third, the application would not be used for document control because: (1) many documents are only provided in paper-based forms by other organisations, (2) digitalisation of all paper-based documents that were already archived by the contractor in a central paper-based document control system before ICT was introduced costs a lot of time, and (3) documents often need to be transferred to other organisations which want to receive these documents in a paper-based form.

The client and contractor agreed that the application would be used to support only deviation processes. These processes consist of the following main steps:

- *Submission of deviations:* both the client and contractor can submit a deviation, which is an alteration to the contract. A deviation can have financial consequences but can also have other consequences related to the specifications mentioned in the contract. When an organisation submits a deviation, it has to be approved by the other organisation.

- *Submission of estimates:* when a deviation has financial consequences, the contractor submits a cost estimate. This estimate has to be approved by the client before the contractor starts to carry out activities related to the deviation.
- *Submission of ready signals:* after the contractor has carried out his activities, he submits a ready signal. After the client has approved this ready signal, the contractor can start with the financial settlement of the deviation. This financial settlement is carried out in the traditional – paper-based – way because ICT is only used internally in the construction trailer.

The client (i.e., contract manager) and contractor (i.e., contract manager and ICT coordinator) customised the application – together with the software vendor and a business consultancy company – based on their customary way of working and the administrative conditions that applied to this project. Using the application, both organisations' internal processes and the interface between the organisations were automated. The software vendor incorporated these processes in the workflow management feature. The simplified workflow processes – focussing on the interorganisational use of ICT – and the number of potential users are shown in Figure 3.3.

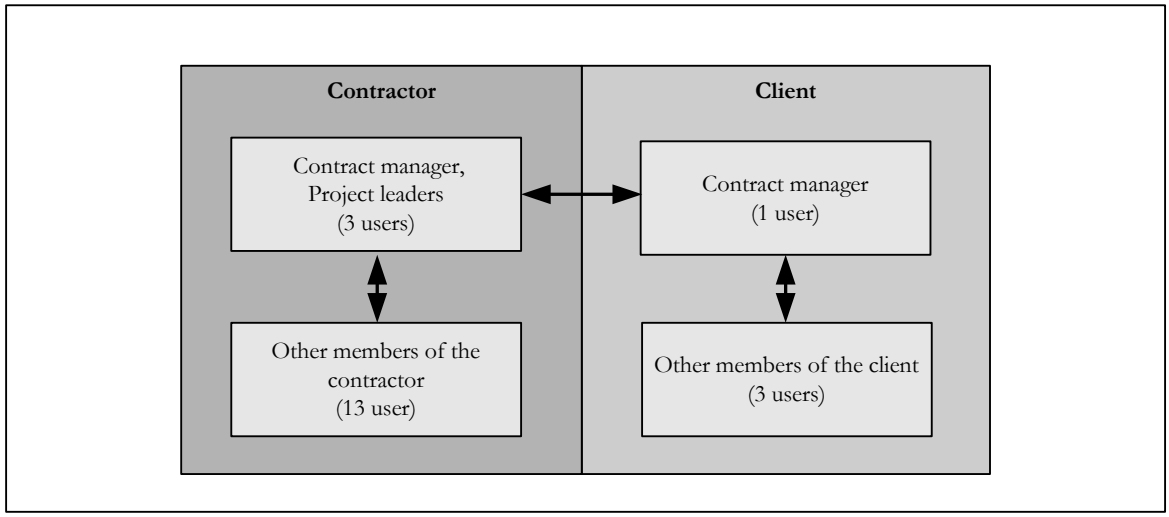

Figure 3.3: Simplified digital workflow processes of Field Study 3

After the application was customised the contractor's ICT coordinator, the business consultant, and the software consultant conducted a limited number of test activities. They only tested the workflow processes and not the functionalities of the software application itself. In their view, the application had already been proven to work in another project in which other organisations had used it.

Some days before actors start to use the application, the contractor's ICT coordinator offered an introduction session to some of the potential users of both the client and contractor. In this session, he only gives a presentation about the application and the workflow processes; potential users did not operate the ICT application themselves. However, not all the potential users are able to attend this session. Both contract managers do not want to invest much time in user training. In their view, they prefer "learning by doing". None of the potential users had prior experience of the application.

Episode 1: Actors start to use ICT (Weeks 1 – 3)[16]

The contractor starts to digitally send new deviations *with* financial consequences immediately after the application becomes available. From this moment, these messages are only sent in digital form and no longer in paper-based form. The contractor intends to digitally communicate the next steps

[16] The researcher started his ethnographic research 2 weeks before Episode 1 began.

within the deviation process (i.e., estimates, and ready signals) as well when these deviations are approved in the application. The volume of information that needs to be communicated is low in both this episode and the others. The first week the contractor sends 3 deviations to the client. The average for all episodes is about 5 new messages a week sent by the contractor. The client (i.e., contract manager; he assesses most deviations himself) digitally reacts to these deviations quickly. After the first week, the contractor imports all deviations that have already been communicated in paper-based form before this episode and still need to be approved by the client (i.e., 30 deviations) in the application because, from now on, the client wants to approve all deviations digitally. It takes the ICT coordinator one day to import these deviations.

At the beginning of this episode, when actors within the contractor start to use ICT they do not know exactly how to use the application. This is mainly caused by the limited user training. However, these problems are solved quickly by user support being provided by the ICT coordinator.

The contractor experiences a lot of time pressure in this (and other) episodes. Therefore, deviations are often discussed first with the client before they are communicated by ICT. These discussions take place especially in formal meetings but also informally. Both the client and contractor say: *"The project has to proceed"*. As a result, not all deviations are imported in the application; the contractor has a backlog in the use of the application. In addition, the contractor often asks the client for solutions in meetings first instead of thinking out solutions himself. This limits the contractor's (design) activities and decreases the risk that the client rejects solutions. However, this limits the use of ICT as well: ICT is not used for discussing deviations but only to record the outcome of these discussions.

The contractor questions the legal status of digital communication because the traditional paper-based practices are mandated in the contract. Therefore, in Week 2, the contractor (i.e., the ICT coordinator) formulates a deviation in which the use of ICT and the consequences of its use are included. This deviation means a modification to the contract. In this deviation, for example, it is formulated that (1) actors do not communicate deviations and estimates in paper-based form any longer and that digital deviations and estimates are not signed; digital communication has legal status, and (2) a statement of approved and rejected deviations, estimates, and ready signals will be signed by the client and contractor in contract meetings.

In Week 3, the ICT coordinator changes jobs. He leaves the contractor and starts to work at the software vendor. However, the client hires him for this project, for example, to spot and solve software problems, and to provide user support.

Episode 2: The contractor stops using ICT because of technical problems (Weeks 4 – 8)
The contractor faces many technical problems with the use of the application. The ICT coordinator has already recorded 50 shortcomings in the application. The main problems for the contractor are:

- *Attached documents are not sent:* when the contractor attaches documents to a message, these attachments are often not sent by the application. Therefore, the client rejects these messages and the contractor has to send the messages again hoping that the attachment will be sent this time.
- *Copy/paste functionalities are lacking*: the contractor wants to copy information from his internal messages to the external messages he sends to the client. However, copying information is not possible. As a result, the contractor has to enter all the information in the external messages again.
- *Statement of deviations is not appropriate*: the statement of deviations does not provide the needed overview of the deviation process. This overview is important to the contractor, because the

contractor and client agreed (and formalised in a deviation; see Episode 1) that they would formally approve (i.e., sign) statements of deviations in contract meetings.

- *Unclear names of messages*: unclear names of messages cause confusion in the use of ICT (e.g., which message has to be used for which information?). In the end, actors did not use the wrong messages because they could consult the ICT coordinator if they were confused. He repeatedly explained the way that ICT should be used.
- *Mistakes in workflow processes*: the contractor is not able to forward the client's reaction to submitted deviations or estimates internally within his organisation.

The problems mentioned above cause much frustration within the contractor's organisation. As a result, the contractor stops using the application at the start of this episode. The contractor does not have enough confidence in the application. He only wants to use ICT again if technical problems are solved. However, deviations are not sent in paper-based forms as well because the client and contractor agreed (and formalised in a deviation; see Episode 1) that deviations would be communicated only digitally. The contractor discusses urgent issues and the way these need to be solved with the client only in meetings.

During this episode, the software vendor implements several improvements in the software. However, the main problems (i.e., the problems mentioned above) are not solved in a satisfactory way. During this episode, the contractor only sends some test messages in order to assess the improvements.

The client is not aware of the contractor's technical problems and the contractor's decision to stop using ICT. At the end of this episode, the client's contract manager starts to question the contractor's use of ICT and the limited amount of deviations he communicates. He says: *"I can't imagine that everything is going that well on the job-site"*. In a meeting between the client's contract manager, the contractor's contract manager, and the ICT coordinator, the problems with the application are explained. In the contractor's project leader's view the application is unreliable and not user-friendly because of technical problems. He says: *"The use of the application is a pilot. (…) You become demotivated as a result of all these shortcomings"*. According to the contractor's contract manager the application was not tested and evaluated in a sufficient way before actors started to use the application.

Some days later in a follow-up meeting that the software vendor and the business consultant attend as well, the actors discuss the status quo and the possibility of solving the technical shortcomings and of making the application user-friendlier. The client wants to invest in improving the application because when the pilot is successful the client will start to use the application in other projects as well. Therefore, he wants to solve the technical shortcomings as soon as possible and to make the application easier to use so that the contractor will use it again. Actors decide that they will restart using ICT when the problems are solved. When deviations can be communicated appropriately, they will continue with estimates and ready signals.

Episode 3: Actors start to use ICT again (Weeks 9 –15)

At the start of Episode 3, some important technical shortcomings are solved: problems with attachments are reduced in an important way (with problems only occurring now and then), copy/ paste functionalities are added, names of messages are changed, and changes are made in workflow processes. Therefore, the contractor starts to use ICT again – for sending deviations at first but then quickly expanding his use to include estimates and ready signals as well, but only if these are the result of deviations that have already been approved digitally. These messages are only communicated digitally. When communicating messages sometimes the attached documents are still not sent with a message. Although this causes confusion, this does not make the contractor stop

using ICT; he just resends these messages with the attached documents. The software vendor still does not solve the problems with the statements of deviations.

The client reacts to messages communicated by the contractor and starts to use ICT to submit deviations to the contractor himself for the first time. In Episodes 1 and 2, no deviations had to be communicated by the client himself. The client perceives important benefits in communicating these deviations digitally: the status of deviations is completely clear. This clarity used to be a problem in the project. However, actors within the client organisation do not know exactly how to act (i.e., who has to do what in the application? Can they send deviations straight to the contractor or does the contract manager need to approve these messages first?). The ICT coordinator provides support in order to solve these user problems.

During this episode, the contractor wants to communicate deviations *without* financial consequences digitally as well. In Episodes 1, and 2, no new deviations without financial consequences needed to be communicated to the client. The contractor wants to submit these deviations in a digital way in order to use ICT for *all* deviations and to get an overview of *all* deviation processes. However, the client is not able to approve or reject these deviations because of shortcomings in the workflow processes. Therefore, the contractor decides not to communicate deviations without financial consequences digitally at this point in time.

At the end of this episode, the client, contractor, software vendor, and business consultant evaluate the functioning of the application again. According to the contractor's contract manager, the application functions better. The understanding of the application is increased and the purpose of the application becomes clear. The contractor's attitude becomes more positive. However, the lack of appropriate statements about the deviations is very frustrating for the contractor because he wants to sign statements of deviations in contract meetings.

In the evaluation meeting both contract managers complain about the amount of time they have to spend on implementing and improving the application. The contractor's contract manager says: *"[Contractor's project leader] already wanted to stop using ICT just 2 weeks after its introduction. Because [ICT coordinator] spent so much time in making the application work, we continued using it. Now we understand the purpose of the application. However, the application is still quite error sensitive"*. The software vendor reacts: *"More time needs to be invested in user training and user support"*. In this meeting, the client's contract manager proposes that communicating in paper-based form should stop and that the application should be used to support *all* communication within the complete deviation process. This means that all estimates that have not yet been communicated digitally and for which ready signals have not yet been approved need to be imported in the application. When this happens, paper-based communication will be completely eliminated in the deviation processes, and actors will be able to get an overview of the whole deviation process in the application. The contractor's contract manager agrees on the condition that the problems with the statement of deviations and estimates are solved.

Episode 4: Actors start to use ICT for the complete deviation process (Weeks 16 – 20)
At the start of this episode, the ICT coordinator imports all the estimates (about 35 items) in the ICT application for which the client has not yet approved the ready statements. Deviations for which ready signals have already been approved in paper-based form are not imported in the application (about 70 items).

During this episode, the software vendor implements improvements in the workflow process for deviations without financial consequences. Therefore, the client is able to approve or reject deviations without financial consequences. The contractor starts to communicate these deviations

digitally and imports all the deviations that are already approved in paper-based form but for which ready signals have not yet been approved in the application (about 100 items).

In this project, the contractor is responsible for detecting construction failures and for formulating measures to correct these. The client monitors the contractor in carrying out this control process. The contractor uses the ICT application to record these 'internal deviations'. The client does not have access to these internal deviations. However, during this episode the client discovers new ICT opportunities. He asks for insight into the contractor's internal deviations. When the client gains insight it is easier for him to monitor the contractor in detecting failures on the job-site and in formulating and carrying out measures to solve these. However, the contractor's contract manager refuses this proposal. He prefers to discuss these issues in contract meetings instead of giving the client access to his internal communications.

At the end of this episode the contractors' and client's contract managers agree that they are starting to realise important benefits from the use of ICT such as faster response times, shorter lead time, and better process controls.

3.3.4 Field Study 4

Prologue
The client's financial mandatary[17] and contract manager initiated the use of ICT in this project after the contract was awarded to the contractor. The main benefits that the client perceived were better document and information control, and more structured and traceable communication. However, the use of ICT was not mandated for the contractor in the contract. Therefore, the contract manager proposed that the contractor, the engineering company, and the subcontractor should use interorganisational ICT. The client would pay for the application, the development of the application, and user support. The other organisations only had to invest time to fit the application to their purposes and working practices. The other organisations agreed on this proposal, because they saw important benefits as well. They formalised this agreement in order to give it a contractual status. Note that in this project, the actors do not work from a construction trailer but from their offices.

The organisations were going to use two different applications from two software vendors: one application for the client (and the engineering company that acted on behalf of the client), and one application for the contractor (and the subcontractor who belonged to the same organisation as the contractor did). These applications were able to exchange messages and attached documents. The client and contractor customised the application – together with the software vendor and an external business consultancy company – to their working practices and priorities. However, the contractor is not involved in the selection of the application. The application appeared not to fit the contractor's objectives (document control, in particular, is lacking in the application). In addition, the engineering company and subcontractor were not involved in the customisation of the application. The client wanted to focus on the application of the client, the application of the contractor and digital communication between these applications. The engineering company was supposed to use the client's application and the subcontractor the contractor's application. The simplified workflow processes and the number of potential users are shown in Figure 3.4.

[17] The person in charge of the finances.

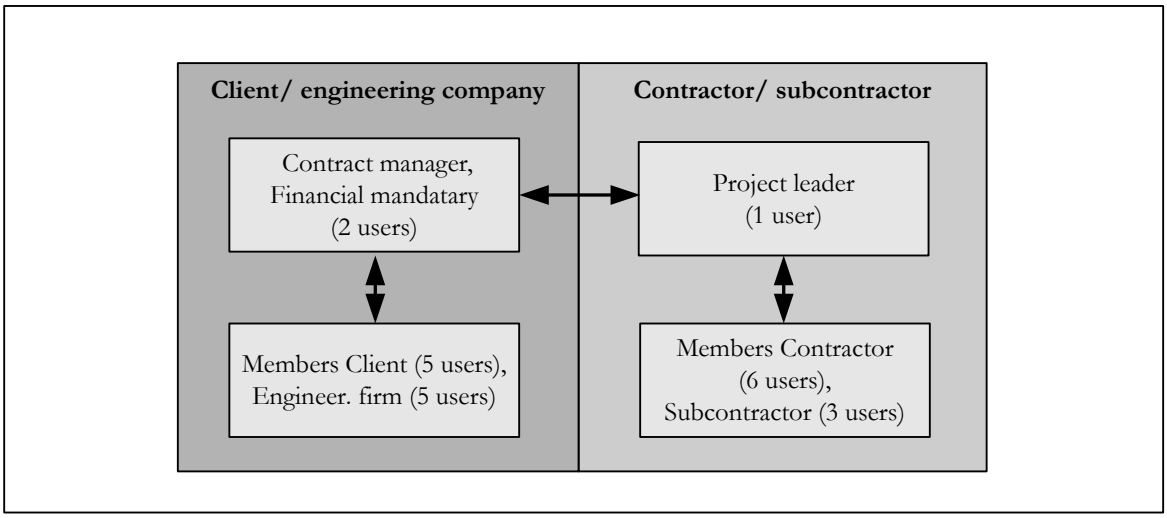

Figure 3.4: Simplified digital workflow processes of Field Study 4

Participating organisations had clear expectations about the intended use the ICT: *ICT would be used to support all formal communication between client, engineering company, contractor, and subcontractor. The only exceptions are invoices and minutes of meetings. Digital communication would replace formal paper-based communications.* This means that drawings would be communicated digitally as well. In this field study, drawings were made in A4 format.

Actors wanted to start using the application as soon as possible. Because of resulting time pressure only a limited number of test activities were conducted. Test activities focused on the interaction between both applications. During the test, the engineering company became involved in the customisation process for the first time. At the end of the test there were some technical problems left in the contractor's application. In addition, the workflow processes were not customised to the engineering company's working practices. Therefore, based on a proposal made by the engineering company, some changes were made in the workflow processes. The client paid for these changes.

Each software vendor arranged a – limited – introduction session to potential users before they started to use ICT. In these sessions, the software vendor demonstrated some digital communication processes; potential users did not use the application themselves. An actor from the client says about the introduction session: *"If a fast software consultant shows how the application needs to be used it all looks very easy. However, remembering how he did it and copying his acts when you have to use the application yourself is a different story".*

Actors started using the application 3 months after the project was awarded to the contractor. Until the application was up and running actors used ordinary mail and e-mail to communicate documents and messages to other actors. Actors only had to communicate a limited amount of information these months.

Episode 1: The contractor and the client start to use ICT (Weeks 1 – 5)[18]

Only the client and the contractor start to use ICT during this episode. The client wants to limit the scope of the application to these organisations to limit the risks of malfunctioning. In the client's view, the scope of the application will be expanded to include the engineering company when ICT has proven to function well. The client and contractor use e-mail to communicate with the engineering company. The subcontractor is not involved yet in this episode. In this and other episodes actors experience only limited time pressure.

[18] The researcher started his ethnographic research in Week 33.

The number of messages that the client (i.e., contract manager and financial mandatary) and contractor (i.e., project leader) communicate to each other is only small in this episode (12 messages are sent between client and contractor). These messages are sent digitally and no longer in paper-based form. This volume and the use of only ICT to communicate formal communication apply to Episodes 2, 3, and 4 as well. Often the client and contractor discuss issues in meetings or informally by e-mail or telephone. Important decisions are always formalised by using ICT. The software vendor provides user support to the client several times in order to solve user problems. The contractor's project leader does not need any user support because of his involvement in customising and testing the application. As a result of obtained insights in the ICT application, he is able to solve user problems himself. In this episode, client and contractor have to make some additional procedural agreements about the use of ICT. They are able to make these agreements quickly.

The contractor tries to use ICT internally as well. In order to guide actors in using the application the contractor's project leader provides user support. However, actors face difficulties in using the application because of several technical shortcomings in it (e.g., sent messages do not always reach the receiver, a lack of overview over sent and received messages). As a result, some actors within the contractor use ICT but others start to use traditional means of communication again (i.e., e-mail).

The application is not used internally within the client's organisation, because nothing had to be communicated internally during this episode.

Episode 2: The engineering company starts to use ICT, and the contractor stops using ICT internally (Weeks 6 – 39)

In the client's view, the application is stable enough to give the engineering company access to the application. Therefore, the engineering company gains access to the client's application. However, the engineering company is facing difficulties with accessibility restrictions of his internal corporate network. The engineering company implements a remote desktop solution to solve this problem. However, the solution is not completely satisfactory. Only one person at a time can use the remote desktop and thus the application. In addition, adding attachments to a message is very time consuming. As a result, the engineering company decides to communicate attachments by using e-mail. When attachments need to be sent, actors use the ICT application and in their messages they refer to e-mails to which the documents are attached.

The contractor starts to face problems when sending messages to the client with documents attached. Often the attachments are not sent although they are attached to a message. In these situations, the client rejects the messages because of the missing attachments. This is very annoying for the contractor's project leader. As a result, he has to send these messages with accompanying attachments again (this happens 11 times) or he communicates the attachment by using e-mail.

In spite of the software vendor's efforts to improve the functionalities of the contractor's application, this application still functions in a dissatisfactory way for the contractor's project leader. Therefore, he decides to stop using ICT internally within his organisation at the start of this episode. In his view internal communication deteriorates rather than improves because of the use of ICT. In addition, it costs him too much time to support actors within his organisation in using ICT. Only the contractor's project leader continues to use ICT to communicate with the client. He still perceives important benefits of the use of the application for the future. Other actors start to communicate in the traditional way again.

The contractor and the client use only ICT to communicate formal information to each other. The only exception is reports of meetings and invoices. Participants use e-mail to communicate reports of meetings and paper-based documents for communicating invoices. E-mail is used as well (1) to bring to someone's attention that a message has been sent, that the other has to react to a message or that response times have expired, and (2) for sending attachments. Often, after meetings are finished, the volume of communication increases because actors are formalising the arrangements made in the meeting by using ICT.

Internally within the client's organisation, actors start to use ICT because the financial mandatary and contract manager start to forward messages to actors within their organisation. The financial mandatary and contract manager are very clear to the actors within their organisation that they have to use ICT. Thus, these actors have no other choice then to use ICT. According to an actor within this organisation he would not have used ICT if this mandate was not present. A software vendor provides user support several times to actors within the client organisations in order to solve user problems.

The subcontractor starts to become involved in the project during this episode. However, because ICT is not used internally within the contractor's organisation, the subcontractor uses traditional means of communication. Actors working for the subcontractor tend to communicate directly with actors from the client and contractor instead of communicating via the contractor's project leader.

Based on their experiences with the ICT application the contractor and the engineering company feel the need to implement changes in their applications half way through this episode. The engineering company's experience led them to conclude that the proposed and implemented changes in the workflow process (see end of prologue) do not reflect their working processes very well. Therefore, the engineering company wants to change the workflow processes in the application. In addition, the engineering company wants to eliminate the unsatisfactory solution to the problems in the corporate network. As a result, the engineering company does not want to continue using the client's application but wants to use an application locally on his own server.

The contractor's project leader in turn is not content with his immature application. The main problems are the limited overview over messages, problems with attaching documents, and missing document management features. In addition, he wants to expand the scope of the application to his internal organisation and the subcontractor again, and he wants to include informal communication in the application as well. He has two important reasons for this. First, he wants to get an overview of the informal communication between the subcontractor and the client. The subcontractor often carries out projects for the client and therefore actors from these organisations know each other very well. They are used to communicating personally with each other. This makes the contractor's project leader unaware of their communications. Second, in the project leader's view, actors often communicate informally. When they have to use ICT for their informal communications as well, they have to use the application more often. Therefore, they get used to the application more quickly.

Therefore, the contractor and the engineering company want to implement changes. The client does not feel a need to implement any changes. He is very satisfied with his application. Therefore, the contractor and the engineering company take the initiative of implementing changes. The last two months of this episode are used to prepare these improvements. During these months, actors only communicate urgent issues with the application. Other communications are saved up for the time that the changes are implemented.

Episode 3: Actors implement improvements (Weeks 40 – 52)
In this episode, the contractor and the engineering company implement several improvements:

- *Changes in used applications:* the contractor implements a new ICT application (Week 40) and the engineering company implements his application locally (Week 45). The contractor and subcontractor are going to use the same application as the client and the engineering company do.
- *Changes in workflow processes:* the contractor and engineering company implement changes in the workflow processes (e.g., changes are made, a workflow for informal communications is added) (Week 44). The changes are approved and tested in a test environment first by representatives of the organisations involved before they are implemented in the application. Changes are explained to actors who are already using ICT and a – very general – user manual is provided for these actors.
- *Changes in actors using the applications:* the scope of the application is expanded to the contractor's internal organisation and to the subcontractor (Week 53; start next episode). To prevent confusion and frustration, the contractor's project leader only wants to expand the scope of the application to other actors when the two former changes have proven to function well. At the end of this episode an instruction session is provided for potential users. In this session, the use of ICT is explained and actors were able to try to use the application themselves. In addition, the contractor provides a – very general – user manual for these actors.

Immediately after the contractor's new application is implemented (i.e., improvement 1) the contractor's project leader starts to use ICT intensively (in Week 41 - 11 messages are communicated). However, after this first week actors use the application to communicate only 10 messages until changes in the workflow processes are implemented at the end of Week 44. After this implementation, actors start to use the application intensively again (in Weeks 45 and 46 - in total 48 messages). Actors saved a number of these messages up in the months before the changes are implemented and a number of other messages could not be communicated using the former workflow processes. Actors are positive about the changes in the applications and in the workflow processes.

In a meeting the contractor, engineering company, and client discuss the client's response times to messages communicated by using the ICT application. The client still has to react to many messages. This is a problem for the other actors involved. The client's contract manager claims that he replied to messages, however, his replies cannot be traced in the application. The contractor and engineering company propose using traditional means of communication (i.e. e-mail) again when the application proves to malfunction. In that situation, messages will be imported in the ICT application at a later moment in time. According to the contractor's project leader, it is of utmost importance that messages and accompanying documents are approved in time. When documents are approved late, the contractor cannot start in time and this will jeopardise the project's progress.

At the end of this episode, the scope of the contractor's application is expanded to his internal organisation and the subcontractor's.

Episode 4: Expansion of ICT use to the contractor's internal organisation and the subcontractor (Weeks 53 – 61)
At the start of this episode, someone from the engineering company replaces the client's contract manager. Together with the financial mandatory, he eliminates the backlog in reacting to messages. Therefore, in one day in Week 54 they send 27 messages to the contractor and the engineering company. For the rest of this episode, new messages are only occasionally sent between actors because there is nothing more to communicate.

In Week 57, the software vendor's server crashes. Users have to work temporarily on another server. However, the application on the server is not identical to the application users are familiar with. In addition, users are regularly confronted with an inaccessible server, different versions of the application, error reports, and messages that are not received. It takes the software vendor about one week to solve the server problems. In the meantime, actors communicate, discuss, and approve several deviations in meetings instead of in the ICT application. The server crash influences actors' confidence in the application in important ways. Actors use e-mail again in which actors indicate that a message is being sent by ICT.

The new users within the contractor's organisation prefer to communicate informally to the contractor's project leader because they are not familiar with the application yet. Therefore, actors do not get used to the application. According to the project leader, the only way to get them used to the application is by forcing them to use ICT. Bad experiences with the application in Episode 1 and the server crash in this episode influence most actors' attitude to the use of ICT negatively. They only have limited confidence in the application. One actor says: *"If they want me to use the application, then it has to work well. Otherwise I will stop using it"*.

The new users within the subcontractor's organisation endorse the benefits of the use of the application, especially for the contractor's project leader. However, they hardly ever use the application. One important reason is that hardly any messages need to be communicated. Another main reason is – as discussed above – that actors within the subcontractor's organisation are used to communicating personally with the client. Other reasons for their limited use of the application are the problems with accessing the web-based application (because of the server crash), the limited amount of available time to learn to use the application, and their limited basic ICT skills and general ICT experience.

Because in this stage communication between actors was almost non-existent and was not expected to change in the short run, the researcher decided to leave the field site.

3.4 Cross-field study analysis: mechanisms influencing the use of ICT

In this section, we will focus on the analytical mechanisms that influence the use of interorganisational ICT over time. Based on our field studies and the method of grounded theory, we are able to determine the preliminary framework as shown in Figure 3.5. This framework consists of several categories and subcategories as well as the relationships between categories, subcategories, and finally the use of interorganisational ICT. From our field studies it follows that these categories and subcategories could be positively (driver) and/or negatively (barrier) related to the use of ICT. These mechanisms are dynamic: barriers can become drivers and vice versa. Using the theoretical framework, the use of ICT during the different episodes described in the previous section can be explained. The four categories and the subcategories influencing these categories are discussed in detail in this section. In this discussion, we refer to the structural use of ICT, which takes place in each episode and avoid giving anecdotal evidence. Based on the discussion in this section and the confrontation between our mechanisms and submechanisms, and existing theoretical models about the adoption and use of ICT, we will present a refined theoretical model in the next section.

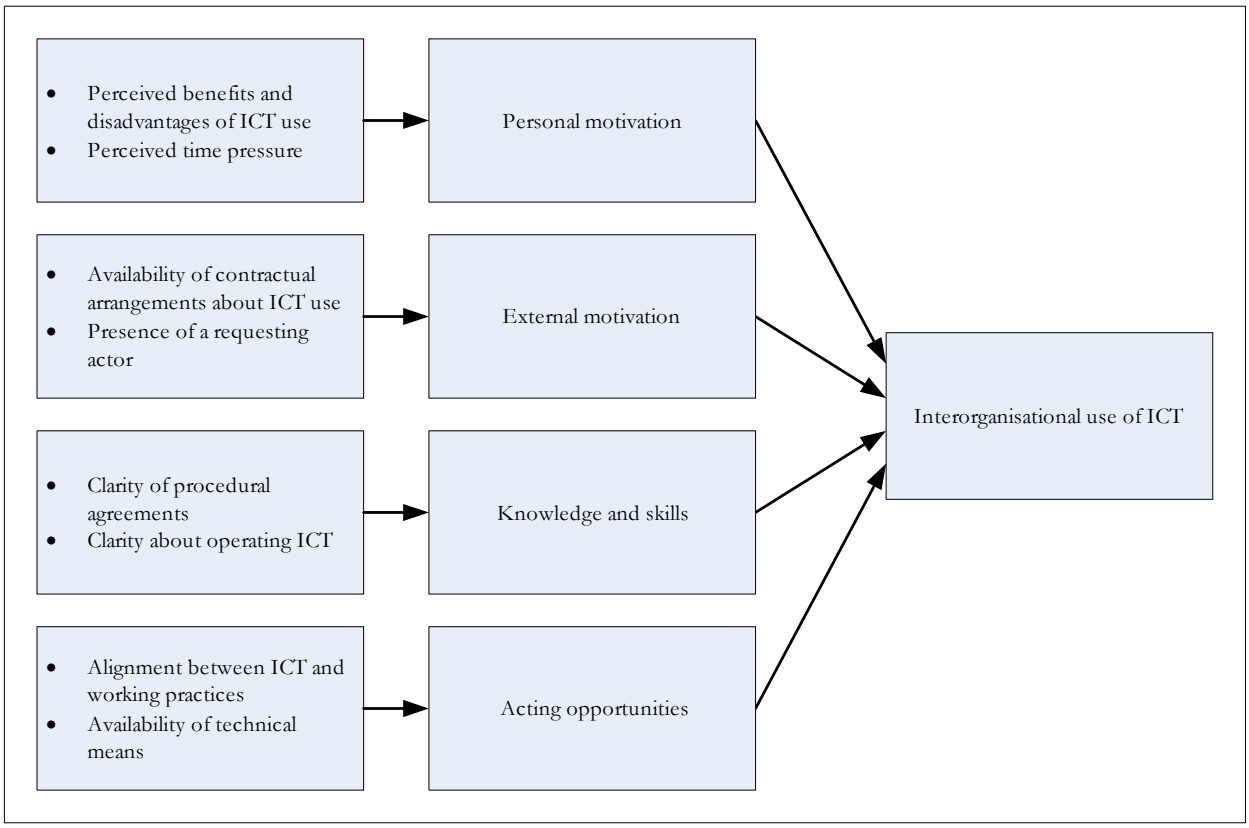

Figure 3.5: Theoretical framework

Before we discuss the theoretical framework in depth we want to link the categories and subcategories to the use of ICT in the episodes as we described in the former section. For each field study, the relationships between the categories, subcategories, organisations, and episodes are summarised in Tables 3.2, 3.3, 3.4, and 3.5. These tables show which mechanisms influence the use of ICT and why this use changes over time. Because we focus on the use of ICT between organisations, we simplify our analysis to the organisational level. Therefore, we distinguish the client (CL), the engineering company (EC), the contractor (CO), and the subcontractor (SC) in our analysis realising that actors representing these organisations act on behalf of these organisations. In these tables we mention drivers (D) and barriers (B) to the intended use of interorganisational ICT. If a cell in a table is blank this means that the subcategory did not have any effect on the way organisational actors use ICT in that episode. Several remarks need to be made concerning the tables:

- *Intended use and intended users:* we took the intended use and intended users (see Prologue of each field study) as our frame of reference when filling in the tables. We did not include barriers and drivers to a use that was not intended. The intended use is dynamic for two reasons. First, actors implemented changes in the application (see Field Study 4, Episode 3). Second, the intended users changed (see e.g., Field Study 2, Episode 2). These dynamics are included in the tables.

Mechanisms	Episode 1 (Weeks 1 – 6)			Episode 2 (Weeks 7 – 12)			Episode 3 (Weeks 13 – 27)		
	CL	**EC**	**CO**	**CL**	**EC**	**CO**	**CL**	**EC**	**CO**
Personal motivation									
Perceived benefits and disadvantages of ICT use			B		D	D/B	B	D/B	D/B
Perceived time pressure		B	B		B	B		(B)	(B)
External motivation									
Availability of contractual arrangements			(D)/B			D/B			D
Presence of a requesting actor					D	D		D	D
Knowledge and skills									
Clarity of procedural agreements						B			
Clarity about the operation of ICT		B	B						
Acting opportunities									
Alignment between ICT and working practices					B	B		B	B
Availability of technical means	B	B		B		B		B	B

Table 3.2: Relationship between episodes, actors, and subcategories (Field Study 1)

Mechanisms	Episode 1 (Weeks 1 – 11)			Episode 2 (Weeks 12 – 13)			Episode 3 (Weeks 14 – 16)			Episode 4 (Weeks 17 – 22)			Episode 5 (Week 23 – 34)		
	CL	EC	CO	CL	EC	CO	CL	EC	CO	CL	EC	CO	CL	EC	CO
Personal motivation															
Perceived benefits and disadvantages of ICT use	B	B	D/B	B		B	B		B	B	B	B	B	B	B
Perceived time pressure	B	B		B	(B)		B	(B)		B	(B)		B	(B)	B
External motivation															
Availability of contractual arrangements			(D)/B			B			D/B						D/B
Presence of a requesting actor		(D)			D			D			D			D	
Knowledge and skills															
Clarity of procedural agreements			B			B			B			B			
Clarity about the operation of ICT			B			B			B			B			
Acting opportunities															
Alignment between ICT and working practices					B	B		B	B		B	B		B	B
Availability of technical means			B			B									

Table 3.3: Relationship between episodes, actors, and subcategories (Field Study 2)

Mechanisms	Episode 1 (Wks 1 – 3)		Episode 2 (Wks 4 – 8)		Episode 3 (Wks 9 – 15)		Episode 4 (Wks 16 – 20)	
	CL	**CO**	**CL**	**CO**	**CL**	**CO**	**CL**	**CO**
Personal motivation								
Perceived benefits and disadvantages of ICT use	D	D/B	D	B	D		D	D
Perceived time pressure		B						
External motivation								
Availability of contractual arrangements		B		D		D		
Presence of a requesting actor		D						
Knowledge and skills								
Clarity of procedural agreements		(B)			B			
Clarity about the operation of ICT		(B)						
Acting opportunities								
Alignment between ICT and working practices				B	B	B		
Availability of technical means				B				

Table 3.4: Relationship between episodes, actors, and subcategories (Field Study 3)

Mechanisms	Episode 1 (Wks 1 – 5)				Episode 2 (Wks 6 – 39)				Episode 3 (Wks 40 – 52)				Episode 4 (Wks 53 – 61)			
	CL	**EC**	**CO**	**SC**	**CL**	**EC**	**CO**	**SC**	**CL**	**EC**	**CO**	**SC**	**CL**	**EC**	**CO**	**SC**
Personal motivation																
Perceived benefits and disadvantages of ICT use	D		D		D	D/B	D/B		D	D/(B)	D		D	D	D	(D)/B
Perceived time pressure																B
External motivation																
Availability of contractual arrangements			(D)			(D)	(D)			(D)	(D)			(D)	(D)	(D)
Presence of a requesting actor																
Knowledge and skills																
Clarity of procedural agreements	(B)		(B)													
Clarity about the operation of ICT	(B)		(B)													B
Acting opportunities																
Alignment between ICT and working practices						B				(B)						
Availability of technical means		B		B		B	B	B		(B)		B	(B)	(B)	(B)	(B)

Table 3.5: Relationship between episodes, actors, and subcategories (Field Study 4)

- *Simplification to the organisational level:* the tables were simplified to organisations but in fact we analysed how actors within that organisation interacted with actors from other organisations. This simplification can only be justified when we take into account two things. First, we focused on actors interacting with actors from other organisations. We did not include all organisational actors in our analysis. Second, often several actors within an organisation (e.g., contract supervisor A and contract supervisor B) were interacting with one or several actors within another organisation. In simplifying to the organisational level we took into account all drivers and barriers actors acting on behalf of an organisation were experiencing when using ICT towards actors from another organisation.
- *Simplification to episodes:* episodes differ in important ways regarding the use of ICT. In the tables, transitions from one episode to another are presented as clear-cut and straightforward. However, transformations sometimes occur not abruptly but incrementally.
- *Differences in importance of mechanisms:* in the tables we showed all the mechanisms that are important in influencing the use of ICT. Mechanisms that appeared to have only a limited or a momentary effect on the use of ICT in an episode but are important to mention – for sake of the cross-field study analysis that follows in this section – are presented between brackets.

