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PROMOTING SCALABILITY AND SUSTAINABILITY OF ICT4D PROJECTS USING OPEN SOURCE SOFTWARE

Jussi Nissilä

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ABSTRACT

There is an increasing consensus that information and communication technologies (ICTs) bring an opportunity for developing countries to reach development goals in various areas, yet a large number of the projects that utilize ICT for development (ICT4D) are considered full or partial failures. One of the most critical challenges identified is that ICT4D practice tends to produce pilot projects, but it fails to provide scalable and sustainable solutions for capacity development. Open source software (OSS), with its particular licensing scheme and community-based development method, has been touted as a possible solution to some of the problems that ICT4D practice is often claimed to cause. However, prior research has barely discussed or empirically studied the potential of OSS in promoting scalability and sustainability of ICT4D projects.

This study aims to provide an answer to the research question: How to promote scalability and sustainability of ICT4D projects using open source software? The study draws from empirical research conducted in a case project to answer the research question. The author of this study participated in a capacity development project in Kenya coordinated by the Food and Agriculture Organization of the United Nations (FAO) and financed by the Government of Finland's development assistance program during years 2006-2008. The project developed a software to help in computerization of agricultural cooperatives and licensed it with an open source software license, so that it could be freely used by both agricultural cooperatives and local ICT companies, in order for the latter to be able to provide support services to the cooperatives. The action case research method was used to both introduce change to the problematic "real-life" situation and to increase understanding of the area of concern. Consequently, this study provides a detailed description how research-based insights were used to manage the sustainability and scalability issues in the case project

The results of the study include an assessment of the role of open source software in promoting scalability and sustainability of ICT4D projects, which implies that OSS may lay a foundation for the creation of a business ecosystem supporting scalability and sustainability, but OSS in itself does not solve challenges related to the demand and supply of technology. In addition, the study discusses the nature of the scalability and sustainability problem and presents a model of the elements influencing scalability and sustainability of ICT4D projects.

The study contributes to the field of open source software research by focusing on a type of an OSS project that has been little studied and highlights the importance of project characteristics and context. It complements the OSS in developing country research that often discusses OSS in an overly positive manner by reporting the challenges experienced in the case project. The study

also contributes to the discussion of ICT4D project failure in development informatics research by improving conceptual clarity, defining the scalability and sustainability problem in detail, identifying elements influencing scalability and sustainability and by providing insights into the role of OSS in solving the scalability and sustainability problem. For practitioners involved with OSS or ICT4D projects, the study provides conceptual tools and advises against expecting simple solutions to difficult development problems.

Keywords: development cooperation, capacity development, information and communication technologies, open source software, scalability, sustainability.

TIIVISTELMÄ

Kehitysmaiden uskotaan voivan saavuttaa kehitykseen liittyviä tavoitteitaan tieto- ja viestintäteknologiaa (engl. information and communication technologies, ICT) hyödyntämällä. Suuri osa ICT-teknologiaa hyödyntävistä kehitysyhteistyöhankkeista kuitenkin epäonnistuu osittain tai täysin. Eräs keskeinen ongelma teknologian hyödyntämisessä kehitysyhteistyössä on ollut, että toiminnan tuloksena syntyy paljon pilottihankkeita, mutta liian harvoin skaalautuvia ja kestäviä ratkaisuja kehitysmaiden toimintavalmiuksien parantamiseksi. Avoimen lähdekoodin ohjelmistoja on pidetty mahdollisena ratkaisuna ICT-teknologiaa hyödyntävien kehitysyhteistyöhankkeiden haasteisiin, sillä niitä voidaan kehittää yhteisöllisesti ja lisensointi mahdollistaa ohjelmistojen vapaan hyödyntämisen. Avoimen lähdekoodin ohjelmistojen käyttöä ICT-teknologiaa hyödyntävien kehitysyhteistyöhankkeiden skaalautuvuuden ja kestävyyden parantamisessa ei kuitenkaan ole juuri tutkittu.

Tämän tutkimuksen tarkoituksena on vastata seuraavaan kysymykseen: Miten ICT-teknologiaa hyödyntävien kehitysyhteistyöhankkeiden skaalautuvuutta ja kestävyyttä voidaan parantaa avoimen lähdekoodin ohjelmistoilla? Aihetta lähestytään tarkasteluun valitun hankkeen kautta empiirisesti. Hanke oli Yhdistyneiden kansakuntien elintarvike- ja maatalousjärjestön koordinoima ja Suomen kehitysyhteistyöohjelman rahoittama valmiuksien kehittämishanke, joka toteutettiin Keniassa vuosina 2006–2008 ja johon tutkimuksen tekijä myös itse osallistui. Hankkeessa kehitettiin ohjelmisto maatalousosuuskuntien tietokoneistamisen tueksi. Tämä lisensoitiin avoimen lähdekoodin ohjelmistolisenssillä, jotta ohjelmisto olisi vapaasti hyödynnettävissä sekä osuuskunnissa että paikallisissa ICT-yrityksissä. Näin paikalliset ICT-yritykset voisivat tarjota tukipalveluita osuuskunnille. Tapaustutkimusta ja toimintatutkimusta yhdistävän tutkimusmenetelmän keinoin pyrittiin sekä ratkaisemaan hankkeen haasteita että lisäämään ymmärrystä tutkimusaiheesta. Tässä tutkimuksessa kuvataan, miten aiempaan tutkimukseen pohjautuvia näkemyksiä hyödynnettiin hankkeen skaalautuvuuteen ja kestävyyteen liittyvien haasteiden ratkaisussa.

Tutkimuksen tuloksena on arvio avoimen lähdekoodin ohjelmistojen merkityksestä ICT-teknologiaa hyödyntävien kehitysyhteistyöhankkeiden skaalautuvuuden ja kestävyyden parantamisessa, minkä mukaan avoimen lähdekoodin ohjelmistoilla voidaan luoda edellytykset teknologian skaalautuvuutta ja kestävyyttä tukevan liiketoimintaekosysteemin synnylle, mutta se ei itsessään ratkaise teknologian kysyntään ja tarjontaan liittyviä haasteita. Lisäksi tutkimuksessa käsitellään skaalautuvuuden ja kestävyyden haasteen luonnetta sekä luodaan malli ICT-teknologiaa hyödyntävien

kehitysyhteistyöhankkeiden skaalautuvuuteen ja kestävyyteen vaikuttavista osatekijöistä.

Tämä tutkimus edistää avoimen lähdekoodin tutkimusta fokusoitumalla hanketyyppiin, jota ei ole juuri aiemmin tutkittu, korostaen hankkeiden luonteen ja kontekstin merkitystä alan tutkimuksessa. Avoimen lähdekoodin hyödyntämistä kehitysmaissa koskeva tutkimus on usein esittänyt avoimen lähdekoodin mahdollisuudet hyvin optimistisesti, jättäen haasteet vähäiselle tarkastelulle – tämä tutkimus täydentääkin alan tutkimusta raportoimalla kohteena olleen hankkeen haasteista. Lisäksi tämä tutkimus edistää kehitysyhteistyötä koskevan informatiikan tutkimuksen puitteissa käytävää keskustelua teknologiaa hyödyntävien kehitysyhteistyöhankkeiden epäonnistumisista selkeyttämällä käsitteitä, tarkentamalla skaalautuvuuden ja kestävyyden haasteen määrittelyä, tunnistamalla skaalautuvuuteen ja kestävyyteen vaikuttavia osatekijöitä sekä parantamalla ymmärrystä avoimen lähdekoodin merkityksestä haasteen ratkaisussa. Avoimen lähdekoodin hankkeiden tai teknologiaa hyödyntävien kehitysyhteistyöhankkeiden parissa toimiville tutkimus tarjoaa käsitteleellisiä työkaluja ja neuvoja, joiden mukaan vaikeisiin kehityshaasteisiin ei tule odottaa helppoja ratkaisuja.

Asiasanat: kehitysyhteistyö, toimintavalmiuksien kehittäminen, tieto- ja viestintäteknologia, avoin lähdekoodi, skaalautuvuus, kestävyys.

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Dedicated to the memory of Jussi Puhakainen.

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In Helsinki, 2 October 2016
Jussi Nissilä

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Paper I: Nissilä, Jussi and Grotenfelt, Outi (2005) Evaluating open source software products. In: Remenyi, Dan (ed.) *Proceedings of the 12th European Conference on Information Technology Evaluation (ECITE 2005)*, Academic Conferences Limited, UK.

Paper II: Rajala, Risto, Westerlund, Mika and Nissilä, Jussi (2006) Software for Free? Revenue Models in the Open Source Business. In: Gupta, Atul (ed.) *Proceedings of the 5th Global Conference on Business & Economics*, Association for Business and Economics Research, Cambridge, England.

Paper III: Puhakainen, Jussi, Malinen, Pasi, Paasio, Antti and Nissilä, Jussi (2007) A Quest for Business Ecosystem for Interorganizational Open Source Software System – Lessons from a Case Study in Developing Country Context. In: Wang, Yi-Chun (ed.) *Proceedings of the Fourth Annual Conference of the Applied Business and Entrepreneurship Association International*, The University of Portland, Maui, Hawaii.

Paper IV: Nissilä, Jussi, Puhakainen, Jussi and Tanhua, Inkeri (2009) Cooworks – A Case Study on an Information System Meant to Enhance Capacities of Agricultural Cooperatives. In: Byrne, E., Nicholson, B. and Salem, F (eds.) *Assessing the Contribution of ICT to Development Goals, Proceedings of 10th International Conference on Social Implications of Computers in Developing Countries*, Dubai, United Arab Emirates.

Paper V: Promises and Pitfalls of Open Source Software Business in Fostering Sustainability in ICT4D Projects. *Unpublished.*

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1 INTRODUCTION

1.1 Motivation for research

International development cooperation is a huge enterprise that expanded after World War II. Over decades, billions of dollars have been used. In 2012 alone, the 29 member countries of the OECD Development Assistance Committee (DAC) used 125.9 billion US dollars in official development assistance (OECD 2013). Despite huge investments into development cooperation, poverty still endures along with many persisting problems in the practice of development cooperation.

There is an increasing consensus that *information and communication technologies* (ICTs) bring an opportunity for developing countries to reach development goals in various areas, including health, education, and organization of production, yet a large number of the projects that utilize *ICT for development* (ICT4D) are considered full or partial failures. The failure of the international community to solve development problems leads to huge financial losses, but more gravely, to enduring poverty and suffering hundreds of millions of people.

Open source software (OSS) has been touted as a possible solution to some of the problems that ICT4D practice is often claimed to cause. Open source software licensing allows anybody to study, change and distribute the software. This particular licensing scheme and a community-based development method associated with OSS have raised hopes that OSS could be used in combating the digital divide, establishing independence, and in creating capacities in the developing world. While both academics and practitioners have acknowledged the promises of OSS in capacity development of developing countries, there is a risk that OSS could end up being just another development fad that, after much enthusiasm, does little to improve development cooperation practice or capacities in developing countries.

Open source software has been studied from the perspective of a range of different academic disciplines, which have jointly shed light on the phenomenon in the form of transdisciplinary research dialogue (von Krogh and Spaeth 2007). Some central questions in this transdisciplinary OSS research field have been why individual developers or companies contribute to OSS projects (Lerner and Tirole 2002a; von Hippel and von Krogh 2003), how governance mechanisms influence OSS development (Benkler 2002; West and O'Mahony 2008) and how

OSS changes the competitive dynamics of technology companies (Dahlander and Magnusson 2008; West and Gallagher 2006).

However, the mainstream OSS research takes poorly into account the particularities of the developing countries. The use of ICT in developing countries is covered by the field of development informatics, which in addition to providing a compelling case that ICTs can be used in achieving development goals (Boas et al. 2005; Câmara and Fonseca 2007) also addresses the ICT4D practice in critical voice, including overall skepticism towards the use of ICTs in development (Heeks 2010; Kleine and Unwin 2009; Schech 2002; Wade 2002) and the failures of ICT4D projects (Heeks 2002; Sahay and Avgerou 2002). Prior research in this field has also brought up the potential of OSS in tackling certain challenges in capacity development and ICT4D practices (Boas et al. 2005; Walsham and Sahay 2006; Weber and Bussell 2005).

One of the most critical challenges identified in prior research is that ICT4D practice tends to produce pilot projects which are managed and financed for a limited period of time, but it fails to provide scalable and sustainable solutions for capacity development (Avgerou 2008; Braa et al. 2004; Sahay and Walsham 1997). In the context of ICT4D projects, scalability is defined as the ability to spread a technological innovation in scale or scope beyond the original setting in which it was developed, and sustainability as the ability to make a technological innovation work over time with appropriate resources and support. While the potential of OSS for developing countries has been widely discussed from the national-level perspective (Câmara and Fonseca 2007; Ghosh 2003; Steinmuller 2001), prior research has barely discussed or empirically studied the potential of OSS in promoting scalability and sustainability of ICT4D projects.

1.2 Objectives and research question

The overall objective of this study is to contribute to the fields of open source software research and development informatics research, and to increase understanding of the use of open source software in capacity development of developing countries. Although sustainability and scalability are major concerns in ICT4D projects, there is very little research on the issue of how open source software affects sustainability and scalability of ICT4D projects. The Research Question (RQ) of this study is therefore:

RQ: How to promote scalability and sustainability of ICT4D projects using open source software?

In order to provide an answer to the research question, the study defines the problem of scalability and sustainability of ICT4D projects in detail. Among others, the importance of scalability has been addressed by Wade (2002), Avgerou (2008) and Walsham and Sahay (2006), while Wade (2002), Heeks (2002), Avgerou (2008), Braa et al. (2004), Kleine and Unwin (2009), Câmara and Fonseca (2007) are among those scholars who have considered the importance of sustainability. This study provides a detailed discussion of the nature of scalability and sustainability and their interrelation in order to define the scalability and sustainability problem of ICT4D projects.

In addition, this study provides a conceptual framework that may be used in promoting sustainability and scalability in ICT4D projects. While sustainability and scalability have been identified as important issues in ICT4D projects, few tools have been provided to understand and manage these issues. Therefore, this study draws from conceptual and empirical research to construct a framework of elements influencing sustainability and scalability of ICT4D projects using OSS.

This study also elaborates the role of OSS in solving the scalability and sustainability problems in ICT4D projects. The potential of OSS for developing countries has been widely discussed (Câmara and Fonseca 2007; Cook and Horobin 2006; Ghosh 2003; James 2003; Steinmuller 2001; Wade 2002), but little empirical evidence has been provided to support these claims or demonstrate how OSS in practice contributes to scalability and sustainability. Based on empirical research in the case project, this study elaborates on the potential of OSS in promoting scalability and sustainability in ICT4D projects.

1.3 Research design and contributions

The study draws from empirical research conducted in a case project to answer the research question. The author of this study participated in a capacity development project coordinated by the Food and Agriculture Organization of the United Nations (FAO) and financed by the Government of Finland's development assistance program. The goal of the project was to enhance the capabilities of agricultural cooperatives in Kenya by means of an information system, which would improve the cooperatives' business performance and consequently the livelihood of the cooperative members, who are among some of the poorest people in the country. As off-the-shelf solutions were not available, the project contracted a Kenyan software company to develop a software product named "CoopWorks". The software was licensed with an open source software license so that it could be freely used by both agricultural cooperatives and local ICT companies, in order for the latter to be able to provide support services to the cooperatives.

This study documents the author's experiences in the described case project and the research process where insights from research were applied in solving challenges of the case project. The study seeks to strike a balance between interpretivism (e.g. Myers (1997)) and pragmatism (e.g. Marshall et al. (2005a) by adopting the action case research method (Braa and Vidgen 1999). This method combines elements from action research and soft case study and aims to both introduce change to the problematic "real-life" situation and to increase understanding of the area of concern.

Based on a mutual agreement with the case project stakeholders, the author participated in the case project during 2006-2008, during which time he supported the project decision-making by providing research-based advice. The focus of the author's participation was on promoting scalability and sustainability of the project's activities. The author was recruited in the project because he had conducted research on the use of OSS in organizations and businesses (covered in Paper I and Paper II), which provided the initial theoretical framework for the action case research. The research continued during the author's involvement in the case project (covered in Paper III, Paper IV and Paper V). These research papers are attached to this study, while the summary of the research process and the findings of the study are included in the main body of this study.

This study provides a detailed description of the problem situation of the case project and how research-based insights were used to manage the sustainability and scalability issues in the case project. The study defines the scalability and sustainability problem in detail, identifies elements influencing scalability and sustainability of ICT4D projects using OSS, and assesses the role of OSS in solving the scalability and sustainability problem of ICT4D projects.

The results of the study contribute to the academic fields of open source software research and development informatics research as well as the practice of ICT4D. The study focuses on a type of an OSS project that has been little studied by general OSS research before and highlights the importance of project characteristics and context. It complements the field that studies OSS in developing countries, which often discusses OSS in an overly positive manner, by reporting the challenges experienced in the case project. The study also contributes to the discussion of ICT4D project failure by improving conceptual clarity, defining the sustainability and scalability problem in detail, identifying elements influencing scalability and sustainability and by providing insights to the role of OSS in solving the sustainability and scalability problem. For practitioners involved with OSS or ICT4D projects, the study provides conceptual tools and advises against expecting simple solutions to difficult development problems.

2 PRIOR RESEARCH

This study builds on and contributes to two academic discourses: the fields of development informatics research and open source software research. Both are multidisciplinary in nature and consist of a wide range of different theoretical and practice-oriented studies. In the intersection of these research fields, there are a number of studies that focus on the use of open source software in developing countries.

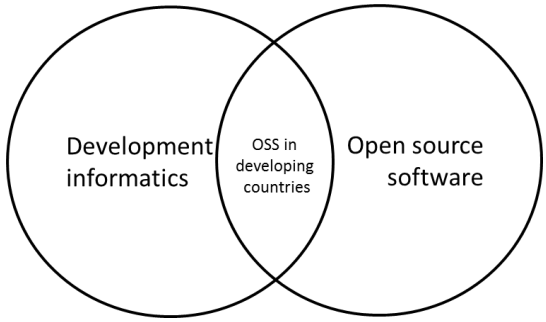

Figure 1: Research fields of this study

The following chapter briefly describes these research fields with the aim of identifying research findings that help in understanding the focal area of this study – the scalability and sustainability of ICT4D projects using OSS.

Many of the studies reviewed as prior research were not published at the time the author conducted the research reported in this study. They are regardless included in the review as they provide insights that are used in the evaluation of the CoopWorks project and in discussing the findings and contributions of this study in relation to the contemporary research fields.

The field of development informatics is reviewed first, and then open source software, and lastly the field of open source software in developing countries.

2.1 Development informatics

2.1.1 Key terms and concepts

The first research field to be reviewed is *development informatics*. Development informatics is a subfield of the broad academic field of *informatics*, the study of the structure and behavior of natural and artificial systems that generate, process, store, and communicate information (Illinois Informatics Institute 2013). Fourman (2002), in his account of the origins and meaning of the word 'informatics', defines it as follows:

"Informatics is the science of information. It studies the representation, processing, and communication of information in natural and artificial systems. Since computers, individuals and organizations all process information, informatics has computational, cognitive and social aspects. Used as a compound, in conjunction with the name of a discipline, as in medical informatics, bio-informatics, etc., it denotes the specialization of informatics to the management and processing of data, information and knowledge in the named discipline".

Heeks (2010) described the sub-discipline of development informatics as the study of the relationship between ICTs and socio-economic development and considers its core to be mainly founded in informatics, particularly in the information systems discipline, and much less in development studies. A closely related term is research on *information systems in developing countries* (ISDC), which emphasizes the context of the information systems use but is similarly interested of socio-economic development (Avgerou 2008). Furthermore, terms such as *information and communication technologies for development* (ICT4D) (Heeks 2006) and *information and communication for development* (ICTD) (Avgerou 2010) are used to describe the practice of using ICTs in the socio-economic development in the context of developing countries, but also sometimes to describe research focused on studying such endeavors.

Even if there are nuances to each of the abovementioned terms (Heeks 2006), researchers commonly use these terms interchangeably to refer to the same body of research and they can therefore be considered synonyms. In this study, the term *development informatics* is used when referring to the body of research and *ICT4D* is used when referring to the practice of applying ICTs in development effort.

The context in which ICT4D is often practiced, as in the case project of this study, is the capacity development of developing countries. Capacity development is one of the defining ideas of international development (Ubels et al. 2010) The United Nations Development Programme defines capacity

development as “the process by which individuals, organizations, institutions and societies develop abilities (individually or collectively) to perform functions, solve problems and set and achieve objectives” (Management Development and Governance Division 1997).

Capacity building is often treated as a synonym for capacity development, although the term ‘building’ implies that capacity can be somehow built from outside, whereas the term ‘development’ stresses the endogenous nature of capacity development (OECD 2002). As researchers and practitioners often use these terms interchangeably, in this study they are treated as synonyms.