The mechanisms and their dynamics are further discussed bellow.

3.4.1 Personal motivation

Personal motivation refers to the extent to which actors are willing to use interorganisational ICT themselves. Personal motivation influences both the willingness of the actors to use ICT and their willingness to invest resources to overcome barriers to the intended use of ICT.

We distinguish two subcategories influencing personal motivation:

a) *Perceived benefits and disadvantages of ICT use:* the extent to which actors perceive the use of ICT as benefiting and/or disadvantaging them. When actors perceive that there are many benefits (and no, or only a few, disadvantages) this will influence personal motivation positively. On the other hand, many perceived disadvantages will influence personal motivation negatively. This subcategory can be a driver and a barrier to the use of ICT.
b) *Perceived time pressure:* the extent to which actors perceive that they have to act quickly when using, or considering the use of, ICT. A high level of perceived time pressure can moderate personal motivation because of the highly perceived benefits of the use of ICT. However, a low level of perceived time pressure does not result in a high level of personal motivation to use ICT per se. This subcategory can only be a barrier to the use of ICT.

These mechanisms and related submechanisms are shown in Figure 3.6 [19] and discussed in greater detail below.

1a) Perceived benefits and disadvantages of ICT use

The first subcategory influencing the personal motivation is 'perceived benefits and disadvantages of ICT use'. These perceptions are influenced in two ways: (1) by perceived *potential* (i.e., possible) benefits and disadvantages, and (2) by *experienced* benefits and disadvantages.

Which of the two mechanisms dominates varies from actor to actor and from situation to situation. In all field studies a clear interplay between these mechanisms is manifest. This interplay determines an actor's willingness to use ICT and to overcome barriers to the intended use of ICT. For example, the contractor's project leader in Field Study 4 is not *experiencing* benefits in Episodes 1, and 2.

[19] The ellipses in this figure mean that these subcategories influence a category in concert.

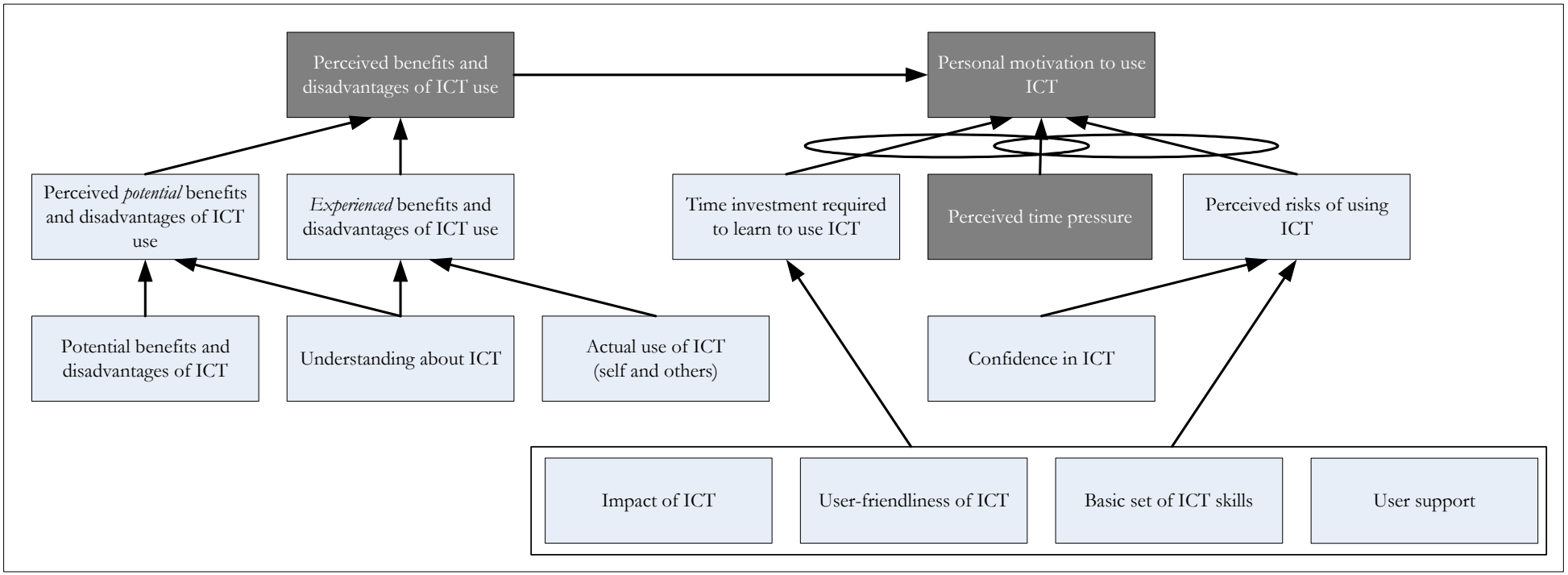

Figure 3.6: Mechanisms influencing the personal motivation to use ICT

However, he perceives important *potential* benefits of the use of ICT for the future. As a result, he keeps on using ICT despite the limitations of his application. In addition, he constantly tries to overcome barriers to the use of ICT and even implements a new ICT application in Episode 3 to reach the potential benefits. However, at the start of Episode 2, in his view the efforts he needs to invest to realise the potential benefits of the poor application are too high. He has to provide too much user support to actors within the contractor. At that stage, internal communication is rather deteriorating instead of improving as a result of the use of the application. Therefore, the contractor's project leader decides to stop using the application within his organisation. In Field Study 2, the interplay between the mechanisms is clearly visible as well. The contractor perceives important *potential* benefits first. Therefore, the contractor invests time to try to overcome barriers to the use of ICT. However, after a while the *experienced* disadvantages start to determine his attitude negatively. The contractor limits and even stops using ICT after a while. The resources the contractor needs to invest to overcome existing barriers are too high. The two mechanisms influencing the perceived benefits and disadvantages of ICT use are discussed separately in more detail below.

Perceived *potential* benefits and disadvantages of ICT use

Our field studies show that each actor perceives a certain configuration of potential benefits and disadvantages in the use of ICT in a certain situation. These perceptions are not uniform but differ between specific features. These perceptions are based on (a) the potential benefits and disadvantages of ICT and its specific features in the situation in which an actor has to use or considers using ICT, and (b) the understanding of an actor about ICT and its specific features, the way it can be used, and its potential benefits and disadvantages. These perceptions will be discussed below.

Potential benefits and disadvantages of ICT

The potential benefits and disadvantages are highly dynamic. We can explain this by focussing on the contractor in Field Study 1. He perceives important disadvantages in communicating documents digitally to the contract supervisors because documents are often not available to the contractor digitally. Therefore, he needs to scan documents first, which is very time consuming because a bulk scanner is not available to him. As a result, the contractor tries to minimise the use of ICT to communicate these documents (see Episode 2). Only when the contract supervisors force him to use ICT to communicate these documents digitally he does purchase a bulk scanner to reduce his scanning efforts (see start Episode 3). The availability of this bulk scanner changes the situation in which he has to use ICT dramatically: Digitalising documents can now be done easily.

However, this contractor (and also the contractor in Field Study 2) perceives important benefits in communicating deviations digitally until participants are located in the construction trailer. Deviations can be communicated much faster. Therefore, the contractor uses ICT for sending deviations. However, this situation changes when actors move into the construction trailer. It becomes just as easy or even easier to hand over deviations to contract supervisors instead of using ICT. This influences the personal motivation to use ICT.

When we switch our attention to the contract supervisors in Field Study 1, then we see that they perceive important benefits in receiving documents and drawings digitally from the contractor when these need to be forwarded internally to actors within the engineering company. The contract supervisors are able to communicate these faster and easier then in the tradition – paper-based – way. However, when the contract supervisors have to assess documents and drawings themselves they first need to plot or print them. This is a disadvantage to them. As a result, the contract supervisors allow the contractor to communicate documents and drawings that the contract supervisors need to assess themselves in paper-based form. However, they want to receive

documents and drawings that other actors within the engineering company need to assess – and thus need to be forwarded by the contract supervisors – digitally. When we relate this situation to Field Study 2, then we see that the contract supervisors cannot use ICT to forward documents to actors within their organisation because the workflow needs to pass the project leader first. The project leader is only available on this project for two days a week. This eliminates an important potential benefit of the use of the application to these contract supervisors.

Actors can try to influence the configuration of potential benefits and disadvantages of ICT of other actors. From our observations we can give several examples of this. First, the organisation that initiated the use of ICT can pay for the application (all field studies) and the customisation of the application (Field Studies 3 and 4). Therefore, this organisation eliminates a possible disadvantage to the use of ICT: a financial investment. In Field Studies 1 and 2, the contractors have to pay for the customisation of the application themselves. At the start of the project both contractors only have a very limited understanding of the application, about the way the application can be used, and about the potential benefits and disadvantages of the application. In addition, the contractors had not included the costs in their bids. Therefore, they are not willing to invest in the application themselves. Second, the use of ICT can be linked to outcomes that are important to other actors. For example, in Field Study 1, the engineering company only pays the contractor when the contractor uses ICT to communicate instalments. This appeared to be an important incentive for the contractor to invest time and money in using ICT in the intended way.

Understanding about ICT
The level of understanding about ICT is highly dynamic. When actors only have a limited understanding about an ICT application their understanding about the potential benefits and disadvantages is limited (or distorted) as well. In all field studies, actors' understanding about the application evolves over time as a result of increased experience with ICT. They discover new benefits and disadvantages.

The way actors act can be based on clear potential benefits and clear potential disadvantages of the use of ICT in certain situations. These are already discussed above. However, actions may also perceive risks in their use of ICT. Some of these risks are real threats; others are the result of a limited understanding about ICT and, after a while, turn out to be unfounded for the actor. In both situations, actions are based on fears about the use of ICT. From our field studies we can give several examples of important fears.

- *Fear of transparency:* in all field studies – in general – actors communicate information digitally that they used to communicate in paper-based form. Therefore, actors do not have to communicate more or other information because of ICT; they only communicate by using other means. Nonetheless, in some situations transparency increases as a result of the use of ICT. Field Studies 1 and 2 offer examples of that. Because of the introduction of ICT, the client can gain better insight into communication between the contractor and the contract supervisors then he used to have. The management of the engineering company likes to show the client that the engineering company has nothing to hide. However, according to a contract supervisor in Field Study 2, giving the client access to, for example, discussions about deviations could be dangerous for two reasons. First, contract supervisors are used to communicating information when discussions and disputes are settled. They want to choose the moment that they communicate to the client themselves. When discussions are communicated openly to the client, the contract supervisors cannot filter information and communication anymore. Second, the client can misinterpret information and communication. Often some background information is needed to interpret information and discussions correctly. In the end, in both field studies, actors do not use ICT to discuss

deviations. The engineering company and the contractor discuss deviations in meetings and the outcomes of these meetings are imported in the ICT application. However, from this example we can learn that transparency may be a benefit to the client and the management of the engineering company but a risk to the contract supervisors.

- *Fear of the legal status of digital communication:* in all field studies the legal status of digital communication is subject to much discussion. However, after a while actors come to terms with the legal status: digital communication is mandated in the contract (Field Studies 1 and 2) or formalised (Field Studies 3 and 4) and digital working practices have proven to be effective after a while (Field Studies 1, 3, and 4).
- *Fear that other actors change information:* sometimes actors question whether information cannot be changed in the application after it is submitted or approved. When actors use ICT for a while, they find out that information cannot be changed after it is communicated. This is very important to the actors involved.
- *Fear about insufficient compliance to the quality management system:* in Field Studies 1 and 2, the contractors fear about not complying with the requirements of their quality management systems. In their quality management systems document control and formal approval procedures are important issues. They question if the external auditor will approve their working practices if they only use the ICT application. This fear is present during all episodes. When they start to have experience with the application they still question whether they are able to meet the requirements. In Field Studies 3 and 4, complying with the requirement concerning the internal approval procedures is less of an issue to the contractors because the workflow processes in the application are based on their internal quality management systems. Moreover, document control is kept out of the application in Field Study 3.
- *Fear about malfunctioning of ICT:* in Field Studies 1, 3 and 4, the scope of the application is limited first because actors want to reduce the risk of malfunctioning of ICT. In Field Study 3, actors use ICT for only a small part of their formal communications (i.e., only deviation processes), and in Field Studies 1 and 4 ICT is only used between two organisations first (i.e., engineering company and contractor; client and contractor). In addition, in Field Studies 1 and 2, the engineering company mandates both digital and paper-based communication in the contract in order to create a safeguard in case the ICT malfunctions. When the application has proven to function well after a while, actors stop communicating in duplicate ways (Field Study 1) and increase the scope of the application.

As shown above fears may be real risks, but may also be perceived risks as a result of a limited understanding of the application. The latter category of fears turns out to be unfounded when the understanding about the application increases.

Experienced benefits and disadvantages of ICT use

An actor does not only perceive potential benefits and disadvantages, but also *experiences* benefits and disadvantages when using ICT. The experienced benefits and disadvantages can approximate the potential benefits and disadvantages. The experienced benefits and disadvantages differ between actors, situations, and features and are influenced in two ways.

First, the actual use of ICT influences the experienced benefits and disadvantages. From our field studies it follows that an actor can use ICT in several – unintended – ways:

- An actor uses ICT in only limited way or does not use ICT at all;
- An actor uses both ICT and traditional means of communication;
- An actor uses ICT in the wrong way.

The functioning of ICT is influenced not only by the way actors use the application themselves, but also by the way other actors use ICT. This use determines an actor's experienced benefits and disadvantages. For example, in Field Studies 1 and 2, the contractor stops using ICT because the engineering company is not responding to messages. The engineering company is not using ICT because of the limited personal motivation to use ICT and a lack of the required knowledge and skills.

Second, an actor's understanding about ICT influences the experienced benefits and disadvantages. An actor might interpret the functioning of ICT in the wrong way. For example, in Field Study 2, the contractor questions the characteristics and the functioning of ICT resulting in resistance to the use of ICT. However, it appears that the contractor does not know all the important assumptions behind the application. Therefore, the benefits are not completely clear to him.

We can summarise that perceived potential *and* experienced benefits and disadvantages of the use of the application determine the personal motivation to use ICT. Perceived benefits and disadvantages are differentiated between actors, specific features, and situations. Perceived *potential* benefits and disadvantages are based on:

- The application of potential benefits and disadvantages of ICT and its specific features to the actor's situation. These benefits and disadvantages are highly dynamic as a result of changing situations in which actors have to use ICT or are considering the use of ICT. Actors can influence the configuration of benefits and disadvantages of other actors, for example, to make investments for other actors or to link the use of ICT to outcomes that are important to other actors.
- The understanding by the actor involved of ICT and its specific features, the way it can be used, and its potential benfits and disadvantages. We can differentiate between clear disadvantages, risks, and unfounded risks that are based on a limited understanding.

Experienced benefits and disadvantages are based on (1) the actual use of ICT by an actor or by other actors, and (2) the understanding of the actor about ICT. All submechanisms do change over time.

1b) Perceived time pressure

The second subcategory influencing the personal motivation of the actors involved is 'perceived time pressure'. When new ICT is introduced in a hectic context this will influence the personal motivation to use ICT in a negative way. In these situations actors tend to communicate as they used to do (e.g., use telephone, fax, e-mail, or mail) although they can see important benefits in using ICT. Actors perceive that they have to act quickly. When high financial interests are at stake the perceived time pressure is increased. The perceived time pressure can moderate the personal motivation to use ICT in two ways: (1) combined with the time investment required to learn to use ICT, and (2) combined with the perceived risks of using ICT.

Time investment required to learn to use ICT

When new ICT is introduced in a project, actors first have to invest time to learn to use it and to overcome barriers to its intended use. However, in situations of high time pressure actors may not be able to invest this time. Consequently, they start to use traditional communication means again. This mechanism turns out to be very influential in Field Study 1 (Episodes 1 and 2) and Field Study 2 (Episodes 1 until 4). In Field Study 1, the contractor solves this problem by adding a project secretary to the users. In Field Study 2, the ICT assistant (Episodes 2 and 3), and project assistant (Episode 5) are made responsible for using the application on behalf of the contract supervisors. Actors in Field Studies 3 and 4 are able to invest the necessary time to learn to use ICT and to overcome barriers to its use. However, in Field Study 4, actors experience high time pressure at a later moment in time after the scope of the application is increased (Episode 4). Therefore, actors –

especially from the subcontractor – face difficulties in investing the necessary time. This is one of the reasons why they continue to use traditional means of communication.

From our field studies it follows that, after a while, the use of ICT will reach a constant level. The organisations get used to each other, to the application, and the new way of working. Actors know how they have to use ICT and incorporate ICT into their daily routines. Although time pressure can still be fierce, this mechanism stops being influential. The following aspects influence the period required to learn how to use ICT.

Impact of ICT
The impact of ICT on the actors involved consists of three elements: the novelty of ICT, the scope of ICT and the volume of communication. In Field Studies 1 and 2, the impact of the application is big. ICT is new to all actors, the application is used to support almost all formal communication and the volume of communication is huge immediately after ICT is introduced. Therefore, after ICT is introduced the needed time investment is high. Although ICT is new to all participants in Field Studies 3 and 4 as well, the impact is less than in Field Studies 1 and 2. Actors use ICT to communicate only deviation processes (Field Study 3), and the volume of communication between participating organisations is only small (Field Studies 3 and 4). Therefore, the impact of ICT on the actors involved is relatively small and actors are not overwhelmed by the new application directly after ICT is introduced. It is important to note that the impact of ICT decreases over time because of increased user experience (i.e., the novelty decreases). This decreases the necessary time investment as well. In addition, in Field Studies 1, 3 and 4, some actors are involved in the customisation of the application (the so-called key users). These actors have more understanding about the application when they start to use ICT and, therefore, need less time to learn to use ICT.

User-friendliness of ICT
The user-friendliness of the application is important in determining the necessary time investment. This user-friendliness determines whether ICT is easy to use. In Field Studies 1 and 2, a complex application is used in which much functionality is incorporated. According to the actors involved, this complexity results in low user-friendliness of the application and resistance to the use of ICT. A contract supervisor says: *"You have to get used to the application. (…) Limited experience is a barrier to the use of ICT. User-friendliness lowers this barrier (…) The user-friendliness of this application is low and needs to be better"*. According to a contractor: *"User-friendliness is the most important factor by far. The use of ICT is mandated. This results in resistance. When they make the application very user-friendly resistance is reduced. Maybe one finds out that the application is useful when one starts to use it"*.

However, it is not only a high level of functionality that is causing low user-friendliness. Limited functionality and technical shortcomings influence the perceived user-friendliness negatively as well. In Field Study 4, the contractor first uses an application in which only limited functionality is incorporated (see Episode 1 and 2). In addition, the application has some important technical flaws. Therefore, actors consider the user-friendliness of the application to be low. Consequently, the contractor's project leader decides to decrease the scope of the application at the start of Episode 2. In his view, it would cost him too much time to support actors within his organisation in using ICT. Internally within the contractor's organisation only the project leader keeps using ICT. This project leader says: *"The user-friendliness of the application is limited. However, user-friendliness is by far the most important factor"*.

Based on user experiences the software vendors implement changes in the application in Field Studies 1, 3, and 4. They try to remove flaws and improve the user-friendliness of the application. This makes the application easier to use after a while and the user-friendliness is therefore dynamic.

However, what appears to be most important is that users get used to the application and find a way to get along with it. After a while, user-friendliness becomes less important to the actors involved.

Basic set of ICT skills
The basic set of ICT skills an actor brings to a project influences the required time investment. When actors have many ICT skills they are able to learn to use ICT fast. When these skills are limited they need a lot of time to learn to use ICT. Across our field studies we viewed many differences between actors involved. In general, the basic sets of ICT skills of older actors are less than the basic skills of younger people. However, we noticed some exceptions to this rule as well.

User support
User support, such as training sessions, user manuals, and user support on-site, influences the necessary time investment. When much user support is provided, actors are able to learn to use ICT faster. In all field studies, actors consider the training session that takes place before they start to use ICT inappropriate. Therefore, when actors start to use ICT they do not exactly know how to use ICT resulting in confusion, incorrect use, and actors that stop using ICT. In Field Studies 1, 3 and 4, these user problems are solved quickly by user support. This user support is provided by a software consultant (Field Study 1, to client in Field Study 4), and by key users who are involved in the development of the application (ICT coordinator in Field Study 3; contractor's project leader in Field Study 4). This support increases actors' understanding about the application and limits the time actors need to invest to learn to use new ICT. In Field Study 2, actors do not know how to use ICT for a long period of time and they have to find out themselves how ICT needs to be used first. This appears to be very difficult and frustrating in a hectic context. Only by Episode 4, does an experienced contract supervisor from Field Study 1 provide user support. This user support stimulates actors to use ICT again in Episode 5.

Perceived risks of using ICT
The introduction of ICT is accompanied by extra risk (compared with traditional situations). When time pressure is high, actors try to prevent risk, also in their communications. Actors are used to traditional – such as paper-based and informal – means of communication and trust these means more than new ICT because, for them, these are proven ways of working. Especially in Field Study 1, at the start of the project, actors tend to reduce risk by using traditional means of communication. When actors consider using the new ICT they question whether a message is sent, if they use the application in the proper way, or if other participants look into the application. To be sure that information reaches other actors, they (also) use traditional – paper-based, and informal – means of communication. The general perception is that one cannot allow any delay.

One can question if risk prevention is only important combined with perceived time pressure. When actors face many risks, they will try to decrease these risks in any way. However, the mechanism of risk prevention is strengthened in an important way when high time pressure is present. When actors try to prevent risk in situations without time pressure, this situation becomes part of the former mechanism ('perceived benefits and disadvantages of ICT use').

The mechanism of the perceived risk involved in using new ICT is determined by the impact of new ICT, the amount of user-support, and the user-friendliness of ICT. Although the subcategories are already discussed above, some additional remarks need to be made in order to explain or clarify these mechanisms in the context of 'perceived risks of using ICT':

- *Impact of ICT:* when the impact of (new) ICT is great, the perceived risks in using this ICT are large, especially when there is high time pressure. Actors become overwhelmed by digital communication and tend to start to use traditional means again.

- *User-friendliness of ICT:* when the user-friendliness of ICT is low, actors experience more risk when using ICT. Some functionality can decrease this perceived risk. For example, in all field studies actors question whether the other actors are looking in the application. Thus, they question whether messages reach the other actors. Therefore, actors often send e-mails to bring to the other actor's attention that a message is being sent by using ICT. This activity can, for example, be eliminated when the application uses e-mail notifications (see e.g., Field Studies 1 and 2).
- *Basic set of ICT skills:* when actors have many ICT skills, they can assess the risks of using ICT in a better way. We observed that actors with limited basis skills often viewed more risk in using ICT as a result of their limited understanding. This mechanism appeared to decrease when actors started to become experienced in using ICT.
- *User support:* when user support is provided, actors understand the application and the way it needs to be used better. However, when user support is low, actors question whether they are using ICT in the proper way, resulting in a high level of perceived risk in using the application. After a while, when actors start to become experienced in using ICT, user support is not needed any longer.

Besides the mechanisms discussed above, the perceived risks of using ICT are influenced by the *confidence* an actor has in the ICT application and its use by himself and others. When actors have had bad experiences with the application because (1) it was malfunctioning (especially Field Studies 3 and 4), or (2) they used the application in the wrong way, or (3) other actors were not using the application (both Field Studies 1 and 2) actors become reserved in their use of ICT. They tend to continue to use traditional means of communication (as well). For example, in Field Study 1, the contractor has had bad experiences with the contract supervisors and other actors within the engineering company using ICT (i.e., they did not react to messages; they sent messages in the wrong way). Therefore, the contractor starts to use (also) traditional means of communication again to make sure that 'nothing goes wrong'. Traditional means of communication seem to be more secure for the actors involved.

In the last episode of our field studies (and sometimes earlier on), most actors have had experience of the application and incorporated ICT into their daily routines. However, in situations of high time pressure, actors often prefer to use other means of communication first. They communicate first informally or sometimes in a paper-based form and then send messages by using ICT later on to arrange things quickly. When they discuss issues informally, they know the other actor's opinion immediately. In addition, in Field Study 1, the contractor sometimes sends important documents in a paper-based form as well to be sure that the information reaches the other person quickly. In these situations, acting quickly is of utmost importance. When actors have to communicate by using ICT, they face the risk of delay. Actors have more confidence in informal communication in particular when there is a high level of time pressure. This situation may change in the future, but remained important throughout our field studies.

We can summarise by saying that perceived time pressure influences the personal motivation to use ICT in two ways: (1) combined with the time investment required to learn how to use ICT, and (2) combined with the perceived risks of using ICT. Both submechanisms are dynamic. In all the field studies, after a while actors get used to each other, to the ICT application and to the new way of working. Actors incorporate ICT into their daily routines and learn how to use ICT. The perceived risks of using ICT tend to decrease after a while as well because the actors get along with the application. However, confidence in the ICT application still impacts on the perceived risks of ICT usage over time. When actors have bad experiences with the application or other actors using the application they tend to use other means of communication in situations of high time pressure. In

addition, they prefer to communicate informally in these situations in order to arrange things quickly. They want to make sure that nothing goes wrong.

3.4.2 External motivation

External motivation refers to the degree to which actors are forced by *other* actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest time and money to overcome barriers to the intended use of ICT.

Two subcategories influence external motivation:

a) *Availability of contractual arrangements about ICT use:* the extent to which actors are forced to use ICT or other means of communication because this is mandated in the contract. When ICT is prescribed, external motivation is present. When ICT is not mandated no external motivation to use ICT exists. A mandate of only other means of communication is even a barrier to the use of ICT.
b) *Presence of a requesting actor:* the extent to which another actor requests certain action(s) (e.g. use of ICT, or non-use of ICT) to take place and the extent that this request impacts on actors. When actors are asked to use ICT and this request has an impact on them, external motivation is present; if this request is absent or if it does not have impact then no external motivation exists. Another actor who requests acting in another way than using ICT might even be a barrier to the use of ICT if this request impacts on actors.

These mechanisms are discussed in more detail below.

2a) Availability of contractual arrangements about ICT use

The first subcategory influencing external motivation is the 'availability of contractual arrangements about ICT use'. Actors can be in the position to mandate the use of ICT. In Field Studies 1 and 2, the engineering company in the contract mandated the use of ICT for the contractor. This appeared to be an important safeguard for the use of ICT: the contractor had to act in the way that the contract mandated. In Field Studies 3 and 4, the use of ICT is not mandated in the contract. The traditional – paper-based – practices are prescribed. Actors decide together that ICT is going to be used and make agreements about the way they will use ICT. However, for the actors involved it is very important to formalise this decision in order to give digital communication a contractual status (Field Study 3, Episode 1; Field Study 4, Episode 1).

Moreover, traditional – paper-based – and digital working practices can be mandated in the contract. In Field Studies 1 and 2, the engineering company prescribed both working practices in the contract to create a safeguard in case the ICT malfunctioned. Therefore, the contractor wants to communicate in a paper-based way as well until the use of only digital means of communication is formalised in a meeting (see Field Study 1, start of Episode 3). This mandate inhibits actors from using interorganisational ICT in the intended way (i.e., the use of only digital communication) for a while.

When actors do not have personal motivation to use ICT, external motivation becomes important in order to force actors to use ICT in the intended way (see e.g., Field Study 1, Episodes 2 and 3, and Field Study 2, Episodes 3 and 5). In Field Study 2, the document controller says in Episode 3: *"The only reason why we use ICT is because it is mandated in the contract"*. However, in this field study the contractor is not able to act according to the contract as a result of unclear use, and a limited alignment between the application and his quality management system. Therefore, the contractor decides to stop using ICT at the end of Episode 3. The contractor only wants to use ICT again when the application is changed and a clear instruction about the use of ICT is provided. In Field Studies 3 and 4, no situations occur in which the client had to force another organisation to use ICT:

the agreements are cooperatively made and actors act according to these agreements. Therefore, when actors could not use ICT as a result of technical problems (e.g., Field Study 3, Episode 2), the contractor simply decided not to communicate because of the agreement to use only ICT. He imported data in the application at another point in time.

Thus, contractual arrangements about the use of ICT are an important safeguard for its use, and contractual arrangements about traditional – paper-based – practices inhibit actors from using ICT in the intended way. However, mandating alone does not guarantee the use of ICT. Keeping an actor to the terms of the contract is important as well. For example, in Field Studies 1 and 2, the contractor starts to use ICT (again) when the contract supervisors keep them to the terms of the contract (Field Study 1, start Episode 2; Field Study 2, start Episode 3). In addition, in Field Study 2, Episode 1, the contract supervisors ask the contractor to communicate both digitally and in paper-based forms because the contract supervisors will not use ICT until they are located in the construction trailer. Note that keeping an actor constantly to the contract can be harsh. In Field Study 1, actors suggest that it is important to be compliant sometimes (contract supervisor: *"When the working climate comes under pressure you sometimes have to be compliant"*; contractor: *"In the long run, parties do not want to make a maximum effort when you continuously keep them to the contract. It is important to build credits and to create goodwill"*).

We can summarise by saying that contractual arrangements are an important external motivation to the use of ICT. A mandate in the contract forces actors to use a means of communication. When the use of ICT is not mandated it is still very important to the actors involved to formalise the agreement to use ICT and to give ICT use a contractual status. From our field studies, it follows that external motivation which occurs as a result of contractual arrangements is dynamic for two reasons: (1) contractual arrangements can be changed during the project, (2) actors must be kept to the contractual arrangements in the contract as well to make them comply with it.

2b) Presence of a requesting actor

The second subcategory influencing external motivation is the 'presence of a requesting actor'. Another actor requesting ICT use – to a certain extent – can be an important external motivation. Some actors are in the position to request ICT use.

First, requesting actors in management positions can have an important impact on the use of ICT. This can be the line management of the organisation or the project management. These actors can request other actors to use ICT (e.g., contractor's project leader, contract supervisors in Field Study 1; contractor's project leader, engineering company's line management in Field Study 2) or to use other means of communication (e.g., contractor's project leader in Field Study 4, Episode 2). They can also allow other actors to stop using ICT (contractor's project leader in Field Study 2, end of Episode 3).

Second, the client, or the client representative can ask the contractor to use ICT. Sometimes a contractor wants to create goodwill or improve his reputation. Therefore, despite disadvantages and the absence of contractual prescriptions the contractor will use ICT. The work planner in Field Study 1 says about this: *"In the end it is of the utmost importance that the engineering company is satisfied. When it lies within my reach to satisfy the engineering company I want to spend even more time on ICT. (…) It is important to create goodwill"*. In addition, the document controller in Field Study 2 says with regard to the contract supervisors: *"You are my client, so I have to do it the way you want"*. In Field Studies 3 and 4, the client requests instead of mandates the contractor to use ICT. Based on this request the actors involved make the agreement that they will use ICT in this project.

However, there are boundaries in the extent to which actors are prepared to manage their actions according to other actors' requests. In several situations, the client or client representative is willing to expand the scope of the application (e.g., Field Study 1, Episode 2; Field Study 3, Episode 4). This is only possible when other actors are positively motivated to expand the scope as well, or when an external motivation is present. For example, in Field Study 1, Episode 2, the contract supervisors propose expanding the scope of the application to include letters and drawings. The contractor perceives some important potential benefits in this extension (e.g., more structured communication). However, he perceives some disadvantages as well. He does not want to invest extra time (i.e., extra scanning activities) and money (i.e., buying a plotter) in using the application. He has not incorporated these costs in his bid. Therefore, the contractor refuses the engineering company's proposal and the scope of the application remains the same. In Field Study 4, Episode 3, the contractor's project leader wants to expand the scope of the application too to eliminate his technical problems and to reduce paper-based communication as much as possible. However, this situation differs with the former situation in two ways. First, the project leader wants to expand the scope to his internal organisation. He is able to externally motivate other actors within his organisation. Second, other organisations are willing to cooperate. Therefore, in Episode 3, he invests in implementing a new application to overcome his technical problems.

Third, just another actor (without a hierarchical status) making a request for ICT use may have an impact on an actor's use of ICT. In all the field studies, there are actors present who try to make other actors use ICT (e.g., contractor's document controller in Field Study 2; ICT coordinator in Field Study 3). The impact of their requests might be small, but they at least make other actors consider overcoming barriers and using ICT again.

We can summarise by saying that a requesting actor could have an important impact on the way other actors use ICT. However, this impact varies from situation to situation and from actor to actor based on interest positions and the position of the actor.

3.4.3 Knowledge and skills

The knowledge and skills required to use ICT refer to the degree to which actors know how to use ICT. When knowledge and skills are limited, the actors themselves are the ones restricting the use of ICT.

Two subcategories influence knowledge and skills:

a) *Clarity of procedural agreements:* the extent to which actors know how to act concerning the ICT application (e.g., what information has to be communicated to whom, and in what form and at what time) and these actions support the intended use of ICT. This clarity can be high or limited, resulting in enough or a restricting amount of knowledge and skills to use ICT.
b) *Clarity about the operation of ICT:* the extent to which actors know how to operate the application. This clarity can be high or low resulting in enough or a restricting amount of knowledge and skills to use ICT.

These subcategories can only be barriers to the intended use of ICT. The mechanisms and submechanisms influencing the knowledge and skills are shown in Figure 3.7 and discussed in more detail below.

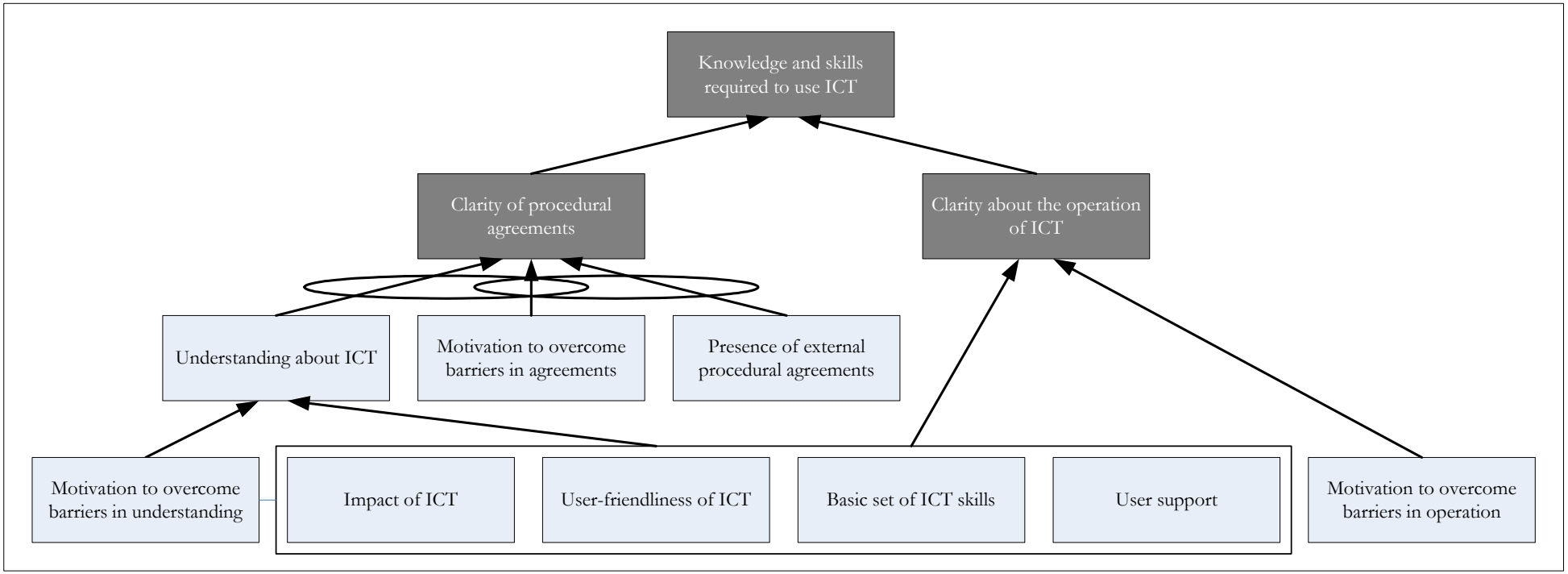

Figure 3.7: Mechanisms influencing the knowledge and skills required to use ICT

3a) Clarity of procedural agreements

The first subcategory influencing the knowledge and skills of the actors involved is 'clarity of procedural agreements'. In the ideal situation, clear agreements are present before the application is introduced in the project. However, in all field studies most procedural agreements evolve after ICT is introduced and actors start to use it. The clarity of procedural agreements is influenced in three ways: (1) by the motivation to overcome barriers in agreements, (2) by the level of understanding about ICT, and (3) by the presence of external procedural agreements.

Motivation to overcome barriers in agreements

The clarity of procedural agreements is strongly related to the level of motivation (personal or external) of the actors involved to make clear agreements. When motivation to make clear agreements is lacking actors will not spent resources in making them. Personal and external motivation has already been discussed extensively above. However, we would like to make two comments on the relationship between motivation and clear procedural agreements. First, actors sometimes benefit from having unclear agreements. For example, in Field Study 1, Episode 2, the contractor does not want to scan complete documents with his unsophisticated scanner. Therefore, he communicates only the first signed page of a document digitally or he does not communicate documents digitally at all. As long as agreements are not completely clear the contractor is able to optimise the use towards his own interests. Second, actors have to be aware of the fact that making clear agreements is important. In several field studies, actors stress that they should have spent more time on making clear (and appropriate) agreements before they started to use ICT.

When motivation to make clear agreements that support the intended use is present, actors can act in several ways. First, actors may try to understand the ICT application and to think out clear agreements themselves. Second, actors may ask other actors for clear agreements. These mechanisms are discussed in greater detail below.

Understanding about ICT

When the understanding about the application is low actors face difficulties in deciding how ICT can or needs to be used. In all the field studies, the actor's understanding about ICT is low when they start to use ICT. They have to use this ICT for the first time. Therefore, it is very difficult for them to decide which procedural agreements need to be made. As a result, in Field Studies 1 and 2, the engineering company mandates the use of ICT towards the contractor in the contract based on a limited understanding of the application. The contractual arrangements, therefore, are not fully clear. Consequently, the contractor faces difficulties in understanding the application and the way this application needs to be used in this project.

In all the field studies, the understanding about ICT evolves over time. The mechanisms influencing the understanding about ICT are the same as the mechanisms influencing the required time investment to learn to use ICT (i.e., impact of ICT, user-friendliness of ICT, basic set of ICT skills, and user support) (see subcategory 'perceived time pressure'). In addition, understanding about ICT is influenced by the motivation to overcome a limited level of understanding. When this motivation is high, actors invest resources to learn how to use the application. This motivation can be a personal motivation or an external motivation. However, in situations in which only external motivation is present, actors often only ask for clear agreements and do not spend the time necessary for understanding the application and for making clear agreements themselves. For example, in Field Study 2, the contractor has a clear positive personal motivation to use ICT. However, this positive attitude turns negative in Episodes 2, 3, and 4. This negatively influenced the contractor's motivation to think out agreements himself.

Based on the mechanisms discussed above, understanding evolves over time in Field Studies 1, 3, and 4. Actors are able to make clear agreements themselves after a while, based on their understanding of the application. However, in Field Study 2, the necessary understanding is lacking for a long time. User support is limited, user-friendliness is considered low, actors are not involved in the development of the application (the application is a copy of the application used in another project), and the motivation to overcome barriers (i.e., a limited understanding) is low. In Episodes 2, 3, and 4, the contractor asks the contract supervisors repeatedly for clear agreements about the use of ICT. This contractor has positive motivation (i.e., external motivation) to make clear agreements, but low personal motivation to spend time in understanding the application and in thinking out clear agreements himself. This contractor says: *"If [the contract supervisors] want us to use ICT, then they have to tell us how we have to use it as well"*. By constantly asking how ICT needs to be used, the contractor tries to increase the engineering company's (i.e., contract supervisor's) motivation to make clear agreements[20]. However, the contract supervisors' personal motivation to understand the application and to think out clear agreements is low as well. Other priorities prevail. They do not have the required time it takes to make clear agreements although the contractor is constantly asking for it. A contract supervisor says: *"We don't want to reinvent the wheel. We haven't asked for this application ourselves. We are confronted with this application"*.

Presence of external procedural agreements

External procedural agreements are agreements that are not thought out by an actor himself but are proposed by other actors. In this situation an actor does not have to spend time in understanding the ICT application and thinking out procedural agreements himself. This mechanism appeared in Field Study 2. First, the engineering company copied – general and unclear – procedural agreements from another project and mandated these for the contractor. Second, the contract supervisors do not want to think out procedural agreements themselves but want to know how ICT is used in another project. This might help them in deciding how ICT needs to be used in their project. They do not have the time to find out how ICT can be used for themselves. Only by the end of Episode 4 does a contract supervisor from Field Study 1 provide user support. This increases the actors' understanding of the application and showed directions for procedural agreements. Therefore, at the start of Episode 5, actors are able to make procedural agreements about the use of ICT.

3b) Clarity about the operation of ICT

The second subcategory influencing the knowledge and skills of the actors involved is 'clarity about the operation of ICT'. When there is a lack of clarity, actors are confused about the use of ICT, make mistakes in their use of ICT, and/or they stop using the application. Ideally, this clarity about the operation of ICT is present before actors start to use ICT. However, in all the field studies these abilities evolve over time after ICT is introduced. Actors have to learn to use ICT. The mechanisms influencing the clarity about the operation of ICT are the same as the mechanisms influencing the required time investment to learn to use ICT (see subcategory 'perceived time pressure'). In addition, clarity about operating ICT is influenced by the motivation to overcome barriers to this clarity (see 'personal motivation' and 'external motivation' for a discussion of motivational mechanisms).

Because the subcategories have already been discussed above, we discuss the mechanisms here only briefly focusing on their relationship with clarity about the operation of ICT:

- *Impact of ICT:* when the impact of new ICT is high actors have to spend more time learning how to operate the application.

[20] In this respect this mechanism is related to the subcategory 'presence of a requesting actor' (see 'external motivation').

- *User-friendliness of ICT:* when user-friendliness of an application is high, actors know more intuitively how they have to operate ICT. When user-friendliness is low, actors have to spend more time to learn how to operate ICT.
- *Basic set of ICT skills:* when actors bring many ICT skills to the project they have to invest less time in learning how to operate the ICT application.
- *User support:* when user support is provided (e.g., training, user manuals, support on-site) actors know better and more quickly how to operate the application.
- *Motivation to overcome barriers in operation:* when actors have a low motivation to overcome barriers, they are not willing to invest resources in learning how to operate ICT.

3.4.4 Acting opportunities

Acting opportunities refer to the extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.

Two subcategories influence the acting opportunities:

a) *Alignment between ICT and working practices:* the extent to which ICT fits in with actors' working practices in the project and their organisation(s). This alignment can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way.
b) *Availability of technical means:* the extent to which technological aspects restrict actors in using ICT in the intended way. This availability of technical means can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way.

These subcategories can only be barriers to the use of ICT. The mechanisms and related submechanisms are shown in Figure 3.8.

4a) Alignment between ICT and working practices

The first subcategory influencing the acting opportunities of the actors involved is the 'alignment between ICT and working practices'. Persons and organisations have their own standard working practices. When a new ICT application is introduced in a project, this has consequences for these practices. When the working practices and the ICT application are not aligned, actors face difficulties in using the application. For example, they do not use ICT, use ICT in only a limited way, or communicate in both digital and paper-based forms. The alignment between ICT and working practices is influenced in three ways: (1) by the motivation to overcome barriers in alignment (i.e., personal or external motivation), (2) by the perceived possibilities of changing working practices, and (3) by the perceived possibilities of changing ICT.

Motivation to overcome barriers in alignment

The motivation to overcome barriers to the use of ICT is strongly related to the alignment between ICT and working practices. When an actor is really motivated to use ICT and to spend resources on overcoming barriers to its use, most alignment problems can be solved. Motivational mechanisms have already been discussed extensively above (see categories 'personal motivation' and 'external motivation').

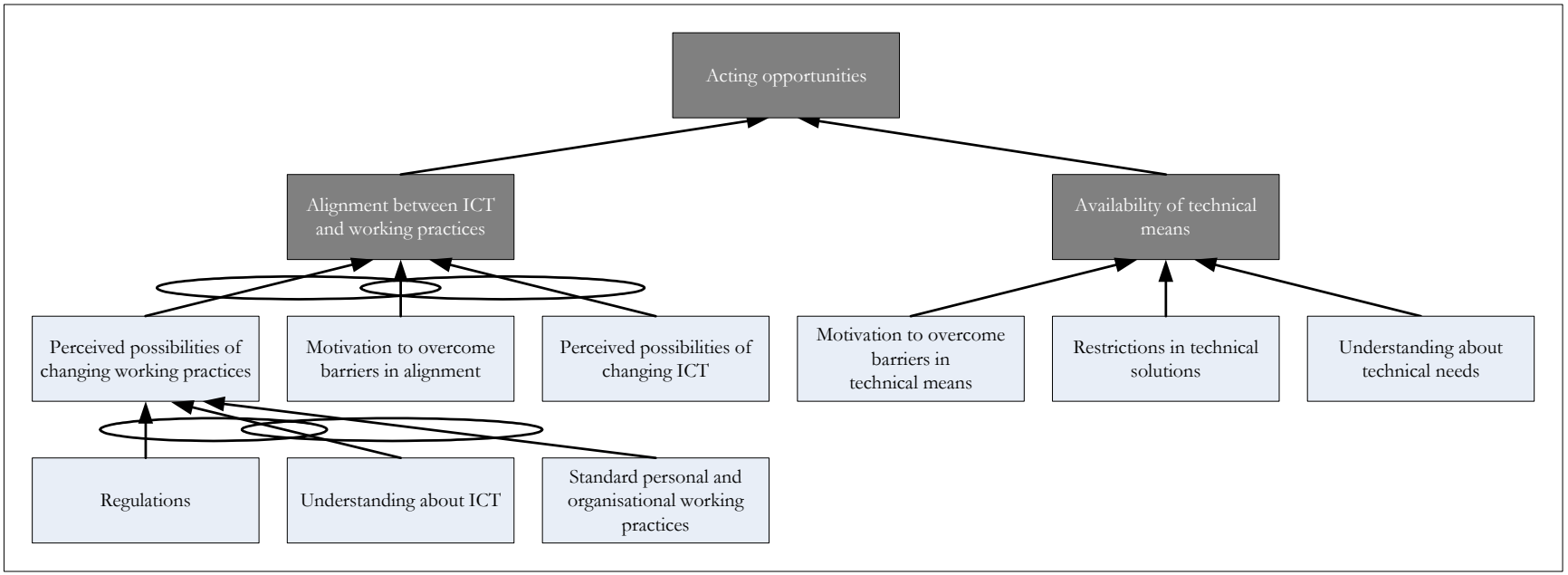

Figure 3.8: Mechanisms influencing the acting opportunities

Perceived possibilities of changing working practices
The possibilities actors have to change their working practices are not unlimited; they perceive restrictions in the way in which they can change their working practices. This is caused in two ways.

First, regulations combined with understanding about the ICT application restrict actors in changing their working practices. Actors want to comply with regulations, such as the ISO specifications for their quality management systems, the requirements of public agencies (e.g., they want to receive computations and drawings paper-based, stamped and signed), and legislation (e.g., legal status). The understanding about the application and the way the application can be used influences the perceived possibilities of changing working practices. Actors need to be aware of the possibilities of using the application in a certain way *and* of complying with legislation at the same time as well. This understanding might be difficult when actors have to use interorganisational ICT for the first time. For example, in Field Studies 1 and 2, the contractors have their own internal quality management system. This quality system is certified according to the ISO specifications. Actors can change their working practices as long as they still comply with the ISO specifications. However, at the start of the project, actors' do not see any opportunity to use ICT and comply with the ISO specifications at the same time. Therefore, they decide to keep on following their standard – paper-based – working practices.

Second, standard personal or organisational working practices may influence the perceived possibilities of changing the working practices. The working practices that need to be adopted to use ICT in the intended way may conflict with the working practices that actors are used to following and which actors might view as superior. We will give two examples illustrating this limited alignment, one from a personal perspective and one from an organisational perspective.

- *Personal perspective:* actors have their own working practices. In all the field studies, ICT is able to support discussions about deviations. However, all the actors prefer to discuss deviations in meetings or informally first. They use ICT to formalise discussions but not to have discussions. In their view having discussion personally is, for example, more appropriate then digital discussion because arguments can be exchanged intensively which accelerates the process of reaching agreement. Therefore, actors – in general – do not use ICT to discuss deviations.
- *Organisational perspective:* actors have to use standard organisational working practices. Actors are accustomed to these standards, such as standard procedures, standard internal ICT applications, and recording certain information on standard forms. Actors know that when they comply with these standards they are working according to the organisation's requirements and that these working practices used to be effective in the past. Therefore, the engineering company in Field Studies 1 and 2 tries to develop a standard *digital* organisational working practice. The application used in Field Study 2 is a copy of the application used in Field Study 1. As a result, the application can be set up quickly in a single construction project. However, the contractor is not able to work appropriately according to the 'standard' developed by the engineering company, especially when using the deviation workflow process. In this process, the contractor is familiar with carrying out additional activities and of recording additional information in their communications (e.g., he is not able to record the required information in digital messages). The contractor is not willing to change his standard working practices because of his limited personal motivation to do so. He says to the engineering company: *"I do what you requested [in the contract]. You cannot forbid me to follow my own internal working practices."* Therefore, the contractor keeps on working according to his own standard paper-based working practices as well.

Actors are able – to a certain extent – to deviate from their standard personal or organisational working practices. However, this brings about risk and an investment in resources (see category 'benefits and disadvantages of ICT use'). When actors only have a limited amount of understanding about the application and the way the application can be used, the perceived risks can even increase. For the actors involved it is easiest to follow their standard personal and organisational working practices as much as possible. Actors do not know for sure if they are going to be effective and efficient, and if they are going to meet their own organisation's requirements when changing their working practices and aligning them to the ICT application.

Perceived possibilities of changing ICT
The possibilities of changing the ICT application to align ICT with the preferred digital working practices are, for two important reasons, not without restrictions.

First, the functionalities of the applications can restrict actors in making the application fit to their preferred digital working practices. For example, in Field Study 4, the contractor starts to use an application in which no document management functionalities are included. Therefore, the application is not able to support version control of documents sent by the contractor. Within the possibilities of this application, the contractor is not able to support his intended digital working practices. After a while, the contractor becomes strongly motivated to change this situation. Therefore, he decides to implement a new application (see Episode 3).

Second, the way other organisations want to use ICT can restrict actors in changing interorganisational ICT to their purposes and preferred digital working practices. For example, in Field Study 2, the contractor wants to have the ICT application changed to their working practices with regard to deviations and extra work. However, the engineering company does not want to change the application because this organisation wants to create an organisational standard in which exactly the same application and accompanying workflow processes are used in each project. Therefore, the engineering company does not want to change the application based on the wishes of one particular contractor. Another example is Field Study 3. In this field study, the client wants to gain insight into the contactor's internal deviation processes in Episode 4. However, the contractor refuses the client's proposal because he prefers to discuss these deviations personally in meetings. Therefore, the application is not changed.

We can summarise by saying that persons and organisations have their own standard working practices. When new ICT is introduced in a project, this has consequences for these practices, and the wishes of the actors involved have consequences for the ICT application as well. When the working practices and the ICT application are not aligned, actors face difficulties in using the application. The possibilities of changing working practices are limited by an actor's understanding about ICT in combination with the regulations, and their standard personal and organisational working practices. Changes in the ICT application are restricted by available functionalities as well as the wishes of the other actors about the use of ICT.

4b) Availability of technical means

The second subcategory influencing the acting possibilities of the actors involved is the 'availability of technical means'. Technological aspects, such as the Internet, the functionalities of the application, or the availability of peripherals may restrict actors in using ICT. One of the characteristics of construction projects is that the construction object is build on-site. In Field Studies 1, 2, and 3, technical means must be available on-site if ICT is to be used in the intended way because actors work from a construction trailer. The availability of technical means is influenced in three ways: (1) by the motivation to overcome barriers in technical means, (2) by restrictions in technical solutions, and (3) by understanding about technical needs.

Motivation to overcome barriers in technical means
The availability of technical means is strongly related to the personal or external motivation to overcome barriers in technical means. When the motivation to solve technical barriers is high, actors will spend resources in overcoming these barriers. When the motivation is low, actors will not solve barriers and might even use technical restrictions as an excuse for not using ICT. Personal and external motivation is already discussed extensively above.

Restrictions in technical solutions
Restrictions in technical solutions may restrict actors from acting in the intended way. Often restrictions can, in principle, be solved; however, the motivation to do so constrains actors in overcoming these restrictions. Sometimes technical restrictions cannot be solved. In our field studies, the Internet connection (i.e., accessibility and speed), the functionalities of the application, and the peripherals restrict actors from using ICT.

- *Internet connection:* in all field studies, Internet connections restrict actors from using ICT in the intended way. This may happen if actors have to use ICT on-site before the construction trailer is available (e.g. contract supervisors in Field Study 1), when they have to use ICT on-site after the construction trailer becomes available (contractors in Field Studies 1 and 2), and when actors have to use ICT from their offices (engineering company in Field Study 4). In addition, when actors do not use web-based ICT, the application is not accessible from another location (see Field Study 3). When actors are positively motivated they are often able to solve these problems. For example, in Field Study 2, the contractor temporarily uses a dial-in connection until a secure Internet connection becomes available to him.
- *Functionalities:* in all the field studies, actors face difficulties with the functionalities of the application. In these studies, the software vendor improves the application based on user experiences in the projects. However, especially in Field Studies 3 and 4, actors keep on experiencing significant functionality problems. This influences their use of ICT. For example, in Field Study 3, the contractor faces many technical problems and therefore he stops using ICT until these problems are solved (see Episode 2). In Field Study 4, the contractor's main problem is that he is not able to obtain an overview of sent and received messages. Several times, the software vendor implements solutions to this problem (Episode 1), but these solutions are not satisfactory to the contractor. Therefore, the contractor limits the scope of his application to the project leader. In the contractor's project leader's view, the application would worsen rather than improve internal communication. In the end, the contractor implements a new application to overcome his technical problems. It appears that the actors had not tested the applications intensively enough to prevent technical problems occurring when they start to use ICT. In Field Studies 3 and 4, only limited test activities were carried out as a result of (1) time pressure because of the very short implementation period (Field Study 4), and (2) a false assumption that the application already functioned very well in another project (Field Study 3).
- *Peripherals*: peripherals do not have to restrict actors in using ICT. However, actors do not always want to purchase the necessary peripherals. For example, in Field Study 1, one of the reasons why the contractor does not want to use ICT to communicate drawings is because a plotter is not available to him in the construction trailer. He is not willing to purchase one in this project because he had not included these costs in his bid. In addition, he needs a bulk scanner to scan documents in an efficient way. Because the use of ICT to communicate documents is a contractual obligation for him, he purchases a bulk scanner. However, this bulk scanner has its limitations as well, because it is not a colour bulk scanner and the scanner can only scan A3 format and smaller documents. In the contractors view, a colour bulk scanner would be too expensive. Because of this limitation, the contractor keeps

sending colour documents and drawings that are larger than A3 in paper-based forms. In Field Studies 3 and 4, the availability of peripherals (i.e., bulk scanner and plotter) is not a problem because these peripherals are already available on-site (Field Study 3), or are available in the office (Field Study 4). In Field Study 4, actors work from the office instead of a construction trailer.

Understanding about technical needs
When the understanding about technical needs is low, actors face difficulties in preparing themselves in an appropriate way to the use of interorganisational ICT. In all the field studies this ICT is new to the actors involved. Therefore, it is difficult for them to decide which technical means have to be arranged. For example, in Field Studies 1 and 2, at the start of the project, the contractors do not know what the application is, how it can be used, and what is needed to use it in the proper way. One of the things they have to arrange to use ICT in the intended way on-site is a secure Internet connection. Both contractors are not able to arrange this connection in time: when the contractors move to the construction trailer the secure Internet connection is not yet available. It takes about 3 months to arrange such a connection. If the contractor had applied for an Internet connection immediately after the contract was awarded, the Internet connection would have been available in time. Therefore, in Field Study 2, the contractor stops using ICT when he moves to the construction trailer. Although the engineering company (e.g., contract supervisors) moves to the construction trailer at the same moment as the contractor, this problem does not apply to them. In both field studies, the engineering company had already applied for an Internet connection before the tender started. In this example, the engineering company could have helped the contractor by providing more clarity at the start of the project, or even earlier, about the importance of arranging a secure Internet connection in time. A contract supervisor says: *"It is important to specify clearly in the contract what the contractor needs to do with respect to ICT"*.

We can summarise by saying that technical aspects may restrict actors in using ICT. When actors are strongly motivated to use ICT, they will find solutions to technical restrictions most of the time. However, sometimes actors are not aware of the technical requirements, or the intended use of ICT cannot be supported by technical means. The motivation to solve barriers and the efforts made by software vendors and other actors to solve barriers make the availability of technical means highly dynamic.

3.5 Discussion and limitations

In our qualitative study, we focused in-depth on the key mechanisms that influence the way actors use interorganisational ICT and how these mechanisms change over time. The main reason for conducting this research is the shortcomings in existing theoretical models about the adoption and use of ICT. To show the contributions and limitations of this research we have to reflect on existing models. Therefore, we will first compare the results of our study with other theoretical models. Based on this comparison we will present our final theoretical model. Second, we will elaborate on our research method.

3.5.1 Reflections on theoretical model

Connecting grounded theory to existing theory is an important step in developing a more substantive theory (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998). In this section we relate our theoretical model to three influential models about the adoption and use of ICT: The Unified Theory of Acceptance and Use of Technology (UTAUT), the Theory of Planned Behaviour (TPB), and the Technology Acceptance Model (TAM). UTAUT integrates several existing models about the individual acceptance of ICT (Venkatesh et al., 2003). TPB is a general theory of human

behaviour (see e.g., Ajzen, 1991) that is often applied to the adoption and use of ICT (Mathieson, 1991; Mathieson et al., 2001; Taylor and Todd, 1995). TAM is considered to be the most influential and commonly employed theory about user acceptance of ICT (Davis, 1989; Davis et al., 1989; Lee et al., 2003).

Based on the results of our field studies and the comparison of our results with these theoretical models we are able to formulate the theoretical model shown in Figure 3.9. In this figure, the intention to use ICT is added based on an analysis of the theoretical models mentioned above. The aspects of the model as indicated by the numbers in Figure 3.9 will be discussed below.

1. Intention to use ICT

The three existing theoretical models share their focus on the intention of individuals to use an application. The intention to use ICT (behavioural intention) has a significant influence on the actual use of ICT (behaviour). According to Ajzen (1991, p.181) "[i]ntentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior". Based on this insight we will include the intention to use ICT in our theoretical model as well, because it is able to fill the gap between motivational categories and the interorganisational use of ICT.

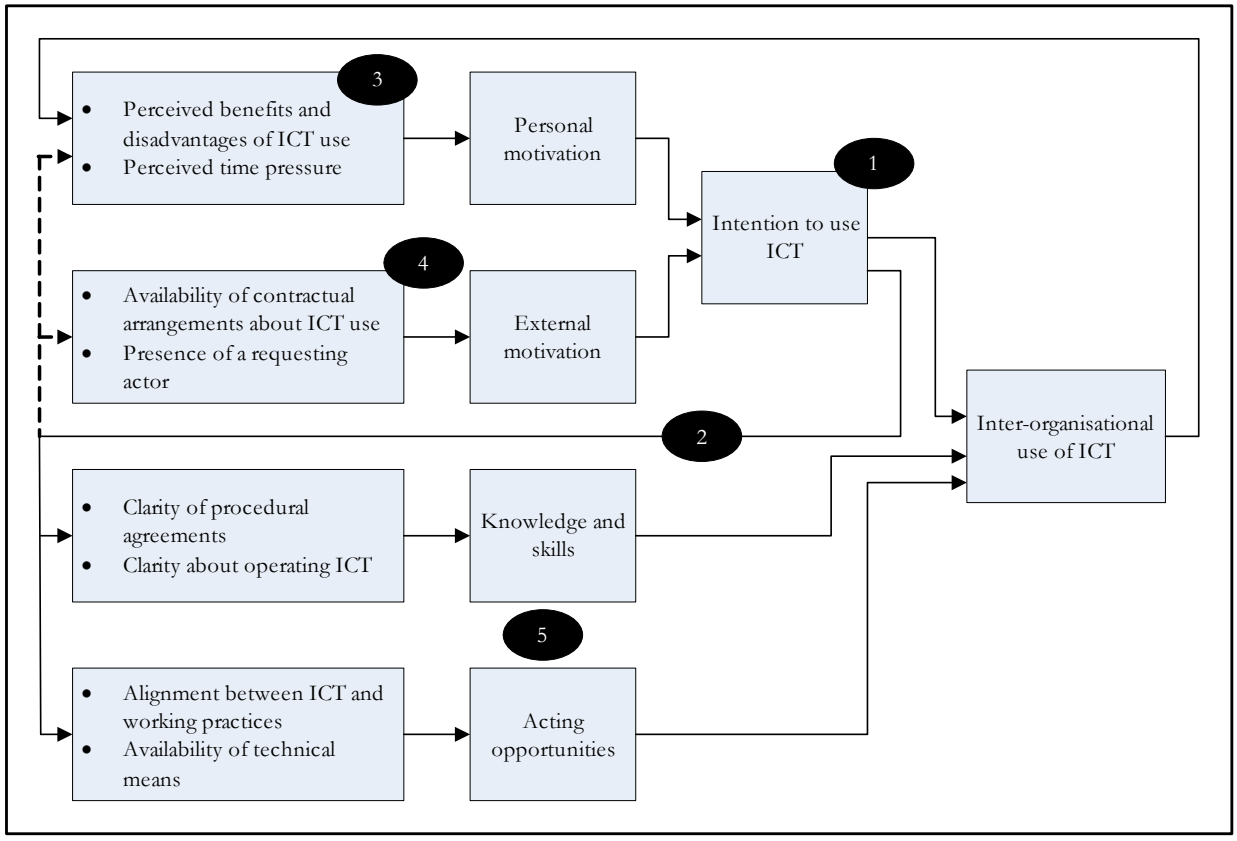

Figure 3.9: Comparison between our model and existing theoretical models

2. Intention to use ICT and to overcome barriers to the intended use of ICT

In our model, the personal and external motivation (clustered as the intention to use ICT) do not only influence the use of interorganisational ICT, but also the motivation to overcome barriers to the intended use of ICT. Thus, the intention to use ICT is influencing the use of interorganisational ICT as well as other subcategories in which barriers may be present. The other theoretical models do not include this relationship. If the motivation to overcome barriers to the intended use of ICT is high actors will try to intervene in two ways:

- *Intervention in an actor's own use:* an actor tries to overcome the barriers he or she is experiencing in the clarity of procedural agreements, the clarity about the operation of ICT, the alignment between ICT and working practices, and/or the availability of technical means. This actor is already motivated to use ICT (see straight lines in Figure 3.9).
- *Intervention in other actors' use:* an actor tries to overcome the barriers for other actors. An actor may be able to overcome the barriers in all subcategories: motivational mechanisms and other restricting mechanisms (dotted and straight lines in Figure 3.9).

An actor's positive intention to use ICT and its accompanying intention to overcome barriers to the intended use of ICT causes dynamics in the use of ICT because this actor starts to solve problems. When such positive motivation is not present, actors will not try to overcome barriers for themselves or others.

3. Mechanisms influencing the personal motivation to use ICT

In our model, personal motivation to use ICT is influenced by the perceived benefits and disadvantages of ICT use. This mechanism is moderated by perceived time pressure. When we compare these mechanisms with the other theoretical models we can make three important observations.

First, UTAUT, TPB, and TAM distinguish a construct that is very similar to the perceived benefits and disadvantages of ICT use. However, from our field studies it follows that we have to make a distinction between clear disadvantages, real risks, and unfounded risks that are based on a limited understanding. In the field studies, real and unfounded risks are very influential in determining the actual use of interorganisational ICT. These aspects are not explicitly included in the other models. In our model they are part of the 'perceived benefits and disadvantages of ICT use' construct.

Second, in our model perceived benefits and disadvantages are influenced by potential benefits and disadvantages of ICT use, understanding about the application, and the actual use of ICT by the actor and by other actors. As explained in the cross field study analysis section, these are dynamic elements: situations (i.e., job characteristics) change, which changes the benefits and disadvantages as well, understanding about the application and its benefits and disadvantages increase when actors start to use ICT, and the way actors and others use ICT themselves changes as a result of the dynamics in drivers and barriers. Only UTAUT includes dynamics in this relationship and is mentioning gender and age as moderating factors (Venkatesh et al., 2003). Venkatesh et al. (2003) suggest that gender and age reveal interesting patterns. However, in their view, there might be underlying moderating factors. In their research, they included experience as a moderating factor as well. However, this moderating factor is not moderating their 'perceived benefits or disadvantages' construct. From our field studies we can make three observations with regard to their moderating factors:

- We did not find that gender was a moderating factor. However, in the 'male dominated' world of construction we only encountered two female users of ICT. Therefore, it is difficult to generalise this statement.
- We noticed that older people – in general – faced more difficulties in understanding the application, the way it could be used, and its potential benefits and disadvantages. In addition, as a result of their restricted understanding they perceived more risks of the use of ICT. Thus, 'understanding about ICT' might be the underlying mechanism of the moderating factor 'age'. This needs to be identified in future research.
- Venkatesh et al. (2003) exclude experience as a moderating factor. However in our field studies, understanding about the application increased as a result of increased experience.

This influenced the perceived benefits and disadvantages of the use of ICT, which suggests that experience is important in determining the perceived benefits and disadvantages.

Third, in our model perceived time pressure is a very dominant mechanism moderating personal motivation as a result of perceived benefits and disadvantages of ICT use. This mechanism influences the personal motivation to use ICT in two ways: (1) combined with the time investment required to learn to use ICT, and (2) combined with the perceived risks of using ICT. UTAUT and TAM include a construct that can be related to one part of this mechanism (i.e., effort expectancy and ease of use). This construct is related to the time investment needed to learn to use ICT. Within UTAUT this mechanism is moderated by experience, gender, and age. From our model, we can confirm the importance of experience in this mechanism because actors first have to learn to use ICT and barriers have to be overcome. After a while actors know how to use ICT and barriers are overcome making this mechanism non-significant. Age and gender might influence this mechanism as well, however, in our view, we have shown the underlying mechanisms of these moderating factors.

4. Mechanisms influencing the external motivation to use ICT

Based on our observations we identify two mechanisms influencing external motivation: 'availability of contractual arrangements about ICT use' and 'presence of a requesting actor'. UTAUT, and TPB include a construct that is related to our mechanism 'presence of a requesting actor', but a construct similar to 'availability of contractual arrangements about ICT use' is not included in these models. This can be explained by the context in which these models are developed and used: a student context, or an organisational context, but not an interorganisational context. Thus, it depends on the context if 'contractual arrangements about ICT use' is influencing the use of ICT.

All theoretical models suggest that requesting actors become significant in a mandatory context. Our research confirms this claim. However, we have to add three comments to this statement. First, after a while, it seems that this mechanism is not significant anymore. The main reason for this is that actors incorporate interorganisational ICT in their working practices. Second, actors might request the non-use of ICT (i.e., the use of other means of communication) instead of ICT. Thus, a mandatory context is able to support and constrain the use of interorganisational ICT. Third, an actor without a hierarchical status may request the use of ICT. This may have an impact on an actor's use of ICT. This finding is in line with research stressing the importance of the presence of 'information technology champions' in determining the success of the introduction of ICT (e.g., Beath, 1991).

5. Mechanisms constraining the use of ICT

In our model we distinguish several mechanisms restricting an actor in using ICT (i.e., knowledge and skills and acting opportunities and accompanying subcategories). Only UTAUT and TPB include a – very general – construct incorporating these constraining mechanisms. For two reasons it is important to further differentiate this construct. First, the three theoretical models are often criticised for their primarily focus on intention and not on other potential constructs. Our theoretical model differentiates the only construct that does not influence the intention to use ICT. Each of these restricting mechanisms has shown to be significant in our field studies. Second, in order to be directive in operationalising the construct into items, which can be used to estimate usage and to guide practice, the general construct needs to be differentiated. Therefore, in our theoretical model we chose to differentiate between these mechanisms and not to use only one single construct for these mechanisms.

In our field studies, the mechanisms 'clarity of procedural agreements' and 'alignment between ICT and working practices' appeared to be very influential in determining the use of ICT. This might be

caused by the fact that interorganisational ICT is used and that organisations needed to get in line to be able to use the application in the appropriate way. In the context of other – more individualistic – applications these mechanisms will be less or not important.

3.5.2 Reflections on research method

In our research we used an in-depth qualitative method. Based on this research and the findings we can make several important observations.

Use of ICT in a web of (social) actions
In our field studies the use of ICT was embedded in a web of (social) actions. The way one actor acted influenced the way another actor acted and the benefits this actor could attain from the use of ICT. In addition, ICT is only one of the means actors can use in communicating. This web of social actions can only be understood when researchers gain in-depth understanding in the social and interorganisational contexts.

Difference between actors, specific features, and specific situations
Our study has shown that, in order to understand the use of interorganisational ICT in-depth, this use needs to be differentiated to specific actors and specific features. The understandings and perceptions of the actors differ between actors and features. In addition, actors use ICT differently in different situations. When analysing or measuring the use of interorganisational ICT researchers should take account of these differences. A lack of differentiation will result in bias and distorted findings.

Changes in ICT use over time
The use of interorganisational ICT has been shown to be highly dynamic. Cross-sectional snapshots in which variables are measured at a single point in time have dominated research into the adoption and use of ICT. These studies are not able to address the dynamics of ICT use. Our study has shown the importance of analysing the use of ICT over time.

3.6 Conclusions and implications for research and practice

We discussed the mechanisms that influence the way in which actors use interorganisational ICT over time in construction projects. Because the insights into these mechanisms were limited, an explorative approach was used to conduct an in-depth analysis of interorganisational ICT use in four construction projects. We used ethnography and the grounded theory approach to conduct this research. Our research resulted in the formulation of a theoretical model that consists of four main categories which determine the way actors use ICT in construction projects: (1) personal motivation (willingness to act), (2) external motivation (forced to act), (3) knowledge and skills (knowing how to act), and (4) opportunities to act. We related the subcategories influencing the way actors use interorganisational ICT in construction projects to these four categories and integrated them into our theoretical model. With this model the use of ICT over time in a construction project can be explained. We related our model to three well known existing theoretical models about the adoption and use of ICT: UTAUT, TPB, and TAM. Based on this confrontation we added the construct 'intention to use ICT' to our model and depicted some missing elements in existing models. Therefore, we suggest our model as a more comprehensive model.