Capacity development is usually considered to be the primary focus of *technical assistance* (Commission 2008). Technical assistance, sometimes referred to as technical cooperation, is the “form of aid given to less-developed countries by international organizations such as the United Nations (UN) and its agencies, individual governments, foundations, and philanthropic institutions. Its object is to provide those countries with the expertise needed to promote development” (Encyclopaedia Britannica 2014). Technical assistance, on the other hand, may be considered a part of the larger framework of international development cooperation. In this study, the term *development cooperation* is used when referring to the general practice of international development cooperation, including technical assistance, while the term *capacity development* is used when referring to activities focusing on capacities.

2.1.2 Literature review

Development informatics is intertwined with the actual practice of development cooperation. There is an increasing consensus that ICTs bring an opportunity for developing countries to reach development goals in various areas, including health, education, and organization of production (Boas et al. 2005; Câmara and Fonseca 2007), yet a large part of the ICT4D projects are considered to be full or partial failures (Heeks 2002). Many persisting problems in the practice of development cooperation has led to vast amounts of literature studying the complexities and frustrations of development (Fukuda-Parr et al. 2002). Next, the intellectual foundations of the development informatics field and some of its most influential research papers are discussed and their relevance for the focal area of this study is reflected upon.

Development informatics literature draws on the development studies tradition, particularly when discussing what constitutes development. Sein and

Harindranath (2004) summarized the general development debate[1] around three perspectives: modernization, dependency and human development.

The modernization perspective dates back to the 1960s modernization literature, such as Schramm (1967) and Lerner (1967), where the main problem was seen to be the diffusion of Western knowledge to the rest of the world (Schech 2002). In relation to ICTs, the modernization perspective assumes that ICTs can help underdeveloped countries to break out of traditional and outdated models of production or even to leapfrog stages of development (Sen and Harindranath 2004). Schech (2002) argued that the dominant approach to ICTs has been[2] framed by the modernization theory and noted that researchers who are critical of this mainstream development paradigm find the use of ICT alarming.

The dependency perspective is centered around the core-periphery model originating from Singer (1950) and Prebisch (United Nations Economic Commission for Latin America 1950), which suggests that economic advancement in wealthy countries and regions – the core – comes at the expense of the poorer countries and regions – the periphery (Boas et al. 2005). The dependency perspective posits that developed countries exploit poorer countries and ICTs only strengthen this positioning (Sen and Harindranath 2004). Yet Boas et al. (2005) suggested that the characteristics of the digital economy reduce the zero-sum competition over development, even if in some ways the core-periphery model still applies, and that shared digital infrastructure based on open source software allows the periphery to pursue development on their own terms.

The human development perspective was developed in the 1990s based on the works of authors such as Sen (1999). It focused on creating a society where individual potential can be realized, instead of focusing on economic growth alone. The role of ICTs in the human development perspective is contributing to the social, cultural, environmental and economic aspirations held by individuals (Kleine 2010). Exogenous processes of technology processes by external actors have also a role, but only in supporting endogenous processes in developing countries (Korpela et al. 2006). Modern capacity development thinking is based on the human development perspective, but it stresses that capacity development must happen on three interdependent levels – the individual, the institutional and the societal level – in order for it to be efficient (Fukuda-Parr et al. 2002).

Avgerou (2010) noted that even if most studies do not openly discuss the issue, each study in development informatics makes assumptions about how ICT

[1] Referring to the works of Nederveen Pieterse J. Nederveen Pieterse, *Development Theory. Deconstructions/Reconstructions.* (London: Sage, 2001). and Allen and Thomas T. Allen and A. Thomas, *Poverty and Development: Into the 21st Century* (Oxford: Oxford University Press, 2000).

[2] Until 2002, when the article was published.

innovation[3] happens in the context of developing countries, and about the meaning and nature of the process of development. She identified four distinct discourses in development informatics literature that are founded on the different understandings of (a) the nature of ICT innovation process and (b) the nature of the development transformation toward which ICT is understood to contribute. The ICT innovation dimension consists of the transfer and diffusion perspective, which considers ICT innovation in terms of transferring ICT and organizational practices from advanced economies and adapting them to the context of particular developing countries, and the social embeddedness perspective, which assumes that IS innovation in developing countries is about constructing new techno-organizational structures within a given local social context. The development transformation dimension includes the progressive perspective, which considers ICT an enabler of transformation in multiple domains of human activities, and the disruptive perspective, which is premised on the political and controversial nature of development, revealing conflicts of interests and struggles of power as part of ICT innovation in developing countries.

Prior research has proposed various frameworks for better analysis. Mansell (1999) underlined the importance of understanding the context of ICT use and the ways ICT can be used in development. Kling (2000) noted that treating ICT as a monolithic entity leads to overestimation the generalizability of specific ICT applications from one context to another. Sein and Harindranath (2004) claimed that it is important to better understand ICT as an artefact itself and proposed three different conceptualizations of ICT: (a) ICT use, (b) how ICT is viewed and (c) how ICT impacts development. The different ICT uses in development were: ICT as a commodity to be traded, ICT supporting general development activities through decreasing information poverty, ICT as a driver of the economy, and ICT directed at specific sectors or projects. The different views on ICT, based on Orlikowski and Iacono (2001), were: the nominal view of ICT being only an object of study, the tool view of ICT being a means to achieve something, the computational view of ICT being technology, the proxy view of ICT being a knowledge enabler, and the ensemble view of ICT being a bigger technology package. The different impacts of ICT, adopted from the work of Sein and Ahmed (2001), were: the primary effect of old technology being substituted by new technology, the secondary effect being an increase in the phenomenon enabled by ICT, and the tertiary effect being the generation of new ICT-related businesses and social change.

[3] She uses the terms “IS innovation”, “IT innovation” and “ICT innovation” to refer to the development and implementation of ICT systems and concomitant organizational change, in order to convey the notion of novelty and open-endedness of the effort and experience of IS implementation and of the associated changes within the hosting organization and beyond it.

Heeks (2008) claims that ICT4D practice is undergoing a phase change from "ICT4D 1.0" to "ICT4D 2.0". In the earlier phase, development actors often tried to find quick, off-the-shelf ICT solutions that could be replicated in poor communities in developing countries, which resulted in many ICT4D projects failing to deliver and survive, and in the projects having a limited impact. What have followed have been the call for sustainability and scalability of ICT4D projects, as well as the need for objective evaluation of ICT4D impacts to patch the adverse effects of hype and uncorroborated stories. According to Heeks (ibid.), the phase change includes the focus shifting from the readiness and availability of ICT solutions to the uptake and impact of ICTs (see Figure 2 below).

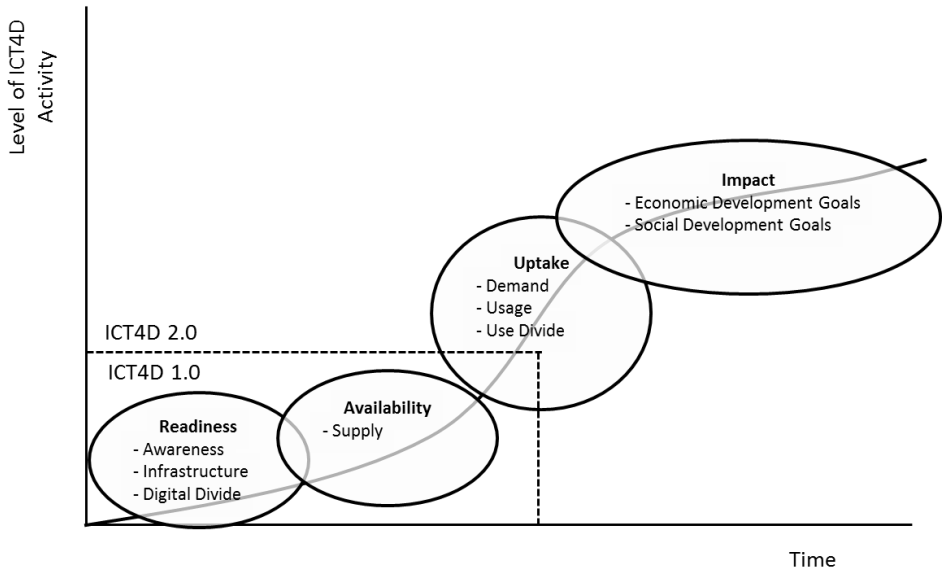

Figure 2: Changing ICT4D issues over time (Heeks 2008)

Heeks (2010) claimed that issues related to ICT readiness have received much interest until recently, as researchers and practitioners alike have started to become interested in the impact of ICT4D projects.

Indeed, a large part of the prior research focuses on criticizing the ICT4D practice. Heeks (ibid.) explained some of the motivations for this, describing the history of ICT4D and how this has featured heavy over-promising – motivated by the Northern private sector seeking markets for their goods – followed by noticeable under-delivery. Kleine and Unwin (2009) noted that ICT4D practice seems to be reinforcing the ruling paradigm, which is top-down and supply lead, in, for the most part, failing to bring significant and lasting benefits for the world's poor. They identified the following lines of criticism of the ICT4D

agenda: using limited development assistance funds to finance ICT projects instead of more pressing needs; creating new forms of dependency by using inappropriate technology; creating increased social polarization as the result of the socio-technological shift; and general concern about spatially and socially uneven diffusion of ICTs, also referred to as the digital divide.

While considering whether developing countries should dedicate resources to ICTs as a sector or should prioritize health, education and other basic needs, Fourati (2009) argued that it is not an either/or situation, as lack of access to information can exacerbate the causes of poverty, and thus developing countries should continue to develop the regulatory environment and the infrastructure to adopt ICTs. For example, Avgerou (1998) reviewed economic and social theory and concluded that IT and organizational innovation is a necessity in order to be part of the global economic activity, but it does not guarantee economic growth.

Wade (2002) discussed the dependency perspective in detail, noting that ICTs can lead the developing countries to a new form of dependency on the developed world. He suggested this to be one of the major risks in the efforts to bridge the digital divide.

The digital divide refers to the existence of ICT "haves" and "have nots" (Bertot 2003). Researchers have studied the issues from many angles. Norris pointed out that the digital divide exists on a global level, on a national level, and on the level of social groups (Norris 2001). Van Dick (1999) noted that there are different types of barriers to access: lack of elementary digital experience, no possession of computers or network connections, lack of digital skills and lack of usage opportunities. Selwyn (2009) elaborates on this, proposing four stages that make up the digital divide: formal or theoretical access, effective access, engagement with ICTs and content and, finally, the outcomes and consequences of ICT use. He also suggested that economic, cultural and social capital influence the digital divide.

Yu (2006) proposes that there are two overlapping research communities that tackle the issue: one that continues the information equality research tradition that was in existence in the 1960s and which therefore has a more solid theoretical foundation, and the other whose discourse is built primarily upon the concept of the digital divide and whose intellectual antecedents are traced to universal access or technology diffusion research. The latter, Yu claims, has been more influenced by various political ideologies, and therefore resulted in a more confusing field in terms of terminology, research results, and practical implications.

In addition, other researchers have noted that the digital divide portrays the development challenge from a rather limited perspective. Luyt (2006), for example, noted that e-readiness indicators frame the digital divide from the perspective of the transnational capitalist class, even if the indicators may be

used in policy making processes. The digital divide debate has also been said to be a discursive move away from the real inequalities, turning a problem based on structural inequality into a technological and administrative problem (Stevenson 2009). Furthermore, the digital divide debate has been criticized for building on the assumption that ICTs can leapfrog over development problems and for ignoring the issue of demand for the ICTs and the issues of scalability and sustainability (Wade 2002).

Even if this criticism of the digital divide debate might be well justified, Heeks (2010) stresses that increasing ICT readiness and the availability of ICT solutions are both necessary phases in reaching higher levels of the "ICT4D Value Chain" – uptake and actual usage of the ICT and finally the micro-level and development impacts resulting from ICT use.

The failures of ICT4D projects and the reasons for this represent a significant topic in development informatics research. Avgerou (2008) identified the problematization of failure as being one of the key research agendas in development informatics literature as, in developing countries, endemic problems hinder both the completion of IS innovation initiatives and the realization of their expected benefits. Heeks (2002) noted that discussing the success or failure of ICT4D projects is difficult for two reasons. Due to subjectivity of evaluation, one person's failure may be another's success. Due to the timing of evaluation, today's success may be tomorrow's failure and vice versa. Yet he proposed that ICT4D projects are categorized in three outcome classes: total failure, partial failure (including sustainability failure), and success. He also suggested that failure may be explained by the gap between the designed outcome and the local actuality and by the gap between the "hard" rationality and the "soft" political thinking and calls for local improvisations to decrease the risk of failure.

Even if defining failure might be difficult, prior research has identified several issues that produce shortcomings in ICT4D projects. Sahay and Avgerou (2002) noted that the development benefits from ICTs have been difficult to reach because many organizations have difficulties in nurturing and cultivating complex technology projects over long periods of time and because the resulting ICT-based systems may have little impact on the organizational weaknesses they were intended to alleviate. Avgerou (2008) further contemplated that a concern that penetrates the whole field of development informatics literature is the fact that there are severely limited financial resources, technology and skills in most developing countries or regions. Avgerou (ibid) concluded that development informatics studies have identified three specific problems that often occur in developing countries, namely scalability failure, sustainability failure and assimilation in dysfunctional organizational process.

Scalability failure and sustainability failure relate to the commonly identified problem that ICT4D projects tend to produce unused and unsustainable pilot

projects (Braa et al. 2004; Heeks and Baark 1999; Littlejohns et al. 2003; Sahay and Walsham 1997). Walsham and Sahay (2006) underlined that sustainability and scalability are important but neglected topics in the field of development informatics and suggest that these challenges are often related to each other. Furthermore, Braa et al. (2004) connected the two issues and suggested that scaling of intervention is a prerequisite for sustainable action. While both issues relate to the (dis)ability of ICT4D projects to have a long-term impact in the development context, scalability and sustainability offer somewhat different viewpoints.

Scalability is, in essence, the challenge of how to spread and successfully adapt one working solution to other sites (Braa et al. 2004). Sahay and Walsham (2006) elaborate on this definition, referring to scaling as the process through which a product or process is taken from one setting and expanded in size and scope in the same setting or incorporated into other settings. In the context of healthcare and health information systems, Sahay and Walsham (ibid) highlighted that scaling needs to be accompanied by the scaling of human resources – both at the level of users and their technical competence (if scaling would lead to higher technical complexity) and at the level of the implementation team providing support services if scaling leads to a wider geographical area, more complex technical problems or increased institutional and political issues. Kleine and Unwin (2009) noted that many ICT4D initiatives, especially in Africa, have been designed as pilot projects to test out the concept and with the intention of scaling the initiative at a later date. They suggested that sustainability must be built into any ICT4D initiative from the beginning and that initiatives should ensure that the intended beneficiaries could afford to use the resulting products or services, meaning that innovative business models need to be developed.

Sustainability, on the other hand, is essentially the challenge of making a solution work in practice, over time, in a local setting (Braa et al. 2004). Walsham and Sahay (2006) simplify this as being the question of "how can ICT-based projects be sustained over long periods with appropriate resources, including money and people". This notion is echoed by Câmara and Fonseca (2007), who defined sustainability as the capacity of a software project to adapt and survive major changes in its current team and in the financial support structure.

Ali and Bailur (2007) argue that, while extensively used in both development and ICT for development literature, sustainability has been difficult to define and operationalize. They questioned whether sustainability was overall achievable or even desirable, and suggested that as constant change is inevitable, ICT4D practice should embrace unintended consequences, improvisation, and bricolage (see Ciborra (1994). However, Avgerou (2008) explained that sustainability is

sought in order to avoid technological and functional degrading over time. Sustainability can thus be considered a prerequisite for long-term use of the technology, also in improvised forms. Prior to this, Korpela (1996) pointed out that without a sufficient network of supporting activities, such as electricity supply or consultancy services, information systems in developing countries are doomed to fail.

The concept of sustainability is challenging, partly because it may be understood in many different ways. Ali and Bailur (2007) noted that development informatics literature distinguishes between five types of sustainability: financial, social, institutional, technological and environmental sustainability. They emphasized that financial sustainability is the greatest challenge for many ICT4D projects, which are donor funded for a finite period of time and often have two opposing objectives related to generating sufficient income yet ensuring equal access to those who cannot afford to pay.

Kuriyan et al. (2008) pointed out that, due to importance of financial sustainability, increasing well-being through market-based solutions is currently an influential model in ICT4D, yet there is little research on how and for whom development-through-entrepreneurship works in practice. Their ethnographic case study suggests that it is difficult to implement both financial and social goals of ICT4D projects, because of entrepreneurs are not compensated for serving the poor they may prefer to cater to wealthier customers.

While research on the subject is may be limited, the idea of "making business work for the poor" has become a mainstream development practice (Development 2004). Public-private partnerships have been one way of implementing this. Hosman and Fife (2008) note that, if projects are designed with sustainability and local needs in mind, public-private partnerships have potential to bring about long-term socio-economic benefits.

In addition to public-private partnerships, discussions on the role of private sector in development have focused on the concept of Bottom of the Pyramid (BOP) (Prahalad 2004), where it has been acknowledged that the largest segment of the economic pyramid, the low income citizens, are a source of untapped business potential. Prahalad (ibid.) talks about market-oriented ecosystems, which focus on the "symbiotic nature of the relationships between various private sector and social institutional players", adapting the business ecosystem term coined by Moore (1993). Foster and Heeks (2013) studied the scaling of ICT in the BOP markets and argued for adopting a systemic view where innovation and diffusion are understood as happening simultaneously in multiple phases within a distributed network of innovators, instead of the simplified dualistic view stemming from the traditional diffusion of innovation literature that is ill-suited to the realities of the BOP markets. Innovation for the BOP is generally considered to demand fragility (in terms of keeping the prices of the technology

low), flexibility (in terms of allowing improvisation of the technology use) and inclusive (in terms of providing the technology for under-served segments). This type of innovation has been discussed lately under terms such as Gandhian innovation (Prahalad and Mashkelkar 2010), inclusive innovation (Georg et al. 2012), frugal innovation (Radjou and Prabhu 2015), frugal engineering (Kumar and Puranam 2011), and jugaad innovation (Prabhu and Jain 2015).

2.1.3 Synthesis

Development informatics literature draws a multifaceted image of the nature of development and the role of ICTs in development. It points out that ICT is not a monolithic entity, and ICT can be analyzed from various angles. Much attention has been given to ICT availability, readiness and uptake, but also increasingly towards the impact of ICT4D projects, which are often considered to be either partial or total failures (Heeks 2002).

In prior research, the area of concern of this study – scalability and sustainability of ICT4D projects – has been identified as being an important factor for the success of ICT4D projects. The importance of scalability has been addressed by, for example, Wade (2002), Avgerou (2008) and Walsham and Sahay (2006). Synthesizing from prior research, in this study scalability in ICT4D projects is defined as the ability to spread a technological innovation in scale or scope beyond the original setting where it was developed, usually in a pilot project.

The importance of sustainability has been addressed, among others, by Wade (2002), Heeks (2002), Avgerou (2008), Braa et al. (2004), Kleine and Unwin (2009), Câmara and Fonseca (2007). In this study, sustainability is defined as the ability to make a technological innovation work over time with appropriate resources and support, in planned or in improvised forms.

Braa et al. (2004), Walsham and Sahay (2006) and Hosman and Fife (2008) are among those to have identified a connection between financial sustainability and scalability, but the nature of this connection has not been deeply elaborated upon. Overall, challenges in scalability and sustainability have been identified as causing ICT4D project failure, but neither the question of why scalability and sustainability seem to be recurring challenges, nor the ways of promoting scalability and sustainability in ICT4D projects, have been studied in-depth.

2.2 Open source software

2.2.1 Key terms and concepts

The other research field reviewed is the study of open source, or more precisely *open source software* (OSS). Open source is not a precise term (Gacek et al. 2001) and it can often be found to refer to a number of issues, including software projects (von Krogh and von Hippel 2006), software products (Lakhani and von Hippel 2003), software development method (Scacchi et al. 2006) or even software development culture – the open source movement (Ljungberg 2000). However, open source software may be exactly defined as software fulfilling the terms of distribution given in the Open Source Definition (OSD)[4] and adopting a license approved by the Open Source Initiative (Open Source Initiative 2004).

The concept of open source software is closely related to that of *free software*[5], both having roots in the hacker culture of the sixties (Ljungberg 2000). The most common software license adopted by the free software movement, the GNU General Public License, is considered an OSS license, which supports the notion that the differences between the two movements are often considered to be political in nature (von Hippel 2001).

Many researchers and practitioners (Crowston et al. 2007) use the term *free/libre open source software* (FLOSS) when referring to both the free software and the open source communities and their work, as the term aims to include both perspectives. From the perspective of the research questions of this study, the differences between free software and open source software are not significant and therefore, for the purposes of this study, open source software (and the abbreviation OSS) and free/libre open source software (and the abbreviation FLOSS) are treated as synonyms. The study refers to open source when discussing the open source phenomenon in general, and to OSS or FLOSS when referring to software programs in particular.

Open source software is often contrasted with the complementary term *proprietary software*, which is understood as software "used, made, or marketed by one having the exclusive legal right" (Merriam-Webster.com 2014). Whether

[4] In short, the terms of the OSD dictate that an OSS software license must generate the following effects: 1) source code must be readable and available, either included with the binary code, or publicly downloadable, 2) free distribution of the software, by any party, on any medium, to any party, gratis or for a fee, 3) derivative works must be allowed, either under similar license and or not, depending of the specific OSS license type, and 4) no discrimination against persons, groups, or fields of endeavour.

[5] The concept of free software consists of the notion of four essential freedoms Richard M. Stallman, 'The Gnu Operating System and the Free Software Movement', in Sam Ockman and Mark Stone Chris Dibona (ed.), *Open Sources: Voices from the Open Source Revolution* (Sebastobol, Calif.: O'Reilly and Assoc., 1999).: 1) freedom to run the program, 2) freedom to modify the program, 3) freedom to redistribute the program, and 4) freedom to distribute the modified versions of the program.

open source software is different from proprietary software has been a subject of different kinds of claims and myths, a situation which many researchers have attempted to clarify. For example, Fuggetta (2003) makes an elaborate effort to prove that benefits often associated with open source software, such as superior development method or increased reliability of the software, are not caused or guaranteed by the software being open source and similar benefits may be acquired with proprietary software. Fuggetta (ibid) claims that, instead, open source rather as a good catalyst that enables the manifestation of these benefits.

Gacek et al. (2001) on the other hand, investigated a number of open source projects and concluded, similarly to Fuggetta (ibid.), that besides adherence to OSD and the characteristics derived from the definition, open source licensing is not a guarantee of any qualities, and the characteristics often associated with open source software vary from project to project. This is plausible as, even in 2002, the number of OSS projects was in the tens of thousands (Krishnamurthy 2002), and the origins, the development method, and the activity of the project developers vary greatly.

It can therefore be concluded that the licensing terms define the nature of open source software. The OSD licensing terms allow the creation of many different types of OSS licenses, which Välimäki (2005) classifies into the following three categories ranging from the most liberal to the most restrictive: permissive licenses, licenses with standard reciprocity obligation and licenses with strong reciprocity obligation[6]. While there are many different types of OSS licenses, the licensing terms guarantee that all open source software embodies certain characteristics that are derived from the OSD. However, most research on open source software has not focused on the open source licensing, but rather on the different kinds of human activities that the licensing terms have enabled.

2.2.2 Literature review

Since the origin of the movement[7], open source has been a popular subject of research. A quick survey of research papers[8] revealed a staggering 10,324

[6] Standard reciprocity means that the distribution terms of the source code must be maintained in further developed versions. This is also called the “copyleft” effect. Strong reciprocity obligation means that in addition to the standard reciprocity effects, derivative works and adaptations must keep the licensing terms intact. This is also called the “viral” effect. The GNU General Public License incorporates the strong reciprocity obligation.

[7] The term “open source” was coined in 1998. Open Source Initiative, 'History of the Osi', <http://opensource.org/history>

[8] The terms “open source” and “free software” were searched in the topics and titles of all articles in the Web of Knowledge database. This revealed 9062 articles in the science and technology domain, 1325 articles in the social sciences domain and 71 articles in the arts and humanities domain. The operation was carried out on 5 October 2013.

research articles published on open source issues, though a majority of them did not study open source as a subject matter, but rather focused on the use of a particular open source-based solution.

A range of different disciplines has paid attention to the open source phenomenon. Gacek et al. (2001) consider computer science, management and organization science, psychology, economics and law and social sciences in general to be relevant disciplines in studying OSS. While researchers conduct research within their own disciplines that builds on the methodological tradition of each discipline, there is a trans-disciplinary dialogue between researchers of different disciplines studying the open source phenomenon (von Krogh and Spaeth 2007).

Von Krogh and von Hippel (2006), continuing the work of Lerner and Tirole (2001, 2005b), surveyed research in the social sciences domain and categorized open source research into three areas where open source phenomenon poses fundamental puzzles that called for both entirely new theory and novel empirical research: (1) motivations of open source software contributors; (2) governance, organization and the process of innovation in open source software projects; and (3) competitive dynamics enforced by open source software. These categories seem to capture accurately the main themes of trans-disciplinary open source research. Next these themes and the most influential research papers in them are discussed, reflecting also on their relevance to understanding the area of concern of this study.

The motivation of open source software contributors has been a significant research theme, especially in the earlier open source research. The question of why developers and companies alike contribute to open source projects has been important, because as a public good, open source software is subject to the free-rider problem and contributors could instead choose to invest their efforts in proprietary technology and appropriate returns from this investment (von Krogh and Spaeth 2007). Von Krogh et al. (2003) further pointed out that joining a developer community does not come without a cost, as complex technologies can erect barriers of understanding and contribution to both users and developers.

In their highly cited article, Lerner and Tirole (2002b) used economic theory to answer these questions and suggested that developers contribute to OSS projects because of career concern incentives and ego gratification incentives, whereas companies benefit indirectly in complementary proprietary segments. Von Hippel and von Krogh (2003) elaborated on this, suggesting that contributions to OSS projects are not purely public goods, but that they have significant private elements as benefits such as fun, reputation, learning and peer recognition are not supplied to the same degree to non-contributors.

Lakhani and von Hippel (2003) concluded, based on a research survey, that mundane tasks in OSS projects, such as user support, are also taken care of based

on similar motives. Contributors participated because they expected to learn from it and because they wanted to gain reputation, particularly among their peers. Other similarly important motives were reciprocity among peers and the need to "help the cause". These kind of softer motivations have also been studied by the means of cultural anthropology (Bergquist and Ljungberg 2001; Zeitlyn 2003) and psychology (Bagozzi and Dholakia 2006; Hertel et al. 2003; Ke and Zhang 2009), which have underlined reciprocal "gift culture" (cf. (Raymond 1998) and other social and group-related factors as incentives to contribute to OSS projects by developers.

Similarly to Hars and Qu (2002), Roberts et al. (2006) drew heavily on theories of intrinsic and extrinsic motivation in psychology and developed a theoretical model related to interrelation of motivations, participation and performance. Furthermore, they evaluated the model using survey and archival data from a longitudinal field study. They found that developers' motivations are indeed related in complex ways and that different motivations have an impact on participation in different ways. As an example, they concluded that developers' paid participation leads to above-average contribution levels and OSS projects should therefore welcome commercial efforts by companies. Wu et al. (2007) also used an extensive field survey to study motivation and continuation and suggested that the OSS community is likely to attract new talent and retain current developers as long as there continues to be a partnership between OSS developers and adopters that provides economic incentives for participation.

While the research on contributors' motivations has focused on the "why" in relation to OSS projects, the research on governance, organization and innovation process addresses the "how" questions. Even if many of the articles included in this second research category also cover issues of motivation, the focus is more on how open source software projects are governed, how the projects are organized and how OSS projects manage their innovation processes.

The importance of governance mechanisms has been underlined by several researchers. Benkler (2002) generalized from the open source phenomenon to suggest that OSS projects and the governance mechanisms they use exemplify "commons-based peer production", a third model of economic production, which has advantages over the property-based production model of the "market" and the contract-based production model of the "firm" when the object of production is information or culture. Benkler suggested that governance mechanisms, such as decentralized information gathering and exchange, reduce the uncertainty of participants, effectively getting the individual agents to self-identify the tasks and performing them. This, he claims, makes large-scale collaboration in the digitally networked environment sustainable and productive.

Intellectual property rights and particularly software licensing have been identified as central governance mechanisms. O'Mahony (2003) aimed to prove

that the common notion that open source developers give away their work for free is not accurate, as the developers only circulate the code itself, but retain the rights to their work and also use a range of legal techniques to govern their collective works. Franck and Jungwirth (2003) suggested that the governance mechanisms of OSS projects, particularly the licensing scheme, are in fact an institutional innovation that enables rent-seeking without crowding out donative behavior and thus enabling the participation of many different kinds of people in the projects.

Previous research also points out that governance mechanisms influence how the communities are going to develop. (Kogut and Metiu 2001) suggested that different governance structures influence the development of the code in OSS projects. Shah (2006) suggested that the governance structures of the community dramatically also affect the participation choices of volunteer software developers. Lerner and Tirole (Lerner and Tirole 2005a) studied the determinants of open source license choice and concluded that projects with unrestricted licenses attract more contributors. Stewart et al. (2006), however, noted that the influence of licensing on development activity depends on the kind of organizational sponsor that a project has. In addition, they suggested that users are most attracted to projects that are sponsored by non-market organizations and projects that employ non-restrictive licenses.

Most of the abovementioned research did not consider how the OSS projects were founded and controlled. West and O'Mahony (2005) distinguished between individually-founded or "organic" communities and organizationally-founded or "synthetic" communities. Later, West and O'Mahony (2008) contrasted community-controlled "autonomous" communities with company-controlled "sponsored" projects, aiming the focus on the governance issues instead of the origin of the project. They identified three design dimensions that together form specific participation architecture (the organization of production, community governance and intellectual property) and two different types of openness (transparency and accessibility). In their study, transparency was found to be critical in aiding adoption of the software and therefore a key goal of all community sponsors, but accessibility was regarded with mixed feelings. The sponsors faced a control vs growth tension: when the sponsors attempted to control the community's strategic decisions in order to advance their own goals, they also limited their community's ability to attract new members and grow.

In addition to governance mechanisms, other factors also influence how OSS communities work and develop. Franke and von Hippel (2003) suggested that developers who were capable of changing the technical characteristics of the software were significantly more satisfied than non-innovating software users. Baldwin and Clark (2006) created a simple game model to show that codebases that are modular and have more options value increase developers' incentives to

join and remain involved in OSS projects and also decrease the amount of free-riding, because these properties create opportunities for the exchange of valuable work among developers. The study by MacCormack et al. (2006) suggests that different modes of organizing software development relate to different product designs and, if proprietary code is released as open source it is particularly important to adapt an "architecture for participation".

On the other hand, softer issues related to social behavior and communication also influence how the projects function. Grewal et al. (2006) argue that social capital, a substitute for positional power related to hierarchies, varies across projects and developers and that it plays a critical role in the success of open source projects. Kuk (2006) argued that individual developers interact strategically with other highly resourceful developers and that these strategic interactions expand knowledge sharing, but with the caveat that extreme concentration of development work could also have an opposite effect. Stewart and Gosain (2006) concluded that adherence to the ideological tenets of the open source community are important to the effectiveness of OSS development teams by supporting trust and communication quality in the teams.

Researchers have been inspired by the decentralized and distributed way that open source projects often work, which has led to the development of new models of innovation and knowledge creation. Lee and Cole (2003) proposed a new community-based model of knowledge creation, based on the flagship OSS project Linux, as an alternative to a firm-based one. On the other hand, however, von Hippel and von Krogh (2003) suggest that OSS development is an exemplar of a "private-collective" model of innovation, containing elements from both a private investment model and a collective action model, and set an agenda for further investigation by organization science researchers. Osterloh and Rota (2007) claim that open source software differs from other types of collective invention because it has managed to survive beyond the phase where the technology reaches commercial maturity. They claim this is because OSS contributors have various incentives to continue the collective action and because the governance mechanisms and pro-socially motivated contributors enforce the common rules.

Open source phenomenon as a new way of innovating and knowledge creation has also gained the interest of for-profit enterprises and the researchers that study them. The third open source research theme, competitive dynamics, focuses further on the perspective of for-profit enterprises on open source software and the competitive dynamics enforced by open source software.

Economists have provided an overview on the effect of open source software in the software market. Mustonen (2003) analyzed the impact of copyleft licensing on the consumer market for software programs and suggested that the impact is dependent on the level of consumer implementation and the size of the

market. Using economic theory and simulation, Bonaccorsi and Rossi (2003) concluded that, while the diffusion of a technology subject to network effects in a presence of a well-established standard is difficult, both commercial proprietary software and open source software are likely to coexist in a market. Economides and Katsamakas (2006) modelled competition of technology platforms and suggested that when a proprietary system competes with an open source-based system, the proprietary system may dominate both market share and profitability, while West (2003) proposed that, in certain conditions, platform providers may prefer a mix of strategies to the pure open or closed alternatives.

The questions of why and how firms participate in the open source phenomenon have been a major interest to researchers. West and Gallagher (2006) used the open innovation framework to explain how firms have used open source software to develop new forms of innovation strategies. They identified four open source strategies; namely pooled R&D, spinouts, selling complements and donated complements; and explained how these strategies tackle different challenges related open innovations. Dahlander (2005) examined how firms involved in OSS business appropriate returns from innovations that are created outside the boundaries of firms. He suggested firms tend to use more than one source of appropriating returns and that firms have to balance the possibility of appropriating returns, while maintaining good relations with the community and obeying its norms and values.

Prior research has revealed that firms use open source in many different ways in their businesses, with each way presenting both benefits and challenges. Henkel (2006) carried out a quantitative study of patterns of revealing firm-developed software code to an OSS project, namely embedded Linux. The study supported the notion of the private-collective model of innovation, but underlined that different types of firms have different rationales for openness. Grand et al. (2004) proposed a four level management model of resource allocation to open source innovation to be used by IT and software firms, ranging from just using open source software to adopting an open source compatible business model. They proposed that each level is associated with certain costs and benefits and substantial resource allocation on lower levels is considered a precondition for being able to enter higher levels. Fosfuri et al. (2008) studied the releasing of software products under OSS licenses by for-profit organizations and concluded that variations in pre-existing stock of intellectual property rights, namely patents and trademarks, help to explain why some firms are taking more commercial actions within the open source domain than others. Later, Deodhar et al. (2012) explored the practices used by software product vendors using hybrid business models that integrate an open source approach with the traditional proprietary business models.

Community involvement has also been a subject of prior research. Through in-depth case studies, Dahlander and Magnusson (2008) studied how firms make use of OSS communities and how this use is associated with their business models. They identified three distinct means by which firms exploit communities: 1) accessing communities to extend the resource base, 2) aligning the firm's strategy with that of the community, and 3) assimilating the work developed within the community in order to integrate and share results. Stam (2009) examined how participation in open innovation communities influenced the performance of firms commercializing OSS and, based on a study among Dutch companies, concluded that extensive technical participation in open source projects is strongly related to performance for firms that also engage in offline community activities, for larger firms and for those with high research and development intensities, but also that higher levels of involvement may be subject to decreasing marginal returns. Later O'Mahony and Bechky (2008) noted that as firms intensify their community participation, they may be forced to create and manage joint institutions that govern firm-community interactions, increasing the costs and thereby decreasing the marginal benefits of community participation.

Even if open source software has become more common in business, prior research has also studied the barriers to adoption. Based on a survey of Italian software firms, Bonaccorsi et al. (2006) found that most firms that supplied OSS-based products and services also received revenues from traditional licensing fees. In addition, they found that the degree of openness toward open source was negatively influenced by switching costs on the supply side and network effects on the demand side. Goode (2004) studied the demand side by surveying Australian firms and their reasons for not adopting open source software. They found that the main reasons for rejecting OSS was that managers perceived no relevance in its offerings, were concerned about unreliable or transient support sources, lack of available resources or did not feel that open source technology were required in their businesses.

The adoption rate has been one of the criteria used for measuring OSS project success. Lee et al. (2009) developed and empirically tested an OSS project success model based on the IS evaluation model of DeLone and McLean (2003). Five success criteria – software quality, community service quality, OSS use, user satisfaction and individual net benefits – were identified in their model and were measured with judgment calls made by users themselves. In prior research, the success of OSS projects has also been characterized as market penetration (Feller and Fitzgerald 2002), the amount of knowledge created by a project (Singh et al. 2011), project popularity and developer activity (Midha and Palvia 2012), among others. A summary provided by Crowston et al. (2006) of information systems success concepts include system creation and maintenance,

system maintenance, system use and system consequences – with numerous possible measures and indicators – highlighting the conclusion made by Midha and Palvia (2012) that the meaning of success in software development context is subjective.

2.2.3 Synthesis

Open source software has been studied from a multitude of perspectives. While sustainability and scalability as such have not been studied in prior research on OSS, all the main streams of research on OSS provide some insights that are relevant for the area of concern of this study.

Prior research underlines that joining a developer community is also not without a cost (von Krogh et al. 2003) and that OSS projects are subject to the free-rider problem (von Krogh and Spaeth 2007). However, prior research concludes that there are a range of motivations for both individual software developers (Lakhani and von Hippel 2003; Lerner and Tirole 2002a; Roberts et al. 2006; von Hippel and von Krogh 2003). Governance structures, licensing and technical characteristics influence how the OSS projects develop (Benkler 2002; Franke and von Hippel 2003; Kogut and Metiu 2001; Lerner and Tirole 2005a; West and O'Mahony 2005, 2008). Similarly, they influence the participation of companies, which have their own motivations to contribute to OSS projects (Bonaccorsi and Rossi 2003; Dahlander 2005; Dahlander and Magnusson 2008; West and Gallagher 2006). These insights provide a basis for understanding the supply of open source software.

Prior research has also studied the barriers to adopting OSS in organizations (Bonaccorsi et al. 2006; Goode 2004) since market penetration, among other things, has been suggested as a key characteristic of a successful OSS project (Feller and Fitzgerald 2002). The factors influencing the adoption of OSS provide a basis for understanding the demand of open source software.

The limitations of prior research in relation to the area of concern of this study is that it is very much focused on OSS projects in the developed countries originating from developer communities or sponsored by for-profit enterprises. The literature that focuses on OSS in the developing country context is therefore reviewed in particular detail in the next chapter.

2.3 Open source software for developing countries

2.3.1 Literature review

In the intersection of the two major research fields described in the previous sections, the open source software research and the development informatics field, there exists a group of studies focusing on the use of open source software in developing countries. Open source software has been seen as a potential means to reducing licensing costs, promoting indigenous technological development, avoiding being hostage to proprietary software, advancing knowledge creation and helping to set up an information economy (Câmara and Fonseca 2007). However, prior research has also warned that simply assuming that OSS is a best fit for developing countries is a perilous one, even if it may provide lower cost, flexibility and adaptability (Byrne and Jolliffe 2007). Most research that studies OSS in the context of capacity development makes some claims or assumptions about the advantages and disadvantages of open source software for developing countries. Overall, this debate includes all the same development debate perspectives described earlier in Chapter 2.1 from modernization and dependency to human development.

Prior research adopting the modernization perspective to development sees OSS as an opportunity for enabling new modes of production and innovation in developing countries. Steinmuller (2001) saw the open source movement as enhancing opportunities for individuals for learning how to produce ICTs and therefore helping the developing countries to "leapfrog" stages of technological development. Ghosh (2003) suggested that, on the global level, OSS presents a technology transfer from rich countries to poor countries, as OSS products, which are often developed by paid software developers, are free for anybody to benefit from.

The role of local adaptation was discussed by Boas et al. (2005) who analyzed the adaptation of technology and business models versus their design locally from the ground up. They noted that, as a production method, open source does not necessarily need customization, and it could be used as a method of ground-up innovation to produce products customized for local use – something that for-profit firms may not do due to lack of potential profits.

The innovation potential of OSS for developing countries was also discussed by Kogut and Metiu (2001) who, after studying the governance mechanisms of open source software projects and their effects on innovation, concluded that open source provides an alternative model whereby innovation could occur on a more distributed basis with developing countries having a bigger role in technological innovation.

Indeed, various research articles report the intentions of developing countries to build their software industries with the help of OSS. Li et al. (2004) considered why and how OSS should be promoted to develop China's software industry and concluded that the Chinese government, in order to build the competitiveness of the industry and to fight software piracy, should take various actions to promote OSS. Shen (2005) agreed that curbing piracy undermines the local software industry and, while seeing the rationale in building a critical mass of users in favor of indigenous software development, also suggested that it is important to learn to recognize the importance of intellectual property rights. Tapia and Maldonado (2009) reported that the Venezuelan government attempted to break the vicious cycle encompassing the lack of ICT workforce and the lack of ICT investments in the country by launching a massive governmental program to support OSS use in the country, yet do not provide an evaluation of the results. Yildirim and Hansal (2011) examined the strategic factors and future trends likely to affect the deployment of OSS in Turkey and offered policy recommendations for exploiting OSS in building a competitive software industry.

Studies that adopt the dependency perspective on development emphasize the potential of OSS in reducing cost, path dependency and vendor lock-in for actors using ICT in developing countries. The discussion has often revolved around the potential of OSS in bridging the digital divide. James (2003) argued that if the digital divide is to be lessened, the cost of computing needs to be drastically reduced. He continued by explaining that, although the operating system Linux can generate substantial savings when used instead of proprietary alternatives, better opportunities for developing countries occur when OSS is combined with other ways of reducing computing costs, including reducing path dependency where newer faster software continuously demands newer faster computers. He also points out that the choice of software affects a developing country's future technological capabilities.

Ghosh (2003) underlined that, since the licensing costs of software in developing countries represent a major share of the total cost of ownership, the cost issue is indeed significant for developing countries. Cook and Horobin (2006) also brought up the issues of cost and vendor lock-in and argued that OSS is a crucial part in achieving an affordable eGovernment that enhances independence and does not contribute significantly to foreign debt.