Our study can be seen as a step towards developing a theoretical model that is able to explain and predict the use of interorganisational ICT over time. In future research, the mechanisms and directions for solutions need to be further developed and tested. Based on our field study and the

technique of theoretical sampling we suggest that subsequent research should examine interorganisational ICT in a context in which:

- Actors with different experiences in using interorganisational ICT have to use this ICT.
- Other types of interorganisational ICT applications are used (e.g., product modelling applications).
- Interorganisational ICT is used in another country then the Netherlands.
- Interorganisational ICT is used in another industry then the construction industry.

Our study also suggests other directions for future research:

- *Relate the theoretical model to social theories:* connecting grounded theory to existing theory is an important step in developing a more substantive theory (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998). Our study showed that the use of interorganisational ICT is embedded in a web of (social) actions. The way one actor acts influences the way another actor acts and the benefits this actor can attain from the use of ICT. In addition, ICT is only one of the means that actors can use to communicate. To gain a better understanding of the way actors act in their social and interorganisational context and how their acts are affected by social relationships, the theoretical model needs to be confronted with social theories.
- *Relate the theoretical model to realised benefits and the effect of ICT on performance:* the theoretical model explains why an actor acts in a certain way in a certain situation. However, the way an actor acts has consequences for the realised benefits and for the performance of a project. Insights in these relationships are important in order to reduce the chance of 'improving' the use of ICT without realising benefits or to avoid reducing the performance of a project. This relationships need to be addressed in future research.

The theoretical model has relevance for practice as well. It can help project managers and/or people responsible for implementing interorganisational ICT to identify the technical *and* nontechnical risks of introducing and using ICT in construction projects. Based on this risk analysis, they can formulate and implement measures to overcome these risks or choose to limit the scope of the application (e.g., limit the scope to only some organisations or to only some communication processes). In addition, the model can be used as an analytical tool to evaluate the status quo use of an underutilised application in a construction project and to formulate and implement improvements based on this analysis.

Chapter 4

The use of interorganisational ICT in United States construction projects

4.1 Introduction[21]

In the previous chapters, we provided an in-depth understanding of mechanisms influencing the use of *document management* and *workflow management* applications across organisational boundaries in *Dutch* construction projects. This demonstrated the key mechanisms that influence the way actors use these applications and how these mechanisms change over time. The mechanisms addressed technological, organisational, and human issues and showed barriers and drivers to the successful use of these applications.

However, these chapters only addressed the use of interorganisational ICT in the context of Dutch construction projects, and did not include an important line of promising interorganisational ICT applications for the construction industry, namely *product modelling applications*. Product modelling applications (e.g., 3D modelling, 4D modelling, Building Information Modelling) are able to support interorganisational cooperation, coordination, and communication as well.

Argyres (1999) showed how the use of product modelling applications across organisational boundaries in the aviation industry supported the coordination of design and production activities and allowed the design and production of a high-technology aircraft (B-2 "Stealth" Bomber), which might have been impossible without the use of this application. Numerous scholars have discussed the opportunities and potential benefits of product modelling applications for the construction industry too (Akinci et al., 2002; Bouchlaghem et al., 2005; McKinney and Fischer, 1998; Whyte et al., 2000). Several investigators even documented and analysed the use of these applications in real time construction projects (Bouchlaghem et al., 2005; Harty, 2005). However, none of these scholars identified or analysed in-depth the mechanisms influencing the use of product modelling applications across organisational boundaries. Bouchlaghem et al. (2005) only suggest that organisational and human issues in particular stand in the way of realising the potential benefits of these applications. There is clearly a need for more understanding of these mechanisms and for solutions to be found to eliminate potential barriers to the successful use of ICT so that the potential benefits of product modelling applications in the future can be realised.

This chapter focusses on the use of interorganisational ICT in construction projects in a country other than the Netherlands, namely the United States. In addition, product modelling applications are added to the research. The first objective of this chapter is to test the robustness of our model in the context of (1) the interorganisational use of ICT in construction projects in the United States, and (2) document management, workflow management, *and* product modelling applications. The second objective is to formulate directions for solutions to barriers to the successful use of interorganisational ICT in construction projects.

The chapter unfolds in the following way. The first section describes the research design of our study. The second presents the condensed results of the first step of our research about the use of document management and workflow management applications across organisational boundaries in

[21] An article based on this chapter has been submitted to *Automation in Construction* for publication.

Dutch construction projects. The third section describes the results of our study in which the interorganisational use of document management, workflow management, and product modelling applications in the context of the United States construction industry is examined. In the fourth section we present directions for solutions based on the Dutch field studies and the analysis of interorganisational use of ICT in the United States' construction industry. We conclude this chapter by discussing and assessing the contributions of our findings, our research limitations, and the implications.

4.2 Research design

In our research, we use the method of grounded theory. Grounded theory is a qualitative inductive research method that generates theory from data, which is systematically gathered and analysed through the research process (Strauss and Corbin, 1998, p.12). In this approach data collection, analysis, and theory are closely interrelated. The researcher makes choices about data collection based on his analysis and the evolving theory. Thus, data analysis occurs in parallel with data collection. One of the major techniques used in grounded theory is theoretical sampling. Strauss and Corbin (1998, p.201) define theoretical sampling as "[d]ata gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons,' whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of properties and dimensions". In using this technique of theoretical sampling we move from the specific to the more general (ibid.). We make choices in selecting places, people, and events based on our evolving theory to maximise the opportunities for comparative analysis. Below we identify the steps we followed when carrying out our research.

Step 1: Analysis of the use of interorganisational ICT in four Dutch construction projects
In the first step we focused in-depth on mechanisms influencing the use of document management and workflow management applications across organisational boundaries in four Dutch construction projects. By identifying and analysing these mechanisms, we could understand and explain why individuals and organisations did or did not use ICT in the intended way. In this step, we combined the method of grounded theory with that of ethnography. Schultze (2000, p.7) defines ethnography as "an anthropological research method that relies on first-hand observations made by a researcher immersed over an extended period of time in a culture, with which he/she is unfamiliar". Ethnographers are primarily concerned with studying, understanding and providing explanations of human behaviour and action in their social, cultural and organisational context (Atkinson, 1990; Harvey and Myers, 1995; Myers, 1999; Prasad, 1997). According to Agar (1996, p.131) the ethnographic research method is used "to transfer observations into accounts that group members say are possible interpretations of what is going on". The main characteristics of the field studies are summarised in Table 4.1.

We used multiple investigators to conduct the research. Each field study was assigned to one researcher. During the field studies, multiple techniques were used to increase the validity of identified constructs (Eisenhardt, 1989). First, the researchers spent most of the time observing participants and informally talking to them. Participant observation took place during the daily routine and in meetings. The researchers took a passive role rather than an active role to minimise the extent of their impact on local practices. In addition, the researchers observed participants' ICT-behaviour to grasp how actors communicated and used ICT. They tried to understand 'what was going on' regarding the use of ICT. Second, the researchers conducted many informal and semi-structured interviews to capture participants' perceptions and understanding. The researchers tried to see the world from the participants' point of view. Without these perceptions and this understanding, it would have been difficult to understand why actors act in a certain way. Finally, the researchers examined documents. Contract documents described the arrangements about what

people should communicate formally. In addition, the researchers collected and analysed other available documents, such as specifications of the ICT application, minutes of meetings, and letters communicated between the engineering company and the contractor. Documents provided important qualitative information that could be compared with the responses of the interviewees and the observations. The researchers took detailed notes during all data collection activities to capture their impressions and insights.

	Field Study 1	**Field Study 2**	**Field Study 3**	**Field Study 4**
Tender sum	26 m Euro	42 m Euro	56 m Euro	1.6 m Euro
Duration contract	15 months	22 months	24 months	32 months
Contract type	Design-bid-build	Design-bid-build	Design-build	Design-build
Used features	Document management, workflow management	Document management, workflow management	Workflow management	Document management, workflow management
Organisations using ICT	Client, contractor, engineering company	Client, contractor, engineering company	Client, contractor	Client, contractor, engineering company, subcontractor
Organisation initiating ICT use	Engineering company	Engineering company	Client	Client
Organisation paying for ICT (customisation, application, training, support)	Engineering company (For own processes and interface with contractor)	Engineering company (For own processes and interface with contractor)	Client	Client; contractor, engineering company pay for modifications (9 months after the introduction of ICT)
ICT use mandated in contract	Yes, for contractor	Yes, for contractor	No	No
Organisations involved in customisation of ICT	Engineering company	Engineering company	Client, contractor	Client, contractor in initial development; all organisations in implementing modifications

Table 4.1: Characteristics of Field Studies

This step resulted in a theoretical model that was able to explain the use of document management applications and workflow management applications across organisational boundaries over time in four Dutch construction projects.

Step 2: Interviews with representatives of the U.S. construction industry

In moving from the specific to the more general (Strauss and Corbin, 1998) we wanted to validate our theoretical model in another context (i.e., another country) and to add another important line of interorganisational ICT to our analysis (i.e., product modelling applications). Thus, we purposefully tested our theoretical model and, when necessary, made modifications or additions to it based on this test. We could use the network of the Stanford Center for Integrated Facility Management (CIFE) to gain access to companies in the United States and decided to collect data by conducting expert interviews. In the expert interviews, we did not reflect on a single case but more generally on drivers and barriers to the successful use of interorganisational ICT in construction projects and directions for solutions to potential barriers.

We conducted interviews with experts from the United States construction industry. In total 20 experts from 10 companies were involved in this study. The main criteria for selecting these

organisations and experts were: (1) their experiences: they needed to be involved in several concrete construction projects in which interorganisational ICT (and especially product models) was used, and (2) the type of organisation they work for: client, designer (architect, engineer), or contractor. Thus we focused on representatives of the main actors in the construction process. At least two representatives of each of these types of organisations were selected. Since our focus is on mechanisms and solutions, we selected frontrunners rather than selecting a random sample of users. These experts could better reflect on possible solutions to potential barriers based on their experiences. A drawback of this decision is that the experts might be biased (or as one expert calls it "brain washed") by the opportunities of interorganisational ICT and not be representative of the United States construction industry.

The insights from the Dutch case studies were used as starting points for conducting the interviews. To make the interviews as efficient as possible experts were asked to complete a short questionnaire by e-mail in advance. This questionnaire included five main parts:

1. General questions about the position of the expert and the organisation the expert is working in;
2. Questions about the experiences of this organisation: how much experience, and scope (experiences with which applications, with which organisations, in which construction phases);
3. Questions about characteristics of ICT introduction: who is initiating, who is paying;
4. General open questions about potential benefits, and disadvantages of the use of ICT, and barriers to the successful use of ICT;
5. Focused statements about ICT use.

The questionnaire is included in Appendix 1. With the responses the researcher could prepare the interviews as thoroughly as possible; he could ask more informed questions, and concentrate in the interview on the most interesting points raised. The interviews were completed in the offices of the experts in October 2006. Each interview took about 2 hours and focused on differences between types of applications, differences in experiences between projects, and solutions to potential barriers. The researcher did not try to test or validate the solutions from the Dutch field studies. When the experts identified a barrier they were asked to suggest potential solutions to these barriers. In addition, based on the philosophy of grounded theory, the researcher added additional questions based on understanding that evolved from carrying out the interviews. The experiences of the experts with document management (DM), workflow management (WF), and product modelling (PM) applications are summarised in Table 4.2. This table shows:

- Experiences of the expert's organisation with the different types of ICT varying from no experience to very little experience (used in one or two projects), moderate experience (used in several projects), and frequent use (used in the majority of projects). The experiences may also be unclear to an expert.
- The organisations this organisation is using the applications with (CL is client; AR is architect; EC is engineer; CO is contractor; SC is subcontractor);
- Construction phases that the organisation is using the applications in (programming, design, construction, and maintenance);
- Types of applications that the expert's organisation has experiences in. For example, one of the experts was able to reflect on the use of product modelling applications, but not on the use of document management applications. The interview focused on the applications that the expert could reflect on.

	Type of organisation	Experience	CL	AR	EC	CO	SC	Phases	Experience
1	Client	DM: unclear WF: unclear PM: moderate	 x	 x	 x	 x		Programming, design, construction	PM
2	Client, architect, engineer	DM: frequent WF: moderate PM: moderate	x x x	x x	x x	x x x	 x	Programming, design, construction	DM, WF, PM
3	Engineer	DM: moderate WF: moderate PM: moderate	x x x	x x x	x x x	x x x		Programming, design, construction, maintenance	DM, WF, PM
4	Architect	DM: very little WF: none PM: none	x	x	x	x		Design, construction	DM, WF, PM
5	Architect	DM: very little WF: very little PD: moderate	x x	x x x	x x	x x	x x	Programming, design, construction	DM, WF, PM
6	Contractor	DM: frequent WF: moderate PM: moderate	x x	x x x	x x	x x x	x x x	Design, construction	DM, WF, PM
7	Contractor	DM: frequent WF: frequent PM: frequent	x x	x x x	x x	x x x	x x	Design, construction	DM, WF, PM
8	Contractor, owner	DM: frequent WF: very little PM: moderate	x x	x x	x x	x x	 x	Design, construction	PM
9	Contractor	DM: frequent WF: none PM: moderate	x x	x x	x 	x x	 x	Design, construction, maintenance	PM
10	General contractor	DM: frequent WF: frequent PM: moderate	x x	x x x	x x x	x x x	x x x	Design, construction	DM, WF, PM

Table 4.2: Summary of experiences of the experts involved

4.3 Interorganisational use of ICT in Dutch construction projects

In this section, we present the condensed results of the first step of our research. We developed a theoretical model containing the mechanisms that influence the way actors use document management and workflow management applications across organisational boundaries over time in four Dutch construction projects. The theoretical model is shown in Figure 4.1. The categories and subcategories shown in Figure 4.1 are defined in Table 4.3.

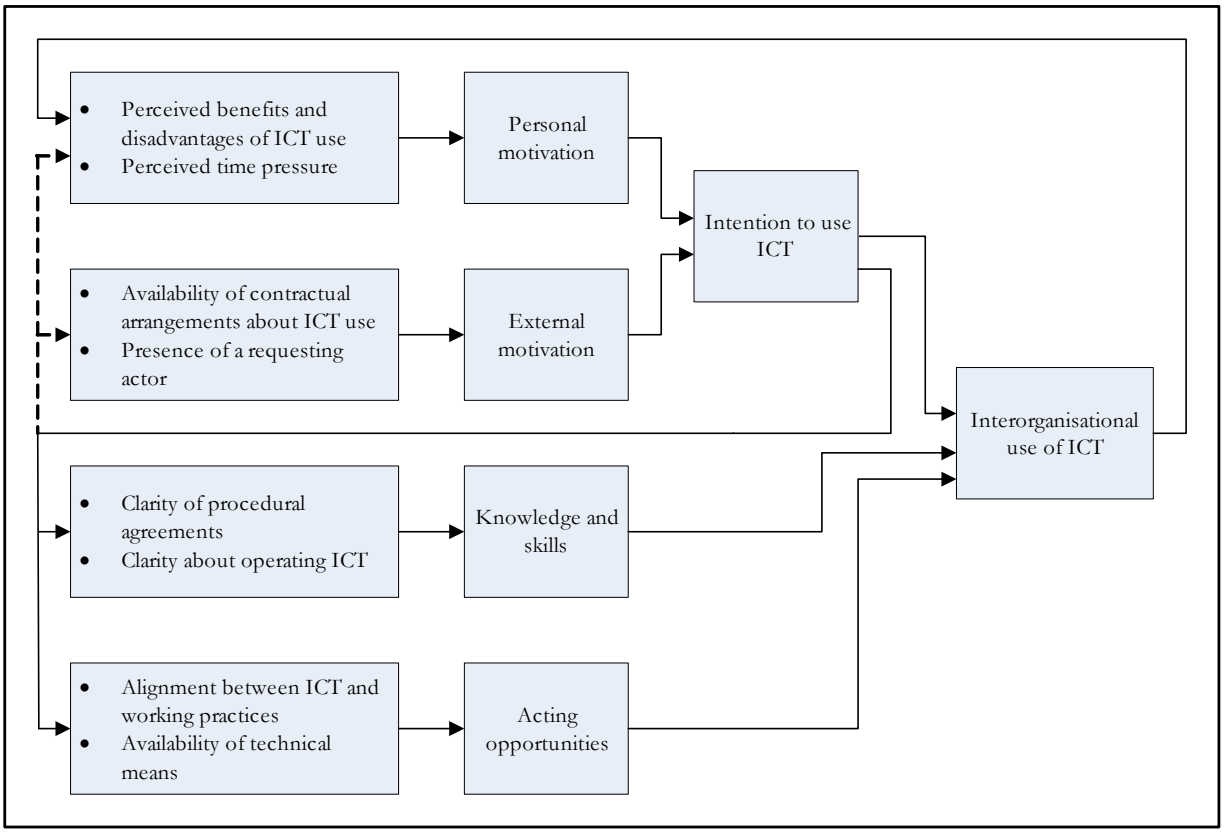

Figure 4.1: Theoretical model

Category, subcategory	Definition
Intention to use ICT	"The motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1991, p.181). This intention influences both the use of ICT and the barriers to the intended use of ICT. Actors may try to overcome barriers for themselves (see straight lines in Figure 4.1) and for other actors (see straight and dotted lines in Figure 4.1).
1. Personal motivation	The extent to which actors are willing to use interorganisational ICT themselves. Personal motivation influences both the willingness of the actors to use ICT and their willingness to invest resources to overcome barriers to the intended use of ICT.
1a. Perceived benefits and disadvantages of ICT use	The extent to which actors perceive the use of ICT as benefiting and/or disadvantaging them. When actors perceive that there are many benefits (and no, or only a few, disadvantages) this will influence personal motivation positively. On the other hand, many perceived disadvantages will influence personal motivation negatively. This subcategory can be a driver and a barrier to the use of ICT.
1b. Perceived time pressure	The extent to which actors perceive that they have to act quickly when using, or considering the use of, ICT. A high level of perceived time pressure can moderate personal motivation because of the highly perceived benefits of the use of ICT. However, a low level of perceived time pressure does not result in a high level of personal motivation to use ICT per se. This subcategory can only be a barrier to the use of ICT.
2. External motivation	The degree to which actors are forced by other actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest time and money to overcome barriers to the intended use of ICT.
2a. Availability of contractual arrangements about ICT use	The extent to which actors are forced to use ICT or other means of communication because this is mandated in the contract. When ICT is prescribed, external motivation is present. When ICT is not mandated no external motivation to use ICT exists. A

Category, subcategory	Definition
	mandate of only other means of communication is even a barrier to the use of ICT.
2b. Presence of a requesting actor	The extent to which another actor requests certain action(s) (e.g. use of ICT, or non-use of ICT) to take place and the extent that this request impacts on actors. When actors are asked to use ICT and this request has an impact on them, external motivation is present; if this request is absent or if it does not have impact then no external motivation exists. Another actor who requests acting in another way than using ICT might even be a barrier to the use of ICT if this request impacts on actors.
3. Knowledge and skills to use ICT	The degree to which actors know how to use ICT. When knowledge and skills are limited, the actors themselves are the ones restricting the use of ICT.
3a. Clarity of procedural agreements	The extent to which actors know how to act concerning the ICT application (e.g., what information has to be communicated to whom, and in what form and at what time) and these actions support the intended use of ICT. This clarity can be high or limited, resulting in enough or a restricting amount of knowledge and skills to use ICT. This subcategory can only be a barrier to the use of ICT.
3b. Clarity about the operation of ICT	The extent to which actors know how to operate the application. This clarity can be high or low resulting in enough or a restricting amount of knowledge and skills to use ICT. This subcategory can only be a barrier to the use of ICT.
4. Acting opportunities	The extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.
4a. Alignment between ICT and working practices	The extent to which ICT fits in with actors' working practices in the project and their organisation(s). This alignment can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way. This subcategory can only be a barrier to the use of ICT.
4b. Availability of technical means	The extent to which technological aspects restrict actors in using ICT in the intended way. This availability of technical means can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way. This subcategory can only be a barrier to the use of ICT.

Table 4.3: Definition of categories and subcategories of the theoretical model

4.4 Results from the United States construction industry

In this section, we present the results of the second step of our research. We will test the robustness of the theoretical model by applying it to another context (United States). In addition, we add another type of application to the research: product modelling applications.

4.4.1 Personal motivation

1a. Perceived benefits and disadvantages of ICT use

All the experts are very positive about the potential benefits of the use of interorganisational ICT in construction projects. According to the experts, construction projects would benefit greatly from the use of interorganisational ICT. Important benefits are, for example:

- Document management: single data source, better coordination, reduced project costs by eliminating the need for shipping of documents and files;
- Workflow management: workflow tracking, higher speed of communication;
- Product modelling: better design coordination, valuable visual tool, single data source.

When we shift our focus to the benefits their colleagues and other organisations perceive in using interorganisational ICT, the experts are less optimistic. They stress that some colleagues and some other organisations start to see benefits. Several experts mention that some subcontractors (e.g., mechanical contractors) are becoming advanced in using product modelling applications and that the awareness

among architects on these applications is increasing rapidly as well. In the context of 'perceived benefits and disadvantages of ICT use' the experts mention the following barriers:

- *A limited awareness of potential benefits:* the attitude about the use of interorganisational ICT is often determined by a limited understanding about this ICT and, therefore, a limited awareness of its real benefits. People and organisations can overestimate the benefits, making the real value disappointing. The opposite happens as well: people and organisations do not see the value of using interorganisational ICT because of a limited understanding about the application. One expert says: *"[Product modelling] requires a different way of working and thinking. This makes it difficult to see the benefits [compared to document management and workflow management]*." Another expert says: *"[Product modelling] is seen as a Disney thing. What is the real value?"*
- *A limited awareness of the needed budget:* there are costs associated with the introduction and use of interorganisational ICT. If these costs are not clear and not included in the cost estimates those project managers who do not see the value of it and whose entire focus is on project margins will adopt resistance to the application. In their view they have to spend additional money and these expenses are cutting into their profit margins. One expert says: *"If you don't have [the costs] in your cost estimates there is a lot of kick back from project managers saying: 'I didn't know that I had to spend this money and now you are cutting into my profit margins'."*
- *The use of ICT can be a disadvantage:* benefits and disadvantages of the use of interorganisational ICT are not distributed evenly across organisations and people. When interorganisational ICT is used in a construction project some *organisations* can benefit more than others, and some participating organisations even have to carry out additional activities. As a result of the fragmented nature of construction projects, the organisations involved often have different priorities and objectives that are not aligned. When organisations have to carry out additional activities (e.g., communicate both digitally and paper-based; have to make a 3D model instead of 2D drawings) they will charge money for that, or they will resist the use of ICT. On a *personal* level, benefits and disadvantages may be distributed unevenly as well. For example, people may have to download and plot drawings themselves instead of – as they used to do - calling someone else that they want to receive paper drawings. In addition, carrying out a single activity might be slower then in the traditional paper-based way as well. One expert says: *"I did an experiment with tablet pc's doing red line mark-ups on it. It is slower. It is not as fast as printing and marking up whilst reading."*
- *An upfront investment is needed:* when organisations want to use interorganisational ICT they need to invest first (e.g., costs of deployment of hardware, software, and training, coordination costs). One expert says in this respect about the use of product modelling applications: *"You have to do that investment in your first project. After a few projects have been completed it starts paying back."* Actors must be willing to invest these resources. Some organisations perceive the introduction and use of interorganisational ICT as an additional cost, others as a great investment (expert: *"It is not a cost. It is a primary saving."*) The ones who are confronted with an organisation mandating or requesting the use of ICT and who see it as an additional cost will try to include these costs in their bids. One expert says: *"In most cases it is not an additional cost to us. Some of the subcontractors are still calling it an additional cost. In those cases we ask them to include their costs in their bids. We will state in the bid documents that we tell them to include, for example, a half percent for modelling and the deliverables that they need to give. So it is built in their bids. The ones that do it anyway will simply decline to add that amount. So they will more likely get the bid."* Note that at the start of every new project, as a result of the use of interorganisational ICT, more time needs to be spent on the coordination between organisations than they used to need without ICT.
- *The introduction of interorganisational ICT is associated with risks:* when interorganisational ICT is used for the first time its introduction is associated with additional risks. One expert says in the context of design-bid-build contracts: *"When your margins are not guaranteed or you certainly don't have common margin objectives there is a risk associated with it. (…) There is no incentive for anyone*

to innovate. They will do it the same way as they have always done it because they know what the outcome will be. Even if it is bad." Another expert says: *"People are unwilling to pay for unproven systems. Profit margins in construction projects are minimal. People are very conservative about trying out new things. Construction is about managing risks and spending as little as possible."*

- *Resistance to increased transparency:* interorganisational ICT is able to provide more transparency in a construction project for the organisations involved. All experts stress that increased transparency is a benefit to the project. However, some experts think some other organisations will view this increased transparency as a disadvantage. The experts give several examples of that:
  1. *"The owner is having a competition with architects based on price. He is selecting the cheapest architect. The architect provides the minimal service in order to create a good price. To make money the architects have to minimise the work. They create something that satisfies the contract but does not necessarily fulfil the demand for the best design and the best plan for construction. Then [the contractor] needs to solve all these problems later. (…) The architect is providing a cheap design and cheap systems typically in 2D. Because the design is not very well worked out the architect doesn't want to communicate in 3D because it is easier for him to hide the omissions. You can be very vague with a 2D drawing. There is no benefit for the architect to work in 3D. (…) So, it is the owners responsibility to choose an architect who can provide a useful output – the 3D model – and not a cheap thing to the contractor."* This example clearly reveals the fragmented nature of construction projects, the lack of aligned objectives of the organisations involved and the resulting barriers to process integration and transparency.
  2. *"A lot of subcontractors make money on change orders. However, nobody will say this to you. They mention other arguments. However, we know who wants to make money out of change orders and who doesn't. We want the client to know everything."* The use of product modelling applications may result in increased transparency in the construction object and in a reduction of omissions in drawings. This reduction of omissions is a clear disadvantage to the subcontractors mentioned above, since there is less opportunity to profit from change orders. However, according to another expert, the use of product models can even be of value to these subcontractors: *"A contractor said to me: 'If the rules of the game are hard bid, you could build a model to show all the things that are not in the drawings and look what the change order opportunities are'."* Thus, increased transparency associated with the use of product modelling applications may be a threat to organisations that want to make money out of change orders. However, these applications might be of value to these organisations as well if they are used to show the change order opportunities to them.

The barriers mentioned above influence the attitudes of the people and organisations involved towards the use of interorganisational ICT and in the end their use of this ICT. One expert gives an example of this: *"In our project the architect does not see the benefits. The project architect sees it as a cost issue. (…) Also it is the first time for the architect to do 3D work. He had to make the investment too. A consequence is that he doesn't participate fully. They do as little as possible or do nothing."* Of course, the way people and organisations use ICT influences the benefits they gain from it. However, the way ICT is used by other organisations influences these gains as well. For example, people do not import information in the application, reducing the value to others because the application is not current, or people make a 3D model that has no value for others. An expert says: *"Since the architect has a different purpose for the model than we do, we found the model of the architect is not of much use to us. We still have to rebuild it."* Thus, the lack of an appropriate level of participation of the key members is an important barrier to the successful use of interorganisational ICT. The more organisations, which use interorganisational ICT in a coordinated way, the more the project can benefit from the use of it.

From the interviews, it becomes clear that the value of ICT is dependent on the characteristics of a project and the organisations and people involved. Some experts have developed criteria to assess

whether a project is suitable for the use of ICT and which features are valuable in a project. These criteria are based on characteristics of the project (e.g., complexity, size, contract types, delivery models), and the organisations involved (e.g., capabilities, motivation to use ICT). One expert says about the decision whether a project is suitable for using interorganisational ICT: *"It is largely related to interorganisational questions: If everybody else on the team is interested and capable we might decide to deploy our resources there rather then somewhere else. If all the trade contractors, the architect, and the owner want to do it then it is high on our list."*

1b. Perceived time pressure

According to the experts, time pressure is an important barrier to the successful use of interorganisational ICT. If actors have to use an application for the first time and time pressure is high they tend to revert to the old ways of doing things. Some experts say about this mechanism:

- *"At the start of the project people try to follow their own ways of working. People not using the proper medium are a real threat. People try to do it faster in the traditional way."*
- *"The idea of adopting a new technology - although it can save time in the long and medium time - is overwhelming them. They already have a system and although it is not the best system… It is like hiring a new person. You need him but you don't have time to hire him."*

Time pressure moderates the effects of a positive configuration of perceived benefits and disadvantages. When this configuration is positive enough actors will still try to use ICT in situations of high time pressure; when this configuration is negative no time pressure, or only a limited amount of time pressure is needed for actors to revert to traditional means of communication. One expert says: *"As soon as the contractor sees the benefit he will spend time on it."* The main reasons why actors revert to traditional means in situations of high time pressure are discussed below.

- *Ability to invest the necessary time to learn to use ICT:* people have to invest time to learn to use new interorganisational ICT and to overcome barriers to its use. Sometimes actors are not able to invest this time in a project (*"people don't come over the hump"*; *"[ICT] is not something on the radar"*). They think they do not have time for it. One expert says about this mechanism: *"We may not have built-in the time necessary in the schedule for learning these new processes. And they need to have the cost estimates done before next Tuesday. They say: 'I don't have time to build the model so I can extract the quantities. I have to do it the old way'."*
- *Risks of using ICT when time pressure is high:* people or organisations are more comfortable doing things in the traditional way than by using new ICT, especially in situations of high time pressure. They do not know the application and if it is working properly, they do not know if they are using it in the right way, and they are uncertain about the outcome of its use. They know that traditional working practices used to be effective, because they have already used these for years. One expert says about this mechanism: *"In the construction industry people have their own way of doing things. Even if they realise it is not the most efficient way of doing it, they know that they can get the project done in that way. They are reluctant to risk doing it in a different way. (…) You have to convince them that it is going to decrease the risk."* When people start to have bad experiences with the use of interorganisational ICT in their project (e.g. bugs in the application), the perceived risks of using ICT increases as well. Therefore, people tend to revert to traditional working practices again.

Above, the use of new interorganisational ICT is presented as something risky. However, not all experts agree on that. In a project where everybody is using interoganisational ICT it is more risky for an actor to use traditional means of communication. Everything that is outside the application stands the risk of being completely ignored. Thus, it depends on the way actors use ICT and traditional means of communication as to whether the use of ICT is a risk.

After a while when participants get familiar with the application and its effectiveness is well proven the use of ICT is not associated with risk anymore. Actors have incorporated the use of ICT in their working practices and have learned to use ICT (*"It is all about a learning curve"*). This situation may occur in the first project in which interorganisational ICT is used, but may also occur in subsequent projects. In the end, the introduction of interorganisational ICT can be a great investment in a context of high time pressure. The learning curve seems to differ between types of applications. According to several experts, the learning curve is steeper for product modelling applications than for document management and workflow management applications. Product modelling applications require a completely new way of working and thinking which makes its introduction more difficult. Therefore, it takes longer at the start of the project to set things up and to get familiar with the application.

4.4.2 External motivation

2a. Availability of contractual arrangements about ICT use

The organisations of all the experts try to initiate the use of interorganisational ICT themselves, at least for one of the studied types of applications. Which of the applications they initiate depends on the value they perceive of using these applications in their projects. This is based on perceptions of potential benefits, or their experience of using this application in the past. Sometimes these organisations are confronted with other organisations initiating the use of interorganisational ICT as well. In the United States the General Services Administration (GSA) – the largest owner in the United States – intends to start mandating that new buildings designed through its Public Buildings Service use product modelling applications (i.e., building information models) in the design stage. They will start to mandate this use from January 2007.

Whether interorganisational ICT is actually used depends on the willingness of the organisations involved or the opportunities of the initiating organisation to mandate its use in their contracts. Of course, an organisation is not always in the position to mandate the use of ICT for other organisations. For example, it is obvious that a client can mandate contractors, and a contractor can mandate subcontractors. However, these organisations cannot mandate the use of ICT the other way around. If one organisation is not in the position to mandate the use of ICT in the contract they have to convince its value to the other organisations (an engineer says: *"We do it in compliance with the client. We do it with the client's blessing."*). One expert suggests that the need to mandate the use of interorganisational ICT in the contract differs between types of applications. He says: *"Working with [product modelling applications] is more difficult than with document management tools so you have to prescribe. [Product modelling applications] need to be prescribed in order to get the organisations in line. (…) Document management tools and workflow management tools requires more discussion and not mandating in the contract. It is up to the project team how they are going to use it. The other organisations see the benefits of it, so they cooperate"*. In other words, by mandating the use of interorganisational ICT in contracts organisations force other organisations to use it. However, the experts view mandating the use of ICT as being tricky in several ways:

- *Mandating reduces competition:* the more advanced ICT is mandated the less potential competition, because fewer organisations are able to use this ICT. Therefore, some organisations mandate the use of document management applications, but do not mandate product modelling applications.
- *Mandating of outcomes is preferable:* experts prefer to mandate only the outcomes of the use of ICT instead of mandating digital working practices. In the context of product modelling they can, for example, mandate that the model needs to be current and updated, that it should represent the true dimensions, and that it should be an object-based model. In their view, other organisations must be able to determine their own working practices because other organisations might work with other applications and according to other digital

working practices. These might be more sophisticated than the ones used by the mandating organisation. However, according to the experts in the United States construction industry, organisations are not able to mandate product models this way at the moment. Other organisations often do not know how to use product modelling applications in the best way. Therefore, some organisations decide to be prescriptive in their contracts. One expert says: *"We need to be prescriptive because people don't know how to use [ICT] so we have to tell them how to do it at first. So, in the end, people know how to do it and know what we want. Then we can prescribe the outcome."*

- *Mandating the use of ICT may raise the price:* according to several experts when the use of ICT is mandated in contracts other organisations may ask money for it. Some organisations will charge the mandating organisation money for using ICT, others simply will not do. The mandating organisation will still have a lowest bidder. However, this price might be higher as a result of mandating the use of ICT. One expert says: *"If we decide to have 3D models instead of 2D documents the [other organisation] will do that but he will charge us money. The question is: do we want that? How much is it worth to us?"*

Therefore, some organisations decide to mandate the use of ICT and others do not. The experts prefer to convince others about the benefits of the use of ICT instead of forcing them to use interorganisational ICT by a mandate.

According to the experts, for most organisations the introduction and use of product modelling applications across organisational boundaries is a learning process at the moment in the United States' construction industry. Therefore, in current situations, its use is often mandated vaguely because the prescribing organisations have to learn how these applications need to be used and mandated at first. Some experts admit that they have to update their contractual clauses, based on their increased understanding about the way they want to use product models (i.e., Building Information Models). In their view it is important to update the clauses because when the use of interorganisational ICT is mandated vaguely other actors have some space to optimise the use of product modelling to their own purposes.