May (2006) put together a compelling case claiming that in addition to practical advantages related to costs, flexibility and building a local knowledge base, OSS offers advantages on the level of political economy, namely by establishing independent national technological capacity. While warning that ICTs and the bridging of the digital divide may bring a new kind of dependency to the developing world, Wade (2002) mentioned open source as one of the possible solutions.

In addition to the many studies reporting national policies related to OSS, Garzia-Perez et al (2006) described the situation in Cuba where OSS is seen as a way of developing technological independence, but identified that there was not enough political will to reduce the gaps between goals and their implementation, which existed particularly due to restrictive policies in the use of Internet and computers. On the other hand, Lungo and Kaasboll (2007) reported positive experiences from case studies in Tanzania related to the quality of OSS and its impact on total cost of ownership and avoiding vendor lock-in.

The human development perspective has also been adopted in some prior research. These studies have contemplated the use of OSS not only in terms of individual learning and empowerment, but also on the scope of the society at large. Burne and Jolliffe (2007) made the point that the value of OSS for developing countries is not based on cost or technical qualities, but should instead be evaluated on how OSS influences the freedom of developing countries from the dependency and human development perspectives. Subramanyam and Xia (2008) also adopted the macro-level view and studied the motivations of OSS developers both in developed (North America) and developing countries (China and India) and found that intrinsic motivations are present in all regions, while project-level preferences revealed that OSS projects are seen by developing country based developers as a means to learn collaborative software development. Câmara and Fonseca (2007) saw that developing countries must absorb knowledge embedded in technology in order to reach sustainability of ICTs and that OSS is both a way of gaining software development skills and an instrument in social change. In their study, they further develop public policies for adopting different types of OSS products from the angle of sustainability of knowledge.

While most researchers adopting any of the three development perspectives seem to agree that OSS is a promising solution in developing countries, there are also a few studies that discuss why OSS should not be adopted. Negash et al (2007) argued that while globally OSS may represent a trend towards networked collaboration, developing countries have limited access to this global network and therefore the determinant factors for OSS adoption in developing countries are different to those in industrialized countries. Their case study analysis suggested that, for example, OSS developers in developing countries require financial compensation to participate in OSS development, local ICT competency is often weak, and software piracy undermines the cost benefits of OSS. Wade (2002) also suggested that without government regulation the opportunities presented by OSS to developing countries are limited by negative effects of network economies, particularly compatibility. James (2003), expanded on this by stating that high piracy rates, a lack of awareness of OSS and path dependency related to technology choices has hindered the use of OSS in

developing countries. May (2006) saw that one of the key problems in using OSS in developing countries is the vicious circle of low penetration, resulting from path-dependency related to using proprietary software and from thus lowered network benefits.

The abovementioned barriers are directly linked to the challenges of scaling and sustainability, which were identified in the development informatics literature as being major issues in using ICT in capacity development. Boas et al (2005) also noted that a certain scale may be necessary to support the creation of customized open source products locally in developing countries. Câmara and Fonseca (2007) differentiated between open source products based on two characteristics that affect their sustainability. These are the degree of shared conceptualization, which influences the potential for reverse engineering, and the degree of modularity, which influences the potential for distributed development. They noted that developing countries should be wary when adopting software with low modularity, as they might risk dependency on private companies or unsustainability.

While depending on software provided by large multinational companies is seen as a problem, researchers have underlined possibilities of involving small local companies in OSS activities. Kleine and Unwin (2009) noted that OSS-based approaches have been an alternative to partnerships with large for-profit companies, ranging from fully free and non-commercial solutions developed by volunteers to models where the software is free but small companies provide services and hardware as mixed solutions. Ghosh (2003) suggested that, thanks to the low entry barriers related to OSS use and learning, local businesses are able to provide commercial support for OSS products and that there is a possibility of a number of small businesses growing to provide commercial support. This, he claimed, is important because of the tendency of proprietary vendors to ignore local needs in developing regions.

2.3.2 Synthesis

In summary, prior research supports the notion that OSS may be a good choice for developing countries. The rationale for using OSS depends on the development perspective adopted in the study. OSS has been seen as a technology transfer from rich to poor countries and thus as a way of "leapfrogging" phases of technological development (Ghosh 2003; Steinmuller 2001). The opportunity of using OSS to reduce costs, path dependency and vendor lock-in for actors using ICT in developing countries has also been emphasized (Câmara and Fonseca 2007; Cook and Horobin 2006; Ghosh 2003; James 2003; Wade 2002). A few studies have also pointed out that issues such as

software piracy, local ICT competence, lack of awareness of OSS and path dependency related to existing technology may limit the use of OSS in developing countries (Byrne and Jolliffe 2007; James 2003; May 2006; Negash et al. 2007). The abovementioned issues influence the supply and demand of OSS in developing countries. Prior research has also noted that certain types of open source software and certain scale of projects may be necessary for sustainability and scalability of OSS in developing countries (Boas et al. 2005; Câmara and Fonseca 2007) and the role of small businesses in providing support services (Ghosh 2003; Kleine and Unwin 2009).

Overall, OSS is seen as an opportunity for enabling new modes of production and innovation in developing countries, although there is not much empirical evidence to support these claims. In addition to the lack of empirical evidence in support of these arguments, the majority of studies in this field focus on the possibilities of OSS in developing countries on the macro level or from a national perspective, thus not offering means that would aid in managing scalability and sustainability in ICT4D projects.

2.4 Research gap

The earlier part of this chapter reviewed prior research on development informatics, open source software, as well as studies from the intersection of these two fields that focus on open source software in developing countries. All these research fields are comparatively extensive, providing a valuable background for this study, but also leave some gaps that need further investigation.

The field of development informatics discusses the applicability of ICTs in capacity development of developing countries, portraying a critical and cautiously optimistic view of the potential of ICT in this context based on both experiences from ICT4D practice and development theory. Prior research, however, calls for sensitivity in understanding the context of ICT use and for acknowledgment of the different notions of ICT in general. Sein and Harindranath (2004) argued that ambiguous findings and diverse opinions in the field can, to a certain extent, be explained by limited conceptualization of ICT as a monolithic and homogenous entity and call for more research that would acknowledge social and organizational aspects in addition to technological ones. In this light, it is evident that when relying on insights from prior research, one has to acknowledge the limitations when the context or the conceptualization of ICT is different.

ICT4D practice has generally been considered problematic and often resulting in failures in terms of project sustainability or scalability. Both scalability and

sustainability have received attention in prior research and they have often been considered to be related to each other. However, the questions of why scalability and sustainability seem to be recurring challenges and how scalability and sustainability can be promoted have not been deeply studied, which is why several researchers call for more research on these topics (Foster and Heeks 2013; Walsham and Sahay 2006).

Open source software in general has often been a subject of myths and claims, both positive and negative, often with little more than anecdotal evidence to support the claims. One could argue that this is partly because open source could be understood as being a product, a project, a development method, or as a movement, and because the variance among projects and products is great. The licensing terms define open source software and its characteristics in one way, but as Hauge et al. (2010) argued, OSS may be adopted for use in various ways, and therefore the researchers should avoid treating OSS and the adoption of OSS as one homogenous phenomenon. Furthermore, researchers should acknowledge the individual context in which OSS is adopted and describe precisely how the organizations they study approach OSS and carefully consider how this adoption influences their findings.

By and large, prior open source software research assumes that OSS projects are founded and controlled either by a community of individuals or by one or more companies. However, as West and O'Mahony (2008) noted, a growing number of projects are founded by non-profit organizations, governments and transnational organizations and this fact should be acknowledged in future research. In the light of this prior research, it is somewhat unclear how our understanding of OSS is relevant in the context of capacity development, in which the OSS projects are usually founded and controlled by international development organizations and where the motivations of project stakeholders and the realities of the environment are somewhat different from the context usually present in OSS research, i.e. the context of industrialized countries.

Many researchers who have studied OSS in developing countries saw opportunities to make use of OSS and its lower cost, flexibility and adaptability in combating the digital divide, establishing independence and building capacities in the developing world. However, it remains unclear if and how OSS affects scalability and sustainability in ICT4D projects. While prior research on OSS in developing countries has touched on issues relevant to scalability and sustainability, the research articles have mostly considered the potential of OSS from the macro or national level perspective, yet provide little empirical evidence to support these arguments. Additionally, while it has been recognized that many ICT4D projects fail – at least in part – due to scalability and sustainability challenges, prior research has barely discussed or empirically studied the potential of OSS in promoting scalability and sustainability of ICT4D projects.

3 METHODOLOGY

In this chapter, the methodology of the study is discussed, elaborating the research domain, the paradigmatic stance and the research method chosen. Checkland and Holwell (1998) propose that at a basic level any piece of research in any mode may be thought of as entailing the following elements: a particular set, or a framework, of linked ideas (F) are used in a methodology (M) to investigate some area of concern (A) (see Figure 3). From doing the research, the researcher may learn new things about all three elements F, M and A.

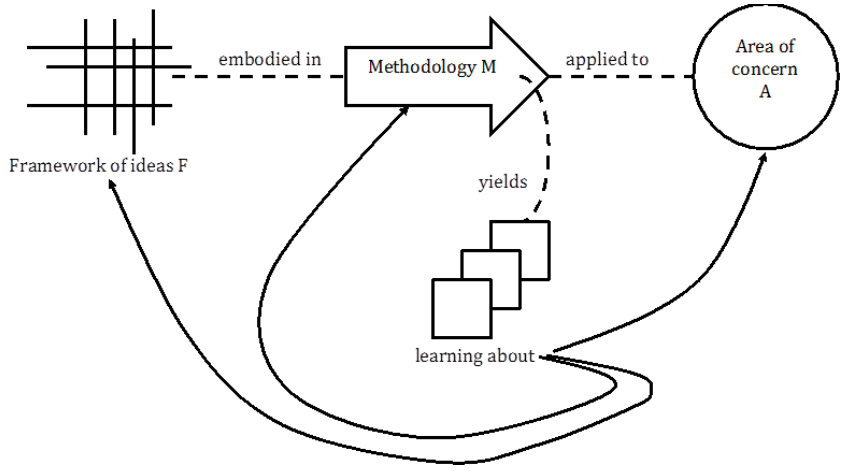

Figure 3: Elements relevant to any piece of research (Checkland and Holwell 1998)

In this study, this conception of research and the provided terminology is used to build a particular methodology for this study in the subsections that follow. The use of methodology in an empirical setting is further elaborated on in Chapter 4 where the research process is described in detail. The framework of ideas, or theoretical framework, is elaborated on in the research papers attached in this study and discussed in Chapter 4. The area of concern refers to the research problem formulated above in Chapter 1.2.

3.1 Research domain

This study is conducted within the academic domain of information system research. The UK Academy for Information Systems (UKAIS 1999) define *information systems* as follows: “Information systems are the means by which people and organizations, utilizing technologies, gather, process, store, use and disseminate information”. The domain of information systems research is defined as involving: “the study of theories and practices related to the social and technological phenomena, which determine the development, use and effects of information systems in organisations and society” (ibid.).

The study of information systems (IS) is a highly applied field (Baskerville and Wood-Harper 1996), which may be seen as originating from computer science, management science and organization science (Lee et al. 1999), but there are also other relevant source disciplines, such as sociology, systems thinking, politics, ethics, applied psychology, economics, etc. (Avison and Fitzgerald 1991). Indeed many researchers (Avison 1997; Jones 1997) emphasize that the study of information systems, or *information systems science*, is a multidisciplinary study, using the theories and methods of various other disciplines, in order to study various aspects related to information systems.

In general, information systems science is a problem-driven discipline, which aims to provide practitioners with knowledge about the subject matter (Probert 1997). However, within IS research there are various different interpretations of the nature of the information systems (technological or social), the interest in them (their effectiveness or their effects), and the field of analysis (individual, organizational or societal (Jones 1997). These interpretations are based on different philosophical stances and understandings of the purpose of research in general; and guide the choice between various research approaches, methods, theoretical backgrounds, and disciplines that are used to study the information systems.

3.2 Paradigmatic stance

Scientific research takes place within frameworks of perception and thinking called *worldviews* (Reason and Bradbury 2001) or *paradigms* (Kuhn 1996). The concept of paradigm refers to the set of practices that define a scientific discipline during a particular period of time (ibid.). A paradigm is a conceptual framework that guides different choices regarding research, including what is studied, what kind of questions are asked about the object of study, and how the research should be conducted. A related concept is that of research epistemologies (Chua 1986) which classifies research into positivist,

interpretative and critical research, the latter of which some information systems science researchers see as a variant within interpretivism (Goldkuhl 2012). Depending on the field of science, there are many classifications of research orientations but in information systems science, the paradigms of *positivism* and *interpretivism* have been most commonly used to describe different orientations in research (Chen and Hirschheim 2004). However pragmatism has been considered as an alternative paradigm by many researchers in the field of information systems research (e.g. (Braa and Vidgen 1999; Goles and Hirschheim 2000; Marshall et al. 2005a; Wicks and Freeman 1998).

Many authors (Chen and Hirschheim 2004; Galliers 1997; Lee 2004; Mingers 2004; Myers 1997) have commented that a positivistic paradigm used to dominate the information systems science field, particularly in Northern America, while calling for more interpretive research. Benbasat and Zmud (1999) initiated a heated discussion on the emphasis of rigor over relevance, explaining that this had stemmed from the goal of establishing IS research as an academic discipline. Lee (1999) emphasized that, while a positivistic approach and the emulation of natural sciences is a valid approach, the IS research community should consider other research approaches if the relevance to practice is sought after.

Whereas positivistic research tends to depict an ahistorical and acontextual view of information systems phenomena (Myers 1997), interpretative research is "aimed at producing understanding of the context of the information system and the process whereby the information system influences and is influenced by the context" (Walsham 1993)[9]. Interpretative research does not predefine dependent and independent variables, but focuses on the full complexity of human sense making as the situation emerges (Kaplan and Maxwell 1994)[10]. It is particularly applicable in complex and emergent situations, where replicability and thereby statistical significance testing in the positivistic sense is difficult (Myers 1997). Other strengths of the interpretative approach are the ability to study change processes over time, to understand actors' meanings, to adjust to new issues and theories as they emerge, and to contribute to the evolution of new theories (Easterby-Smith et al. 1991)[11].

Pragmatism is concerned with action, change and the interplay between knowledge and action, making it appropriate as a basis for research approaches that intervene in the world and which do not merely observe it (Goldkuhl 2012).

[9] As quoted by Michael Myers, 'Interpretative Research in Information Systems', in J. Mingers and F. A. Stowell (eds.), *Information Systems: An Emerging Discipline?* (1997).
[10] As cited by ibid.
[11] As cited by David Avison, 'The 'Discipline' of Information Systems: Teaching, Research and Practice', in John Mingers and Frank Stowell (eds.), *Information Systems: An Emerging Discipline?* (Cambridge: McGraw-Hill, 1997).

The central tenet in pragmatism is that the worth of a proposition or theory is to be judged by the consequences of accepting the proposition or theory, and consequently, a theory is true if and only if it is useful (Marshall et al. 2005a). Adopting this view in studying social objects means that the aim of research is not to "discover" eternal truths about a given reality, but that researchers may construct pictures, frameworks and metaphors that are insightful and help us to improve practice (ibid). In this study, a balanced approach between pragmatism and interpretivism is sought, as the aim is to both increase understanding and to improve practice related to the research question.

3.3 Soft systems thinking

The research design of this study was heavily influenced by *soft systems thinking*. Systems thinking is a body of knowledge that emerged in the 20th century through the critique of reductionism of positivistic sciences. Systems thinking is also understood as an approach to problem solving. Flood (2001) stated: "With systems thinking, it is argued that valid knowledge and meaningful understanding comes from building up whole pictures of phenomena, not by breaking them into parts". Systems thinking is built on a belief that the world is systemic – phenomena are understood to be an emergent property of an interrelated whole. Systems are composed of subsystems, which interact with and transform one another, and the properties of the system as a whole result not only from the properties of its respective subsystems, but also from the interactions across them. Furthermore, changes in one (sub)system create changes in other related (sub)systems.

Soft systems thinking is a form of systemic thinking that emphasizes the human perception of reality (Jackson 1991). It sees social reality as the construction of people's interpretations of their experiences and in this way it is firmly linked to interpretive theory (Flood 2001). Soft systems thinking has merged with action research in the works of many scholars, for example by Susman and Evered (1978) and Checkland (1981).

According to soft systems thinking, in order to achieve a meaningful understanding of any (social) situation, it is necessary to study the cultural aspects of the context as well as the interpretations and perceptions that people form within this cultural context, and to enter the action context as both an actor and as a researcher (Flood 2001). Understanding the whole of a phenomenon involves the construction of understanding in terms of constitutive meaning, social practices and actions taken. Conceptual models (cf. Bunge 1972) may be employed in heuristic fashion to see if they provide insights into or assist in the construction process. Conceptual models (whether systems models or others) are

not to be taken as representations of reality, but used as lenses or "a pair of spectacles" (Flood 2001) through which one can interpret reality.

Although no formal systems method was used in the case project of this study, research-based conceptual models were used in interpreting the problem situation and in designing an intervention. Adopting the notion of Checkland and Holwell (1998), soft systems thinking was used as a method of learning.

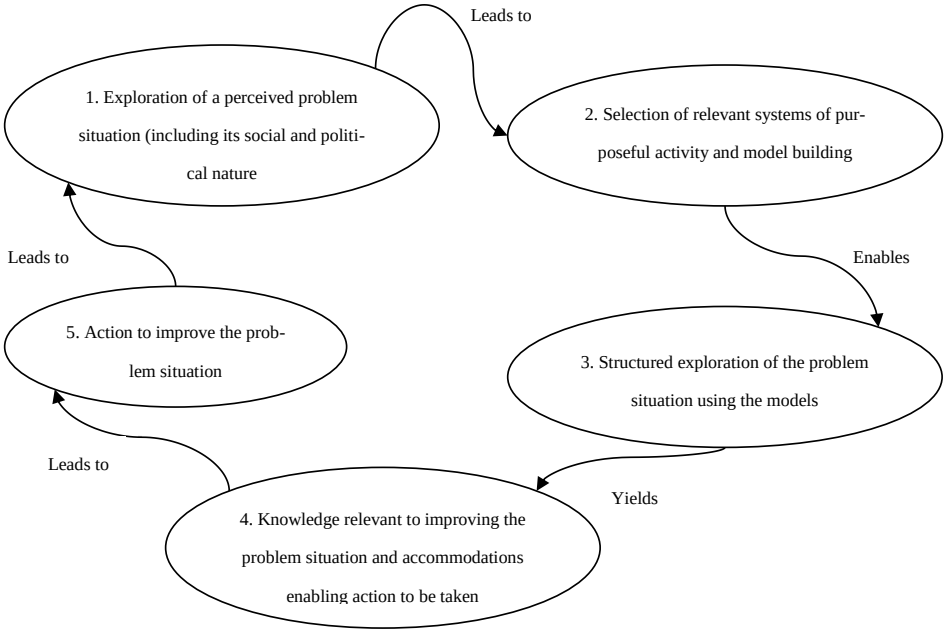

Figure 4: Soft systems thinking as a method of learning (Checkland and Holwell 1998)

3.4 Research method

3.4.1 Action case as a hybrid research method

The main research method of this study is *action case*, which was first conceptualized and developed by Braa and Vidgen (Braa and Vidgen 1999; Vidgen and Braa 1997). Braa and Vidgen (1999) proposed that information systems research in organizational settings can be classified into three ideal types according to the outcomes of the research: research aiming for reduction and prediction, research aiming for interpretation and understanding, and research aiming for intervention and change. The first approach is located within positivism, the second in interpretivism and the third in pragmatism (Goldkuhl

2012). This framework of information systems research outcomes is illustrated in Figure 5.

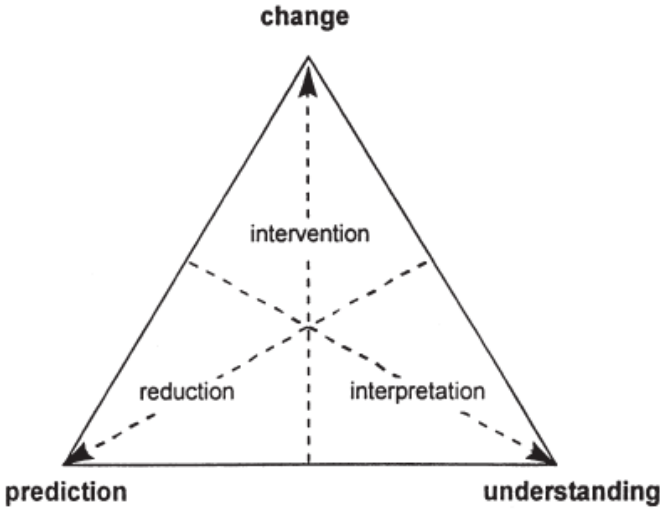

Figure 5: IS research framework (Braa and Vidgen 1999)

Braa and Vidgen (1999) suggested that this framework may be used to position research methods in information systems research, as illustrated in Figure 6. The purified research methods (action research, field experiment and “soft” case study) reside in the tips of the triangle and hybrid research methods (action case, quasi-experiment and “hard” case study), which include two research objectives, reside in between the extremes.

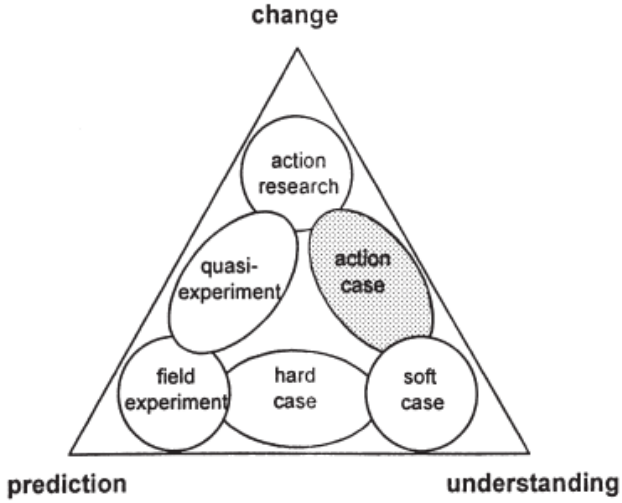

Figure 6: Research methods in the research framework (Braa and Vidgen 1999)

Action case method was developed by Braa and Vidgen (1999) to fulfil the need for a hybrid research method between pure action research and pure soft case study, which would balance the objectives of change and understanding. Since its development, the action case method has been used in a number of studies in the field of information systems research and informatics (Henfridsson et al. 2001; Househ et al. 2011; Hughes and Wood-Harper 1999; Johansson et al. 2007; Mattsson et al. 2009; Nurmi et al. 2011; Saebo 2007; Vidgen et al. 2004).

In the abovementioned studies, action case method was chosen for various reasons. In some studies, the researchers had not planned or emphasized the intervention, but as they had had an impact in the case situation, and element of change was introduced in the study (e.g. Braa and Vidgen (1999); Nurmi et al. (2011)). In others, the researchers had planned to make an intervention, but also the element of understanding the case situation was emphasized (e.g. Mattsson et al. (2009); Vidgen et al. (2004)).

During the design of this study, action research was one of the dominant approaches – particularly in Nordic information systems research – and also later inspired new approaches such as the action design research (Sein et al. 2011). Rapoport (1970) defined it in the following way: “Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable framework”.

As a research method, action research is committed to producing new knowledge by seeking solutions or improvements to “real-life” practical

problems or situations (McKay and Marshall 2001). This is typically an iterative process that capitalizes on learning by both researchers and subjects of the study within the context of the subjects' social system (Baskerville and Myers 2004).

While there are various ways of conducting action, the action research process is often seen to involve a cycle in which a theoretical framework that informs the problem solving exercise and the action research process is employed (Baskerville and Wood-Harper 1998). This cycle is a process of two elementary stages. First, there is a diagnostic stage involving analysis of the social situation and hypotheses being formulated about the nature of the research domain. Second, there is a therapeutic stage that involves change experiments, followed by study of the stage-change.

While the cyclical nature and the focus on introducing change in real-life problem situations make action research a unique research approach in many ways, there are similarities with the case (study) research. Case research refers to a multitude of approaches that aim for in-depth understanding of the context of a phenomenon. The case method does not explicitly control or manipulate variables, it studies a phenomenon in its natural context, and makes use of qualitative tools and techniques for data collection and analysis (Cavaye 1996). Braa and Vidgen (1999) suggested that there are two main types of case studies: the positivist-informed hard case study and the interpretivist-informed soft case study.

Cunningham (1997) suggested that action research is another type of case study alongside intensive case study and comparative case study, which all serve different purposes. Intensive case study is for developing theory from intensive exploration, comparative case study is for developing concepts based on case comparison, and action research is for developing concepts that help facilitate the process of change.

Like action research, case study research may also be used to study the long-term changes of the studied phenomenon in either single or multiple contexts. The case study method also includes conceptual research, but the main interest is on the analysis of the social situation during a diagnostic stage. As a process, action research may be seen as including phases of conceptual research and a diagnostic stage, but also the active intervention of the researcher during the therapeutic stage (Avison 1997).

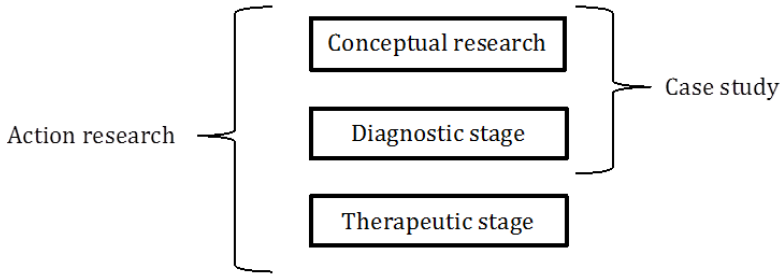

Figure 7: Building blocks of action research and case study research

This study uses the action case method because the research process as a whole included elements from both pure case study and pure action research. In addition, the intervention introduced in the case project by the researchers was limited in scope and prior research did not provide a solid theoretical foundation that could have been tested in practice. This underlined the need for increased understanding of the area of concern. Thus, a research method combining the objectives of change and understanding was adopted.

3.4.2 Dual cycle research process

The research design of this study is crafted on the foundations of action research. One of main concepts adopted from action research is its cyclical nature. The usual representation of the AR process is a single cycle (Marshall et al. 2005b). Baskerville and Wood-Harper (1996)[12] present an elaborate description of the cycle as having the following five phases:

- Diagnosing, where primary problems causing desire for change are identified, and theoretical assumptions about the nature of the organization and its problem domain are made.
- Action planning, where actions to relieve the observed primary problems are being made, guided by a theoretical framework indicating both desired future stage as well as needed changes.
- Action taking, during which the action plans are implemented, with or without the researchers.
- Evaluating, where it is determined whether the theoretical effects of the action were realized, and if these effects relieved the problem. The rea-

[12] Referring to G. I. Susman and R.D Evered, 'An Assesment of the Scientific Merits of Action Research', *Administrative Science Quarterly*, 23/4 (1978), 582-603.

sons for success or failure are identified, and frameworks are adjusted for further action.

- Specifying learning, which is actually an ongoing process, where the knowledge gained is directed for the use of the organization, to improve further actions, and for the scientific community.

In an action research study, the action research cycle can either be passed through once (referred to as linear action research) or repeated until satisfactory outcomes have been achieved either in the same context or in a different site (referred to as multiple iterations of action research) (Baskerville and Wood-Harper 1998). In case of multiple iterations, the change or extension of the theoretical framework, methodology or area of concern is typical as the research process yields opportunities for learning(Checkland and Holwell 1998).

This study seeks to combine the research objectives of change and understanding, and therefore adopts the notion of dual cycle action research. McKay and Marshall (2001) suggested that there are in fact two cycles in action research, one overlaid on the other and operating in tandem with one another: the first cycle relates to the problem solving interests and responsibilities (the problem solving cycle), while the second to the research interests and responsibilities (the research cycle). These two cycles are highly interlinked and somewhat contingent on each other.

The elements of research (see Figure 3) in dual cycle action research are presented in Figure 8 and explained as follows. The researcher identifies a real-world problem situation (P), which enables the researcher to find out about an area of concern of potential interest to his/her research themes (A). P may be a specific, real-world example of a particular A, or it may be a different but overlapping issue, which still allows the researcher to investigate A. The ownership of A rests with the researcher throughout the research process, while by contrast P remains in the ownership of the stakeholders of the problem situation.

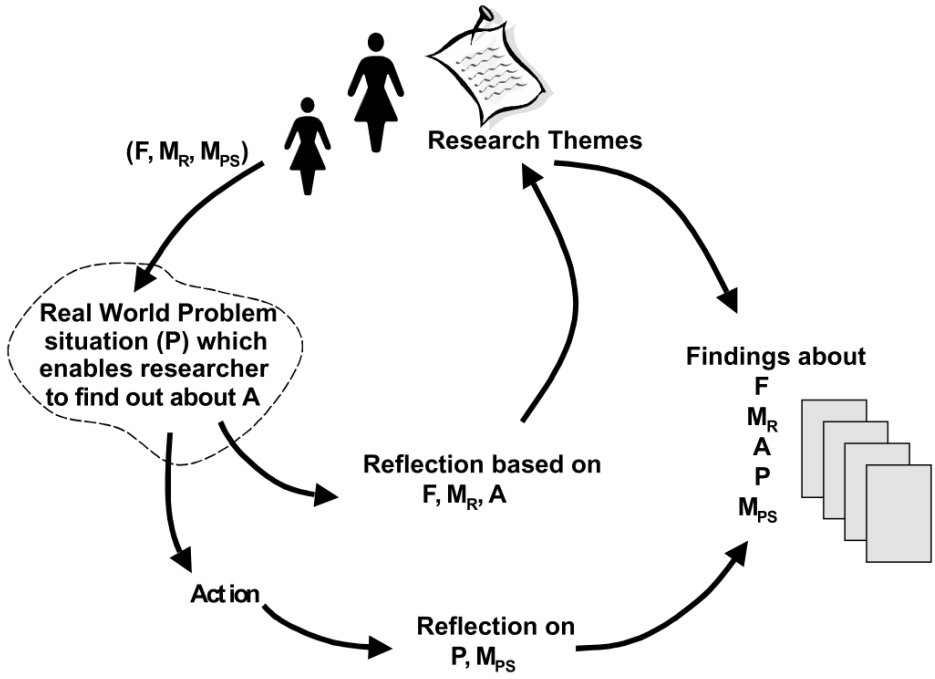

Figure 8: Dual cycle action research framework (McKay and Marshall 2001)

McKay and Marshall (2001) explain the framework so that prior to any intervention, the researcher must declare both a theoretical framework (F) and the research method (MR), which are used in formulating and guiding the intervention in a way that the research interests are fulfilled. In addition, the researcher may use a problem solving method (MPS) to guide the problem solving intervention, even if no formal method is required. Research must be designed in a way that allows the researcher to generate new knowledge of F and/or A and possibly also of MR, thus enabling the researcher to answer the research questions. However, due to the nature of the research process, new insights that have not been anticipated in the research questions may arise. In addition, as the researcher is making an intervention in P, possibly using MPS, the researcher is in a position to reflect on P and on MPS, giving rise to experiential learning.

3.4.3 Conducting action case research

In designing the guidelines for conducting action case research, this study adopts elements from pragmatic action research, interpretive soft case study research, and qualitative research alike. Qualitative methods are largely used in both action

research and soft case research for data collection and analysis. In qualitative research, the researcher develops categories and meanings from the data through an iterative process that starts by developing an initial understanding of the perspectives being studied (Kaplan and Duchon 1988). Qualitative data can be collected with interviews, making field notes describing observed events, or deriving from documents, papers and archives (Cavaye 1996).

In action research, the active participation of the researcher is essential for data collection and analysis. Baskerville and Wood-Harper (1998) explain that whereas in passive observation the researcher is required to have an *a priori* framework (such as a classification scheme for speech acts) or an *a posteriori* framework (such as grounded theory categories) to filter the critical data in complex social settings, in action research the filter may be defined and refined by the state change represented in the stimulus-reaction pairs. The researcher actively participates in taking an action, witnesses the changes in the social setting, and constructs a filter for critical data based on things that changed.

Combining action and research introduces some challenges for conducting research. One widely recognized issue is that in action research there is a risk of the distinction between "researcher" and "researched" becoming blurred (Checkland 1981; Mansell 1991) and therefore the researcher may also be accused of biased view on the research subject (Stowell et al. 1997). To counter this, Avison (1997) suggested that the researcher does not seek to influence the situation more than would be expected from other participants. In addition, Mansell (1991) suggested that the researcher should consult the problem owners who have their own theories about the cause of their problems and the solutions required.

In addition, there is a risk that findings are biased by the personal biases of the researcher, especially if there are conflicts of interests between the researchers and the practitioners (Kock 2004). Avison et al. (1999) suggested that the researchers and the practitioners should share a mutual ethical framework to avoid this type of conflict. To further improve the quality of findings, Stowell et al. (1997) suggested the recoding of observations so that they can be revisited for validation purposes and to support critical reflection and learning. In general, in qualitative research, thick description of the researched phenomenon is necessary in order to promote understanding (Stake 1995).

Overall, Myers (1997) suggested that the key issue regarding the quality of interpretative research is the significance of the findings to researchers and practitioners, and that it can be evaluated both in terms of theory and data. A sufficient quantity of data must be collected in order to provide a rich description of the context and so that alternative perspectives can be provided and critical views can be offered. In terms of theory, key issues are whether the study makes

a contribution to the field, if it offers rich insights, and whether the study contradicts conventional wisdom.

Braa and Vidgen (1999) identified various characteristics of the action case method, which they considered important in designing and conducting action case projects. These characteristics, which include many of the elements discussed above, are presented in Table 1 below.

Table 1: Characteristics of the action case method (Braa and Vidgen 1999)

Factor	Attribute	Action case concern
Suitability	Research design	Has a framework of ideas and a methodology been declared?
	Researcher skills	Does the researcher have the skills and experience to make an intervention?
Interpretation	Richness	Is the context of the research rich enough to provide understanding?
	Focus	Is the research question sufficiently focused?
Intervention	Scale	Is the scale of the subject for research manageable?
	Participation style	What level of participation can be expected from the organization members?
	Critical impact	Is a critical approach required?
Practicability	Economics	Is sufficient financial support and researcher time available?
	Access	Can access be negotiated with stakeholders?
	Politics	Does the research conflict with the organization's politics? Is there sufficient backing for the action and case components?
	Control	Can the research project be controlled?

The principles discussed in this chapter are used in the description of the empirical research, discussed in Chapter 4 below.

4 ACTION CASE RESEARCH

In this chapter, the empirical research process and the applied methods are described in detail. The chapter begins with discussion of the case project background, which in addition to the information included in the research papers, adds to the rich description of the case project and its context. Next, the execution of the case project is described, the focus being on the role of the researchers in each phase of the case project. Finally, the research process is summarized using the characteristics important for designing and conducting action case research.

4.1 Case project background

Cooperatives and other member-financed and member-governed organizations are essential vehicles for achieving sustainable agricultural and rural poverty reduction objectives (Rouse 2006). Agricultural cooperatives play an important role also in the Kenyan economy, especially in the rural parts of the country, which are also some of the poorest regions.

For a long time, the government played a major role in the Kenyan cooperative sector, managing and financing their activities while the cooperative members were not involved in the decision-making and the cooperatives did not function as profit-oriented businesses. With the liberalization of the economy, the government has decreased its control, assistance and also credit to the agricultural sector and the cooperatives, while at the same time there has been increasing competition from the private sector. Many agricultural cooperatives are finding it increasingly difficult to maintain profitability and mobilize capital to finance marketing operations. The result has been growing member dissatisfaction, decline in the activity of cooperative memberships and many agricultural cooperatives have closed down their operations. (Rouse 1998).

In 1993, the Food and Agriculture Organization of the United Nations (FAO) launched a program to address the capital scarcity problem in developing and transition countries and initialized a series of studies on the capital formation of agricultural cooperatives. Findings from a related study (Jämsén et al. 1999) suggested computerization of cooperative administration to be a key instrument in developing the capital formation processes in cooperatives. The study found that manual bookkeeping led to long delays in member transactions and financial

reporting, lack of information sharing and transparency between management and members regarding the financial state and profitability of the cooperative, weak member participation and therefore also to a low level of member capital contributions to finance the business activities.

It is important to note that, compared to many other African countries, Kenya is fairly advanced in terms of ICT. While Kenya ranks only 124th of all the world's countries in the ICT Development Index[13], it ranks 8th of the 37 African countries (Union 2015). As is typical in African countries, the rate of fixed telephone subscriptions, fixed broadband subscriptions and households with computers is low, while the number of mobile phone owners and users is rather big. Kenya is also outperforming its peers in terms of innovation, as reported by Global Innovation Index 2015[14] (Cornell University et al. 2015), producing new innovations mainly in ICT, such as the M-PESA mobile banking system (Morawczynski and Miscione 2008). Kenya is one of the leaders in ICT in Africa, which has attracted R&D activities of multinational corporations (Cornell University et al. 2015) and therefore a good base for ICT-related development.

FAO proceeded with a computerization initiative and launched a study in 2001 with the Ministry of Cooperative Development and Marketing (MoCDM) of the Government of Kenya to examine the feasibility of computerized systems in Kenyan agricultural cooperatives. The study revealed that, due to the complex information processing needs of agricultural cooperatives, computers were rarely used in cooperative administration. Some producer organizations were using tailor-made information systems, but they were too expensive for poor farmers' societies and cooperatives (Rouse 2005). Therefore, at the request of MoCDM, a project was launched by the FAO to develop and test the use of a software application in a pilot cooperative. The pilot project would also function as a model for adaptation and replication in other cooperatives.

A management and member information system (MMIS) software coined "CoopWorks" was developed in collaboration with a chosen pilot cooperative in 2003-2005. In addition, cooperative staff was trained to use the software and to operate the computers, which were introduced in the pilot cooperative using the project funding. A small Kenyan software company was contracted to develop the CoopWorks software, which was then licensed with an open source software compatible license.

[13] The ICT Development Index (IDI) is a composite index that measures ICT access, ICT use and ICT skills based on a limited set of data that can be acquired from countries at all levels of development. IDI is published by the United Nations International Telecommunication Union.

[14] The Global Innovation Index (GII) is a composite index that measures both innovation input (institutions, human capital and research, infrastructure, market sophistication, business sophistication) and innovation output (knowledge and technology output, creative output). It is published by Cornell University, INSEAD and the World Intellectual Property Organization WIPO.

During the final evaluation workshop of the project, it was established that the users were satisfied with the system and its technical features. The MMIS would save staff time spent daily on record keeping and calculating member account details, payment periods for members were expected to drop to 1-2 days, instead of the standard 2-3 weeks. The management reports were useful for decision-making and for reporting performance to members, which contributed to membership increasing from 800 members in 2004 to some 2000 members by the end of 2005. It was seen that once it was fully operational, the system would be of great value and use for individual members, staff, the board, and the business performance of pilot cooperative as whole.

The involvement of the FAO was intended to be project based, only to initiate the action and to leave the responsibility of continuing the action to the local parties. However, the FAO representatives felt that the local stakeholders were not ready to take full responsibility for disseminating and developing the software in a sustainable manner. Furthermore, while the pilot project was considered quite a success by both the cooperative staff and by the project stakeholders alike, there were some issues related to software quality, software development timetable, and inadequate training of stakeholders and cooperative staff that were considered to require further efforts before the software would be ready for dissemination to other agricultural cooperatives (Seiffert 2005). A follow-up project jointly with the FAO, MoCDM, the Government of Finland and other organizations was therefore planned to tackle these issues.

4.2 Case project execution

A team of researchers, including the author, was asked to participate in the follow-up project, which was also called the CoopWorks project, according to the name of the software. The team was contacted because some of the researchers had previously collaborated with the FAO in studying the capital formation of agricultural cooperatives. This study (Jämsén et al. 1999) suggested computerization as a means to support capital formation and related needs for information. The author was included in the team, as he had engaged in open source software research for several years.

The researchers got involved in the project properly during the pilot evaluation workshop, which was also where the follow-up project was planned. The researcher team and the project management agreed on a collaboration framework, agreeing that the researchers could do research in the project while providing advice for the project management on various issues related to information technology and business.

The role of the author and the rest of the research team in the project was to function as experts, providing advice for the project management based on their prior research experience and to conduct desktop research and field research to support the project decision making. Using terminology by Baskerville and Wood-Harper (1998), the researchers were engaged in “facilitative involvement”, as the power and responsibility for solving the problem situation laid with the project management.

It is possible to use the five phase action research cycle by Baskerville and Wood-Harper (1996), discussed earlier in Chapter 3.4, to understand the role of the researchers in the case project. While the follow-up project did not have a true waterfall-model-like sequential process, the project advanced in similar phases: from diagnosis of the initial problem to action planning, followed by action taking and lastly evaluation. Learning was actively sought throughout the project.

The roles of the researchers, including the activities carried out in different phases, are summarized in Table 2 below and further elaborated on in the following sections.

Table 2: Role of the research team in action case research phases

Action case research phase	Role of the research team
Diagnosing	The research team participates in the final evaluation workshop of the pilot project. They are asked to join the follow-up project and help promote scalability and sustainability of the software project, among other issues.
Action planning	The research team conducts desk research and participates in an inception mission to Kenya, where the problem situation is further analyzed and actions are planned. At the same time as some awareness-building actions are already carried out, the research team conducts further desk research.
Action taking	The project management implements the planned actions, including software development and community development. The research team helps in implementation by organizing a training seminar in Finland.
Evaluating	The author conducts interviews in Rome and Kenya to evaluate the status of the problem situation, reasons for success and failure, and to reconstruct the historical chain of events, including stakeholder motivations.
Specifying learning	Shared understanding regarding the problem situation and possible action items were continuously developed throughout the project. Learning is sought by using research-based conceptual models for interpreting reality.