Another option is to prequalify other organisations with regard to their ICT capabilities. Some of the experts already prequalify other organisations with regard to their product modelling capabilities or plan to do so. When they prequalify with regard to these capabilities only those organisations that can deal with product models will be invited or they will get a low score on the 'product modelling criteria'. One expert says: *"If we go to the mechanical guy we say 'here you have our prequalifications and you must be able to do [modelling]'. When they say: 'we have never heard of it', then they get a low score on that criteria. (…) When they say 'no' we might say we still work with them and that we will build the model."* However, others experts are reserved in their use of prequalifications. In their view, there are insufficient numbers of organisations that can deal with product models. Therefore, prequalification will reduce competition too much. In addition, the need to prequalify organisations with regard to their capabilities to use or build product models will disappear in the near future. One expert says: *"Are you going to ask them if they make use of a computer or Word as well?"*

2b. Presence of a requesting actor

Organisations can mandate the use of interorganisational ICT for other organisations in their contracts. However, they can request (i.e., ask for) its use as well. Several experts are confronted with this situation occasionally. This request might be clearly or vaguely formulated based on the experiences of the requesting organisation. In addition, this request might result in added costs (see also 'Availability of contractual arrangements about ICT use'). An expert says about this mechanism: *"Some clients are contemplating the use of [product modelling applications]. They say: 'we don't know anything about it, what do you recommend us to do, and how much would that cost?' They don't know how useful it is yet. You can*

have a general contractor who is already using it and saving money with it. You can also have a general contractor who has no idea about it and then it would be an added cost." However, clients may also discourage the use of interorganisational ICT. One expert says about this: *"[The client] wants a quick start. Often time pressure comes from [the client]."* Another says: *"We do whatever [the client] tells us to do. When he says: 'I don't want to pay you to spend a lot of time on doing [ICT] stuff. I want you to do the building.' We will do just that."*

Internally within organisations actors such as the line management or project management might also request the use of interorganisational ICT (*"We get a lot of support from the executive management. So the people don't have that much choice."*; *"The use of [workflow management application/ document management application] is a corporate mandate"*). However, they might also prohibit or discourage the use of ICT (*"When the manager doesn't really see the benefits of it and he sees a person spending a lot of time building a model he might have problems with it."*). Therefore, several experts stress the importance of strong leadership and a positive organisational culture for change. People need space to invest some time and money and to take some risk to adopt interorganisational ICT. One expert says about actors willing to use ICT: *"If they see support and put high priority on it, they can change. It is, in the end, people doing it. If there is a positive culture for change it would be easier. Sometimes they are forced to change. That is why leadership is the key."*

4.4.3 Knowledge and skills

3a. Clarity of procedural agreements

The experts stress the importance of making clear agreements about the use of interorganisational ICT before actors start to use ICT. They give examples for workflow management and product modelling applications:

- Workflow management applications: organisations have to make clear agreements about the workflow processes that are going to be used in the project. An expert says: *"If you don't make a requirement that all communication is via [workflow management application] you can expect information in many different ways. Digitally or not digitally. Is a fax received or a letter dropped on your table or is there electronic communication? Once you say we are going to use this particular workflow – and I am talking about at the start of a construction projects – then you want to enforce it in a single path. Anybody has to use the same line."*
- Product modelling applications: if organisations want to use and reuse information interorganisationally they have to make agreements, for example, about who is going to make changes in the model and at what time, and about the level of detail that is going to be provided in the model. One expert says about discussions about the level of detail: *"We are going into a meeting at the start of the project. I have a lot of consultants. I say: 'Mr. architect what are you going to provide in the model?' If I see something we need and he is not doing it I say what we need and why we need it. (…) When they say: 'We don't have enough budget to do it', then the next question is: 'Will you give us your model so we can do it?' We are initiating the level of detail and ask every consultant whether they agree or not about the level of detail we are asking for."*

Making clear procedural agreements is an important requisite for attaining the potential benefits of interorganisational ICT, such as streamlining information and communication and eliminating useless activities. Actors have to coordinate their activities. However, making clear procedural agreements takes a lot of time at the start of the project. According to the experts, actors often do not take enough time for this. An expert (client) says: *"The contractor wants to get started immediately. (…) Till you start you cannot finish. But when you have a broader perspective then you realise at the beginning the transactions that are going to occur. Then you realise that it goes much faster if this is standardised and coordinated."* When the use of interorganisational ICT is new to the actors involved it is difficult for these actors to assess how the application needs to be used and how this use will affect them. Therefore, actors need to spend more time in coordinating and making clear procedural agreements.

One of the characteristics of construction projects is that organisations *often* work together on a temporary basis. Each of the organisations involved has its own standard working practices and in every project these organisations have to make procedural agreements again in order to coordinate activities and to make the use of interorganisational ICT possible. Because of the 'one-off' nature of these cooperations organisations are not very familiar with each others working practices. Therefore, they have to find out, in every project, how participating organisations work and how ICT can be used in the most beneficial way. An expert (client) says: *"We don't see deeply enough into the contractors' organisations to be able to say: "You have three subcontractors there who do their work electronically. Let's have a separate meeting with them and find out how exactly they do it and which standards they are using. Or can we do something so we can communicate more directly with them so they have the full benefit of the design information we have got. The reverse is true as well: the contractor cannot look into our organisation to understand what data he might be able to take forward with great utility."*

Long-term relationships would make the use of interorganisational ICT easier. However, long-term relationships often do not exist in current construction practice in the United States. One expert says: *"We cannot integrate too much because the price will go up."* Sometimes organisations work with other organisations on a regular basis. However, none of the experts' organisations use interorganisational ICT in a structured way (i.e., repeatedly) with these organisations. This lack of long-term relationships does not inhibit the organisations of the experts from using interorganisational ICT but setting up long-term relationship would eliminate several problems that occur in the current situation, such as having to make procedural agreements between participating organisations within each individual project again.

3b. Clarity about the operation of ICT

According to the experts the capabilities that the actors involved need to operate interorganisational ICT in a construction project, is sometimes an important barrier to the successful use of this ICT, both internally within their own organisation and within other organisations. The effectiveness of interorganisational ICT becomes marginalised when actors do not have the necessary capabilities to operate the application. The chance of there being a lack of the capability to operate interorganisational ICT introduces risk in the project. One expert says, in the context of product modelling applications: *"Unskilled people cause problems. If you give a 3D model of this column to somebody, you have to make sure that the person you are giving it to knows exactly what to do with it. That he doesn't have a question about how to scale it or where to locate it in your project. You need to make exactly sure that the entire transaction is going to be complete. That they are not missing anything."*

A lack of skills to operate interorganisational ICT is particularly a threat when ICT is new. Experts stress that current knowledge and capability problems will disappear in the near future. They give two reasons for this:

1. People start to have experience with interorganisational ICT.
2. Young people have a basic set of ICT skills.

When the skills to operate interorganisational ICT increase the risks of using these applications decrease. One expert mentions about this mechanism: *"As the skill sets come in you see better usage in the projects. What you have to do with the old blood is to make them comfortable with it and show them the benefits and encourage not only the use of it but also explain why they should use it and what the benefits are of using it. Also we provide internal training. (…) The more training they get the more comfortable they get and they can see what they can do with the tool which they weren't aware of."*

4. Acting opportunities

4a. Alignment between ICT and working practices

According to several experts, a limited alignment between ICT and working practices is an important barrier to the successful use of ICT. Every organisation has its own working practices and these need to be aligned first in order to attain the benefits of interorganisational ICT. Actors need to invest resources in aligning these working practices. The motivation to align is not always present. In addition, organisations are not always able to change their working practices. The experts give two main reasons for that. First, organisations have their own standard working practices and internal applications. The use of interorganisational ICT may conflict with these working practices and applications. Actors sometimes refuse to adapt these applications and working practices for one project. Second, organisations may choose to follow their traditional working practices, because they see no opportunities to act digitally. The experts give several examples about why organisations do not see these opportunities:

- *Need for signatures:* some organisations require signed documents to know for sure that the document is approved or to be sure about the legal status of information. Some organisations are very strict about the need for signatures and do not accept only digital communication. One expert says in the context of product modelling applications: *"Maybe in the future we will have only the model. If we have the legal and compliance environment saying it is OK to deliver your client a 3D model and this is the design requirement then you can maybe not do it on paper."* Other organisations are more relaxed about digital practices, especially about exchanging documents digitally. One expert says: *"Why does there need to be a legal status? (…) Once there is a level of trust between you and them and anybody in the process is really only trying to get to an end as quickly as possible, then handing somebody a computer file is OK."* Another says: *"There is no signature. However, this does not mean that it has no legal status. It is not something you heard about. It has some legal status."*
- *Insurance models do not support digital communication:* insurance companies perceive the exchange of 3D models as a risk because, in their view, the more information is provided to other organisations the more the exposure to lawsuits will increase. Therefore, the insurance companies do not support the 3D modelling process. According to one expert this is an impediment to the exchange of 3D models. He says: *"If the insurance company says: 'you may do what you want but when you give out a 3D model I am not going to insure what you are doing', I am putting my office at risk. That is what happens towards architects. It is complicated to deal with legally. Is it something you can rely on in court? What is its legal value in the event of something going wrong? It is a risk. It is unclear what its value is in the eyes of the law. It comes back to the newness."*
- *Government agencies request paper-based drawings:* drawings still go in paper-based form to government agencies because they still request information this way. One expert describes this process of sending drawings to the building department: *"You print it out. Stamp it and sign it. You give it to the building department. The building department reviews it. They mark it up. They stamp it as approved or require changes and send it back to you. You make more corrections and bring it back to their original comments. This is an entirely paper-based system."*
- *Drawings and documents need to be paper-based on-site:* people on-site often still want to receive paper-based documents and drawings. One expert says: *"You never get rid of paper drawings. A foreman wants to have paper drawings."*

As a result, organisations still choose to communicate drawings and some documents in paper-based form as a supplement to digital communications. Therefore, participants duplicate their efforts. Interorganisational ICT may help organisations in improving their (communication) processes. For example, in case of the use of workflow management applications, all the last changes are in the application, the information flow is more reliable and more structured. However, when actors decide

to duplicate their processes as a result of the reasons mentioned above, additional risks are imported in the project. When actors communicate both digitally and in paper-based form often an agreement is made that the paper-based drawings and documents are the ones that take precedence. If actors use the electronic documents and drawings they may use the wrong information if there are differences between an electronic document and a paper document. One expert says about these practices: *"We could be in a problem if there happens to be a difference between the electronic document and the paper document. When we build something up from the electronic document we would be liable."*

4b. Availability of technical means

According to the experts, a lack of the necessary technical means is sometimes an important barrier to the successful use of interorganisational ICT. Sometimes this impels actors to limit the scope of the use of interorganisational ICT. However, according to the experts this problem soon starts to decline. The organisations of the experts have appropriated technical means and sometimes they even deal with other organisations that are more sophisticated than their own. The experts mention several technical barriers to the successful use of interorganisational ICT.

- *Software interoperability:* paper-based communication is very flexible. Each organisation can use its own application. However, when organisations start to communicate and exchange information digitally interorganisationally then these organisations have to align their applications. If the experts' organisations implement a *document management application* and/or *workflow management application* among organisational boundaries in a project they choose to implement one application and not to integrate different corporate applications as a result of a lack of standards and interfaces between applications. Therefore, they eliminate interoperability problems. At the moment, organisations often use different *product modelling applications* in a project. Each organisation already purchased their software licenses independent of the project. This gives interoperability problems in the project because organisations cannot export and import all the information from applications of other organisations. The experts mention several directions for solutions to this problem. (1) Develop a project standard: the client mandates or participating organisations agree on the product modelling application that is going to be used in a project (expert: *"If you want to work on this project you need to use [a certain product modelling application]."*). (2) Develop a government standard that is mandatory in every project. For example, GSA managed to develop a government standard that will be mandated in every project from January 2007. Several vendors modified their software to conform to GSA requirements. (3) Develop an industry standard: the development of the Industry Foundation Classes (IFC) by the International Alliance of Interoperability (IAI) is an important initiative that is trying to provide an international information exchange standard. The lack of an industry standard is not holding the experts back from using interorganisational ICT. However, the availability of an industry standard would reduce or eliminate interoperability problems and make the introduction of interorganisational ICT easier.
- *Technology infrastructure in offices:* the availability of the technology infrastructure that is needed to use interorganisational ICT is restricting a lot of organisations in the United States construction industry in their use of ICT (e.g., hardware, software, appropriate Internet connections). According to the experts some organisations do not even have e-mail. They stress that, in general, the bigger the company, the more sophisticated their technology infrastructure is.
- *Technology infrastructure on the job-site:* the availability of a technology infrastructure might be a problem on the job-site. For example, the necessary peripherals (e.g., plotter) are often not present on site, especially in smaller projects. In addition, not all the organisations involved have an Internet connection on site or this connection only becomes available after some months. An expert comments about arranging an Internet connection on the job-site: *"Our*

job-sites are very well connected. However, it does sometimes take 1 to 2 months to get an Internet connection on-site. We do have to know when we are going to start the job. And we do start them up with less than adequate access and then bring it in as quickly as we can." This may restrict actors in their use of interorganisational ICT. However, it seems that temporarily solutions to this problem can be found as well. Another expert says: *"It takes a few weeks to get access on site. You can always go wireless for a short period. Satellite providers offer Internet services too nowadays. We use it often."*

Most experts agree on the fact that technical means do not have to be a barrier to the use of interorganisational ICT anymore. However, sometimes people use a lack of adequate technology infrastructure as an excuse for not using ICT. When organisations are willing to use interorganisational ICT, existing problems can be solved. Because interorganisational ICT is still new to a lot of actors, the understanding of the technical needs can cause problems. One expert says in this respect: "*I have to go to the project manger and say: 'You are going to use [a product model]. Do you know you need to have a projector? If you don't have a projector you have to look at a laptop'. Dumb things like that. (…) Because it is so new people don't know they need it. So we have to remind these guys what they need or need to do. (…) It is like you tell them: 'Did you bring pencil and paper?' Next job you don't have to tell them. (…) Costs are a little bit of an issue. It is relatively easy to solve. When you have a one hundred million dollar project a few thousand dollars investment pays for itself quickly."*

4.5 Directions for solutions

Based on both steps of this research, we are able to present directions for solutions to potential barriers to the successful use of interorganisational ICT in construction projects. In Table 4.4, these directions for solutions are presented. In this table we focus on solutions that can be implemented at a *project level*. We do not present directions for solutions at an organisational level, or at the level of the construction industry. In Table 4.4 we present (1) the directions for solutions, (2) the purpose of these solutions, (3) the mechanisms this solution is related to, and (4) the source of the solution. Solutions follow from (a) the Dutch field studies, (b) the interviews with expert from the United States construction industry. We abbreviated the mechanisms as follows:

- BD: Perceived benefits and disadvantages of ICT use;
- TP: Perceived time pressure;
- CA: Availability of contractual arrangements about ICT use;
- RA: Presence of a requesting actor;
- PA: Clarity of procedural agreements;
- OI: Clarity about the operation of ICT;
- IW: Alignment between ICT and working practices;
- TM: Availability of technical means.

Directions for solutions	Purpose of direction for solution	Related mechanisms								Source
		BD	TP	CA	RA	PA	OI	IW	TM	
Educate the actors involved about (1) the ICT application, (2) how this ICT can be used, and (3) the potential benefits, disadvantages and risks (and provide solutions to these).	Reduce distorted perceptions about benefits, disadvantages, risk, and possible solutions.	■								a, b
Be clear to the actors involved about the necessary investment, so organisations can include these in their cost estimates.	Reduce resistance caused by unforeseen investments.	■								a, b
Decrease the investment of other organisations by paying for the use of ICT (application, training, etc.), or convince the client to do so.	Reduce an important disadvantage, that is, the necessary investment.	■								a, b
Customise the application and make agreements about the use of the application based on the purposes, needs, and working practices of the actors involved.	Make all participating organisations benefit from the use of ICT.	■				■		■		a, b
Use incentives to the use of ICT (e.g., divide savings between participating organisations, link payments to ICT use).	Build in financial drivers to encourage the use of ICT, so actors become more motivated to use ICT.	■								a, b
Customise the ICT application in scope and used functionalities to the specific project based on the mechanisms shown in the theoretical model.	Reduce the risk of malfunctioning of ICT, which eliminates its potential benefits.	■	■	■	■	■	■	■	■	a, b
Evaluate the realised benefits of the use of ICT regularly and intervene quickly if the intended benefits are not realised.	Reduce the risk of frustrated users, a lack of confidence in ICT, and user rejection as a result of malfunctioning of ICT.	■								a, b
Let actors use their current applications when using interorganisational ICT or implement ICT that works in a similar way to the applications participants already use.	Reduce the novelty of ICT and, therefore, the required time investment to learn to use ICT, and the perceived risks of using ICT.		■			■	■			b
Pre-qualify organisations regarding their ICT capabilities.	Reduce the risk of selecting organisations that are not able to use ICT.		■			■	■	■	■	b
Provide user support to potential uses (e.g., training, user manuals, support on-site) to let them understand the application, and the way it needs to be used.	Reduce the time investment needed to learn to use ICT, the perceived risks of using ICT, and any frustration as a result of wrong use.		■			■	■			a, b
Select ICT that is easy to use, that prevent users from making mistakes, and that has features build in that reduces risks (e.g., notification features). Propagate this user-friendliness towards potential users.	Reduce the required time investment to learn to use ICT, the perceived risks of using ICT, and any frustration as a result of wrong use.		■				■			a, b

Directions for solutions	Purpose of direction for solution	Related mechanisms								Source
		BD	TP	CA	RA	PA	OI	IW	TM	
Educate the actors involved about the importance of building time into the timetable to fit ICT to their purposes, to make clear agreements, and to learn to use ICT.	Enlarge the awareness of the need to invest time at the start of the project to attain benefits later on.	■	■			■	■	■	■	a, b
Let an actor who is able to use ICT properly operate the application. This actor can be an employee of the organisation, but can also be hired from another organisation.	Prevent situations in which actors are not able to use ICT.		■				■	■	■	a, b
Test the ICT application (e.g., alignment between ICT and working practices, functionalities, bugs) carefully before ICT is introduced in the project.	Prevent situations in which ICT is not able to support the actions of the actors involved. This reduces the risks of frustrated users, a lack of confidence, and user rejection.							■	■	a
Mandate the use of ICT in the contract or convince the client to do so.	Force actors to use ICT.			■						a, b
Convince other actors (e.g., client, management of organisation) about the benefits of the use of ICT so they start to request its use.	Force actors to use ICT.				■					a, b
Do not allow users to by-pass ICT.	Prevent situations in which actors do not use ICT and – by doing so – eliminate potential benefits of the use of ICT for themselves and others.			■	■					a, b
Educate the people and organisations involved on (1) the ICT application, (2) how this ICT can be used and aligned to their working practices, and (3) the importance of aligning their working practices to each other and to ICT.	Reduce distorted perceptions about the need for alignment and the opportunities to align ICT and working practices.							■		a, b
Give electronic communication legal status, for example, by making use of electronic signatures or by approving statements of electronic communication formally in meetings.	Give electronic communication legal status.							■		a, b
Develop a project standard for exchanging information (i.e., all actors use the same application, or use applications that are able to exchange information).	Eliminate interoperability problems.								■	a, b
Educate participating organisations about the technical needs.	Reduce distorted perceptions about technical needs.								■	a, b

Table 4.4: Directions for solutions

4.6 Conclusions and implications for research and practice

In this chapter we have discussed the mechanisms that influence the way in which actors use interorganisational ICT in construction projects and directions for solutions for the potential barriers to the successful use of this ICT. Because the insights into these mechanisms were limited, an explorative approach was used to analyse the use of ICT in construction projects. We used the grounded theory approach to conduct this research. Based on the principles of grounded theory we moved from the specific (i.e., real time construction projects), to the more general (i.e., expert interviews). Our research resulted in the formulation of a theoretical model that consists of categories and subcategories that determine the way actors use ICT in construction projects.

The theoretical model was first developed in the context of four Dutch construction projects (see Chapters 2 and 3). In this chapter, we have shown the usefulness of the model for analysing, understanding, and explaining the use of interorganisational ICT (including product modelling applications) and the drivers and barriers to the successful use of this ICT in the United States construction industry as well. Our research in the context of the United States construction industry did not induce us to add additional categories or subcategories to the theoretical model or to rename or change categories or subcategories. However, this study showed differences between types of applications on the dimensional level of subcategories. For example, product modelling applications are more difficult to learn and to understand because a different way of working and thinking is needed. This influences several categories and subcategories. Furthermore, we were able to classify directions for solutions detected in the Dutch field studies (step 1), and the study in the United States construction industry (step 2) to the subcategories in the theoretical model.

To date, little is known about the mechanisms that determine the use of interorganisational ICT in the context of construction projects. When we compare our findings with results from other studies in which the use of interorganisational ICT in real time construction projects is documented (e.g., Andresen et al., 2003; Harty, 2005; Hjelt and Björk, 2006; Howard and Petersen, 2001; O'Brien, 2000; Thorpe and Mead, 2001; Weippert et al., 2002) then we can make the following observations.

First, these studies do not address all the mechanisms mentioned in our theoretical model and do not address these mechanisms in a holistic way. The subcategory 'availability of contractual arrangements' – which is a very influential mechanism in our research – is non-existent in these studies. This might suggests that in these studies the use of interorganisational ICT is only observed and analysed in a voluntary context. In addition, some subcategories only get limited - and fragmented - attention in these studies. Only several researchers mention (often to a limited extent) issues related to perceived time pressure (Howard and Petersen, 2001; O'Brien, 2000; Thorpe and Mead, 2001), presence of a requesting actor (O'Brien, 2000; Weippert et al., 2002), clarity of procedural agreements (Andresen et al., 2003; O'Brien, 2000), and alignment between ICT and working practices (Andresen et al., 2003; O'Brien, 2000; Thorpe, 2003). The subcategories 'perceived benefits and disadvantages of ICT use' and 'clarity about the operation of ICT' get extensive attention in the studies.

Second, these studies do not develop any directions for solutions to barriers to the successful use of interorganisational ICT based on their analysis of real time projects. The ones that do recommend some solutions (e.g., Andresen et al., 2003; O'Brien, 2000) do not connect these in a structured way to mechanisms influencing the use of interorganisational ICT.

Thus, our main contribution is that we present a holistic theoretical model that is able to explain the use of interorganisational ICT over time in a construction project. In addition, we present solutions to potential barriers that can be related to this model. Our study can be seen as a first step towards

developing (1) a theoretical model that is able to explain and predict the use of interorganisational ICT, and (2) solutions to potential barriers to the successful use of ICT in the context of construction projects. Therefore, in future research, the mechanisms and directions for solutions need to be further developed and tested. Other directions for future research are:

- *Relate the theoretical model to social theories:* connecting grounded theory to existing theory is an important step in developing a more substantive theory (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998). Our study showed that the use of interorganisational ICT in construction projects is embedded in a web of (social) actions. The way one actor acts influences the way another actor acts and the benefits this actor can attain from the use of ICT. In addition, ICT is only one of the means that actors can use to communicate. To gain a better understanding of the way actors act in their social and interorganisational context and how their acts are affected by social relationships, the theoretical model needs to be confronted with social theories.
- *Develop directions for solutions at organisational and industry level:* in our research we developed directions for solutions at project level, based on the mechanisms influencing the use of interorganisational ICT in construction projects. However, we can also try to intervene in the mechanisms at an organisational (i.e., what can an organisation do?) or industry level (i.e., what can the industry do?). The mechanisms developed in our study are important entry points for developing these directions for solutions. Our research already shows some – obvious – directions for solutions at these levels: (1) develop standard digital working practices at an organisational level, (2) use ICT within long-term relationships between organisations, (3) develop an industry standard for exchanging information, and (4) make legislation fit with digital working practices. Note that the implementation of these solutions starts by implementing them in a first project. Thus, all barriers to the introduction of interorganisational ICT at project level do apply to the introduction of these 'higher level' solutions in the first project as well.
- *Develop strategies and protocols for implementing ICT:* based on the mechanisms and directions for solutions developed in this research, strategies and protocols need to be developed and tested which facilitate the successful implementation of interorganisational ICT.
- *Test the developed directions for solutions:* the directions for solutions presented in this study need to be further tested in construction projects. Therefore, an obvious direction for future research is to implement these solutions in real time construction projects and evaluate the effects of the solutions on the successful use of interorganisational ICT. Based on this evaluation the solutions can be further refined.
- *Carry out a comparative study with other industries:* in our study we focussed on the use of interorganisational ICT in construction projects. In future research, the mechanisms, related barriers, and directions for solutions developed in this research should be compared with experiences in other industries. A comparative study might help the construction industry, and other industries to find opportunities to further improve the use of interorganisational ICT. In this comparative study researchers should try to understand mechanisms influencing the way actors use interorganisational ICT in the industry context.

The theoretical model and directions for solutions have relevance for practice as well. It can help project managers and/or people responsible for implementing interorganisational ICT to identify the technical *and* nontechnical risks of introducing and using ICT in construction projects. Based on this risk analysis and an assessment of the directions for solutions, they can formulate and implement measures to overcome these risks or choose to limit the scope of the application (e.g., limit the scope to only some organisations or to only some communication processes). In addition, the model can be used as an analytical tool to evaluate the status quo use of an underutilised

application in a construction project and to formulate and implement improvements based on this analysis.

Appendix 1: Questionnaire

Interorganisational use of IT[22] in construction projects

This questionnaire is confidential

(Please fill in the grey boxes)

Name: _____

Organisation: _____

1. What organisation are you working in? (please tick the appropriate box(es))

   ☐ Client
   ☐ Architect
   ☐ Engineer
   ☐ Contractor
   ☐ Subcontractor
   ☐ Supplier
   ☐ Other (please give details):

   _____

2. What type of work is your company mainly involved in?

   _____

3. What position do you hold? (give a short description)

   _____

We define interorganisational IT (Information Technology) as a digital coordination and collaboration tool used for communicating and sharing project information between participating organisations in a construction project. In this research we focus on advanced applications which participants have to make arrangements about before they can start using these tools. Examples of interorganisational IT are:

- Document management tools: these tools are used in order to store, organise, and manage a collection of documents within a construction project. General project-related files, such as project photos, contracts, drawings, specifications, cost data etc. are stored at a central location.
- Workflow management tools: these tools are used to manage the flow of information and to monitor and record the progress of tasks in construction projects.
- Product modelling tools (3D/ 4D CAD/ BIM): these tools are used to make a graphical model (i.e., representation) of a building object. 4D CAD applications add a further dimension (i.e., time) to the 3D CAD application. Product models can store both graphical and non-graphical data.

[22] The term IT is used in this questionnaire, because this term is more familiar to people from the United States construction industry.

4. How much experience has your organisation had in using interorganisational IT?

☐ Frequent (we have used it on the majority of our projects)
☐ Moderate (we have used it on some projects)
☐ Very little (we have used it on one or two projects)
☐ None (please go to question 7)

5. What experience has your organisation had in using interorganisational IT? (please select the appropriate IT tool(s) and participating organisation(s))

IT tools	**Participating Organisation(s)**						
	Client	Architect	Engineer	Contractor	Sub contractor	Supplier	Other:
Document management tools	☐	☐	☐	☐	☐	☐	☐
Workflow management tools	☐	☐	☐	☐	☐	☐	☐
3D/ 4D modelling tools	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐

6. In which of the following phases is your organisation using interorganisational IT?

☐ Programming
☐ Design
☐ Construction
☐ Maintenance
☐ Other:

_____

7. Who is paying for the interorganisational IT in most of your projects?

☐ Client
☐ Architect
☐ Engineer
☐ Contractor
☐ Subcontractor
☐ Supplier
☐ Other:

_____

8. Who is initiating the use of interorganisational IT in most of your projects?

☐ Client
☐ Architect
☐ Engineer
☐ Contractor
☐ Subcontractor
☐ Supplier
☐ Other:

_____

9. What do you believe are the three main benefits of the use of interorganisational IT in construction projects? (give a short description)

    1. _____
    2. _____
    3. _____

10. Are these benefits attained in construction projects?

    ☐ Yes
    ☐ Partly
    ☐ No
    ☐ We have never used interorganisational IT
    ☐ I don't know

11. What do you believe are the main disadvantages of the use of interorganisational IT in construction projects? (give a short description)

    1. _____
    2. _____
    3. _____

12. What do you believe are the three main barriers to *the introduction* of interorganisational IT in construction projects? (give a short description)

    1. _____
    2. _____
    3. _____

13. What do you believe are the three main barriers to *the successful use* of interorganisational IT in construction projects? (give a short description)

    1. _____
    2. _____
    3. _____

14. Please indicate your reaction to the following statements by ticking the appropriate boxes.

	Agree	**Tend to agree**	**Neutral**	**Tend to disagree**	**Strongly disagree**
Construction projects would benefit greatly from the use of interorganisational IT	☐	☐	☐	☐	☐
Most of my colleagues see clear benefits in using interorganisational IT	☐	☐	☐	☐	☐
Other participating organisations see clear benefits in using interorganisational IT	☐	☐	☐	☐	☐
The introduction of interorganisational IT is difficult because of a lack of long-term relationships with other organisations	☐	☐	☐	☐	☐

	Agree	Tend to agree	Neutral	Tend to disagree	Strongly disagree
The introduction of interorganisational IT in construction projects is difficult because of a lack of an industry standard	☐	☐	☐	☐	☐
At the start of a project there is a limited readiness to invest resources (time, money) in order to adjust interorganisational IT to the way of working of participating organisations	☐	☐	☐	☐	☐
The use of interorganisational IT in construction projects is dangerous because of increased transparency of information and communication	☐	☐	☐	☐	☐
There is a limited willingness to use interorganisational IT because of the limited legal status of electronic communication	☐	☐	☐	☐	☐
The use of new interorganisational IT is difficult because of high time pressure in construction projects	☐	☐	☐	☐	☐
When IT is introduced project participants tend to use traditional means of communication (instead of IT) because of high level of time pressure	☐	☐	☐	☐	☐
When IT is introduced project participants tend to use traditional means of communication (instead of IT) because new IT introduces extra uncertainties	☐	☐	☐	☐	☐
My organisation is not able to initiate the use of interorganisational IT for other organisations	☐	☐	☐	☐	☐
My organisation uses IT because it is forced to do so by another organisation	☐	☐	☐	☐	☐
My organisation prescribes the use of interorganisational IT for other organisations in the contract	☐	☐	☐	☐	☐
The introduction of interorganisational IT is difficult because participants lack the necessary skills	☐	☐	☐	☐	☐
The use of interorganisational IT in construction projects is difficult because of the low IT maturity of participating organisations	☐	☐	☐	☐	☐
The use of interorganisational IT is difficult because the necessary technology is not always available on-site (for example, internet, scanner, plotter)	☐	☐	☐	☐	☐
When using interorganisational IT we face difficulties in complying with our quality system	☐	☐	☐	☐	☐

15. Please use the space below to provide any comments you wish to make:

Thank you for taking the time to complete this questionnaire.

Appendix 2: Participating organisations

List of participating organisations
DPR Construction
United States General Services Administration (GSA)
Holder Construction Company
Kieran Timberlake Associates
Parsons Brinckerhoff
Sundt Construction
Turner Construction
Van Tilburg Banvard & Soderbergh (VTBS Architects)
Walt Disney Imagineering
Webcor Builders

Part 2: production of critique and re-definition

Chapter 5

The use of interorganisational ICT: a critical interpretation

5.1 Introduction[23]

Chapters 2, 3, and 4 provided insight into the use of interorganisational ICT in construction projects. This chapter builds upon these insights. A critical perspective will be used to analyse the interorganisational use of ICT, and the barriers to its intended use. Based on this analysis, we will suggest directions for change. Therefore, the first objective of this chapter is to demonstrate how a critical perspective (i.e., critical social theory) can be applied to provide in-depth understanding and insights in the use of interorganisational ICT. The second objective is to formulate suggestions for change to eliminate current barriers to the intended use of interorganisational ICT based on our critical analysis.

The chapter has the following structure. In the first section, we will elaborate on our research design. Second, we present the condensed results of our 'insight production' section (i.e., our theoretical model). Third, a critical perspective will be presented that is useful for deepening our insights into the interorganisational use of ICT. Fourth, this perspective will be used to reinterpret the results of the insight production section. Fifth, based on our critical analysis we present suggestions for change. The final part describes our conclusions and the implications for research and practice.

5.2 Research design

Alvesson and Deetz (2000) propose guidelines for doing critical research. They identify three different tasks that need to be addressed in order to reach the ultimate goal of change: insight, critique, and transformative redefinition. The three elements will be discussed further below.

5.2.1 Insight production[24]

The first task, insight production, may be seen as an outcome of successful interpretation (Alvesson and Deetz, 2000). Insight production calls for local understanding, and interpretations in which empirical material is viewed from a multitude of angles and is related to wider economic, social, historical, and political forces (Alvesson and Deetz, 2000; Howcroft and Trauth, 2004; Richardson and Howcroft, 2006).

In our research we focused in-depth on mechanisms influencing the use of interorganisational ICT in four construction projects. By identifying and analysing these mechanisms, we could understand and explain why individuals or organisations did or did not use ICT in the intended way. The main characteristics of the field studies are summarised in Table 5.1. The field sites shared the fact that they are construction projects. Construction projects are temporary cooperations between organisations in which coordination and communication is of vital importance. Together these organisations have to realise a construction object such as a railway, bridge or building. The use of

[23] An article based on this chapter has been submitted to a scientific IS journal for publication.

[24] In this chapter we build the production of critique on the insights from the four field studies and not the expert interviews, because - from a critical perspective - we have to look in depth to the use of interorganisational ICT in its specific project context.

ICT can offer many benefits in this context and companies have now started to use interorganisational ICT. However, the use of ICT across organisational boundaries in construction projects is still limited and not as effective as it could be (e.g., Alshawi and Ingirige, 2003; Andresen et al., 2003; Hjelt and Björk, 2006; Nitithamyong and Skibniewski, 2004; Sulankivi, 2004). Therefore, we viewed construction projects as an interesting research object.

	Field Study 1	**Field Study 2**	**Field Study 3**	**Field Study 4**
Tender sum	26 m Euro	42 m Euro	56 m Euro	1.6 m Euro
Duration contract	15 months	22 months	24 months	32 months
Contract type	Design-bid-build	Design-bid-build	Design-build	Design-build
Used features	Document management, workflow management	Document management, workflow management	Workflow management	Document management, workflow management
Organisations using ICT	Client, contractor, engineering company	Client, contractor, engineering company	Client, contractor	Client, contractor, engineering company, subcontractor
Organisation initiating ICT use	Engineering company	Engineering company	Client	Client
Organisation paying for ICT (customisation, application, training, support)	Engineering company (For own processes and interface with contractor)	Engineering company (For own processes and interface with contractor)	Client	Client; contractor, engineering company pay for modifications (9 months after the introduction of ICT)
ICT use mandated in contract	Yes, for contractor	Yes, for contractor	No	No
Organisations involved in customisation of ICT	Engineering company	Engineering company	Client, contractor	Client, contractor in initial development; all organisations in implementing modifications

Table 5.1: Characteristics of field studies

To fulfil the task of insight production in the context of construction projects the methods of ethnography and grounded theory were followed. Schultze (2000, p.7) defines ethnography as "an anthropological research method that relies on first-hand observations made by a researcher immersed over an extended period of time in a culture, with which he/she is unfamiliar". Ethnographers are primarily concerned with studying, understanding and providing explanations of human behaviour and action in their social, cultural and organisational context (Atkinson, 1990; Harvey and Myers, 1995; Myers, 1999; Prasad, 1997). According to Agar (1996, p.131) the ethnographic research method is used "to transfer observations into accounts that group members say are possible interpretations of what is going on". Therefore, the method of ethnography was useful for providing local understanding from multiple angles (i.e., perspectives), about the way actors use interorganisational ICT.

We combined the method of ethnography with grounded theory. Grounded theory is a qualitative inductive research method that generates theory from data, which is systematically gathered and analysed through the research process (Strauss and Corbin, 1998, p.12). In this approach data collection, analysis, and theory are closely interrelated. Carmaz and Mitchell (2001, p.160) stress that "[u]sing grounded theory methods can streamline fieldwork and move ethnographic research toward theoretical interpretation". Vica versa, ethnography also strengthens the method of grounded theory.

It helps "grounded theorists to go deeper in their studied phenomena to understand experience as their subjects live it, not simply talk about it" (ibid., p.161). The method of grounded theory is also useful for this research because of its focus on process, that is, on sequences of evolving action/ interaction and its changes over time, which can be traced back to changes in the conditional context (Strauss and Corbin, 1998). These might be local 'micro' conditions but also wider 'macro' conditions. This allowed the researchers to move beyond interpretative narratives and include economic, social, historical, and political conditions in the study.

We used multiple investigators to conduct the research. Each field study was assigned to one researcher. During the field studies, multiple techniques were used to increase the validity of identified constructs (Eisenhardt, 1989). First, the researchers spent most of the time observing participants and informally talking to them. Participant observation took place during the daily routine and in meetings. The researchers took a passive role rather than an active role to minimise the extent of their impact on local practices. In addition, the researchers observed participants' ICT-behaviour to grasp how actors communicated and used ICT. They tried to understand 'what was going on' regarding the use of ICT. Second, the researchers conducted many informal and semi-structured interviews to capture participants' perceptions and understanding. The researchers tried to see the world from the participants' point of view. Without these perceptions and this understanding, it would have been difficult to understand why actors act in a certain way. Finally, the researchers examined documents. Contract documents described the arrangements about what people should communicate formally. In addition, the researchers collected and analysed other available documents, such as specifications of the ICT application, minutes of meetings, and letters communicated between the engineering company and the contractor. Documents provided important qualitative information that could be compared with the responses of the interviewees and the observations. The researchers took detailed notes during all data collection activities to capture their impressions and insights.

The task of insight production resulted in a theoretical model that was able to explain the use ICT across organisational boundaries in the four construction projects. This task provided an in-depth understanding about the way interorganisational ICT is used. In this chapter only the outcome of this task, that is, the theoretical model will be presented. We will focus on the next two tasks of the critical perspective that build on the understanding provided by the theoretical model.

5.2.2 Production of critique

The second task, critique, builds upon insight (Alvesson and Deetz, 2000, p.144). The researcher "deepens insight-oriented interpretations through more critical theoretically-oriented explorations of these interpretations" (ibid., p.151). According to Alvesson and Deetz (2000, p.150) "[c]ritical studies are inclined to pay attention to and interpret 'raw material' for advanced interpretations in terms of power and domination, broadly defined". This means that critical researchers try to challenge taken-for-granted assumptions, beliefs, ideologies and discourses (Richardson, 2005, p.282). In this research, we follow Alvesson and Deetz (2000) with their suggestion not to integrate insight and critique production but to postpone the production of critique first. In separating these tasks the researchers are more open in their interpretations of empirical material and avoid a bias towards elitism.

In carrying out the task of the 'production of critique' we use critical social theory to adequately understand social phenomena. In this study, parts of Habermas' (1984, 1987) critical social theory and especially his models of action and his concepts of system and lifeworld will be adopted. Habermas' critical social theory (i.e., The Theory of Communicative Action) is used because of the greater impact of his work on the information systems discipline than any other critical social theory school of thought (Hirschheim and Klein, 1994; Ngwenyama and Lee, 1997), the existence of a

theory about communication within his work (Ngwenyama and Lee 1997), and the scope and depth of his treatment of social action and social change (Hirschheim et al., 1996). More specifically, his models of action and his concepts of system and lifeworld are valuable for this research. Several researchers have already adopted these elements in their analysis of information systems.

First, several scholars relate the use of ICT to Habermas' *models of action* (Cecez-Kecmanovic and Janson, 1999; Ngwenyama and Lyytinen, 1997). These models of action can be used as a framework to analyse how the social system and the technical system interact. According to Ngwenyama and Lyytinen (1997) there needs to be a fit between social action and the technical system to avoid user rejection or failure of well-designed applications. This is particularly important for our research because, from our insight production activity, it follows that actors regularly act differently in construction projects than they are intended to do. For instance, ICT is used in a different way than is originally intended.

Second, several scholars use Habermas' concepts of *system* and *lifeworld* to analyse the use of ICT (Cecez-Kecmanovic, 2002; Myers and Young, 1997). The introduction and use of ICT needs to be viewed from a system and lifeworld point of view. Other organisations can steer an organisation towards using ICT in a way that is not in line with its lifeworld. This may result in user resistance and user rejection. These concepts of Habermas' critical social theory are interesting for our research because the use of interorganisational ICT is forced upon organisations in two field studies and this has an important impact on the working practices of these organisations. The way interorganisational ICT is introduced in the field studies puts crucial constraints on the mechanisms influencing interorganisational ICT.

Therefore, to analyse the interorganisational use of ICT in our field studies, we will adopt Habermas' critical social theory in general and his models of action and concepts of system and lifeworld in particular. We will emphasise that we did not *test* Habermas' critical social theory in our research or carry out our insight production activity based on this theory. We have taken an open stance towards the empirical material whilst carrying out the first task of our research and then used Habermas' critical social theory to deepen our understanding of the interorganisational use of ICT in a critical fashion and to provide suggestions for change.

5.2.3 Production of transformative re-definition

The third task, transformative re-definition, is the natural counterpart to insight and critique (Alvesson and Deetz, 2000, p.144). The aim of this task is to develop critical and relevant knowledge to understand and facilitate change (Richardson, 2005). According to Alvesson and Deetz (2000, p.151-152) transformative re-definition "aims to support imagination in such a way that a qualitative, different reality is seriously considered". However, Alvesson and Deetz (2000, p.153) warn that transformative re-definition should not dominate empirical research because these studies tend to be utopian and not appropriate for studies with research ambitions. In this research we will use our analysis and theoretical explorations to point to the origins of unintended use. Based on these origins we are able to provide suggestions for change.

5.3 The use of interorganisational ICT: insight production

The first activity within a critical methodology is the act of 'insight production'. This act resulted in a theoretical model containing mechanisms that influence the way actors use interorganisational ICT. The theoretical model is shown in Figure 5.1. The categories (or mechanisms) and subcategories (or submechanisms) shown in Figure 5.1 are defined in Table 5.2.

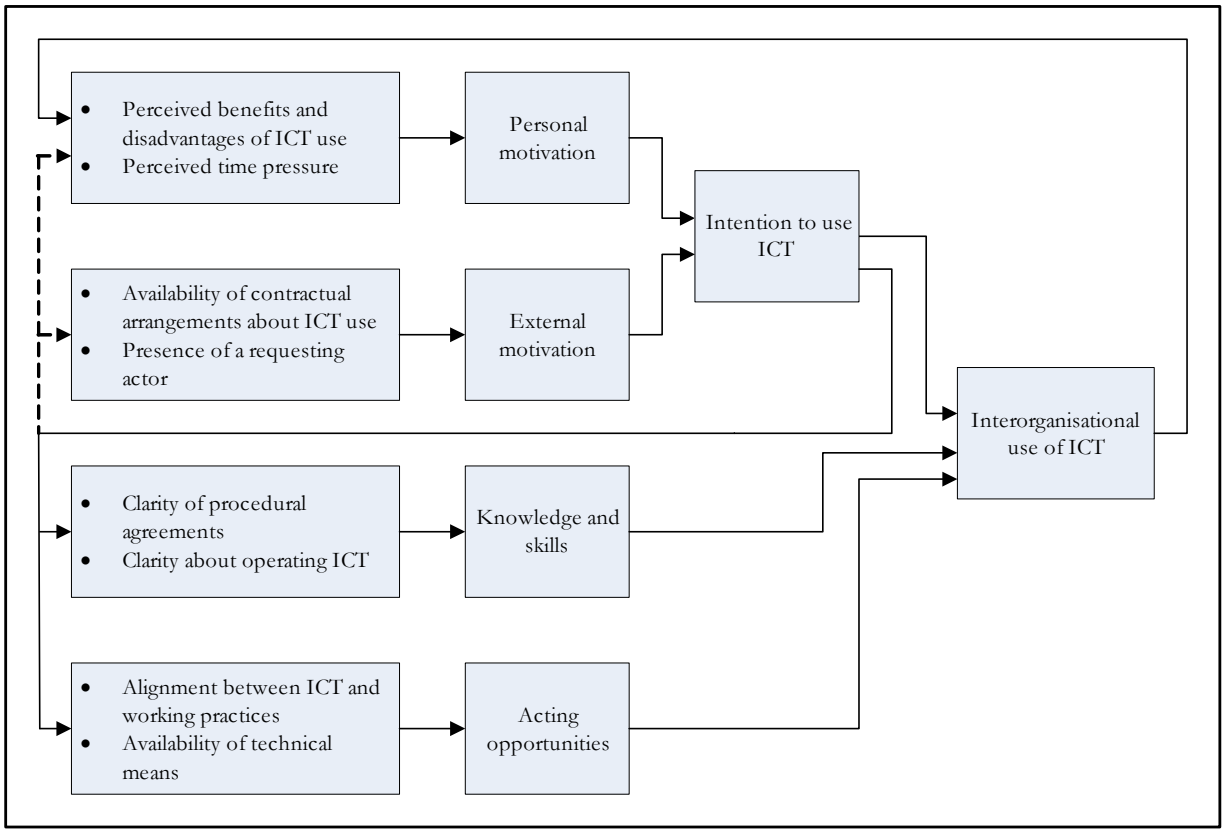

Figure 5.1: Theoretical model

Category, subcategory	Definition
Intention to use ICT	"The motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1991, p.181). This intention influences both the use of ICT and the barriers to the intended use of ICT. Actors may try to overcome barriers for themselves (see straight lines in Figure 5.1) and for other actors (see straight and dotted lines in Figure 5.1).
1. Personal motivation	The extent to which actors are willing to use interorganisational ICT themselves. Personal motivation influences both the willingness of the actors to use ICT and their willingness to invest resources to overcome barriers to the intended use of ICT.
1a. Perceived benefits and disadvantages of ICT use	The extent to which actors perceive the use of ICT as benefiting and/or disadvantaging them. When actors perceive that there are many benefits (and no, or only a few, disadvantages) this will influence personal motivation positively. On the other hand, many perceived disadvantages will influence personal motivation negatively. This subcategory can be a driver and a barrier to the use of ICT.
1b. Perceived time pressure	The extent to which actors perceive that they have to act quickly when using, or considering the use of, ICT. A high level of perceived time pressure can moderate personal motivation because of the highly perceived benefits of the use of ICT. However, a low level of perceived time pressure does not result in a high level of personal motivation to use ICT per se. This subcategory can only be a barrier to the use of ICT.
2. External motivation	The degree to which actors are forced by other actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest time and money to overcome barriers to the intended use of ICT.
2a. Availability of contractual arrangements about ICT use	The extent to which actors are forced to use ICT or other means of communication because this is mandated in the contract. When ICT is prescribed, external motivation is present. When ICT is not mandated no external motivation to use ICT exists. A

Category, subcategory	Definition
	mandate of only other means of communication is even a barrier to the use of ICT.
2b. Presence of a requesting actor	The extent to which another actor requests certain action(s) (e.g. use of ICT, or non-use of ICT) to take place and the extent that this request impacts on actors. When actors are asked to use ICT and this request has an impact on them, external motivation is present; if this request is absent or if it does not have impact then no external motivation exists. Another actor who requests acting in another way than using ICT might even be a barrier to the use of ICT if this request impacts on actors.
3. Knowledge and skills to use ICT	The degree to which actors know how to use ICT. When knowledge and skills are limited, the actors themselves are the ones restricting the use of ICT.
3a. Clarity of procedural agreements	The extent to which actors know how to act concerning the ICT application (e.g., what information has to be communicated to whom, and in what form and at what time) and these actions support the intended use of ICT. This clarity can be high or limited, resulting in enough or a restricting amount of knowledge and skills to use ICT. This subcategory can only be a barrier to the use of ICT.
3b. Clarity about the operation of ICT	The extent to which actors know how to operate the application. This clarity can be high or low resulting in enough or a restricting amount of knowledge and skills to use ICT. This subcategory can only be a barrier to the use of ICT.
4. Acting opportunities	The extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.
4a. Alignment between ICT and working practices	The extent to which ICT fits in with actors' working practices in the project and their organisation(s). This alignment can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way. This subcategory can only be a barrier to the use of ICT.
4b. Availability of technical means	The extent to which technological aspects restrict actors in using ICT in the intended way. This availability of technical means can be high or low resulting in situations in which actors are, or are not, able to use ICT in the intended way. This subcategory can only be a barrier to the use of ICT.

Table 5.2: Definition of categories and subcategories of the theoretical model

5.4 Habermas' theory of communicative action

The results of the insight production activity will be deepened in the act of 'production of critique'. We use Habermas' critical social theory for our critical analysis. In this section, several concepts of his theory will be discussed. Because of the extensiveness and complexity of Habermas' theory we are only able to discuss those elements of his work that are the most valuable for our research: his models of action and his concepts of system and lifeworld.

5.4.1 Models of action[25]

In this subsection we focus on Habermas' models of action. These models are described in his well known book *The Theory of Communicative Action* (1984, 1987). Habermas' theory is rooted in the view that communication is a rational enterprise. In Habermas' (1984, p.22) view "[r]ationality is understood to be a disposition of speaking and acting subjects that is expressed in modes of behavior for which there are good reasons or grounds". This points in the direction of the concept of the universal validity claims. In order to act, rational acts must rest upon criticisable validity claims. According to Habermas (1984, p.38) "[a] *validity claim* is equivalent to the assertion that the *conditions for the validity* of an utterance are fulfilled". The term argumentation is used for that type of

[25] An earlier version of this subsection has been included in articles that are published in *Construction Innovation* (Adriaanse and Voordijk, 2005) and *International Journal of Human Resources Development and Management* (Adriaanse et al., 2004).

speech in which participants thematise contested validity claims and attempt to vindicate or criticise them through arguments (ibid., p.18). "The 'strength' of an argument is measured in a given context by the soundness of the reasons" (ibid., p.18). "The forms of argument are differentiated according to universal validity claims, which are often recognizable only in connection with the context of an utterance, but which are not first constituted by contexts and domains of action" (ibid., p.38). Several forms of argumentation with corresponding validity claims are distinguished (see Table 5.3).

Forms of argumentation	**Controversial validity claims**[26]
Theoretical discourse	- Truth of propositions - Efficacy of teleological actions
Practical discourse	- Rightness of norms of action
Aesthetic criticism	- Adequacy of standards of value
Therapeutic critique	- Truthfulness or sincerity of expressions
Explicative discourse	- Comprehensibility or well-formedness of symbolic constructs

Table 5.3: Forms of argumentation and validity claims (based on Habermas, 1984, p.23)

In uttering a sentence the speaker raises a validity claim implicitly or explicitly. The hearer has only the choice of accepting or rejecting the validity claim (taking a "yes" or "no" position) or leaving it undecided for the time being (abstaining). Taking a position on a validity claim "means that the hearer agrees or does not agree with a criticisable expression and does so *in light of reasons or grounds*" (ibid., p.38).

The validity claims discussed above bring us to the concept of world relations. In raising a validity claim an actor takes up a relation to a world. Habermas (1984) renounces the ontology of one world (i.e., the objective world) and distinguishes three worlds to which speakers relate: the objective world, the subjective world, and the social world. He defines these worlds as follows (ibid., p.52):

- Objective world: "the totality of facts, where "fact" signifies that a statement about the existence of a corresponding state of affairs, *p*, can count as true".
- Social world: "the totality of all interpersonal relations that are recognized by members as legitimate".
- Subjective world: "the totality of experiences to which, in each instance, only one individual has privileged access".

When an actor raises the validity claims of truth and efficacy, this actor refers to something in the objective world, with the validity claim of rightness an actor relates to something in the social world, and with the validity claims of adequacy, and truthfulness or sincerity an actor refers to something in the subjective world. A presupposition for the recognition of these validity claims is the comprehensibility or well-formedness of symbolic expressions.

[26] Habermas (1984) states that only the truth, rightness, and comprehensibility or well-formedness are universal validity claims that can be tested in discourse. In these cases "a rational agreement could in principle be achieved, whereby the phrase 'in principle' expresses the idealizing proviso: if only the argumentation could be openly enough and continued long enough" (ibid., p.42). In the other cases Habermas (1984) uses the term "critique" or "criticism" instead of "discourse". These validity claims cannot be tested in discourse. For example, the sincerity of expressions cannot be tested discursively, but only shown. According to Habermas (1984, p.41) "insincerity can be revealed by the lack of consistency between an utterance and the past or future actions internally connected with it". Aesthetic criticism is "not invested with a clear-cut validity claim" (Habermas, 1984, p.42). This validity claim is sometimes called a claim to authenticity or appropriateness.

The validity claims and world relations are fundamental to Habermas' (1984) models of action. These models of action can be used as a framework to analyse how the social system and the technical system interact (Ngwenyama and Lyytinen, 1997). Habermas (1984) distinguishes four ideal models of (social) action with increasingly complex aspects of rationality[27]: teleological action, normatively regulated action, dramaturgical action, and his own communicative action. Habermas (1984, p.96) "uses the term 'action' only for those symbolic expressions with which the actor takes up a relation to at least one world". These actions are "called 'social' which in its meaning as intended by the actor or actors, take account of the behavior of others and is thereby oriented in its course" (Weber, 1978, p.4). According to Ngwenyama and Lee (1997), in real-world communications these ideal models can only be approximated. Ngwenyama and Lyytinen (1997) stress that in complex situations all models of social action are present. They suggest, however, that "[a] specific action type will take the foreground depending on the type of group process involved and its institutional properties" (ibid., p.79).

Within the model of *teleological action,* an actor tries to realise an end[28] by choosing between alternative courses of action. The actor selects appropriate means to realise this end. This type of action is "guided by maxims, and based on an interpretation of a situation" (ibid., p.85). The model of teleological action presupposes a relation between the actor and the objective world, either presently existing or producible through actions. Teleological action can be divided into instrumental action and strategic action. *Instrumental action* is directed toward achieving personal goals in a non-social way. An actor follows technical rules of action and tries to manipulate objects in ways that will serve his or her self-interest. Within *strategic action* an actor tries to achieve one's goals by influencing decisions of other actors. Each of the other actors "is oriented to his own success and behaves co-operatively only to the degree that this fits his own egocentric calculus of utility" (ibid., p.88). Within strategic action "the degree of conflict and co-operation varies with the given interest positions" (ibid., p.101). An actor tries to find the best strategy to pursue his self-interest. When people cooperate because this is the only way to achieve their goals, they use communicative action (Weigand et al., 2003, p.11). In this view, interests can still control communicative action.

Within teleological action, two types of argumentation can be distinguished:

- The *truth* of a proposition is judged according to "whether the actor has succeeded in bringing his perceptions and beliefs into agreement with what is the case in the world" (ibid., p.87);
- The *efficacy* of teleological actions is judged according to whether the actor "succeeds in bringing what is the case in the world into agreement with his desires and intentions" (ibid., p.87).

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[27] Habermas' presentation of the different models of action has been criticised by Joas (1991). According to Joas (1991, p.101) Habermas does not give "a comprehensive typology of a general theory of action, but rather a classification that aims from the start at Habermas' distinction – admittedly a convincing one - of various kinds of possible relations to the world". In a reply to this critique Habermas (1991, p.249) states that he is "concerned with an explanation for social action, not with constructing an anthropology of action as a whole". Ngweyama and Lyytinen (1997) distinguish instrumental action, strategic action, communicative action and discursive action in their framework. According to Lyytinen (1992) these four action types are prominent in information systems. Although Habermas does not distinguish discursive action, it could easily be added to his analysis (ibid.). Actors use discursive action when an agreement between a group of actors about a shared background can no longer be taken for granted (Hirschheim et al. 1996; Lyytinen, 1992; Ngwenyama and Lee 1997; Ngwenyama and Lyytinen, 1997). Within this action type actors try to discover or weight the arguments proposed for or against a message. In this chapter we follow Habermas' original classification and view discursive action as part of communicative action.

[28] Note that all models of action presuppose a teleological structure of action. Speakers want to realise some ends. However, within communicative action the relation between language and reaching understanding "is not one of means and ends" (Habermas, 1991, p.241). Although, for example, within strategic action and communicative action actors have a different attitude, both models of action also differ in their structural characteristics (ibid.).

In the model of *normatively regulated action,* the intention of the actors involved is to fulfil generalised expectations of behaviour by conforming their behaviour to shared norms and values. In addition, normatively regulated action can be based on the formalised domains of actions (i.e., the system, as will be explained later). In this case, social norms may override self-interests or personal goals. This type of action presupposes not only an objective world but also a social world. All members of a social group who share a social world (i.e., the normative context is recognised as valid) may expect the others to behave in certain situations in a certain way. When actors do not recognise the normative context as valid, this context becomes another feature of the objective world (White, 1988, p.37). According to White (1988, p.21) the model "offers a necessary explanatory supplement" to the strategic model of action (see also Ngwenyama and Lee, 1997).

Within normatively regulated action, two types of argumentation are possible:

- The *rightness* of actions is judged "according to whether they are in accord with or deviate from an existing normative context, that is, whether or not they are right with respect to a normative context recognized as legitimate" (Habermas, 1984, p.89);
- The *legitimacy* of norms is judged "according to whether they can be justified, that is, whether they deserve to be recognized as legitimate" (ibid., p.89).

In the model of *dramaturgical action,* social actors consider themselves as a visible public for each other, before which a view of themselves is presented[29]. With this self-presentation before others the actor is trying to evoke "a certain image, an impression of himself, by more or less purposefully disclosing his subjectivity" (ibid., p.86). In doing so, an actor is "styling the expression of one's own experiences with a view to the audience" (bid, p.86). The dramaturgical model of action presupposes two worlds, the internal world (subjective world) and the external world (objective world and social world). The external world can be defined as "being shared with others" (ibid., p.52).

In case of dramaturgical action, one type of argumentation is possible:

- In case of beliefs and intentions (cognitive acts) the *truthfulness* or *sincerity* of self-presentation is judged according to "whether at the proper moment the actor is expressing the experience he has, whether he means what he says, or whether he is merely feigning the experience he expresses" (Habermas, 1984, p.93). With desires and feelings "it is sometimes difficult to separate questions of sincerity from those of *authenticity*" (ibid., p.93). Authenticity of self-presentation is judged according to "whether the feeling or need expressed is what one really feels or needs" (White, 1988, p.39).

Within the model of *communicative action* "actors seek to reach an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement" (Habermas, 1984, p.86). This requires "a cooperative process of interpretation aiming at situation definitions that are intersubjectively recognized" (ibid., p.70). Also within communicative action participants can pursue their individual goals. They assume, however, "that they can harmonize their plans of action on the basis of common situation definitions" (ibid., p.286).

Habermas (1984, p.99) distinguishes the following validity claims an actor must raise with his utterance in this model of action:

- Truth: "[t]hat the statement made is true (or that the existential presuppositions of the propositional content mentioned are in fact satisfied)";

[29] Dramaturgical action shares some characteristics with latently strategic action. Habermas (1984, p.94) states that only when the self-presentation is judged "according to the criteria of success by the audience as well, it no longer falls under the description of dramaturgical action".

- Rightness: "[t]hat the speech act is right with respect to the existing normative context (or that the normative context that it is supposed to satisfy is itself legitimate)";
- Truthfulness: "[t]hat the manifest intention of the speaker is meant as it is expressed".

A presupposition for the recognition of the three claims mentioned above is that the comprehensibility or well-formedness of the symbolic expressions employed can be criticised. In order to communicate successfully a listener must both comprehend (validity claim: comprehensibility or well-formedness) and accept (validity claims: truth, rightness or justice, and truthfulness or sincerity) the speech act.

Habermas (1984) argues that all the models of action mentioned above take language as a mechanism for coordinating action. In all cases, action is mediated through speech acts. Within instrumental action language is used "solely as a medium of transmitting information" (Habermas, 1998, p.221). Strategic action takes "language as one of several media through which speakers oriented to their own success can influence one another in order to bring opponents to form or to grasp beliefs and intentions that are in the speakers' own interest" (ibid., p.95). Normatively regulated action "presupposes language as a medium that transmits cultural values and carries a consensus that is merely reproduced with each additional act of understanding" (Habermas, 1984, p.95). Dramaturgical action "presupposes language as a medium of self-presentation" (ibid., p.95). According to Habermas all these concepts of action are one-sided. They are all a *limited case or borderline case*[30] of communicative action. "Only the communicative model of action presupposes language as a medium of uncurtailed communication whereby speakers and hearers, out of the context of the preinterpreted lifeworld, refer simultaneously to things in the objective, social, and subjective world in order to negotiate common definitions of situations" (ibid., p.95).

Habermas uses Austin's (1962) speech act theory[31] in general and the distinction between illocutionary (i.e., to act by saying something) and perlocutionary acts (i.e., to bring about something through acting by saying something) in particular, in order to demarcate communicative action from strategic action[32]. Within communicative action "all participants pursue illocutionary aims with their mediating acts of communication", whereas within linguistically mediated strategic action "at least one of the participants wants with his speech act to produce perlocutionary effects on his opposite number" (Habermas, 1984, p.295). Strategic action may be open or latent. In latently strategic action, at least one actor has to assume that language is used with an orientation to mutual

[30] Initially Habermas (1984) speaks about pure types (or limit cases) of communicative action when referring to normatively regulated action and dramaturgical action. Habermas (1991, p.242) now prefers to speak about borderline cases because both models of action are tailored to fulfil one respective function of language (i.e., one specific aspect of validity). Habermas (1984) uses speech act theory to extent his analysis further. According to Habermas (1984, p.178) a formal pragmatic theory of communication "could be made fruitful for a sociological theory of action if we could show how communicative acts – that is speech acts or equivalent nonverbal expressions – take on the function of coordinating action and make their contribution to building up interactions". Based on an analysis of Weber's Theory of Action, Habermas (1984) describes mechanisms for coordinating action. Within this analysis he distinguishes two action orientations: actions oriented to success (or consequences) (i.e., teleological action) and actions oriented to reaching understanding (or agreement) (i.e., communicative action). In this view normatively regulated action and dramaturgical action are borderline cases of communicative action (Habermas, 1991, p.242).

[31] Another well-known scholar who uses Austin's (1962) speech act theory is Searle (1969). Habermas also discusses Searle's theory. He rejects this theory because Searle "restricts himself to the perspective of the speaker" and he uses a one-world ontology. Because of that, according to Dietz and Widderhoven (1991), Habermas' theory is superior to Searle's theory. Some scholars have discussed the possibility of combining both theories (Auramäki and Lyytinen, 1996; Schoop, 1999).

[32] Several scholars have criticised this distinction between communicative action and strategic action (e.g., Alexander 1991; Berger, 1991; Joas, 1991). According to them the distinction is only analytical. For an in depth reply to these critiques see Habermas (1991, p.235-243). Habermas concludes "[t]he sociological observer is also in principle able to distinguish between communicative and strategic action" (ibid., p.242-243).

understanding. Within communicative action illocutionary aims are pursued 'without reservation', which means that cases of latent strategic action are excluded. In case of communicative action social action is coordinated by speech acts (with corresponding validity claims), whereas openly strategic action is coordinated by power claims.

5.4.2 System and lifeworld

A key issue within Habermas' *The Theory of Communicative Action* (1984, 1987) is the differentiation between two analytical concepts of integration (or social order): system and lifeworld. According to Habermas (1987, p.151) the "fundamental problem of social theory is how to connect" these conceptual strategies "in a satisfactory way". Below we will discuss the concepts of system and lifeworld and how these can be connected. In our discussion we will translate these concepts to an interorganisational context.

Lifeworld: social integration
Social integration rests on the concept of the lifeworld and on structures of action oriented towards reaching understanding (i.e., communicative action[33]). Within the lifeworld concept of social order integration takes place by harmonising action orientations (Habermas, 1987, p.117). When participants try to reach understanding, the lifeworld itself is not thematised but functions as a shared background that makes mutual understanding possible. Habermas' (1987, p.126) describes the lifeworld as "the transcendental site where speaker and hearer meet, where they can reciprocally raise validity claims that their utterances fit the world (objective, social, or subjective), and where they can criticize and confirm those validity claims, settle their disagreements, and arrive at agreements". This discussion, however, is limited to the perspective of the participants. In order to make the concept of the lifeworld suitable for social theory, Habermas (1987) broadens the concept of the lifeworld. He introduces the everyday concept of the lifeworld in which "persons do not only encounter one another in the attitude of participants; they also give narrative presentations of events that take place in the context of their lifeworld" (ibid., p.136).

Communicative action is possible because of the lifeworld, but the lifeworld is also reproduced through processes of mutual understanding. In Habermas' (1987, p.145) view, the rationality of the lifeworld grows as a result of communicatively achieved understanding, that is, "consensus forming that rests *in the end* on the authority of the better argument".

Habermas' (1984, 1987) concept of the lifeworld can be translated to an interorganisational setting. Each organisation has its own lifeworld of its members that can be defined as: "the symbolically created, taken-for-granted universe of daily social activities of organisational members, which involves language, social structures and cultural tradition as the background knowledge that members share" (Cecez-Kecmanovic, 2002, p.218). In organisational literature these lifeworlds are often called interpretive schemes (Broadbent et al., 1991).

System: systemic integration
The system can be defined as the formally organised domains of action (Habermas, 1987). Within the system concept, action is coordinated by harmonising the consequences of action via functional interconnections. Within the system, diverse activities and decisions are integrated through steering media such as money and power, regulated by market mechanisms (i.e., subsystem of economy) and bureaucratic mechanisms (i.e., subsystem of administration). With an increasing system

[33] Critiques are often based on false parallels between types of action and concepts of social order (Habermas, 1991). For example, the definition of the lifeworld does not mean that this concept of integration is free of strategic action. However, social integration primarily occurs via communicative action (Habermas, 1984; 1991). From the lifeworld concept of social order "the action system is integrated through consensus, whether normatively guaranteed or communicatively achieved" (Habermas, 1987, p.150).

differentiation "increasingly autonomous organisations are connected with one another via delinguistified media of communication: these systemic mechanisms – for example money and power – steer a social intercourse that has been disconnected from norms and values" (ibid., p.154). With this increasing differentiation, the capacity for material reproduction grows.

If we translate the concept of the system to an interorganisational context, we can define the system as "concrete facilities, such as aggregations of actors, physical artefacts (machinery, buildings and technology), processes and structures that are integrated in order to achieve certain goals" (Cecez-Kecmanovic, 2002, p.218). The system incorporates the formal domains of action (i.e., objective world) in an organisation and strives, for example, for increased productivity, efficiency, and effectivity. Subsystems, such as administrative systems, financial systems, and production systems, are part of the organisational system. Below we will show when, according to Habermas, the system has a distorting effect on the lifeworld.

Relationship between system and lifeworld

In Habermas' (1987) view, systems and steering media need to be expressions of the lifeworld. Further rationalisation of the lifeworld opens up new opportunities to steer systems and subsystems, and to increase system complexity and differentiation. Thus, further rationalisation of the lifeworld enables new levels of integration. However, this process of increased rationalisation of the lifeworld and the corresponding differentiation of the system can become distorted, especially in a specialist context. If systems and subsystems become more and more complex as a result of more differentiation, it might become independent of the lifeworld. The steering media start to coordinate autonomously on the basis of built-in structures without resort having to be made of the resources of the lifeworld (Habermas, 1991, p.258). This means that the system "escapes from the intuitive knowledge of everyday communicative practice" (Habermas, 1987, p.173). As a result system integration (via the steering media) becomes uncoupled from social integration (via the mechanism of mutual understanding). The formally organised domains of action are split off from the lifeworld and become integrated only via steering media.

When system integration and social integration are uncoupled, system integration can intervene – via steering media – in social integration. The lifeworld is made dependent upon the system. In that situation "integrative achievements do not fall within the bounds of the horizon to which participants in interaction orient themselves" (Habermas, 1991, p.252). Communication and the rationalisation of the lifeworld become distorted by "systemic constraints that *instrumentalize* a communicatively structured lifeworld" (Habermas, 1987, p.187). This means that actors act according to the formalised domains of action, steered by steering media, independent of their own lifeworld, and their lifeworld demands. As a result, the imperatives of the systems may "suppress forms of social integration even in those areas where a consensus-dependent coordination of action cannot be replaced, that is, where the symbolic reproduction of the lifeworld is at stake" (ibid., p.196). Habermas (1987) describes this process in which steering media distort the symbolic reproduction of the lifeworld as 'the colonization of the lifeworld'.

The relationship between system and lifeworld can be translated to an interorganisational setting. Organisations have their own distinct lifeworlds, systems, and steering media (Broadbent et al., 1991). Broadbent et al. (1991) discuss the process in which societal steering institutions steer the behaviour of organisations and show that societal institutions are able to change organisational steering media and to colonise the organisational lifeworld. Myers and Young (1997) suggest that an organisation may be able to steer the behaviour of other organisations as well. Broadbent et al. (1991) stress that steering media have the potential to colonise the lifeworld but there is no guarantee that the intended changes in behaviour will be realised. In their analysis, they simplify the

analysis of systems and lifeworlds to the organisational level to reduce the number of participants involved in their study.

The system and lifeworld, and the way these are connected via steering media with colonising potential provide important concepts for analysing integration in social situations. However, according to Habermas (1987) the relative weight of social integration and system integration in social situations is a question that can only be answered empirically. In addition, whether the lifeworld is colonised by the system and whether the system has a "distorting effect" on "organisational reality" is an empirical question (Power and Laughlin, 1992, p.132). This emphasises the importance of completing the 'insight production' activity before starting the 'production of critique' activity in which these insights are theoretically explored more deeply.

5.5 The use of interorganisational ICT: a critical interpretation

In this section, our interpretation of concepts of Habermas' critical social theory will be used for interpreting and analysing the use of interorganisational ICT in our four field studies. Thereby we focus on the *actual use* of interorganisational ICT in construction projects. However, from our field studies it followed that the pre-usage phase is important to analyse as well. This phase defines part of the historical context of the actors involved and determines the characteristics of the ICT application and the functionalities that are available to these actors. The way ICT is developed and implemented influences its use. Therefore, we start with a description of the pre-usage phase.

5.5.1 The pre-usage phase

The four construction projects were temporary cooperations between participating organisations. In these projects, a competitive tendering procedure was used. In competitive tendering, tenders are invited from any contractor and, in general, the lowest tender is accepted. This tendering procedure had two important consequences. First, the client or the client's representative did not know in advance which contractor was going to carry out the project, because this organisation did not know in advance which contractor would be the lowest bidder. Second, when actors wanted to use interorganisational ICT this ICT needed to be set up between participating organisations for the course of only one project. In all four projects, the client or the client's representative (i.e., the engineering company) initiated the use of interorganisational ICT.

In the construction projects, ICT applications were used to support parts of the formal communication between the client, the contractor, and the engineering company (i.e., the main participants in the construction projects). Only in Field Study 4, was the subcontractor added. In addition, informal communication was supported by interorganisational ICT as well in that project. The ICT application used in the projects incorporated document management and/or workflow management features. The workflow management feature was used to manage the flow of documents and information and to monitor and record the progress of tasks. With the document management feature documents could be stored, organised, and managed in a digital way. The use of interorganisational ICT was new to all actors involved. We can analyse the introduction, customisation, and implementation of this interorganisational ICT on two levels: the organisational level and the individual level.

On an organisational level, the organisation initiating the use of interorganisational ICT had its own system, lifeworld, and steering media, just as the other organisations involved did (see Figure 5.2 [34];

[34] This figure is inspired by Broadbent et al. (1991). They suggest that the lifeworld is colonised by steering media and systems.

the initiating organisation and one of the participating organisations are shown). The introduction of interorganisational ICT had an impact on the working practices of participating organisations. ICT might enable the actions of these organisations, but might constrain their actions as well. In order to attain the potential benefits of interorganisational ICT these organisations had to change their working practices. The way these organisations aligned their working practices and customised interorganisational ICT to these working practices and their priorities can be based on two concepts of integration: (1) *rationalisation* of the lifeworlds of participating organisations based on communicatively achieved understanding, which opens up new opportunities to steer systems and subsystems (see straight lines in Figure 5.2), and (2) the initiating organisation changes the organisational steering media of other organisations and, thereby, steers systems and subsystems, and potentially *colonises* the lifeworlds of these organisations (see dotted lines in Figure 5.2).

In Habermas' view the alignment needs to be based on the first concept of integration. From that concept interoganisational ICT is the result of communicative action between the organisations involved, and is supporting instead of restricting the working practices and priorities of the organisations involved. The second concept might put crucial constraints on the rationalisation of the lifeworld. Both concepts appeared in our field studies and will be discussed in greater detail below.