4.2.1 Diagnosing

The case project was a follow-up for the pilot project where the CoopWorks software was initially developed in a pilot agricultural cooperative in Kenya. The follow-up project was initiated at the final evaluation workshop of the pilot project, at the end of year 2005, where the research team also participated. The project was coordinated by the FAO and managed by the Joint Coordination Committee, which included the most important local stakeholders, including the MoCDM.

The follow-up project had several aims. One of the expected end-results was that the software would be tested and available, not only in Kenya, but also globally, and that there would be technical and policy guidelines for the use of cooperative managers and governments for the dissemination of the software and computerization of agricultural cooperatives in general. Furthermore, it was planned that additional modules would be created so that the system could be

used in contexts other than dairy cooperatives as well. The original idea was that one of these modules would be developed in Kenya, one in another African country, and one in an Asian country. However, due to a lack of resources and the software not being ready, it was later decided not to introduce the software in any other countries, but to concentrate solely on Kenya.

In addition, at the beginning of the project one goal was to develop a "light version" of the MMIS. The MMIS software itself was licensed with an open source software compatible license, but at the time the system required heavy and expensive proprietary software on both the client computers and the servers to run. It was agreed that the research team would help the project management in the product development strategy, i.e. in understanding the potential problems and advantages that different choices would have on the project and the project stakeholders.

As the follow-up project would only receive funding for a few years, it was also the wish of the FAO that ultimately they would be able to disengage from the product development and support, one of the goals was also to collect information and form an understanding of the viability of the CoopWorks project on a commercial basis in the long run. In other words, it was hoped that dissemination of the software, its adoption to use and support services would be carried out by cooperatives, ICT and some other organizations, but in a way that would not require financial support from FAO or its project. It was agreed that the research team would develop a strategy to engage the local business ecosystem and the open source community to support the project and thus improve the sustainability and scalability of the software.

In addition, the research team was to assess how the introduction of CoopWorks influences the socioeconomic development of co-operative members, participate in seminars and trainings and help in other ways as agreed during the project. It was agreed that the research team could conduct academic research alongside the project activities, which was seen to support the project in a positive manner.

4.2.2 Action planning

After the follow-up project initiation, the research team proceeded with the first set of activities, which were jointly agreed with the project management. These included a literature review, participating in an inception mission in Kenya and an ex-ante assessment of the socio-economic impact of the project activities. The role of the research team focused around the sustainability and scalability issues of the project, and the use of open source software in capacity development of developing countries.

The objective of the literature review was to draw from theories and ideas in the fields of business management, development studies and information system science. It was agreed that the focus would be on the potential benefits of open source software for developing countries, which was understood to be an important issue for the project, but one that had been the subject of little research at the time. The literature review was carried out in early 2006.

In May 2006, the research team participated on an inception mission in Kenya that aimed to form an understanding of core issues such as the long-term viability of the software project on a commercial basis, decisions made regarding the software technology, training needs, and socio-economic development issues. The research team visited the pilot cooperative, interviewed the key stakeholders of the project, and participated in project meetings. With the help of their background knowledge and gathered data, the research team analyzed the situation and provided the project management with a report that identified challenges, key findings and suggestions for the project. The report focused on issues related to the technology platform choices, the community of users and developers, the business ecosystem, and socio-economic issues of the project.

Based on the results of the inception mission and the advice given by the research team, the project coordinator and the Joint Coordination Committee formulated a detailed project plan regarding project policy and software design. The plan was to rewrite the software emphasizing open source and scalability, moving away from the previous idea of developing a separate “light” version, but rather recreating the original software product. In addition, awareness-raising actions, including seminars and the creation of a website, were planned to grow the business ecosystem and developer community and to further the dissemination of the software. The research team was then asked to conduct further research to support decision-making regarding the further development of the software, especially regarding whether the project should join forces with existing open source software projects. In addition, a training plan was designed with an aim to build the knowledge base of Kenyan actors. This desk research phase took place at the end of 2006 and early 2007.

4.2.3 Action taking

Using the desk research report, the project management made decisions regarding the software and other project issues, and executed the plans. It was decided that the project should stay solitary and that the new version of the software would be developed by a Kenyan software company. The project also decided to introduce the CoopWorks software to additional agricultural

cooperatives in Kenya, so that the software would be further tested in different organizations and so that there would be a larger user base.

The TSE team participated in the action-taking of the project by organizing a training seminar in Finland in the spring of 2007. The objective of the training was to support the project goals by building the knowledge base of the Kenyan business community, non-profit organizations and policy-makers on both business and technology issues. The training seminar in Finland was followed by a dissemination seminar in Kenya, where the experiences of the training seminar were shared with a larger group of different stakeholders and interested parties.

The plan was that the newly built software, which was to make use of a software stack with more open source software, would be easier to use and easier to adopt for use by both agricultural cooperatives and ICT companies, which were to provide support services for the software and even participate in developing the software further. At the same time, awareness-building activities were carried out and materials were produced to support the adoption of the software. Later, the software was also introduced to two more agricultural cooperatives for piloting purposes.

4.2.4 Evaluating

By the spring of 2008, the project had already achieved most of the goals regarding the development of the software itself; a range of different awareness-building events had been organized, and other activities had been carried out. The project was planned to end in summer or autumn 2008 and the continuation of the project's activities were being planned. At this time, the research team had carried out all the agreed activities. At this stage, the author conducted a round of research-motivated interviews, including trips to the FAO headquarters in Rome and to Kenya, in order to evaluate the status of the project, as well as reasons for success and failure.

The results of the evaluation portrayed a multi-faceted image of the success of the project. While the project had managed to redevelop the software and improve its quality, its adoptability and its modularity, the software was only in use in the three pilot cooperatives where it had been introduced by the project. The use of the MMIS had improved the business performance of the pilot cooperatives, but in terms of project scaling and sustainability, the results were not that good.

The author created an in-depth case description of the case project, including a historical chain of events and stakeholder viewpoints. In addition, the author focused on the sustainability and the scalability issues of the case project. Case project data was analyzed according to the action research method, constructing a

filter for critical data from analyzing the situation and its changes, and identifying critical issues and action items in collaboration with the practitioners. The author also used interpretive case study methods, which aimed to critically evaluate the status of the project, by interviewing the different project stakeholders to understand their motivations and to include various perspectives in the case description.

The author and the rest of the research team disengaged from the project after the interview round of the evaluation phase. The remaining project activities were completed by the autumn of 2008 and some follow-up activities, including the development of additional product modules on the system, were started with separate project funding.

4.2.5 Specifying learning

Learning was sought throughout the project by various means. Shared understanding regarding the problem situation and possible action items were continuously developed throughout the project, discussed in meetings, trainings and in other communication points and shared with all key stakeholders through project reports.

Empirical data that was mainly qualitative in nature was gathered throughout the case project in various ways. The research team participated in meetings of the joint coordination committee and other project management meetings, visited the pilot cooperative, interviewed key stakeholders (in many cases, on multiple occasions), observed email communications, participated in discussions, and organized interactive training sessions. The observations and interviews were conducted not only for practical purposes, but in many cases also for research purposes. In addition, the researchers examined related project documentation, studies and websites, and also analyzed the software product. Notes were made of the observations on a daily basis, and interviews were recorded in most cases to increase the validity of the data. Increased validity was sought also by triangulation of data – including various sources of data, various situations where they were collected, and talking to various people about same issues.

In addition to gathering data, the role of the research team was to bring in their expertise as academic researchers and to use academic theories and insights in order to better understand the problem situation and to find solutions to its problems. The research team adopted the soft systems inspired learning method, as discussed earlier in Chapter 3.3, in which learning is sought by using research-based conceptual models as tools for interpreting reality and for designing an intervention. The research team facilitated a dialogue between the problem solving cycle and the research cycle, communicating the conceptual models used

and the insights gained during the project on various points to the academic forum.

This study documents the learning process throughout the case project. The research interest cycle actually began before the author was involved in the case project. Paper I and Paper II included in this study were both written before the case project and they describe the conceptual models that the author and the research team used to analyze the problem situation in the early phases of the case project.

Paper I reports the findings of a piece of conceptual research that was conducted in 2004, in which the characteristics of OSS products were studied and a framework for evaluating OSS products was developed. Paper II reports the findings of a piece of case study research conducted in 2005, in which open source business was studied and a related revenue model framework was developed based on previous research and two business cases. The framework developed in Paper I was used in the CoopWorks project as a conceptual model to analyze demand-side issues of the problem situation. Similarly, the framework developed in Paper II was used as a conceptual model to analyze supply-side issues.

Paper III reports findings from the early phases of the case project. It was written in 2007 after the diagnosing and action planning phases of the case project. Paper III reports on the study as a case study research, as the intervention had not yet been carried out. It summarizes the findings from the early phases of the case project, the key conclusions and suggestions provided by the research team at that point of the case project, the focus being on the technical aspects of the project, and the community development.

Paper IV and Paper V report on the findings of the research cycle after the action taking and evaluation phases of the case project had been conducted in 2008. Paper IV focuses on the capacity development perspective and provides normative insights based on the empirical research in the case project. Paper V, on the other hand, aims to combine both the supply-side and the demand-side perspectives, and offers the most mature case description and analysis. The research presented in Paper IV and Paper V is reported as action research, as the focus was on the intervention made in the case project.

Figure 9 illustrates the sequence and time period of the phases of the action case research, including the preceding research. In addition, it portrays the change of emphasis from soft case research in the earlier phases to action research in the later phases of the research.

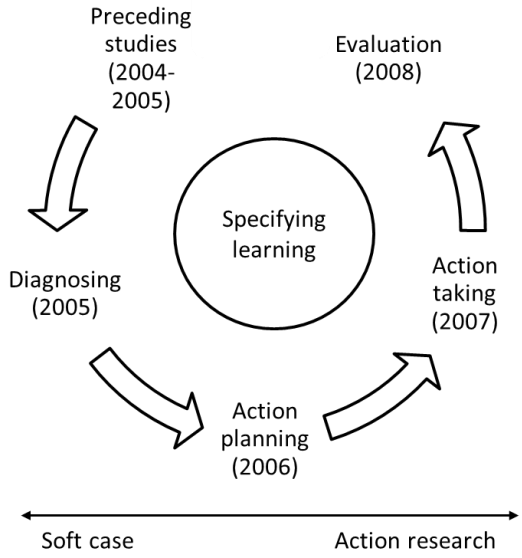

Figure 9: Phases and emphasis of the action case research

Table 3 below summarizes the research papers included in this study, the phase of the research cycle they are reporting learning from, the number and title of the papers, and the content focus of the papers. In addition, the research approach of each paper is explained using concepts by Avison (1997); Cunningham (1997), as described earlier in Chapter 3.4.1. The learning related to each research paper is further discussed in Chapter 5 below.

Table 3: Summary of included research papers

Learning from	**Paper**	**Title**	**Approach**	**Focus**
Preceding studies	Paper I	Evaluating open source software products	Conceptual study	Demand for OSS
	Paper II	Determinants of open source software revenue models	Comparative case study	Supply of OSS
Diagnosing and action planning	Paper III	A quest for business ecosystem for interorganizational open source system	Intensive case study	Analysis of the problem situation
Action taking and evaluation	Paper IV	CoopWorks – A case study on an information system meant to enhance the capabilities of agricultural cooperatives	Action research	Capacity development in the case project
	Paper V	Promises and pitfalls of open source software business in fostering sustainability in ICT4D projects	Action research	Both supply and demand issues in the case project

4.3 Action case research characteristics

As described in detail in this chapter, the research process included elements from both interpretive and pragmatic research. In terms of the methods used, conceptual research, case study research and action research were all used during the whole process, which began in studies preceding the case project and continued until the end of the case project. The research approach portrays the characteristics of action case research, which was discussed earlier in Chapter 3.4. The research process is summarized in terms of the characteristics of action case research in Table 4 below.

Table 4: Characteristics important for action case research, adapted from Braa and Vidgen (1999)

Factor	**Attribute**	**Action case concern**	**Characteristics of this study**
Suitability	Research design	Has a framework of ideas and a methodology been declared?	It was agreed with the project management that the researchers would make use of the theoretical framework founded on open source research and engage in further desktop research and field research in order to provide advice to support the project decision-making.
	Researcher skills	Does the researcher have the skills and experience to make an intervention?	The author had engaged in open source software research for several years by means of conceptual research and case study research, developing initial understanding of the subject of research.
Interpretation	Richness	Is the context of the research rich enough to provide understanding?	The researchers were involved with many issues in the case project, such as technological choices, business models, socioeconomic issues and training, which provided a rich context with plenty of data.
	Focus	Is the research question sufficiently focused?	Whereas the original was to evaluate the overall success of the case project, the focus of the research was shifted to focus on the sustainability and scalability of the case project.
Intervention	Scale	Is the scale of the subject for research manageable?	The research focused on one case project with a limited number of stakeholders and a limited time-scale, which was manageable.
	Participation style	What level of participation can be expected from the organization members?	The researchers interviewed the problem owners, i.e. the joint coordination committee members, about the causes and solutions for the problems. The committee retained the decision-making power.
	Critical impact	Is a critical approach required?	The researchers paid attention to power issues within the case project organization and conducted a study on socioeconomic issues related to cooperative staff and members.

Practicability	Economics	Is sufficient financial support and researcher time available?	The case project funded both the field research and the desktop research. The author was engaged in the research project as a full-time researcher.
	Access	Can access be negotiated with stakeholders?	The project management helped the researchers to organize the field research, including access to cooperatives, software companies, and project stakeholders.
	Politics	Does the research conflict with the organization's politics? Is there sufficient backing for the action and case components?	The research was approved by the joint coordination committee members and was not deemed political as such. However, it is possible that some committee members did not agree with all the researchers' advice due to political issues.
	Control	Can the research project be controlled?	As the decision-making power resided solely with the joint coordination committee, full-scale action research would have been difficult. However, the author focused the research on scalability and sustainability, balancing the motivations of change and understanding.

5 PAPER RESULTS

In this chapter, the findings of the research papers included in Part 2 are reviewed in the light of the framework of ideas, the methodology, and the area of concern. The papers that are included in the study are reviewed, starting with the role and temporal location of the paper in the action case research process. First, the objectives, the research approach, the methods used and the findings of each paper are described. Then the findings of each paper are reflected upon in light of the action case research process, including both the research cycle and the problem solving cycle.

5.1 Paper I: Evaluating open source software products

Paper I improves our understanding of adoption of open source software by the user organizations, therefore also forming a foundation for better understanding of scalability and sustainability from the demand perspective. The research described in Paper I was carried out before the author became involved with the case project and the understanding gained during paper research functioned as a preliminary conceptual model against which the first observations of the problem situation of the case project were made during the early phases of the case project.

5.1.1 Review of Paper I

In addition to individual users and programmers, many companies, public institutions and governmental agencies are involved in using and developing open source software as they are looking for solutions to combat the increasing costs and lacking agility of information systems. The availability of the source code, the right to modify the code and the open source development method create hopes of better software quality, yet it is not always obvious how OSS differs from proprietary software – for example, in terms of total cost of ownership, software usability, or maintainability.

Prior OSS research concludes that there have been many misbeliefs concerning open source software and the concept and its implications often blur with the concept and implications of, for example, Linux, open standards and

shared source. Prior research on information system evaluation, a significant research field in itself, features almost no discussion related to how open source software should be understood and evaluated. There is no comprehensive framework with which to evaluate open source software products or proposed normative approaches for taking evaluating the applicability of OSS into one's information systems.

This paper discusses OSS from the perspective of an IT manager evaluating software products in the application acquisition process. A conceptual research approach is adopted in order to create a preliminary version for a comprehensive framework to evaluate open source software products. The paper focuses on the evaluation of a single software product, as opposed to a complete information system developed in-house or outside an organization, a typical perspective in IS evaluation.

In the paper, frameworks from previous IS evaluation literature and IT infrastructure literature are combined in order to create an evaluation framework. This framework is then adapted to the open source software context by taking into consideration the unique characteristics of open source software derived from OSS licensing and software development methods.

As a result, the paper presents an evaluation framework that may be used to compare open source software with proprietary software, but also to compare OSS products with each other. A normative evaluation approach of the technical, economic and environmental perspectives, as well as the application, infrastructure and organization levels of the proposed framework is further presented.

As a practical contribution, the evaluation approach presented herein may be used by IT managers who are considering OSS products for their organization's information system. As a theoretical contribution, the evaluation framework may be used by researchers to better understand how OSS differs from proprietary software and how OSS projects differ from each other.

The created evaluation framework and the evaluation approach presented thereafter were based on a limited review of previous literature and were based only on conceptual research. They should therefore only be considered as tentative constructions. In order to provide more usable results, a more thorough literature review and validation of the constructions using empirical research methods in real-world organizations are required.

5.1.2 Learning based on Paper I

Paper I focused on open source software from the perspective of user organizations, analyzing which characteristics can be said to be a quality of all

OSS products, and which are dependent on the license used, software development method, or some other feature adopted in the context of the software product in question.

The paper concluded that two features define the nature of open source software and form the core characteristics of such software. The first is the Open Source Definition and the software licensing schemes derived from the definition, which cause all OSS products to have certain qualities, such as the ability to be used without restrictions and modifiability of the software code. The second feature is the open source software development method, which often leads to certain benefits, but which is not used in all OSS projects.

The paper stressed that there are no guarantees that every OSS product would deliver any benefits beyond features derived from licensing, and that characteristics of the software project organization, such as the software development method and the user/developer community, are important in delivering benefits related to OSS products.

The paper adopted a comprehensive evaluation approach, suggesting that decisions to acquire an OSS application in any organization should take the technical properties of the software, the economic circumstances of the organization and the organization's internal and external environment into consideration. Even if the paper focused on the acquisition of a single software product, it proposed that the evaluation should include the application level, the infrastructure level and the organizational level, as all software functions in a context of a technological infrastructure and an organization with processes and human interaction.

These ideas formed the preliminary conceptual model that was used in the action case research process to explore the problem situation. Upon first entering the project setting during the evaluation of the pilot software, the research team began by evaluating the application itself, but also the technology stack including hardware, operating system, and other software components required to run the CoopWorks software, and the requirements related to the user organization, which suggested that several services should be available to support the use of the software. The ensuing evaluation considered the technical properties of the software and the technology stack, the affordability of the software, hardware and services, and finally the environmental requirements, particularly related to the external policies and attitudes of the project's stakeholders.

In the light of this evaluation, it became evident that it was not sufficient for the software product itself to be licensed with an open source software license: the project should incorporate other OSS characteristics in order to be able to make full use of the benefits that are often associated with the OSS approach. It was considered necessary, for example, to pay attention to the software development organization, which so far had not been the target of attention, and

the whole technology infrastructure used. Based on the suggestion made by the research team, more emphasis was then given to developing the user/developer community of CoopWorks. In addition, the researcher team began to analyze the software and hardware requirements and the organizational context of the CoopWorks software, which was considered important for the sustainability and scalability of the software project.

In terms of the sustainability and scalability of OSS use, the paper emphasized that the demand for the software would be dependent on technical, economic, and environmental issues and the "fit" between the software application itself, the IT infrastructure and the user organization. Despite being useful in understanding these aspects of the problem situation and providing insights that helped to plan further actions in the project, the OSS evaluation framework presented in the paper did not take the context of the case project, namely the capacity development of developing countries, into consideration. It became evident that the context would affect the sustainability and scalability of the software project, but it remained unclear how exactly, and how the evaluation approach should be used in this new context. In addition, the paper focused on the perspective of the user organizations, the demand side, and provided limited assistance in understanding the supply side, namely the perspective of the ICT companies.

5.2 Paper II: Determinants of open source software revenue models

Paper II improves our understanding of adoption of open source software by ICT companies, therefore also forming a foundation for better understanding scalability and sustainability from the supply perspective. The research described in Paper II predates the author's involvement with the case project, and the understanding gained during the work on the paper functioned as a preliminary theoretical framework against which the preliminary observations of the problem situation of the case project were made in the early phases of the case project.

5.2.1 Review of Paper II

Since the free software movement reinvented itself as the open source movement, a wide range of IT companies has based their business models partly or fully on open source software. Business models of the providers of proprietary software are typically grounded, in one way or another, on the distribution of access to the use of software-related intellectual property protected by copyright

laws, but as OSS is freely distributable and is typically accessed free of charge, business models based on OSS have to rely on other revenue streams.

Open source software has generally been quite actively studied by scholars from various fields, such as economics, law, psychology, anthropology, and computer science. However, to date the business aspects of open source have so far been the subject of relatively little research, and consequently the profitability and business models of OSS are still poorly understood phenomena. There is no single framework that would explain the potential determinants of firm-level revenue model choices in open source software business.

Paper II utilizes qualitative research methods and the case study approach to establish a conceptual framework considering the business model elements as the determinants guiding and constraining the selection of the revenue model in OSS business. The conceptual framework, which draws heavily on business model research and existing OSS research, is applied in two business case studies to analyze the revenue model choices in the selected OSS business cases, namely MySQL and RedHat, and to study the usability of the framework.

The paper identifies three endogenous business model elements and four exogenous variables that affect the firms' revenue model choices. The identified endogenous determinants include offering, resources and value network. The exogenous variables identified include customers, competing environment, technological infrastructure, and financing environment, each of which affect the business and the revenue model choices of a firm. The revenue model itself is characterized by two dimensions, namely revenue source and cost structure. The case studies confirm the insight that the selection of revenue model is dependent on these other business model elements, and that changes in any of the business model elements may have a profound influence on the choice of revenue model choice.

As a result, the paper establishes a framework, which identifies the endogenous business model elements and exogenous factors that guide, enable and constrain the choice of the firm-level revenue model options in OSS business. The paper contributes to existing business model research by introducing a model that identifies the determinants of revenue model choices. It also contributes to existing OSS research by offering a model to explain how businesses based on open source software may design profitable business models.

The practical implications of the paper drawn from the case studies suggest that profit-seeking firms operating in the OSS field must maintain a balance between their profit-oriented business objectives and the non-commercial principles of the OSS community. The open source business models are in many cases depending on the open source community to develop software in their product offering, for support or for customers. The case studies emphasized the

importance of the licensing arrangements and the relationships with the open source community for viability of the business.

As a limitation of the research, the paper notes that the conceptual framework was used to analyze just two OSS businesses, and further research is called for in order to analyze the influence of various factors through a greater number of cases.

5.2.2 Learning based on Paper II

Paper II adopted the perspective of ICT companies providing OSS-based offerings to the marketplace and analyzed which business model elements and external variables should be considered when designing revenue models for profitable OSS-based businesses.

The paper noted that commercial activity has become increasingly common in the field of open source software and showed that open source software can be attractive for business, especially because companies may take advantage of the free software products and the development efforts of the OSS community. The paper identified many revenue models for OSS-based businesses, which rely on selling services to facilitate OSS use, selling connected hardware, or selling commercial closed applications to use with OSS.

However, the previous research and the case studies also indicated that businesses need to consider the needs and values of both the open source community and the commercial business network as intentions to control the community development may diminish creativity and general interest towards the software project.

The paper adopted a comprehensive business model approach, suggesting that revenue model choices are affected by endogenous business model elements that may be controlled by the company itself, such as offering, resources and capabilities, and value network, as well as exogenous elements, i.e. external factors such as competing environment, technical infrastructure, customers and financing environment. The case studies confirmed that the insight that selecting the revenue model is dependent on the other business model elements, and that changes in any of the business model elements may affect the entire revenue model choice.

These ideas formed a conceptual model that was used in the action case research process to explore the problem situation, particularly from the supply side, i.e. from the perspective of the ICT companies. The comprehensive business model framework adopted from Paper II focused on the sustainability and scalability of the case project, and paid particular attention to revenue generation. The insights gained from the paper research suggested that businesses

based on OSS may indeed be profitable. Therefore, ICT companies were seen as potential partners in marketing and developing the software and providing support services for the user organizations during the planning of the follow-up project.

However, the paper emphasized that the business is sustainable only if the companies are able to generate a valuable offering and appropriate revenue from it. The research team considered it important to work actively with the ICT companies to develop the software itself and the network of companies, so that the companies could be able to design profitable business models.

Based on the recommendations of the research team, the project began to educate interested ICT companies about CoopWorks software and its possibilities, and began discussions with the companies about the endogenous elements of the business model framework, such as the value proposition, the value network, required resources and the revenue model.

While the paper included both conceptual research and empirical research in the form of a case study approach and thus provided a more tested framework of ideas to be used in the action case research process, the adopted approach had one major limitation.

The paper discussed open source phenomenon using the concepts of business models and revenue models, which are traditionally used for examining the business behavior or business opportunities of a single firm. However, in the case project the focus was on designing an approach to develop a network of business actors to support the development and marketing of CoopWorks software. The perspective in the case project was therefore on the level of a group of companies and not on an individual company.

In the case project, the business model and the revenue model concepts were used to examine the sustainability of the CoopWorks project and the profitability of unspecified ICT companies that share a similar environment and the same software product as the basis of their offering, but which may differ in terms of the other elements of the business model. In the terms used in the paper, the companies shared similar exogenous elements (competing environment, technological infrastructure, customers, and financing environment) and the same technology and licensing of the software product offering, but may have differed in value proposition, organizational and managerial capabilities, value network and the revenue model.

While the business model framework proved to be a suitable tool with which to analyze the business opportunities related to CoopWorks and to plan the business operations with the ICT companies, it still remained unclear how profitable business based on CoopWorks would turn out to be and therefore also how sustainable and scalable the software project itself would be on the level of a network of business actors. Again, the context of the case project, the capacity

development of developing countries, was something that was not taken into consideration when developing the business model framework, and it was unclear how this would affect the usability of the framework. Later in the action case research process, the hypothesis that changes in any of the business model elements would significantly affect other elements would also be studied in more detail.

5.3 Paper III: A Quest for Business Ecosystem for Interorganizational Open Source System

Paper III contributes to our understanding of choices regarding OSS technology and how those choices in the case project influenced the adoption of the technology by various stakeholders. The paper was one of the first endeavors of the research team to discuss the case project subject to the action case research process in an academic forum. The research team used the conceptual models from Paper I and Paper II to analyze the problem situation in early phases of the case project. Paper III was authored after diagnosing and action-planning phases of the case project were conducted.

5.3.1 Review of Paper III

Many developing countries and software projects in developing countries choose to use open source software for political or economic reasons, as OSS licensed software is often cheaper and as the software development process, being based on values of openness and sharing, is attractive in itself. Traditionally, OSS projects are founded by voluntary individuals who develop software to solve their own problems and more commonly also by commercial actors wishing to profit from using OSS. However, especially in the context of developing countries, some OSS projects are publicly funded, aiming to solve the problems of a particular group of beneficiaries and typically including developers and stakeholders from various organizations, i.e. interorganizational software projects.

Although there is a relatively large amount of literature on OSS project management, the studies discussing OSS in the context of developing countries is limited and there is very little research on publicly funded interorganizational OSS projects. The paper studies management and business issues of interorganizational OSS projects in the developing country context with the aim of providing normative guidelines for researchers and practitioner engaging in such projects. It draws on existing OSS literature and presents an exploratory

case study in a developing country context by applying qualitative methods, multiple sources of evidence and participatory observation.

The case study concerns a donor-funded project which aims to enhance the capacities of agricultural cooperatives and producer organizations in developing countries through developing and disseminating a management and member information system based on open source software. The paper describes the background and mission of the project, the technology choices, and the role and aims of the research team in the project. The primary aim of the research was to collect information and form an understanding of the long-term viability of the project on a commercial basis, and to understand how the technological choices may affect the project outcome and its sustainability.

The paper discusses many management issues related to the capacity development of developing countries. It uses the concept of a business ecosystem to describe the situation where a network of both commercial and non-commercial stakeholder organizations is needed to provide support services for the information system uptake and use and to analyze the problematics of the situation. The paper also addresses the viability of OSS business in the context of developing countries and concludes that the choices related to the technology have severe consequences in relation to the business ecosystem and the business models.

The paper presents only the initial findings of a single case study and the generalizability of the normative guidelines is discussed, noting that the research team has found the findings useful also in other contexts.

5.3.2 Learning based on Paper III

Traditionally, open source software is developed to solve problems affecting the programmers themselves and, increasingly, is based on commercial motivations. The paper focuses on the third alternative, when open source software is developed with public funding in order to solve problems of a third party, where high impact of the software and financial sustainability of the project are important issues.

The starting point of the paper was that there was a recognized need for the OSS-based information system that was being developed and that introducing computers and the information system to the pilot cooperative brought real benefits and success for the cooperative. As the software itself was considered useful, it was important to address the sustainability issues of the project.

The paper describes the aims of the problem solving cycle, the most important being the assessment of the long-term viability of the project on a commercial basis, as the public funding would not be enough to market, introduce and

support the software use. The paper presents the idea of a local business ecosystem of public and private organizations that would each provide different services to support the aims of the CoopWorks project based on their own organizational agenda. The paper emphasizes that, in a business ecosystem, the organizations would not necessarily only compete with each other, but that a business ecosystem is bound to have win-win and lose-lose situations. The cooperatives, for example, would benefit from the birth of commercial activities based on the CoopWorks software, and therefore the interest of the cooperatives and the local ICT entrepreneurs would be largely similar.

In the case project, the commercial activities of the private organizations could not be based on traditional license fee based revenue models as the CoopWorks software was licensed with an OSS license. However, the paper refers to the range of open source business models that would available for use. The paper also discusses the potential benefits of the open source approach for commercial actors, including the fact that OSS licensing allows the growth of development communities to develop and support the software and increased adoption rate of the software by users, which would lead to a larger base of potential customers.

Even if the CoopWorks project was not established as a traditional open source software project using the open source software development method, the paper mentions the possibility of building a developed community to support the software development, which would bring several benefits such as involving innovative new developers, allowing free development of new modules, a potential increase in code quality and improved involvement of users. However, the paper stressed that the growth and activity of such a community is not easily attained, and it would require leadership and much work.

Another aim of the research process mentioned in the paper was to form an understanding regarding the technological choices, and how these choices would affect the goals and the sustainability of the project. The use of CoopWorks software developed in the pilot project required many expensive proprietary software components, which was not only expensive for the cooperatives, but which could cause the development effort to fragment into several subprojects using different technology platforms for the CoopWorks software. The paper suggested therefore studying the possibility of developing a platform independent version or a version that would be based on open source software. Such a change would allow a larger user and developer community, since adopting CoopWorks would not require certain expensive software components to be used.

The paper discusses the disadvantages of proprietary software dependence for developing countries, such as diminished adoptability due to high costs and inflexibility, and piracy issues, and supports the implementation of platform independent or OSS-based solutions, which allow adoption to a variety of needs. In general, the paper emphasizes the importance of the developer community in

publicly funded interorganizational OSS projects. It suggests strategies such as avoiding the fragmentation of the developer community and "productization" activities, for example producing guidelines and developing investment processes, in order to increase the community size and activity level. The involvement of governmental, non-governmental and business organizations is considered important, and encouragement of all related business activities is supported.

These normative guidelines mentioned in the paper were used to advise the project management of the CoopWorks project about supply-side perspective, namely the business development issues and technological choices. The project management took decisions based on this advice during the second implementation phase and the results were evaluated in the final evaluation phase of the project. The results of the evaluation are reported and discussed in papers IV and V.

5.4 Paper IV: CoopWorks – A case study on an information system meant to enhance the capabilities of agricultural cooperatives

Paper IV contributes to our understanding of project context in scalability and sustainability of ICT4D projects using OSS and how scalability and sustainability were managed in the case project. Paper IV was in effect the second endeavor to discuss the case project on an academic forum. It builds on the understanding gained from Paper III and its limitations. Paper IV was written shortly after the action taking phase had been carried through and the author had conducted the interview round related to the project evaluation. The research paper includes a more thorough description of the case study, but offers a rather limited analysis, which was further improved in Paper V.

5.4.1 Review of Paper IV

Developing countries face many problems: poverty, hunger, diseases, environmental disasters and other issues, such as inequality, corruption, prohibition of association or self-expression, and a lack of educational infrastructure. The discourse about the goals of development refers to the efforts to address these problems. Answering to basic needs equals surviving and coping with day-to-day life. Answering to the strategic needs, on the other hand, is synonymous with capacity development: finding solutions to strategic needs means building capacities to achieve the future needs.

Many global development organizations, such as the FAO, are using ICT as part of their technical development cooperation. ICTs can aid in capacity development by providing possibilities for organizations and companies in developing countries. Though ICTs alone are not an answer to the problems developing countries are facing, ICTs can be used as tools for addressing the development goals on the strategic level.

Development cooperation is frequently criticized for being ineffective and capacity development projects are often deemed to be undermining local capacities, yet there has been a multitude of research on information system adaptation and investment successes, less on failures and recovery. Paper IV presents a case of publicly funded open source software (OSS) project aiming for capacity development in Kenya and other developing countries. The case study provides first-hand experiences on how open source software may be used in capacity development, as well as experiences on the challenges such a venture may face.

The paper aims to pinpoint key challenges in capacity development in the context of the presented case study and to illustrate the importance and the challenges of adopting open source software in capacity development. Qualitative empirical data was gathered with interviews and observations and used as a descriptive case study, but as the research process also included researcher involvement, the research approach could be described as action case research.

The paper builds on a brief literature review on capacity development, its goals and how ICT can potentially help in capacity development. It elaborates on the key challenges in capacity development in the context of the presented case and discusses the successes and failures of the case project.

The case suggests that, while ICTs and OSS are generally seen as beneficial in reaching development goals and addressing some of the crucial problems in capacity development, in practice the application of ICTs and OSS may be problematic, especially if the project uses a top-down, hierarchical approach or if it is subject to a technology “fetish” (cf. Heeks (1999). The case project could be considered a success as a pilot project and indeed many benefits were derived from ICT to the beneficiary organization. However, from the capacity development perspective it was largely a failure, as too much emphasis was placed on technology and project management and too little on the actual needs of users. As a conclusion, the paper presents a number of challenges that may be faced by capacity development projects using ICT and OSS, based on the literature review and reflected on through experiences gained from the case study.

5.4.2 Learning based on Paper IV

As Paper IV was authored after the evaluation phase, it focused on evaluating the case project. As the case project was a capacity development activity, in the paper, the success of the project was measured against a framework of capacity development. The paper discusses the general capacity development approach, the rationale of using ICTs in capacity development and using open source software in particular. The case project was then evaluated against these three perspectives.

In essence, the paper concludes that the project could be defined as either a success or a failure depending on the perspective. The pilot cooperative and its members were happy with the results, but on the other hand, the project barely benefited other cooperatives. The project succeeded in producing a robust software product for the information system, which was the main objective of the project, but not in scaling the project to reach critical mass of users and developers and a business ecosystem, which was important for the sustainability of the project goals.

The use of ICT in capacity development was clearly promising and the use of open source software addressed many of the problems that traditional development cooperation projects are criticized for, as by using OSS the ownership of the development agenda and its means were planned to be given to the beneficiaries. However, the project still embodied characteristics of top-down decision-making, technology orientation and waterfall-type planning, which contributed to the project's modest success. While the project defined the agricultural cooperatives as main beneficiaries of the project, much attention was paid to producing the project target, the software, and to its stakeholders, rather than focusing on the needs of the cooperatives. Using OSS did not solve the challenges related to the cooperatives, namely their ability to invest in the information system in terms of both skills and capital, even if its use was justifiable on other terms. The conclusion was that the low costs and high adoptability of OSS do not ensure scaling of the technology if other related costs are too high, thus contributing to decreased sustainability.

The paper analyzed the project's success against the capacity development framework, focusing on the demand-side perspective and the cooperatives. This perspective was broadened in Paper V to include both the demand-side and the supply-side perspectives and discussing in detail the sustainability and scalability issue.

5.5 Paper V: Promises and pitfalls of open source software business in fostering sustainability in ICT4D projects

Paper IV contributes to our understanding of project context in scalability and sustainability of ICT4D projects using OSS and how scalability and sustainability were promoted in the case project. The paper draws from the whole action case research process and was authored after the evaluation phase of the case project, when the active participation of the research team to the project's activities had already ended. The paper offers the most detailed and mature description of what happened in the case project, developing further ideas related to the success of the case project that were introduced in the previous papers and also introducing new perspectives related to the role of the private sector in capacity development projects. However, the paper findings were not used in the case project as such due to the project having already ended and the findings were presented to the academic audience only for the purpose of learning about the studied subject.

5.5.1 Review of Paper V

While the intention of development cooperation projects is to have a long-term impact and capacity development of developing countries, the projects often face significant challenges in scaling up the development effort. The issue of scaling is particularly important in ICT4D projects, where the development impact of the intervention is often larger as more people use or are influenced by the use of a technology. Another important objective in ICT4D projects is financial sustainability, mainly because of the large amount of financial resources needed to develop, implement and support information and communication technologies in the long run.

Previous research on development informatics has recognized the importance of scaling and financial sustainability, but has so far failed to provide answers as to why ICT4D projects typically produce mostly unused and unsustainable pilot projects. Concepts such as public-private partnerships and Bottom of the Pyramid (BOP), which have gained popularity in capacity development discussion as the importance of the involvement of the private sector has been acknowledged in the general paradigm shift in development cooperation from social engineering toward helping self-help, have been proposed as possible solutions, but research has not yet shown their impact on the sustainability of ICT4D projects.

Paper V studies the sustainability challenge by means of action research in a capacity development project, where open source software and open source based business models were used as means to facilitate the adoption and

financially sustainable scaling of the information system by the users and service providers alike. The project developed a software product, which was licensed with an open source license in order to increase its adoption by cooperatives, and sought to build a public-private partnership based network with local software entrepreneurs to market and support the software.

The paper builds on previous development informatics research, open source software literature and studies on the role of the private sector in development projects, aiming to contribute to the understanding of the problems of scaling and financial sustainability in ICT4D projects. Experiences gained from the case project suggest that, while the promises of open source software and open business based public private partnerships have been identified by researchers and practitioners alike, in practice such enterprises in a development context are prone to severe challenges due to the low purchasing power and lack of knowledge of the intended beneficiaries.

As a result, the paper provides a better understanding of the role of open source software and OSS based business models as means to improve the scaling and financial sustainability of ICT4D projects. It confirms the promises offered by these means, but emphasizes that the lack of resources on the demand side and the lack of profits on the supply side are difficult problems to solve in the context of capacity development of developing countries while the project form imposes additional challenges to the capacity development efforts. Therefore, the paper concludes that OSS and OSS based business are not silver-bullet solutions that could automatically solve development challenges.

The findings of the paper are made in the setting of the case project and in the context of capacity development of developing countries in general, and the applicability of these findings to other settings is subject to debate. Further analysis on the importance of these findings and the generalizability of the results are to be addressed in future research.

5.5.2 Learning based on Paper V

Paper V included both the demand-side and the supply-side view, i.e. both the user organizations' and the service provider organizations' perspectives in studying the fostering of sustainability and scalability in ICT4D by means of open source software and OSS based business models. The paper describes how the long-term impact of ICT4D projects is influenced by the financial sustainability and the scaling of the project's activities. In addition, the paper mentioned that as scaling of an intervention is a prerequisite for sustainability of local action and furthermore that local action cannot be scaled if the intervention

is not properly resourced, scaling and financial sustainability are intertwined in ICT4D projects.

The paper emphasized the importance of scaling information systems to cater for other organizations beyond pilots and establishing a network of public and private sector organizations to provide services for the user organizations. However, the paper concluded that the case project did not reach its objectives regarding scaling and financial sustainability as on the demand side too few cooperatives adopted the software for use and on the supply side too few companies were offering services for the software users.

The project did succeed in developing the software and in gathering positive experiences from three pilot cooperatives. However, the project failed to widen the user base. This was partly explained by the underdeveloped state of the dairy cooperatives, which made investing difficult. Ironically, this was also one of the original motivations to start the computerization initiative. Another reason for the failure was the fact that a low number of customers did not attract service providers and in turn the low number of service providers was partly responsible for the low number of customers. However, with more time and resources, the critical mass of clients and providers could have been reached, but as the project was limited with both, the results were suboptimal.

The findings of the paper stress that while OSS based business models may solve some financial sustainability issues in capacity development, the sustainability and scalability of the project may fail due to development challenges on both the users' and the service providers' side. Therefore, both the demand-side and the supply-side issues should be addressed hand-in-hand.

6 DISCUSSION AND CONCLUSIONS

In this chapter the results of this study, which are based on the papers briefly presented in the previous chapter, are discussed in the light of prior research reviewed in the earlier sections and summarized in concluding thoughts: contributions of this study to both research and practice, as well as its limitations and ideas for future research.

6.1 Discussion

The overall objective of this study was to increase understanding of the use of open source software in capacity development of the developing countries, with a specific aim to study scalability and sustainability of ICT4D projects using OSS. The study proposed the following Research Question (RQ): *How to promote scalability and sustainability in ICT4D projects using OSS?* In the discussion that follows the aim is to provide an answer to this question in light of the prior research and the findings from the action case research process, which were described in the papers and summarized earlier in this study. The chapter begins by defining the problem of scalability and sustainability in detail in order to better understand the nature of the issue under study. The chapter continues by focusing on those elements identified in the action case research process as influencing scalability and sustainability in order to better understand what happened in the case project. Finally, the role of OSS in solving the scalability and sustainability problem is assessed, reflecting on the experiences from the case project against prior research and the presented framework in order to provide an answer to the Research Question.