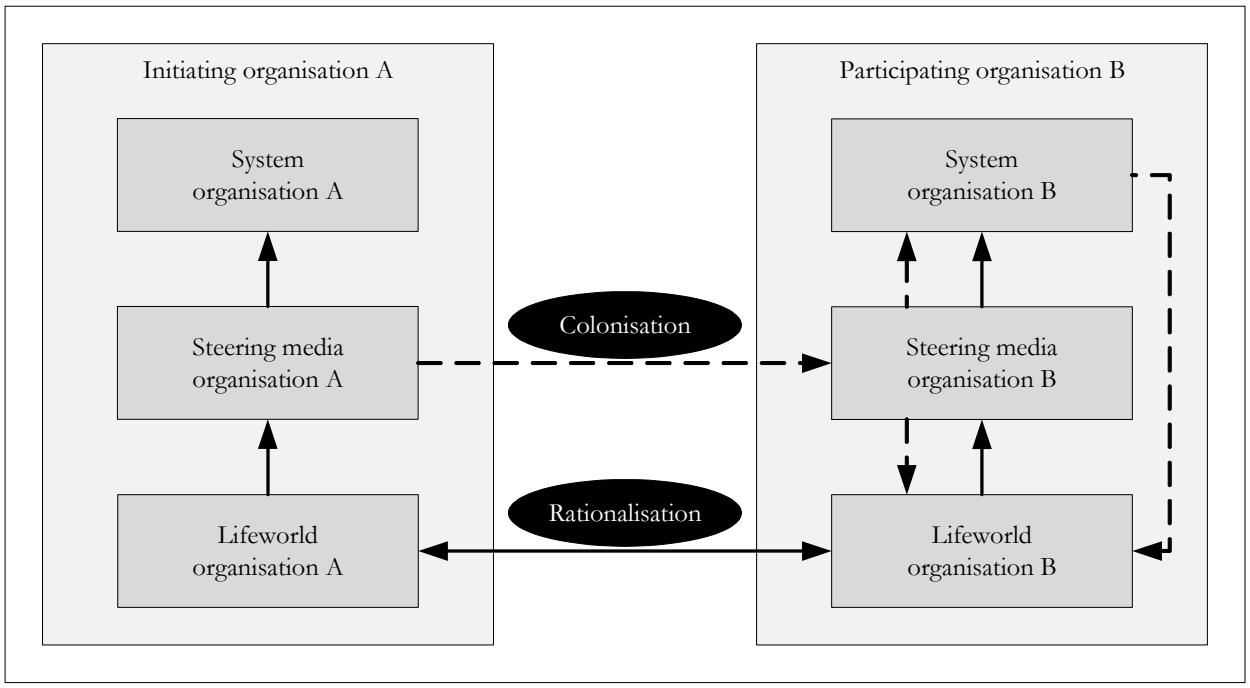

Figure 5.2: Systems, lifeworlds and steering media in an interorganisational context

In Field Studies 1 and 2, the same engineering company (i.e., one of the contract supervisors in Field Study 1, the project leader in Field Study 2) initiated the use of ICT. Before the project was awarded to the contractor, the engineering company customised the application – together with the software vendor and an external business consultancy company – based on its customary way of working and the administrative conditions that applied to this project. With the use of the application, the engineering company's internal processes *and* the interface with the contractor were automated; the engineering company expected to realise benefits from this use such as reduced administrative load, more structured communication, better process, document and information control, and faster exchange of information.

In both projects, the engineering company in the contract mandated the use of ICT for the contractor. In the contract, both the traditional paper-based communication processes as well as the digital communication processes were prescribed in order to create a safeguard in case the ICT application malfunctioned. In the contract, it was also formulated that when information is communicated in both paper-based and digital forms, the digital communication takes precedent. Thus, the engineering company used the contract as a steering medium to change and formalise domains of action (i.e., the interface between the engineering company and the contractors), and to make the contractors use interorganisational ICT. If the contractors wanted to carry out the projects they had no choice other than to except the claim of power (i.e., external motivation) accompanied with the contract and, therefore, use ICT.

The contractors were allowed to use the engineering company's ICT application free of charge. However, the engineering company had not incorporated the contractors' internal working processes in the application. The contractors had no experience with the application and the application was completely new to them. After the contract was awarded, the contractors were allowed to customise the application to their own working practices at their own expenses. However, both contractors decided not to invest time and money in aligning the application to their own internal working processes and they made one person responsible for using ICT. The contractors decided to communicate documents internally in the traditional – paper-based – way. Thus, both contractors decided not to 'internalise' the application to their internal organisational working practices and priorities. The contractors might have acted differently: they could have rationalised their lifeworlds to bring these in line with the steering media and systems and customised ICT to their working practices and priorities. Communicative action was needed to facilitate this rationalisation process.

The introduction of interorganisational ICT had an important effect on the interorganisational working practices, that is, the interorganisational formalised domains of action. The contractors were not involved in determining digital working practices and customising interorganisational ICT to these domains of action. Therefore, by using a steering medium (i.e., contract), the engineering company was able to transform interorganisational working practices and introduce interorganisational ICT. This had a – potentially – colonising effect on the contractors' lifeworld in the usage phase (see Colonisation in Figure 5.2).

In Field Studies 3 and 4, another strategy was used. In these projects, the client initiated the use of interorganisational ICT, but had not mandated the use of the application in the contract. The client proposed that the other organisations involved used interorganisational ICT. These organisations decided to assist in using the application in their project. However, one may question whether this decision was based on communicative acts. From our field studies, it follows that contractors often wanted to create goodwill or improve their reputation. Therefore, despite some disadvantages and the absence of contractual prescriptions, the contractor would use ICT. This made the client's proposal to use interorganisational ICT and the following discussion between the actors involved not completely power free. In Field Study 3 and 4, the client decided to pay for the application, the customisation of the application, and user support. Other participating organisations only had to invest time to make the software vendor customise the application to their working practices.

In both projects, key users from the organisations involved made agreements about their communicative behaviour, the use of ICT, and the customisation of ICT together. Therefore, the formal domains of action (i.e., system) were more an expression of the organisational lifeworlds than in Field Studies 1 and 2. However, whether the rationalisation of the lifeworld had been successful might be questioned. Communicative action is possible because of the lifeworld, but the lifeworld is also reproduced through communicative actions. The understanding of the actors involved about

interorganisational ICT was only limited, because this is the first time they were confronted with such an application. Therefore, they needed to rationalise their lifeworld through communicatively achieved understanding (see Rationalisation in Figure 5.2). For several reasons, actors are constrained in their communicative acts. These constraints will be discussed at the end of this subsection.

So far, we have discussed the pre-usage phase on an interorganisational level. However, the intraorganisational system, lifeworld, and steering media influence interorganisational use of ICT as well. Whether the organisational system is an expression of the lifeworld depends on the involvement of organisational participants in the process in which the formal domains of action are determined. This process can be based on the rationalisation of the lifeworld or on steering independent of the lifeworld. Both concepts of integration are discussed below and have – in the end – consequences for the interorganisational use of ICT.

First, the micro lifeworlds of actors within an organisation determine the organisational lifeworld. However, actors within organisations that were supposed to use interorganisational ICT were not involved equally in the process of determining digital working practices and customising the ICT application. The involvement of these actors in this process differed between our four projects. In Field Study 1, key users from the engineering company were involved in the pre-usage phase, and in Field Studies 3, and 4 key users from all participating organisations were involved. These key users represented other users who shared the same role in the project, thus the formal domains of action (i.e., interorganisational ICT) were an expression of the micro lifeworlds of the key users and supposed to be an expression of the micro lifeworlds of other users they represented. However, the application used in Field Study 2 was a copy of the application used in Field Study 1. No customisation activities had taken place to adjust the application and its digital workflow processes to the project. Therefore, the application appeared not to fit with the working practices and priorities of the main actor group within the engineering company that had to use interorganisational ICT: the contract supervisors. In addition, because of a lack of involvement in customisation activities this actor group only had a very limited understanding of the application, the reasons why this ICT was customised in this way, and how this application could or should be used. The system did not reflect their micro lifeworlds.

Second, the use (or non-use) of interorganisational ICT cannot only be mandated between organisations, but also internally within an organisation. The management of an organisation or the management of a project had the authority to legitimately steer the internal organisational system for the project independently of the organisational lifeworld. These actors (e.g., contractor's project leader, contract supervisors in Field Study 1; contractor's project leader, engineering company's line management in Field Study 2) could request other actors to use ICT, which potentially has a colonising effect on the organisational lifeworld.

Above we discussed two concepts of integration: rationalisation of the lifeworld, and steering independent of the lifeworld. In Habermas' view integration needs to be based on the rationalisation of the lifeworld. However, based on our observations, we can distinguish several constraints on this rationalisation, that is, communicative acts that increase the understanding about interorganisational ICT, each others working practices, and potential digital working practices. This constrained rationalisation process reduces or eliminates the potential of the lifeworld to steer working practices and interorganisational ICT (systems; formalised domains of action) based on mutual understanding between participating organisations, the software vendor, and the business consultant company. Below we discuss the constraints that appeared to be most important in our field studies. These constraints are sometimes interrelated.

- *Financial and interests constraints:* in Field Studies 1 and 2, adjustments in the application had to be paid for by the contractors themselves. These contractors had not included these costs in their bids. Based on this lack of financial resources and the limited perceived benefits of the use of interorganisational ICT (see knowledge constraints) they decided not to invest in customising interorganisational ICT to their internal working practices and priorities. This ICT did not have the highest priority for them. They did not 'internalise' interorganisational ICT and decided not to take the step to rationalise their lifeworlds to bring these in line with the steering media and systems. This decision limited the impact of ICT on their working practices as well, because they kept on communicating internally in the traditional – paper-based – way. In Field Studies 3 and 4, the client paid for the customisation of the application himself. This eliminated the other organisations' financial investment. Therefore, the contractors (i.e., key users) customised interorganisational ICT – together with the software vendor, and a business consultancy company – to their working practices and priorities, and thus, their lifeworlds.
- *Time constraints:* Field Studies 1 and 2 are design-bid-build projects. After the contract was awarded to the contractor, time pressure was immediately very high. One of the results was that the contractor and the engineering company had to digitally communicate a lot of messages and documents quickly after the project was awarded. The engineering company wanted to use interorganisational ICT as soon as possible and, therefore, interorganisational ICT was already set up before the contract was awarded. This eliminated the opportunities for a cooperative set up of interorganisational ICT with the contractor based on the adoption of communicative acts, because the contractor was not yet selected. In Field Studies 3 and 4, this situation is different. These are design-build projects, which means that the contractor was already selected earlier in the construction process. However, this does not always mean that participating organisations have a lot of time available to cooperatively set up interorganisational ICT. In Field Study 4, participating organisations wanted to implement interorganisational ICT as quickly as possible after their decision to use this ICT was made. Therefore, they, for example, tested the application only to a limited extent. This restricted the rationalisation of their lifeworlds, and especially the assessment of whether the application correctly reflected their systems and lifeworlds. The limited test activities resulted in a lot of technical shortcomings at the start of the usage phase.
- *Knowledge constraints:* in all the field studies, interorganisational ICT was new to the actors involved. As a result, actors only had a limited understanding about the application, the way the application could be used, and the way this application had to be implemented in their project. Of course, the software vendor and business consultant company supported the actors in making several decisions. However, in the end, actors had to make decisions themselves about the use of interorganisational ICT (e.g., Are we going to invest in interorganisational ICT? How are we going to mandate interorganisational ICT in the contract? How does interorganisational ICT need to be customised to our working practices and the working practices of other organisations?). Because of the limited understanding and the limited shared background knowledge (i.e., lifeworlds) of the organisations involved, actors faced difficulties in their communicative acts and, therefore, in reaching understanding about action situations. This restricted the rationalisation of the lifeworld. As a result, actors sometimes made inappropriate decisions. For example, (1) the use of ICT was mandated in the contract in general and not appropriate terms, (2) the application did not provide the necessary functionalities, and (3) the digital workflow processes did not reflect the working practices of the organisations appropriately.
- *Authority constraints:* in Field Studies 2 and 3, actors assumed that the application had already been used and had proven to function well in another project. Therefore, no (Field Study 2), or only limited activities were carried out to test the application. In Field Study 2, no

customisation efforts were even conducted. As will be shown later, this resulted in an inappropriate application.

Thus, the alignment of organisational working practices and the customisation of interorganisational ICT to these working practices is a complicated process determined by steering media, the rationalisation of the lifeworlds, and constraints to the rationalisation of the lifeworlds. In Habermas' view, the outcome of this process needs to be an expression of the lifeworlds of the organisations involved (i.e., working practices, priorities). However, in reality, at least in our field studies, this outcome is often not completely realised. Not all organisations are able to participate in the customisation process or are not able to participate in a sufficient way. One of the complicating factors in construction projects is the temporary cooperation between organisations as a result of the open tendering procedures. As a result, interorganisational ICT is developed that is able to support communication but creates distortions as well. This outcome of the pre-usage phase sets the scene for the actual use of interorganisational ICT.

5.5.2 Usage phase

In this subsection, we will reinterpret the results from the 'insight production' activity (i.e., the theoretical model) from the perspective of Habermas' critical social theory. We will first do this by using the concept of the models of action. Second, we will elaborate on barriers constraining actors in using ICT in the intended way and the origins of these barriers.

Adoption of models of action in ICT usage situations

The use of interorganisational ICT can be analysed from the perspective of Habermas' models of action. We will use these models to analyse how the social system and the technical system interact, and how and why actors adopt these models of action. However, only analysing the use of ICT would be too limited. Based on our observations in the field studies we have to add two other elements. First, the intended use of interorganisational ICT has to be analysed. Analysing the intended use and comparing this use with the actual use provides important insights into reasons why interorganisational ICT is not used in the intended way. In addition, when actors initiate the use of ICT, they may perceive risks in using interorganisational ICT in the context of construction projects and will try to formulate measures to overcome these risks to the use of ICT in advance. The intended use and the risks and measures can also be analysed from the perspective of Habermas' models of action. Second, in all field studies, barriers restrict actors in using interorganisational ICT *after* they started to use ICT. When barriers are constraining actors in using ICT, these actors can do two things: (a) they can try to remove these barriers, or (b) they can start to use other means of communication. The attitude and the actions of the actors involved towards overcoming these barriers can be analysed from the models of action as well. Therefore, we will analyse three aspects from Habermas' models of action: (1) the intended use, (2) the actual use, and (3) the attitude and actions towards overcoming barriers to the intended use. We will analyse those aspects for each model of action separately.

Instrumental action

Intended use

In all the field studies, actors are intended to adopt instrumental action. Based on technical rules and technical knowledge about the operation of ICT actors are intended to use the application as an 'instrument' to perform activities in a more efficient and effective way then they used to do in paper-based forms. The application is intended to be used, for example, to trace documents, information, and communication, to monitor the progress of tasks, and to carry out activities more efficiently (e.g., print out statements instead of filling in an Excel sheet). In addition, communicating or forwarding messages to other actors (e.g., submitting a document) is instrumental action as long as the other actor is viewed

as an object instead of a subject. In that situation, instrumental action is intended to result in faster communication and exchange of information. If other actors are regarded as subjects, actors adopt one of the other (i.e., social) models of action.

The opportunities for the application to support actors in performing activities in a more efficient and effective way, differ between the field studies. In Field Studies 1 and 2, both contractors decided not to align the application to their own internal working processes and priorities, but to communicate documents internally in the traditional – paper-based – way (see pre-usage phase). This influenced their opportunities to use the application to perform activities in a more efficient and effective way, because all paper documents had to be digitalised before they were sent to other organisations, and all digital information received from other organisations had to be printed. In Field Studies 3 and 4, the application is aligned to the working practices and priorities of the organisations involved; the application is, therefore, expected to be able to support these organisations in performing their activities in a more efficient and effective way.

Actual use

In the model of instrumental action, the application is supposed to make actors act more efficiently and effectively. Therefore, its use is supposed to have benefits for the actors involved compared to traditional – paper-based – situations. However, in our field studies, not all actors involved do perceive its use as beneficial in all situations (see mechanism 'personal motivation'). In addition, sometimes actors are willing to use ICT but are not able to use this ICT in the intended way as a result of constraining mechanisms (see 'knowledge and skills' and 'acting opportunities'), and actors first have to learn to use ICT before they can attain the full benefits of its use. Actors are not always able to invest the required time to learn to use ICT (see submechanism 'perceived time pressure'). As a result, some actors do not have a personal motivation to use interorganisational ICT. These actors tend to use other means of communication reducing the value of interorganisational ICT for themselves and others for the future, because information is not imported in the application.

The situation described above, can be translated to Habermas' model of instrumental action. Actors try to achieve their ends by choosing between alternative courses of action. One of their options is to use interorganisational ICT. Others options are to use other means of communication. Habermas mentions two criteria that can be used to judge instrumental action.

- The efficacy of actions is judged. This criterion is related to the mechanisms 'personal motivation', 'knowledge and skills', and 'acting opportunities' in our theoretical model. First, 'personal motivation' does influence the decision an actor takes about using ICT in a certain situation based on *expectations*: is the use of ICT efficient and effective in this action situation? Second, whether the instrumental act was, in the end, efficient and effective depends on the other constraining mechanisms (see 'knowledge and skills' and 'acting opportunities'). An actor may judge *after* the action is carried out: was the use of ICT efficient and effective in this action situation? This judgement is an input to an actor's future instrumental actions, because it influences expectations about future actions. Note that the efficacy of actions depends on the actions of other actors as well. For example, if other actors are not using the ICT application to communicate documents, the instrumental act of printing out statements of communicated documents out of the ICT application is not effective.
- The truth of propositions is judged. This criterion is related to the submechanism of 'perceived benefits and disadvantages of ICT use': are the perceptions about potential and realised benefits and disadvantages true? Based on these perceptions actors try to achieve their ends by choosing between alternative courses of action. Actors often act based on a distorted understanding of ICT and, therefore, distorted perceptions about benefits and disadvantages of ICT use, especially as a result of the novelty of the application. In addition, this criterion is related to the other submechanism of 'personal motivation' ('perceived time pressure') and the mechanisms

of 'knowledge and skills', and 'acting opportunities' because actors' perceptions about these mechanisms might be distorted as well. For example, an actor's proposition that he or she is or is not able to operate or use ICT might be false. Again, the novelty of the ICT application is mainly responsible for causing these distortions.

We have already discussed how the engineering company steers the contractors towards using interorganisational ICT in the pre-usage phase in Field Studies 1 and 2. In addition, the application used in Field Study 2 is an exact copy of the application used in Field Study 1. No customisation activities are carried out. This has two important consequences for the contractor in Field Study 1, and the contractor and the engineering company in Field Study 2. First, interorganisational ICT is not aligned to their working practices and priorities, and therefore, these actors do not view interorganisational ICT as an instrument that makes them perform activities in a more efficient and effective way. Second, because the actors are not involved in customising interorganisational ICT, their understanding about interorganisational ICT is only limited, which results in distorted perceptions about ICT, its benefits and the way it has be used.

Overcoming barriers to the intended use
Actors can act from the instrumental model of action as well when they are confronted with barriers in the use of interorganisational ICT. If actors act from this non-social model of action they choose between alternative courses of action to realise an end. If interorganisational ICT is important to an actor in realising an end and the resources an actor has to invest are not too high, this actor will try to overcome these barriers. For example, actors make clear procedural agreements, purchase a bulk scanner, or implement a new application. If actors have to relate to other actors who are regarded as subjects, actors adopt one of the other models of action. The same mechanisms and criteria about the use of interorganisational ICT from the instrumental model of action described above, apply to the activities actors do in their attempt to overcome barriers to the intended use of ICT (i.e., efficacy of action and truth of propositions is judged). Whether an actor tries to overcome barriers to the intended use of ICT depends on the judgements of these criteria.

We can summarise by saying that actors are intended to adopt the instrumental model of action to use interorganisational ICT to perform activities in a more efficient and effective way. If they actually use interorganisational ICT and if they try to overcome barriers to the intended use of this ICT they are adopting this model of action as well. They use interorganisational ICT (or other means of communication) and decide to overcome barriers based on a judgement of the criteria of truth and efficacy. These judgements are related to the mechanisms of 'personal motivation', 'knowledge and skills', and 'acting opportunities' in our theoretical model. These judgements are influenced by actors' involvement and participation in the customisation of interorganisational ICT in the pre-usage phase. From our observations, it follows that an actor him or herself, *and* other actors – including the researcher – are able to judge an actor's actions based on the criteria of truth and efficacy. These judgements are partly distorted by their perceptions (i.e., understanding about ICT).

Strategic action

Intended use
In all field studies, the use of ICT is not intended to support (i.e. enable) but to reduce (i.e., constrain) strategic action. When actors use ICT all communication is recorded. Therefore, it is completely clear what actors agreed upon and when information is communicated. This reduces an actor's opportunity to act strategically (e.g., *"We haven't settled that issue that way!"*; *We haven't received that information!"*; *"I have already sent you that information a week ago, I think there is delay in your mail delivery"*). Thus, the use of ICT is intended to reduce strategic action. One initiating actor says: *"The use of ICT reduces the possibilities to be naughty"*. However, before actors start to use ICT the initiating actors are

afraid of actors using the ICT application strategically as well. Therefore, information is protected in the ICT application by different 'safes': (1) a collective safe, and (2) a safe for each of the participating organisations. It is impossible for organisations to see information and communication in the safe of another organisation. In addition, a basic assumption behind the application is that submitted documents and messages cannot be changed anymore. However, actors still fear that other actors will find a way to change information. One actor says: *"One important risk is that actors misuse ICT. Can actors change a document after it is approved? The application needs honesty, transparency, and trust. This is not always present"*. Thus, misuse of the application is a risk that needs to be prevented.

Actual use

The model of strategic action shares with instrumental action the characteristics of teleological action: an actor tries to realise an end by choosing between alternative courses of action. However, within this model of action an actor tries to influence the decisions of others. Of course, mandating the use of interorganisational ICT is a strategic act (see steering media in pre-usage phase). However, after actors started to use ICT they are able to act strategically as well.

In all field studies, if actors use interorganisational ICT they digitally communicate – in general – information that they used to communicate in paper-based forms in other projects. Therefore, actors do not have to communicate more or other information because of ICT. The only difference is that actors involved use digital means and that information and communication is 'fixed'. This reduces the opportunities for strategic action. Nonetheless, in some situations transparency increases or is intended to increase as a result of the use of ICT. We give two examples of that.

First, in Field Studies 1 and 2, because of the introduction of ICT, the client can gain better insight into communication between the contractor and the engineering company (i.e., contract supervisors) than he used to have. The management of the engineering company likes to show the client that the engineering company has nothing to hide (see dramaturgical model of action). However, according to a contract supervisor in Field Study 2, giving the client access to, for example, discussions about issues (i.e., deviations) can be risky for two reasons. First, contract supervisors are used to communicate information to the client after discussions and disputes are settled. They want to choose the moment they communicate to the client themselves. When the client has insight in all digital discussions, the contract supervisors cannot filter information and communication anymore. Second, the client can misinterpret information and communication. Often some background information is needed to interpret information and discussions correctly. In the end, in both field studies actors do not use ICT to discuss deviations. The engineering company and the contractor discuss deviations in meetings and the outcomes of these meetings are brought in the ICT application. As a result, deviations are not discussed by using interorganisational ICT. However, from this example it follows that increased transparency can be a benefit to the client and the management of the engineering company but a threat to the contract supervisors.

Second, in Field Study 4, the contractor's project leader wants to expand the scope of the application to his internal organisation and the subcontractor and to include informal communication in the application as well. One of the reasons for these changes is that he wants to get an overview of informal communication between the subcontractor and the client. The subcontractor often carries out projects for the client and therefore actors from these organisations know each other very well. They are used to communicating with each other personally. This makes the contractor's project leader unaware of their communications, although the contractor's project leader is, in the end, responsible. However, after the scope of the application is expanded, the subcontractor often does not use the application. As a result, the contractor's project leader is not able to gain the desired insight into the informal communication between subcontractor and client.

From these examples, it follows that the use of interorganisational ICT has the potential to increase transparency. This increased transparency can be viewed as a strategic act of the management of an organisation or the management of the project. However, other actors can act strategically as well. They can bypass the application and, therefore, eliminate the potential increased transparency. Actors often give many reasons for not using the application in these situations: "*The application does not work", "I don't know how to use the application"*, or "*The application does not support our working practices*". However, this non-use can be a latent strategic act as well: actors do not see any reason to overcome barriers to the use of interorganisational ICT or try to find reasons for their non-use.

The strategic model of action, in the same way as the instrumental model of action, is influenced by the mechanisms 'personal motivation', 'knowledge and skills', and 'acting opportunities'. These relationships are already discussed in our analysis of the instrumental model of action. However, other actors may try to steer the way an actor acts (i.e., uses interorganisational ICT) as well; these 'steering acts' can only be understood from the strategic model of action. First, other actors may try to influence the configuration of benefits and disadvantages to steer the acts of other actors (see submechanism 'perceived benefits and disadvantages of ICT use'). From our observations it follows that the use of ICT can be linked to outcomes that are important to other actors. For example, in Field Study 1, the engineering company only pays the contractor when the contractor uses ICT to communicate certain documents (i.e., instalments). This appeared to be an important incentive for the contractor to use ICT in the intended way. In this situation, the steering medium of money is used to influence the way the contractor acts. Second, another actor may request ICT use (e.g., an actor in a management position, the client) (see submechanism 'presence of a requesting actor'). These actors can request other actors to use ICT or to use other means of communication. In addition, they can allow other actors to stop using ICT. For example, a contractor says about his client: *"In the end it is of the utmost importance that [the client] is satisfied. When it lies within my reach to satisfy [the client] I even want to spend more time on ICT. (…) It is important to create goodwill"*. Another contractor mentions to a client: *"You are my client, so I have to do it the way you want it"*. In other words, some actors can steer the acts of actors by the steering medium of power. However, there are boundaries to the extent to which actors are prepared to make their actions conform to other actors' requests. A contractor says: *"When you have to do much more work than was mentioned in the specifications we won't do it even if the engineering company is requesting it"*.

Overcoming barriers to the intended use

The same mechanisms and criteria described above about the use of interorganisational ICT from the strategic model of action apply to the activities that actors conduct to overcome barriers. Actors choose between alternative courses of action in realising their ends based on their perceptions about the objective world. These actions are judged by the truth of the propositions and the efficacy of actions.

As we have already discussed above, actors may bypass interorganisational ICT and give all kinds of reasons for doing so. This non-use may be a covert strategic act. In these situations, actors will not try to overcome barriers to the intended use of ICT and, therefore, a steering medium is needed. For example, in Field Study 1, the engineering company only pays the contractor when the contractor uses ICT to communicate instalments (see above). As a result, for these instalments, the contractor eliminates barriers to the intended use of ICT as soon as possible. However, these steering media are not always available. Below we give several examples in which actors try to expand the scope of interorganisational ICT in situations in which a steering medium is not present.

In Field Study 1, the engineering company proposes expanding the scope of the application to other communications (i.e., letters and drawings). The contractor perceives some important potential benefits in this extension. However, he perceives some disadvantages as well. He does not want to invest extra time (i.e., extra scanning activities) and money (i.e., buying a plotter) in using the application. He has not incorporated these costs in his bid. Therefore, the contractor refuses to agree to the engineering

company's proposal and the scope of the application remains the same. Another example is Field Study 3. In this project, the contractor is responsible for detecting construction failures and for formulating measures to correct them. The client monitors the contractor in carrying out this control process. The contractor uses the ICT application to record these 'internal deviations'. The client does not have access to these internal deviations in the application and, after a while, wants to gain insight into the contactor's internal deviation processes. However, the contractor refuses the client's proposal because he prefers to discuss deviations personally in meetings instead of giving the client access to his internal communication. Therefore, the application is not changed.

These examples show that actors may try to influence the decisions of other actors to overcome barriers to the intended or desired use of ICT. This can be done by strategic acts and by communicative acts. If actors cannot change attitudes with the force of the better argument or with steering media, actors will not decide to overcome barriers to the intended or desired use of ICT. In these situations actors may try to eliminate barriers for other actors.

We can summarise by saying that the use of ICT is intended to reduce strategic action, and misuse of the application is perceived as a risk that should be prevented. However, the introduction of interorganisational ICT can be a strategic act (see Field Studies 1 and 2 in pre-usage phase). Also, after actors start to use ICT they may act strategically by using ICT in a certain way or by trying to modify or resist modifying ICT. This model of action, in just the same way as the instrumental model of action, can be analysed from the following validity claims: the efficacy of actions, and the truth of the propositions. These judgements can be made by the actor himself or herself, as well as by the other actors. These judgements are related to the mechanisms of 'personal motivation', 'knowledge and skills', and 'acting opportunities' in our theoretical model and can be influenced by other actors using steering media. In this view the model of action is related to 'external motivation' as well.

Normatively regulated action

Intended use
Organisations initiating the use of interorganisational ICT try to reduce the risk that actors are not using ICT and try to give the use of this ICT contractual status by introducing the model of normatively regulated action. In this model of action, actors use ICT with the intention of fulfilling expectations of behaviour. In Field Studies 1 and 2, the engineering company mandated the use of ICT towards the contractor in the contract (see pre-usage phase). Moreover, the engineering company prescribed both digital and traditional – paper-based – working practices in the contract to create a safeguard in case the ICT malfunctioned. Therefore, the contractor had no other choice than to use ICT. In addition, when the application is not functioning well the engineering company is able to 'switch' to traditional means of communication. In Field Studies 3 and 4, actors make agreements about their communicative behaviour and the use of ICT together and formalised this agreement to give these contractual status. In this situation, the agreement is not based on a mandate but on a cooperative agreement between the organisations involved. When agreements are mandated or a collective agreement is made, the use of ICT becomes part of the normative context. As a result, (1) the use of ICT can be judged as to whether it is right with respect to the normative context and (2) the use of ICT may be normatively regulated because actors make their behaviour conform to the normative context to fulfil expectations that are viewed as legitimate.

Actual use
In the model of normatively regulated action, actors use ICT with the intention of fulfilling expectations of behaviour. This model of action is related to the submechanism 'availability of contractual arrangements about ICT use'. From our field studies it follows that this model of action

becomes very important when actors do not have the personal motivation to use interorganisational ICT in the intended way. We will give two examples of this.

First, in Field Study 2, the contractor has a positive personal motivation to use interorganisational ICT at the start of the project. However, as a result of experiences with the application and other actors (i.e., the engineering company) not using this application this personal motivation turns negative. Therefore, his use of ICT becomes determined by an external motivation instead of self-interests (contractor: *"The only reason why we use ICT is because it is mandated in the contract.*"). Thus, the contractor starts to adopt the model of normatively regulated action, and aligns his actions to the normative context that is recognised as legitimate, that is, the contract (i.e., validity claim: rightness of actions). However, the contractor is not able to act according to the contract as a result of unclear use, a limited alignment between the application and his quality management system, and problems with the ICT application (see mechanisms 'knowledge and skills' and 'acting opportunities'). The engineering company (i.e., the organisation that mandated the use of interorganisational ICT in the contract) is not able to solve these problems. Therefore, the contractor decides to stop using ICT. The contractor only wants to use ICT again when the application is changed and clear instructions about the use of ICT are provided. This means that, in Habermas' terms, the contractor does not recognise the norms as prescribed in the contract as being legitimate anymore (i.e., validity claim: legitimacy).

Second, in Field Study 3, the actors involved made agreements together about the use of interorganisational ICT and formalised these agreements to give these contractual status. Actors act according to these agreements. When the contractor start to have technical problems with his application and he is not able to use it in an appropriate way, he simply decides not to communicate. He wants to act according to the normative context recognised by him as legitimate, that is, the agreements (i.e., validity claim: rightness of actions). He imports data in the application at another point in time when technical problems are solved. He is able to postpone his use of ICT and acts according to the agreement because he does not face high time pressure in using interorganisational ICT. However, because the agreement to use ICT is cooperatively made, the contractor is strongly motivated to act according to this agreement.

Within the normatively regulated model of action, actors conform their behaviour to a normative context. For this model of action it is of utmost importance that these norms are completely clear to the actors involved (see submechanism 'clarity of procedural agreements'). When the understanding about the application is low actors face difficulties in deciding how ICT can or needs to be used. In all field studies, actors' understanding about ICT is low when they start to use it. They have to use this ICT for the first time; therefore it is very difficult for them to decide which procedural agreements need to be made. As a result, in Field Studies 1 and 2, the engineering company mandates the use of ICT for to contractor in the contract based on a limited understanding about the application. Therefore, the contractual arrangements are not fully clear and the contractor faces difficulties in understanding the application and the way this application needs to be used in this project. As a result, the contractual agreements (i.e., the normative context) give actors opportunities to use ICT differently than is intended.

Overcoming barriers to the intended use

Actors can act from the normatively regulated model of action as well when they are confronted with barriers to the use of interorganisational ICT. If actors act from this model of action they try to fulfil expectations of behaviour. In our field studies, this situation only occurs when actors want to make their behaviour conform to the contract or to formalised agreements with contractual status (see submechanism 'availability of contractual arrangements about ICT use'). These arrangements need to be clear to normatively regulate actions (see submechanism 'clarity of procedural agreements'). In the

actor's view they have no choice other than to use ICT. Therefore, barriers need to be overcome in order to fulfil expectations about the intended use.

However, from our observations it follows that within this model of action, actors are not as active in trying to overcome barriers to the use of ICT as in situations in which a positive personal motivation to use ICT is present. For example, in Field Study 2, the contractor's personal motivation to use interorganisational ICT becomes negative after a while. Because the use of ICT is a contractual obligation the contractor has no other choice than to use ICT. However, the contractor is, among other things, confronted with unclear agreements about the use of ICT (see submechanism 'clarity of procedural agreements about ICT use'). This is restricting the contractor in his ability to use ICT in the intended way. The contactor has low personal motivation to spent time in understanding how to use the to application and to think out clear agreements themselves. This contractor says: *"If [the engineering company] wants us to use ICT, then they have to tell us how we have to use it as well"*. The contractor does not spend time in thinking out agreements himself, but decides to constantly ask the engineering company how ICT needs to be used. If the contractor had had positive personal motivation to use ICT, then he would have thought out clear agreements himself (see e.g. contractor in Field Study 4). Thus, actors try to fulfil expectations, but do try to limit their efforts as well. In this view, norms override self-interests (see teleological models of action: instrumental action and strategic action) in the area where these norms are judged as legitimate. Within this area actors try to act according to the normative context that is recognised as valid (validity claim: rightness of actions), outside this context they adopt the teleological model of action.

We can summarise by saying that contractual arrangements make actors adopt the model of normatively regulated action (see submechanism 'availability of contractual arrangements about ICT use'). This model of action can be used as a safeguard to the intended use of interorganisational ICT as long as the normative context is recognised as legitimate. Situations may occur in which actors are not able to act according this context and, therefore, do not recognise the normative context as being legitimate anymore (see mechanisms 'knowledge and skills' and 'acting opportunities'). Contractual arrangements can become part of the normative context as a result of a strategic act (see Field Studies 1 and 2), or as a result of a communicative act (see Field Studies 3 and 4). Within this model of action, the way actors act is judged according to the criteria of rightness of actions, and legitimacy of norms. Contractual arrangements influence both the use of ICT and the activities actors carry out to overcome barriers to the intended use of ICT. However, within this model of action, actors are not as active in using ICT and trying to overcome barriers to the use of ICT as they are in situations in which a positive personal motivation to use ICT is present. In order to make actors use interorganisational ICT the normative context needs to be completely clear to the actors involved (see submechanism 'clarity of procedural agreements'). Only in that situation, can both the actor *and* other actors judge actions based on the criteria of rightness and legitimacy.

Dramaturgical action

Intended use
In Field Studies 1 and 2, actors are expected to adopt dramaturgical action. Actors are intended to use ICT to present a view of themselves towards an 'audience' (i.e., the client). In Field Study 1, the engineering company gives the client viewing permissions in the application. As a result, the client will have easier and better access to project information and communication than in traditional projects where such an application is not used. The management of the engineering company perceives important benefits in presenting itself to the client as being transparent (*"We show that we have nothing to hide"*) (see submechanism 'perceived benefits and disadvantages of ICT use'). However, being transparent is a risk as well. Therefore, in Field Study 1, the engineering company limits the scope of the application to the contractor until the application functions well.

Actual use
In the model of dramaturgical action, actors use ICT to present a view of themselves towards an 'audience'. The only notable example of this model of action is the engineering company in Field Studies 1 and 2, who wants to present a view of himself as being transparent towards the client. Unfortunately in both field studies, the clients do not use the application because they do not perceive benefits in doing that. Therefore, we are not able to judge the clients' reaction towards the engineering company's dramaturgical actions (i.e., validity claims: truthfulness or sincerity of self-presentation). Note that being transparent to the client can be viewed as beneficial by the project or line management of the engineering company but as a threat to other actors involved. See the model of strategic action for a discussion of this issue.

Communicative action

Intended use
In all field studies, actors intend to adopt communicative action. Actors intend using ICT to reach an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement. Interorganisational ICT is intended to be used in two ways: (1) to store, and access project information and documents (document management feature), and (2) to communicate messages and documents digitally to other actors (workflow management feature). The first act can be seen as an indirect communicative act. Actors store information and documents at a central location (i.e., in the application), so the latest information and documents are clear and available to all actors. This makes action situations and plans of actions clear to all actors involved. These actors are intended to use the information and documents to coordinate and perform their acts in the future. The second act can be seen as a direct communicative act. Actors communicate messages and documents digitally to reach an understanding and to coordinate their actions by way of agreement. Actors can use ICT to discuss action situations. However, they may also decide to use ICT to formalise the outcome of 'non-digital' discussions. For example, actors discuss issues in meetings and use ICT to formalise their agreements. In all field studies, both scenarios are intended to be used. In several field studies, initiating actors expect that the use of ICT will shorten meetings because issues have already been discussed digitally. One important benefit of using ICT to submit and discuss information and documents is that information and communication is 'fixed' resulting in more structured communication and better process, document, and information control.

Actual use
Interorganisational ICT was intended to be used in two ways: (1) to store and access project information and documents, and (2) to communicate messages and documents digitally to other actors. In the model of communicative action, actors use ICT with the intention of reaching an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement. If actors adopt this model of action, they criticise the validity claims of truth, rightness, truthfulness, and comprehensibility or well-formedness of expressions. The first three validity claims have already been discussed in the former models of action. The comprehensibility or well-formedness is a presupposition for the recognition of these validity claims.

However, individuals and organisations often do not use interorganisational ICT in this way but use ICT from the other models of action. Individuals and organisations often have their own standard working practices (see submechanisms 'alignment between ICT and working practices') and interest positions (see mechanism 'personal motivation'). When new ICT is introduced in a project, this has consequences for their working practices (and the wishes of all the actors involved have consequences for the ICT application as well). When the working practices and the ICT application are not aligned actors face difficulties in using the application. The possibilities of changing working

practices are limited by an actor's understanding about ICT (claim of truth), regulations (claim of rightness), and standard personal and organisational working practices that may be viewed as being better than digital working practices (interest positions). Below we give two examples of this.

(1) Storing and accessing project information and documents: although documents that are communicated to other organisations by using interorganisational ICT are stored in the application, not all actors use this application to access their documents. For example, in Field Studies 1 and 2, the contractors have their own internal quality management system. This quality management system is certified according to the ISO specifications. Actors can change their working practices on the condition that they still comply with the ISO specifications. However, the contractors do not see opportunities to use ICT and comply with the ISO specifications at the same time. This is partly caused by the decision not to implement interorganisational ICT internally within their organisations (see pre-usage phase). Therefore, they decide to keep on following their standard – paper-based – working practices internally and they do not use the ICT application to access documents. The situation differs with that of the contractors in Field Studies 3 and 4. Their applications are customised based on their internal working practices.
(2) Communicate messages and documents digitally to other actors: in all field studies, ICT is able to support discussions between actors from different organisations. However, in all studies, actors prefer to discuss issues in meetings or informally first. They use ICT to formalise these discussions but not to have discussions. In their view having personal discussions is more appropriate then having digital discussions because arguments can be exchanged intensively speeding up the process of coming to an agreement. Therefore, actors do not – in general – use ICT to discuss deviations. Actors decide to use ICT to formalise the outcome of 'non-digital' discussions.

In these situations actors do not have the motivation to use ICT in the intended way (see mechanisms 'personal motivation' and 'external motivation'), or they are restricted in the successful adoption of the communicative model of action (see mechanisms 'knowledge and skills' and 'acting opportunities'). Based on our observations, we are able to relate the actual use of ICT to the pre-usage phase: if actors are not involved in the customisation of interorganisational ICT and when – as a result – the application is not aligned to the internal working practices (and the regulations that apply to these working practices), actors are not able to use interorganisational ICT in the intended way.

Overcoming barriers to the intended use

Actors can adopt the communicative model of action when they are confronted with barriers in the use of interorganisational ICT. In this model of action, actors try to reach an understanding about the action situation (i.e., barriers) and their plans of action (i.e., how to overcome barriers) by way of agreement. However, in practice, these models of action are only adopted to a limited extent as a result of constraining conditions. The main constraint to the adoption of this model of action is a lack of a personal motivation to use interorganisational ICT. For example, (a) the use of interorganisational ICT is perceived as a disadvantage, (b) overcoming barriers does not get a high priority because of high time pressure, and (c) necessary investments are not included in the bids. In these situations an external motivation is needed to force (or steer) actors to overcome barriers. From the field studies it follows that actors will adopt the communicative model of action when a personal motivation to use ICT is present (see e.g., contractor in Field Study 4).

Another important constraint to the communicative model of action is the knowledge constraint. Because of knowledge constraints actors are not able to overcome barriers to the intended use of ICT. However these constraints work in concert with the lack of motivation to use ICT. Field Study 2 offers

an example of this mechanism. In this field study, no activities are carried out to customise interorganisational ICT to the project (see pre-usage phase). In addition, actors only have a limited understanding about interorganisational ICT. When actors start to use ICT they are confronted with barriers to the intended use and are not able to solve these barriers because of their limited understanding (e.g., a lack of background knowledge because the application is a copy from Field Study 1), and the hectic context in which they have to use ICT (i.e., submechanism 'perceived time pressure'). Therefore, they are not able to overcome their knowledge constraints and – in the end – the barriers to the intended use of ICT. Only after months, an experienced user from Field Study 1 provides user support. This user support stimulates actors to overcome barriers to the intended use.

We can summarise by saying that the actors are intended to adopt the communicative model of action to use interorganisational ICT. However, they often do not use interorganisational ICT in this way and adopt other models of action. In these situations actors do not have the motivation to use ICT in the intended way (see mechanisms 'personal motivation' and 'external motivation'), or they are restricted in the successful adoption of the communicative model of action (see mechanisms 'knowledge and skills' and 'acting opportunities'). From our observations it follows that these situations are often caused by constraints in the pre-usage phase. Actors can also adopt the communicative model of action when they are confronted with barriers in the use of ICT. However, in practice, this model of action is only adopted to a limited extent as a result of a lack of a personal motivation and knowledge constraints.

Barriers to the intended use of interorganisational ICT

Based on our analysis, we can conclude that all five models of action provide important lenses when analysing the intended use, the actual use, and the activities actors carry out to overcome barriers to the intended use of interorganisational ICT. In the field studies, interorganisational ICT is intended to support instrumental action, communicative action and sometimes also dramaturgical action. However, in practice, actors adopt strategic action and normatively regulated actions as well. In our analysis we focussed on how and why actors adopt a model of action to understand why actors use or do not use ICT in the intended way, and why actors decide or decide not to overcome barriers to the intended use. From our observations and the discussion of the models of action, it follows that fundamental to the intended use of interorganisational ICT are: (1) whether actors choose to adopt the *intended* model of action, and (2) whether actors choose to use ICT in the intended way from this model of action. Several barriers restrict actors in using a model of action or in using a model of action in the intended way. The validity claims, together with the mechanisms influencing the use of ICT, provide entry points to understanding the decisions and the actions of the actors involved. Based on our analysis of the mechanisms and validity claims in the context of our field studies, we are able to formulate barriers to the intended use of interorganisational ICT. These barriers *follow from the field studies* and are shown in Table 5.4, together with the models of action, intended use, mechanisms influencing the use, and the validity claims.

Our field studies showed that actors start to adopt the normatively regulated model of action if they are not personally motivated to use interorganisational ICT but the use of ICT is mandated in the contract. However, if no normative context is present, actors start to adopt the teleological (i.e., instrumental, strategic) models of action. In addition, actors may decide not to use ICT in the intended way, although they adopt the intended model of action, based on the barriers to the intended use of ICT. Most of the barriers to the intended use of ICT can be traced back to the steering media and restrictions to the rationalisation of the lifeworld as discussed in the pre-usage phase. This results in situations in which:

- Organisations set up interorganisational ICT before other organisations are selected, thus eliminating the opportunities for a cooperative set up.
- Organisations and actors do not 'internalise' interorganisational ICT on a project-level. ICT is not customised to the working practices and priorities of the organisations and actors involved, and thus, their systems and lifeworlds.

Model of action	Intended use of ICT	(Sub)mechanisms	Validity claims	Barriers to the intended use of interorganisational ICT
Instrumental action	Actors use ICT to perform activities in a more efficient and effective way.	• Personal motivation • Knowledge and skills • Acting opportunities	• Truth of propositions • Efficacy of teleological actions	• Limited perceived value or many perceived disadvantages of ICT use in an action situation • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions • Others do not use ICT in the intended way
Strategic action	The use of ICT reduces the opportunities for strategic acts. However, actors may still act strategically when using ICT. Other actors may be able to steer an actor's actions if this actor is not using ICT in the intended way.	• Personal motivation • External motivation • Knowledge and skills • Acting opportunities	• Truth of propositions • Efficacy of teleological actions	Use by an actor: • See instrumental model of action Steering by an actor: • Limited opportunities to mandate the use of ICT towards an actor • Limited opportunities to influence the perceived configuration of benefits and disadvantages of ICT use for an actor • Limited opportunities to remove restrictions to the intended use of ICT for an actor
Normatively regulated action	Not intended, but used as a safeguard.	• Availability of contractual arrangements • Knowledge and skills • Acting opportunities	• Rightness of actions • Legitimacy of norms	• Lack of contractual arrangements or agreements about ICT use • Unclear agreements about ICT use • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions
Dramaturgical action	Actors use ICT to present a view of themselves towards an 'audience' (i.e., other actors).	• Perceived benefits and disadvantages of ICT use	• Truthfulness or sincerity of self-presentations	• Others do not use ICT in the intended way
Communicative action	Actors use ICT to reach an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement.	• Personal motivation • Knowledge and skills • Acting opportunities • External motivation	• Truth of propositions • Rightness of actions • Truthfulness of self-representations • Comprehensibility or well-formedness of expressions	• Limited perceived value or many perceived disadvantages of ICT use in an action situation • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions • Others do not use ICT in the intended way

Table 5.4: Models of action, mechanisms and barriers to the intended use of ICT

- Organisations and actors lack the understanding about interorganisational ICT which they need to make appropriate decisions about its use. As a result of this limited understanding, and the limited shared background knowledge (i.e., lifeworlds) of the organisations and actors involved, actors face difficulties in their communicative acts and, therefore, in reaching understanding about action situations.
- Organisations and actors make an insufficient assessment about whether interorganisational ICT correctly reflects their systems and lifeworlds.

These situations cause barriers to the intended use of interorganisational ICT and to the willingness to overcome barriers to this use.

5.6 The use of interorganisational ICT: re-definition

In this study we adopted Habermas' critical social theory and showed how this theory can be used to interpret and analyse the use of interorganisational ICT in four construction projects. This analysis resulted in barriers to the intended use of interorganisational ICT being identified; it also pointed to the origins of these barriers. In this section, we will use this analysis to develop knowledge that facilitates change. Directions for change are formulated at project level and not at organisational or industry level. In addition, suggestions for change are formulated from the point of view of the organisations initiating the use of interorganisational ICT in our field studies (i.e., the client, or client representative).

As indicated in the former section, most of the barriers to the intended use of interorganisational ICT can be traced back to the pre-usage phase. Based on the analysis, the ideas and opinions of local actors, and the concepts of Habermas' critical social theory we are able to formulate the following suggestions for facilitating change:

- *Mandate the use of interorganisational ICT in the contract:* mandating the use of ICT towards a contractor provides clarity about the use of ICT. Mandating ICT is not always perceived as something bad. From our observations it follows that some contractors do appreciate the use of interorganisational ICT, others do not. The contract is an important steering medium and provides a safeguard and a normative context for ICT use during the project.
- *Be clear with contractors in the tendering phase about the necessary investments:* if contractors have not included the costs of setting up and using interorganisational ICT, this will result in resistance if they are confronted with additional costs after the contract is awarded. Therefore, being clear eliminates this resistance and encourages (or steers) contractors to put money aside for developing, implementing and using interorganisational ICT.
- *Mandate activities to rationalise the lifeworld of the organisations involved in the contract:* the contract can be used to steer organisations towards rationalisation of the lifeworld. To attain the benefits of interorganisational ICT, participating organisations need to align their working practices and to customise interorganisational ICT to these practices. Time needs to be put aside to conduct these activities. For example, an ICT start-up can be mandated in the contract to facilitate coordination between participating organisations and to set up interorganisational ICT.
- *Educate participating organisations and actors about the benefits of interorganisational ICT:* because the lifeworlds are not rationalised towards interorganisational ICT yet, actors are often not aware of its potential benefits, which results in resistance to its use. Educating participating organisations about interorganisational ICT, how this ICT can be used, the potential benefits and disadvantages, and solutions to these, reduces distorted perceptions about interorganisational ICT.
- *Facilitate the rationalisation of the lifeworld:* in the field studies interorganisational ICT is new to the actors involved. Because of their limited understanding about interorganisational ICT, and the

limited shared background knowledge (i.e., lifeworlds) of the actors involved, actors face difficulties in their communicative acts and, therefore, in reaching understanding. In our field studies this restricted the rationalisation of the lifeworld and resulted sometimes in inappropriate decisions being made and resistance to the use of ICT. Rationalisation of the lifeworld should be facilitated to avoid or reduce these problems. For example, experienced actors could facilitate the rationalisation process. However, in this example, experienced actors should facilitate communicative action and not restrict communicative action by making claims of authority.

- *Adjust interorganisational ICT to a specific project and the organisations and actors involved:* interorganisational ICT should be customised to the purposes, needs, and working practices, that is, the systems and lifeworlds of the actors involved. This eliminates or reduces resistance to the use of interorganisational ICT.
- *Use steering media to encourage the intended use of ICT:* use the steering media of money (e.g., divide savings between participating organisations, link payments to ICT use) and power (external motivation) to make actors use interorganisational ICT. Each actor who does not use interorganisational ICT significantly reduces the benefits of the use of this ICT for others.

5.7 Conclusions and implications for research and practice

In this chapter we adopted Habermas' critical social theory and showed how this theory can be used to interpret and analyse the use of interorganisational ICT in four construction projects. The use of the lens of Habermas' critical social theory enabled us to deepen our former 'insight oriented' interpretations. Based on this understanding we were able to formulate barriers to the intended use of ICT, and suggestions of ways of overcoming these barriers.

Based on the results of our study, several remarks can be made. Below we will reflect on the usefulness of Habermas' theory for analysing the interorganisational use of ICT, and the critical methodology used in this research.

The dominance of Habermas' critical social theory within the information systems research field is often criticised (e.g., Howcroft and Trauth, 2004; Brooke, 2002; Richardson and Robinson, 2007). However, our study has shown that Habermas' models of actions provide very useful lenses to understand how actors are intended to use and use interorganisational ICT, and how they try to overcome barriers to the intended use of ICT. In addition, the concepts of system and lifeworld and the connections between these concepts are useful for analysing constraints to the communicative model of action and the rationalisation of the lifeworld. Therefore, in our view, the adoption of Habermas' critical social theory for analysing the use of interorganisatonial ICT should not be discouraged but encouraged.

Our research showed that the introduction of interorganisational ICT could have a colonising effect on the lifeworld of organisations using this ICT. However, in our study, interorganisational ICT itself did not steer the lifeworlds of the organisations involved, as suggested by Myers and Young (1997). It is only when interorganisational ICT is accompanied by an external motivation that the introduction of this ICT can have a colonising effect. In addition, our research confirmed the importance of analysing the social system and the technical system, and how these interact, to understand how and why actors use interorganisational ICT (Ngwenyama and Lyytinen, 1997). This analysis could explain user resistance and unintended use. However, this analysis should not be restricted to only the actual use and intended use of interorganisational ICT. To understand the dynamics of the use of interorganisational ICT, the attitudes and actions of the actors involved towards overcoming barriers to the intended use should be analysed as well.

The application of the three tasks proposed by Alvesson and Deetz (2000) appeared to be useful for analysing interorganisational ICT from a critical perspective. The insight production task is important to gain in-depth insight in how and why actors use interorganisational ICT in the interorganisational context[35]. The production of critique task allowed us to deepen our insights into the intended and actual use of interorganisational ICT, and how actors tried to overcome barriers to the intended use. The application of Habermas' critical social theory helped us to develop suggestions for change as well (task 'transformative re-definition'). We concur with Alvesson and Deetz (2000), and emphasise that these suggestions should not dominate empirical research in studies with research ambitions.

[35] Therefore, in this chapter we focused on the four field studies and did not include the interviews with experts from the United States Construction Industry.

Part 3: conclusions, contributions and recommendations

Chapter 6

Conclusions, contributions and recommendations

In this final chapter, the conclusions and recommendations of the research are presented. This chapter has the following structure. First, the results of the research will be summarised by providing answers to the two main research questions. Because the answers are developed incrementally during the research we will summarise the steps taken and reflect on the results of each step. Second, the contributions of this research will be formulated. The final part presents recommendations for both research and practice.

6.1 Results

This section summarises the results of the research. The results are structured along the lines of the two main research questions. These questions are:

- What are key mechanisms that influence the way actors use interorganisational ICT and how and why do these mechanisms change over time?
- What are directions for solutions to the barriers to the successful use of interorganisational ICT in construction projects?

6.1.1 Key mechanisms

In the first step of this research (see Chapters 2 and 3), the use of interorganisational ICT (workflow management and document management applications) in four Dutch construction projects was analysed. Ethnography and the grounded theory approach were used to conduct this research. This research resulted in the formulation of a theoretical model including mechanisms that addressed technological, organisational, and human issues and showed barriers and drivers to a successful use of these applications. Within this model, the main mechanisms influencing the interorganisational use were:

- *Personal motivation:* the extent to which actors are willing to use interorganisational ICT themselves in the context of a construction project. Personal motivation influences both the willingness to use ICT and the willingness to invest resources to overcome barriers to its successful use.
- *External motivation:* the degree to which actors are forced by other actors to use ICT. External motivation influences both the use of ICT and the efforts made to invest time and money to overcome barriers to the successful use of ICT.
- *Knowledge and skills:* the degree actors know how to use ICT. When knowledge and skills are limited, actors themselves are restricting the use of ICT.
- *Acting opportunities:* the extent to which actors are able to use ICT in the intended way. When the acting opportunities are limited, ICT is not able to support the actions of the actors involved.

With this theoretical model, the use of ICT over time in the four construction projects could be explained. However, this research only addressed the use of interorganisational ICT in the context of Dutch construction projects, and did not include an important line of promising interorganisational ICT for the construction industry, namely product modelling applications.

In the second step of this research (see Chapters 4) the robustness of the theoretical model was tested in the context of the interorganisational use of ICT in projects in the United States

construction industry. In addition, product modelling applications were added to the research. In this step, interviews with 20 experts from the United States construction industry were conducted. This study showed that the mechanisms influencing interorganisational ICT were not different in this context. However, it also showed differences between types of applications on the dimensional level of the mechanisms. For example, product modelling applications are more difficult to learn and to understand because a different way of working and thinking is needed. Two important consequences of this are that (1) actors need to spent more time learning to use ICT and (2) actors have more distorted perceptions about the benefits of this interorganisational ICT.

In the third step of this research (this step is presented in Chapter 3), we related the theoretical model to existing models about the adoption and use of ICT: The Unified Theory of Acceptance and Use of Technology (UTAUT), the Theory of Planned Behaviour (TPB), and the Technology Acceptance Model (TAM). Based on this comparison we added the construct 'intention to use ICT' to our model and depicted some missing elements in existing models. Therefore, we suggest that our model is a more comprehensive model. Our theoretical model is shown in Figure 6.1.

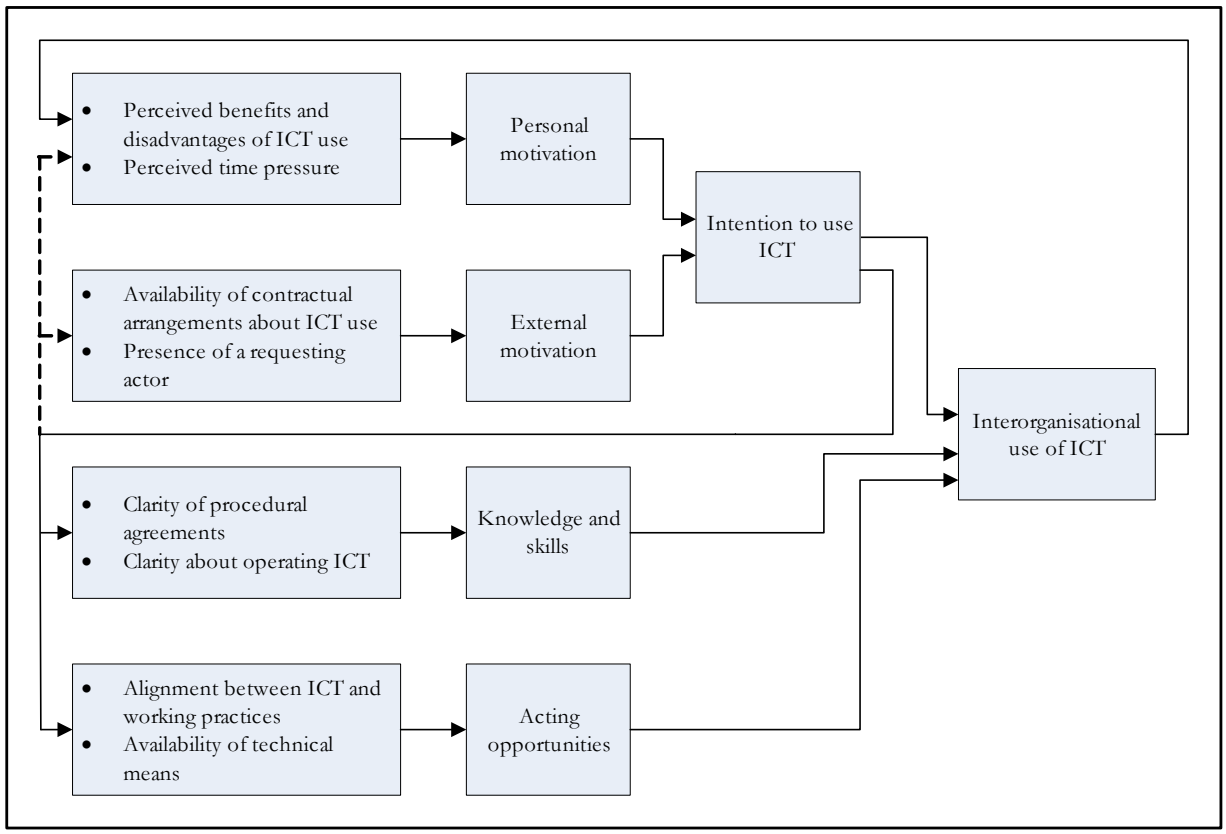

Figure 6.1: Theoretical model

Finally, in the fourth step, concepts of Habermas' critical social theory (i.e., models of action, concepts of system and lifeworld) were used as a lens to analyse interorganisational use of ICT, and barriers to the intended use at a deeper level. This provided more in-depth understanding and insights in the way the social system and the technical system interacted, and how and why actors adopted models of action and used interorganisational ICT. Our analysis showed that Habermas' critical social theory could be used to understand how actors were intended to use and actually did use interorganisational ICT, and how they tried to overcome barriers to the intended use. In addition, the concepts of system and lifeworld and the connection between these could be used to analyse barriers to the communicative model of action.

Fundamental to the intended use of interorganisational ICT were: (1) whether actors chose to adopt the *intended* model of action, and (2) whether actors chose to use ICT in the intended way from this model of action. Our analysis showed that several barriers restrict actors in using a model of action or in using a model of action in the intended way. These barriers were related to the mechanisms of our theoretical model. The models of action, mechanisms, and barriers are summarised in Table 6.1.

Model of action	Definition	(Sub)mechanisms	Barriers to the intended use of ICT
Instrumental action	Actors try to achieve personal goals by following technical rules of action and trying to manipulate objects.	• Personal motivation • Knowledge and skills • Acting opportunities	• Limited perceived value or many perceived disadvantages of ICT use in an action situation • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions • Others do not use ICT in the intended way
Strategic action	Actors try to achieve their goals by influencing decisions of other actors.	• Personal motivation • External motivation • Knowledge and skills • Acting opportunities	Use by an actor: • See instrumental model of action Steering by an actor: • Limited opportunities to mandate the use of ICT towards an actor • Limited opportunities to influence the perceived configuration of benefits and disadvantages of ICT use for an actor • Limited opportunities to remove restrictions to the intended use of ICT for an actor
Normatively regulated action	Actors try to fulfil generalised expectations of behaviour by conforming their behaviour to shared norms and values or formalised domains of actions.	• Availability of contractual arrangements • Knowledge and skills • Acting opportunities	• Lack of contractual arrangements or agreements about ICT use • Unclear agreements about ICT use • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions
Dramaturgical action	Actors consider themselves as a visible public for each other, before which a view of themselves is presented.	• Perceived benefits and disadvantages of ICT use	• Others do not use ICT in the intended way
Communicative action	Actors seek to reach an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement.	• Personal motivation • Knowledge and skills • Acting opportunities • External motivation	• Limited perceived value or many perceived disadvantages of ICT use in an action situation • Perceived restrictions in ICT use (knowledge and skills, acting opportunities) and perceived solutions • Others do not use ICT in the intended way

Table 6.1: Relationship between models of action, mechanisms, and barrier to the intended use of ICT

6.1.2 Solutions to barriers

In carrying out steps 1 and 2, as mentioned when discussing the former research question, we collected directions for solutions to the barriers to the successful use of interorganisational ICT. These barriers were related to the mechanisms of the theoretical model. These directions for solutions are presented in Table 4.1.

In carrying out step 4, we were able to develop knowledge that facilitates change. Suggestions for change were formulated from the point of view of the organisations initiating the use of ICT in our field studies (i.e., the client, or client representative). These suggestions were:

- *Mandate the use of interorganisational ICT in the contract:* mandating the use of ICT towards a contractor provides clarity about the use of ICT. Mandating ICT is not always perceived as something bad. From our observations it follows that some contractors do appreciate the use of interorganisational ICT, others do not. The contract is an important steering medium and provides a safeguard and a normative context for ICT use during the project.
- *Be clear with contractors in the tendering phase about the necessary investments:* if contractors have not included the costs of setting up and using interorganisational ICT, this will result in resistance if they are confronted with additional costs after the contract is awarded. Therefore, being clear eliminates this resistance and encourages (or steers) contractors to put money aside for developing, implementing and using interorganisational ICT.
- *Mandate activities to rationalise the lifeworld of the organisations involved in the contract:* the contract can be used to steer organisations towards rationalisation of the lifeworld. To attain the benefits of interorganisational ICT, participating organisations need to align their working practices and to customise interorganisational ICT to these practices. Time needs to be put aside to conduct these activities. For example, an ICT start-up can be mandated in the contract to facilitate coordination between participating organisations and to set up interorganisational ICT.
- *Educate participating organisations and actors about the benefits of interorganisational ICT:* because the lifeworlds are not rationalised towards interorganisational ICT yet, actors are often not aware of its potential benefits, which results in resistance to its use. Educating participating organisations about interorganisational ICT, how this ICT can be used, the potential benefits and disadvantages, and solutions to these, reduces distorted perceptions about interorganisational ICT.
- *Facilitate the rationalisation of the lifeworld:* in the field studies interorganisational ICT is new to the actors involved. Because of their limited understanding about interorganisational ICT, and the limited shared background knowledge (i.e., lifeworlds) of the actors involved, actors face difficulties in their communicative acts and, therefore, in reaching understanding. In our field studies this restricted the rationalisation of the lifeworld and resulted sometimes in inappropriate decisions being made and resistance to the use of ICT. Rationalisation of the lifeworld should be facilitated to avoid or reduce these problems. For example, experienced actors could facilitate the rationalisation process. However, in this example, experienced actors should facilitate communicative action and not restrict communicative action by making claims of authority.
- *Adjust interorganisational ICT to a specific project and the organisations and actors involved:* interorganisational ICT should be customised to the purposes, needs, and working practices, that is, the systems and lifeworlds of the actors involved. This eliminates or reduces resistance to the use of interorganisational ICT.
- *Use steering media to encourage the intended use of ICT:* use the steering media of money (e.g., divide savings between participating organisations, link payments to ICT use) and power (external motivation) to make actors use interorganisational ICT. Each actor who does not use interorganisational ICT significantly reduces the benefits of the use of this ICT for others.

6.2 Contributions

This research has both scientific and practical contributions. These are discussed below.

6.2.1 Scientific contribution

Contribution to construction management research
The use of ICT can offer many benefits in improving interorganisational communication, cooperation, and coordination in the context of *construction projects*. However, interorganisational ICT has often added limited value in construction projects and has failed to meet expectations (e.g., Alshawi and Ingirige, 2003; Andresen et al., 2003; Hjelt and Björk, 2006; Nitithamyong and Skibniewski, 2004; Sulankivi, 2004). Little is known about the mechanisms that determine the use of interorganisational ICT in the context of construction projects and how this use is influenced over time. The main contribution of this research is that it presents a holistic theoretical model that is able to explain the use of interorganisational ICT over time in construction projects. The interplay between barriers and drivers does not only explain the use of ICT but also the efforts made to invest time and money to overcome barriers to the successful use of ICT.

Contribution to information systems research
Researchers have made significant progress over the last decades in developing models that could help predict ICT adoption and use. However, existing models are criticised for their limited explanatory power and for their contradictory results across studies in the major relationships between constructs (e.g., Lee et al., 2003; Legris et al., 2003; Sun and Zhang, 2006). Most of these limitations were caused by the central methodological perspectives which were used in studies examining the adoption and use of ICT: the quantitative perspective and the positivist perspective (Sun and Zhang, 2006). To address these limitations we have conducted a qualitative study in which we focused in-depth on mechanisms that influence the actual use of interorganisational ICT in its social and interorganisational context. In combining our theoretical model with existing theoretical models about the adoption and use of ICT we showed some important directions for improvement of these models.

Contribution to Habermas' critical social theory
The positivistic perspective has dominated information systems research (Chen and Hirschheim, 2004; Orlikowski and Baroudi, 1991; Richardson and Robinson, 2007). Only limited attention has been paid to the interpretive perspective, and the critical perspective is almost non-existent. Over the last 15 years a small but growing number of researchers have adopted a critical perspective in general and critical social theory in particular to analyse the development and use of ICT (Howcroft and Trauth, 2004; Richardson and Robinson, 2007). However, a lack of empirical studies is a major weakness of critical social theory (Howcroft and Trauth, 2004; Lyytinen, 1992). In this research, we used parts of Habermas' critical social theory to interpret and analyse the use of interorganisational ICT. By using a critical perspective barriers to the intended use of ICT and ways of overcoming these constraints are identified. In our research we showed the usefulness of this theory as a lens to analyse the mechanisms influencing the use of interorganisational ICT.

6.2.2 Practical contribution

Our research has generated various solutions for practical problems. The theoretical model, solutions, and suggestions for change can help project managers and/or people responsible for implementing interorganisational ICT to identify the technical *and* nontechnical risks of introducing and using ICT in construction projects. Understanding the mechanisms (and accompanied risks) is a first step towards a successful implementation of interorganisational ICT. Based on this risk analysis

and an assessment of the directions for solutions and suggestions for change, they can formulate and implement measures to overcome these risks or choose to limit the scope of the application (e.g., limit the scope to only some organisations or to only some communication processes). In addition, the model can be used as an analytical tool to evaluate the status quo use of an underutilised application in a construction project and to formulate and implement improvements based on this analysis. Moreover, practitioners could use the suggestions for change to develop and implement interorganisational ICT in their own construction projects.

6.3 Recommendations

6.3.1 Suggestions for further research

Our study can be seen as a first step towards developing (1) a theoretical model that is able to explain and predict the use of interorganisational ICT over time, and (2) solutions for potential barriers to the successful use of ICT in the context of construction projects (i.e., directions for solutions and suggestions for change). Therefore, in future research, the mechanisms, directions for solutions, and suggestions for change need to be further developed and tested.

Our study also suggests other directions for future research:

- *Develop interventions at an organisational and industry level:* in our research we developed directions for solutions and suggestions for change at a project level, based on the mechanisms influencing the use of interorganisational ICT in construction projects. However, we can also try to intervene in the mechanisms influencing *inter*organisational use of ICT at an organisational (i.e., what can an organisation do?) and industry level (i.e., what can the industry do?). The outcomes of our study are important entry points for developing these interventions.
- *Develop strategies and protocols for implementing ICT:* based on the mechanisms, directions for solutions, and suggestions for change developed in this research, strategies and protocols need to be developed and tested, which facilitate the successful implementation of interorganisational ICT.
- *Test the developed directions for solutions and suggestions for change:* the directions for solutions and the suggestions for change presented in this study have not yet been tested scientifically in real time construction projects. Therefore, an obvious direction for future research is to implement these in real time construction projects and evaluate the effects of them on the successful use of interorganisational ICT. Based on this evaluation the directions for solutions and suggestions for change can be further refined.
- *Carry out a comparative study with other industries:* in our study we focussed on the use of interorganisational ICT in construction projects. In future research, the mechanisms, related barriers, directions for solutions, and suggestions for change developed in this research should be compared with experiences in other industries. A comparative study might help the construction industry, and other industries to find opportunities to further improve the use of interorganisational ICT. In this comparative study researchers should try to understand mechanisms influencing the way actors use interorganisational ICT in the industry context.
- *Relate the theoretical model to realised benefits and the effect of ICT on performance:* the theoretical model explains why an actor acts in a certain way in a certain situation. However, the way an actor acts has consequences for the realised benefits and for the performance of a project. Insights in these relationships are important in order to reduce the chance of 'improving' the use of ICT without realising benefits or to avoid reducing the performance of a project. These relationships need to be addressed in future research.

6.3.2 Recommendations to practice

We recommend practitioners to apply the theoretical model, directions for solutions, and directions for change to deliberate about the introduction of interorganisational ICT in each construction project again. The theoretical model can be used as an assessment tool to determine the scope of interorganisational ICT and to develop a strategy for implementing ICT in a project.

Based on the theoretical model, the directions for solutions, and the suggestions for change on a project level, the following *additional* recommendations to implement interorganisational ICT can be formulated on the organisational and industry levels. These recommendations are developed in cooperation with the User Group.

Organisational level:

- Develop a strategy for implementing interorganisational ICT in an organisation. The theoretical model, directions for solutions, and suggestions for change can be used as a tool to determine this organisation specific strategy.
- Educate actors within organisations on (1) interorganisational ICT, (2) how this ICT can be used, and (3) the potential benefits, disadvantages and risks of this ICT (and provide solutions to these). This increases the awareness about interorganisational ICT, decreases distorted understandings, and increases the number of 'interorganisational ICT champions' in the organisation.
- Develop an organisational standard for using interorganisational ICT (application(s), digital working practices). This reduces the novelty of interorganisational ICT and the costs of implementing interorganisational ICT in each individual project because the same application(s) and working practices are used each project again.
- Use interorganisational ICT within long-term relationships. This reduces the novelty of interorganisational ICT and the costs of implementing interorganisational ICT in each individual project.
- Develop criteria for assessing whether a project is suitable for using interorganisational ICT. These criteria need to be assessed at the start of each project. This increases the awareness of the management and employees about the usefulness of this ICT in certain situations and creates a working practice in which the use of interorganisational ICT is assessed at the start of each project again.
- Develop best practices to ensure that actors do not have to discover project by project how interorganisational ICT can or needs to be used, and what is important to implement interorganisational ICT successfully.

Industry level:

- Develop a strategy for implementing interorganisational ICT (and moving from paper-based forms of communication to digital working practices) in the (Dutch) construction industry. The theoretical model, directions for solutions, and suggestions for change can be used as a tool to determine a country specific strategy.
- Educate organisations on an industry level with regard to (1) interorganisational ICT, (2) how this ICT can be used, and (3) the potential benefits, disadvantages and risks of this ICT usage (and provide solutions for these). This increases the awareness about interorganisational ICT, decreases distorted understandings, and increases the number of 'interorganisational ICT champions' in the industry.
- Develop and implement an industry standard for information exchange and communication between organisations that is independent of any ICT applications. This reduces the need for project-specific customisation because organisations can adapt their internal applications

to this industry standard. Convince clients and contractors to mandate this standard in their contracts.

- Align regulations to digital working practices to reduce or eliminate situations in which actors are restricted in their use of interorganisational ICT.
- Develop best practices to ensure that organisations do not have to discover project by project how interorganisational ICT can or needs to be used, and what is important to implement interorganisational ICT successfully.

Most interventions at the organisational and industry levels (e.g., standards, use within long-term relationships, best practices) can only be implemented by starting to implement interorganisational ICT successfully in the first project(s). Therefore, all barriers to the introduction of interorganisational ICT at a project level do also apply to the first steps of introducing interventions at the organisational and industry levels.

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