6.1.1 Defining the problem of scalability and sustainability

What is the nature of scalability and sustainability problem in ICT4D projects? Both concepts have received attention from various development informatics researchers, who have addressed central challenges of ICT4D projects. The importance of scalability has been addressed by, for example, Wade (2002), Avgerou (2008) and Walsham and Sahay (2006). The importance of sustainability, on the other hand, has been underlined by, for example, Wade

(2002), Heeks (2002), Avgerou (2008), Braa et al. (2004), Kleine and Unwin (2009), Câmara and Fonseca (2007). Ali and Bailur (2007) problematized the concept of sustainability, arguing that it might be impossible to define what may be essential for sustainability. They also questioned the rationale of sustainability overall, as conditions are rarely permanent or controllable. Yet Heeks (2008, 2010) claimed that sustainability and scalability are issues that have to be addressed because so many ICT4D projects have failed to deliver results, survive and reach a large number of people.

To define the scalability and sustainability problem, this section provides a detailed explanation of why scalability and sustainability were important in the case project and how the papers elaborate the problem.

In this study, the focus on scalability and sustainability arose from main challenges of the case project. Paper III provides a description of these challenges and illustrates the nature of the research problem. The main challenges, as identified by the project, were the dissemination and adoption of the CoopWorks software by users, developers and local ICT companies, and the formation of a network of both commercial and non-commercial organizations that would help in developing, supporting and marketing the software. As the project donor was to finance the activities with a limited budget and for a limited period of time, the long-term viability of the CoopWorks project on a commercial basis was deemed a central issue in overcoming these challenges. As such, the case project provides additional evidence of the importance of sustainability in ICT4D projects. It particularly underlines financial sustainability as the central challenge, echoing the findings of Ali and Bailur (2007) and Kuriyan et al. (2008), among others.

The case project also provides additional evidence of the importance of scalability, which Avgerou (2008), for example, identified as one of the major problems in ICT4D projects alongside financial sustainability. Paper IV points out that even if ICT4D projects may succeed as a pilot and reach certain goals without large-scale adoption of the technology, from the capacity development perspective the project's level of success is evaluated against the number of users and service provider organizations that benefit from the technology. In effect, paper IV suggests that scaling is necessary for ICT4D projects, if and when capacity development is considered a central objective of the project.

The connection between financial sustainability and scalability has been brought up by, for example, Walsham and Sahay (2006) and Hosman and Fife (2008), but the nature of this connection has not been elaborated on in prior research. This issue is discussed in Paper V, which based on the case project concludes that financial sustainability is a prerequisite for scalability, as the dissemination and adoption of the technology requires financial resources. Paper V also concludes that scalability is a prerequisite for financial sustainability, as

the adoption of the technology by both user organizations and the service providers was dependent on the critical mass of demand and supply. The notion that scalability is a prerequisite for sustainability was earlier proposed by Braa et al. (2004). They referred to scaling as establishing networks to facilitate learning processes and emphasized the institutional sustainability, using the terms introduced by Ali and Bailur (2007), of the action oriented research itself. This study, on the other hand, emphasizes the financial sustainability of ICT4D projects, and refers to scaling as a necessary means to build a critical mass of supply and demand of the technology. In addition, this study introduces the notion that when financial resources are needed to disseminate and use the technology, financial sustainability and scaling are two challenges that are deeply intertwined with each other.

Another notion that arises from the action case research process is related to the subject or the focus of sustainability. In prior research, for example Heeks (2002) and Avgerou (2008) talk about sustainability failure of information systems projects, while Câmara and Fonseca (2007) discuss the sustainability of software projects and Hosman and Fife (2008) discuss the sustainability of ICT projects. The research related to CoopWorks gives us reason to question whether the sustainability of the project itself is the main issue. The case project suggests that it is the sustainability of the technology's use by user organizations and the related service provision by ICT companies that matters. In other words, this study suggests that the challenge of sustainability relates to the sustainability of the technology use and the sustainability of the business ecosystem, which was necessary for the technology adoption on a larger scale. It is not suggested that the researchers mentioned above refer to sustainability of the project alone, but rather it is suggested that the choice of words may affect the focus of both academic research and ICT4D activities, and therefore one should take care to acknowledge the correct terms are used in each case.

6.1.2 Elements influencing scalability and sustainability

The previous section discussed the nature of the scalability and sustainability problem, underlining their interrelation and their importance in ICT4D projects. But what concepts and frameworks can one use in promoting scalability and sustainability? The research interest cycle of the action case research process produced a number of papers, which were presented in this study in the order in which they were written. Each of the papers discusses concepts and frameworks that were used in promoting the sustainability and scalability of the case project. These elements are reviewed here in order to establish a framework that can be

used as a conceptual model in promoting scalability and sustainability in ICT4D projects using OSS.

Paper I improves our understanding of the adoption of open source software by the user organizations, therefore also forming a foundation for a better understanding of scalability and sustainability from the demand perspective. The paper presents a comprehensive framework of OSS evaluation, which suggests that OSS applications should be evaluated against technical properties, economic circumstances and both the internal and external environment. Applying this framework in the action case research process suggests that these elements influence the adoption of OSS in user organizations, which in turn influences the demand of the technology and therefore the scalability and sustainability of ICT4D projects using OSS.

Paper II improves our understanding of the adoption of open source software by ICT companies, therefore also forming a foundation for a better understanding of scalability and sustainability from the supply perspective. The paper presents a comprehensive framework for analyzing revenue models in businesses using OSS, suggesting that certain endogenous and exogenous business model elements guide, enable and constrain the revenue model choices of ICT companies involved in OSS-based business. The endogenous business model elements that may be controlled by the company itself included the offering, resources and capabilities, and the value network, whereas the exogenous elements included external factors such as the competing environment, technical infrastructure, customers and financing environment. The application of this framework in the action case research process suggests that these elements influence the adoption of OSS in ICT companies providing services, which in turn influences the supply of the technology and therefore the scalability and sustainability of ICT4D projects using OSS.

Paper III contributes to our understanding of the choices regarding the OSS technology itself and how those choices influence the adoption of the technology by various stakeholders. The paper proposes that a business ecosystem of non-commercial and commercial organizations is the key in diffusing the OSS product and providing services supporting its use, when no single organization is capable of doing this independently. Furthermore, the paper suggests that the viability of the business ecosystem relies on effective use of the OSS-based business models and technology choices regarding architecture, including versioning and modularity, licensing of the OSS product and properties of the technology stack. The action case research suggests that these technology choices influence the adoption of the software by user organizations and ICT companies, which form the foundation of the business ecosystem, and the long-term development prospects, and therefore the scalability and sustainability of ICT4D project using OSS.

Paper IV and Paper V both contribute to our understanding of the project context in scalability and sustainability of ICT4D projects using OSS. Paper IV discussed the use of ICT and OSS against the capacity development framework and proposes that, while the OSS approach promotes the transfer of the development agenda to local actors, the use of OSS does not automatically solve problems of donor-centric development projects, which in the case project was one reason for the beneficiaries' needs being overlooked. Overlooking these needs negatively influenced the adoption of the technology by beneficiaries, i.e. the cooperatives, which, the paper argues, would have been a prerequisite for the success of the case project from the capacity development perspective. Paper V, on the other hand, focuses on the relation between financial sustainability and scalability and discusses the difficulties of reaching the critical mass of users and service providers – as is required for scaling in a financially sustainable manner – when the project has limited time and resources. In essence, Paper V underlines the challenges of the project as an organizational form and, together with Paper IV, suggests that the characteristics, resources and goal-setting of the project itself influence the manageability of the scalability and sustainability challenges of ICT4D projects using OSS.

Jointly the elements discussed in the papers form a conceptual model of elements influencing scalability and sustainability of ICT4D project using OSS. This conceptual model is depicted in Figure 10 below.

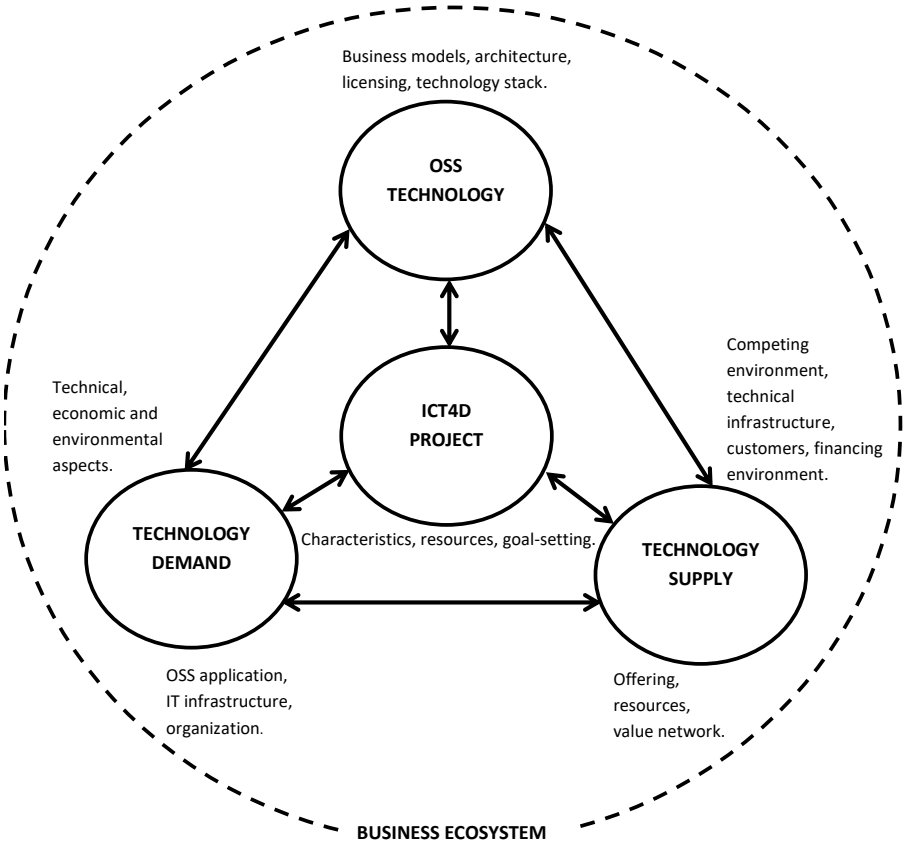

Figure 10: Elements influencing the scalability and sustainability of ICT4D project using OSS

As discussed and depicted in Figure 10, in the CoopWorks project, scalability and sustainability were influenced by the demand for the technology, the supply for the technology, the OSS technology itself and the project context, which together form the foundation for the business ecosystem, which was considered necessary for scalable and sustainable capacity development using OSS. In the following section, this conceptual model is used to further analyze how the promotion of scalability and sustainability was managed in the CoopWorks project.

6.1.3 Promoting scalability and sustainability using open source software

Earlier in this chapter, the nature of the scalability and sustainability problem was discussed and a conceptual model of the elements influencing scalability and

sustainability was derived based on what was learned from the CoopWorks project. This section builds on this understanding and discusses how the CoopWorks project succeeded in promoting scalability and sustainability using OSS.

One of the starting points of the case project was that licensing the software with an open source license and adopting other principles of the open source approach would have a positive impact on the scalability and sustainability of the project's activities. The reasons for using OSS in the case project reflect those mentioned by, among others, Câmara and Fonseca (2007), that point to being less dependent on technology vendors, to promoting local knowledge creation and to the lower costs deriving mainly from the lack of licensing fees. Furthermore, in the case project, the hopes that small local ICT companies would start providing services to support the use of OSS were emphasized, echoing the possibilities mentioned by Kleine and Unwin (2009) and Ghosh (2003).

However, as Paper III, Paper IV and Paper V explain in detail, while OSS was seen as contributing to scalability and sustainability, the use of OSS did not provide definitive answers to the problems of scalability and sustainability. At the end of the project, a small number of cooperatives used the technology and a small number of ICT companies provided services to support its use. Cooperatives needed financial support from the project, because adopting and using the technology was considered expensive. While the project managed to develop the technology and the cooperatives using the technology benefited from its use, the project did not manage to scale the technology use significantly or to secure its long-term sustainability. The project may therefore be considered a *partial failure*, as discussed by Heeks (2002).

Paper IV and Paper V name several reasons for the low demand of technology, including high price of the investment, lack of support services and lack of resources and expertise in the potential user organization. How did the use of OSS influence the demand of technology? The potential user organizations did not perceive additional value in OSS licensing in itself. However, the general view in the case project was that the total cost of ownership was lower using OSS than by using proprietary software, due to the lack of licensing fees. Still the cost of the investment was considered too high by many of the potential users of CoopWorks. This implies that the use of OSS may not be used as a "silver bullet" solution to cost-related issues.

On the contrary, the case project suggests that service prices may have been higher due to the scarcity of OSS-related skills in the local ICT industry, thus implying that the use of OSS may also have a negatively effect on the total cost of ownership. These finding support the notion put forward by Byrne and Jolliffe (2007) that assuming that OSS is the best fit for developing countries on the basis of it being less expensive is a perilous one.

The experience from the case project echo the findings by Goode (2004), who reported that Australian firms reject OSS for similar reasons, such as problems in the support services and little perceived value in OSS in itself. Though one must remember that the context of this project was fairly different: the user organizations did not have much experience in using information systems and they were relatively poorly resourced.

Paper IV and Paper V discuss reasons for the low supply of technology, which included limited profit generation possibilities due to the limited financial resources of the clients and the limited number of interested clients in general. This resulted in the ICT companies considering other businesses to be more attractive. How did the use of OSS influence the supply? OSS licensing was used to enable the ICT companies to freely develop and offer services to support the use of CoopWorks, but in this case, it was not enough to boost supply.

Paper V identifies two major issues that further explain the challenges in promoting scalability and sustainability in the case project. Both of these issues are a form of negative feedback loop and it is suggested that they contributed to the lack of both supply and demand of the technology, which undermined the creation of the business ecosystem deemed essential for scalability and sustainability of the technology use. In essence, they are examples of "endemic problems [that] hinder both the completion of IS innovation initiatives and the realization of their expected benefits", as Avgerou (2008) described the challenges in the developing country context.

The first negative feedback loop existed because few clients with limited resources lead to the market not being attractive to the service providers, the ICT companies, while few service providers in the market lead to the technology not being attractive to the client, the cooperatives. Paper V calls this negative feedback loop a "vicious circle of low penetration", adopting the notion put forward by May (2006). However, while May considered network externalities and lock-in effects related to compatibility to be underlying reasons for this vicious circle, this study suggests that the investment capabilities of the user organizations, the cooperatives, was the main source of friction.

The second feedback loop also relates to the investment capabilities of the cooperatives. Paper V explains that the inability of the cooperatives to make investments due to their underdeveloped state was one of the major reasons for starting the development initiative promoting the computerization of the cooperatives, which in turn lead to the creation of the CoopWorks software. However, as noted above, the inability of the cooperatives to invest also meant they were unable to benefit from the development initiative that created the CoopWorks software. This study therefore suggests that is it difficult to break the vicious circle of underdevelopment by means of ICT4D projects.

In summary, despite the success of the project in developing a usable software product and in improving the state of the pilot cooperatives and their members, the project may be considered a partial failure due to its limited success in promoting scalability and sustainability. Evidence from the case project implies that OSS may be used in creating a business ecosystem to support the use of the technology on a commercial basis in the long-term: OSS licensing enables ICT-companies to provide services to support the use of the technology and the lack of licensing fees lowers the cost of the technology investment. However, using OSS was not sufficient to boost supply and demand enough to break the vicious circle of low penetration in the case project.

The lesson learned is that OSS technology itself is just one element that influences the scalability and sustainability of ICT4D projects. OSS may play a part in promoting sustainability and scalability, laying the foundation for demand and supply of technology and for the whole business ecosystem, but OSS may not be enough to solve issues in the demand or the supply of technology. The evidence from the case project suggests that shortcomings in any of these elements – in this case deriving mostly from the underdeveloped state of the user organizations that undermined the technology demand – compromise the performance of the whole business ecosystem.

6.2 Contributions to research

Prior research has studied open source software and development informatics extensively, providing a good view of both from several perspectives. The field of open source software research has focused mainly on three perspectives: (1) motivations of open source software contributors; (2) governance, organization and the process of innovation in open source software projects; and (3) competitive dynamics enforced by open source software. The field of development informatics research has studied development from the following three perspectives: (1) modernization; (2) dependency; and (3) human development.

The issues of scalability and sustainability of ICT4D projects using OSS has been touched upon to a certain degree by both fields. The scalability and sustainability problem has been identified in prior development informatics research as being one of the central problems in ICT4D projects. However, prior research does not provide much insight into why scalability and sustainability problems persist, how these challenges may be studied or how they could be managed in ICT4D projects. While general OSS research touches on many issues that are relevant for scalability and sustainability issues, the majority of OSS research has focused on studying OSS projects in the developed countries

originating from developer communities or from for-profit enterprises and, as this study also suggests, they have limited value in the context of OSS projects initiated by development cooperation organizations in developing countries. The field of research that focuses on OSS in developing countries usually adopts the macro-level perspective and therefore provides a limited view on sustainability and scalability issues from the micro-level perspective of ICT4D projects. The potential of open source in capacity development has been discussed, but prior research has provided little evidence to support this notion. The issue of how open source software promotes scalability and sustainability in ICT4D projects has barely been touched upon, while both research and practice view the potential of OSS in a positive manner.

This study is based on the review of prior literature in the field of open source software research and development informatics and an action case research, where insights from prior research were utilized in the context of a case project. While it is not claimed that the findings of this study stemming from the case project could be directly generalized into other project contexts, the research process contributes to the fields of open source software research and development informatics in several ways.

Firstly, the study focuses on open source activities that have been rarely studied in prior research: namely an OSS project, which was initiated by an international development cooperation organization in order to further the capacity development of developing countries. The findings of the study suggest that the characteristics and the context of the OSS project are important elements in applying and carrying out research in this field. In the case project, the focus was not on motivating software development, managing the innovation process or the competitive dynamics among technology providers, but rather in the adoption of the technology by user organizations and service providers, which was identified as being a crucial issue for the sustainability and scalability of the capacity development activity. While sustainability and scalability have been highlighted as important challenges in development informatics research, to date they have not received much attention in OSS research. The study suggests that OSS research should continue to improve its context sensitivity and acknowledge the variety of OSS projects that exist beyond the archetypes of community-controlled and company-sponsored projects.

Secondly, the study contributes to research that focuses on OSS in developing countries by adopting the micro-level perspective of a capacity development project, which has so far been a rarely adopted perspective. Research adopting the micro-level perspective is important not only because it may be applied to capacity development practice, but also because studying the actual use of OSS in a capacity development project reveals that OSS as a solution in the developing country context has its challenges. This possibility has often been

ignored in prior research, which often discusses OSS as a potential solution to a series of challenges in developing countries in an overly positive manner.

Thirdly, the study contributes to development informatics research by providing an alternative point-of-view to the ICT4D project failure discussion. This study supports the notion that whether a project is deemed a success or a failure depends on the perspective taken, but at the same time, the findings of the study highlight the importance of sustainability and scalability in reaching the capacity development objectives of the case project. The study also emphasizes that sustainability and scalability of the ICT4D project itself is not the most critical issue, but rather it is the sustainability and scalability of the use of the technology, rather than the project itself, that ultimately impacts capacity development. Being clearer about the focus of research could improve conceptual clarity and reduce the risk of misinterpretations.

Fourthly, the study elaborates on the issues of scalability and sustainability, which have been identified as major challenges in prior development informatics research, but which have not yet been studied to a larger degree. The study presents a case project where the issues were identified as critical challenges, defines the scalability and sustainability problem in the context of this project as a critical challenge related to the adoption of the technology by users and service provider organizations, identifies elements which influence scalability and sustainability, and provides insights into the role of OSS in solving the sustainability and scalability problem. Thus, the study provides conceptual tools, which may be applied to future research on the sustainability and scalability of ICT4D projects.

6.3 Contributions to practice

As the research fields that this study is based on, development informatics and open source software research, are both very close to practice and also aim to provide concrete solutions to pragmatic problems, it is natural that this study also has implications for practice. One of the starting points of the study was to apply conceptual models from research in the context of the case project by means of action case research. Therefore, the study contributes to practice by improving understanding of how the results of both research in development informatics and open source software research may be applied in practice and in solving pragmatic problems.

For managers of OSS projects that wish to extend the use of their technology to developing countries, but who are not aware of the particularities of the developing country context, the study provides insights as to what may be the barriers of adoption by user organizations and service providers. In addition, the

study emphasizes that the applicability of research-based insights may depend on the context and that stakeholders of OSS projects who wish to apply such insights should acknowledge the variety of OSS projects and their contexts.

For managers of ICT4D projects, the study provides heightened understanding of the importance of sustainability and scalability, conceptual models that may be used to better analyze and manage the elements that influence sustainability and scalability and experiences of how to promote sustainability and scalability using OSS, which may to a certain degree be used also in the context of similar projects. In particular, the study emphasizes that, although research often presents OSS as a solution to many usual challenges in capacity development, it is not a silver-bullet solution. Likewise, the study suggests that addressing sustainability and scalability issues from the beginning of the project is not a guaranteed way of solving these issues.

For capacity development organizations and the stakeholders of ICT4D projects, the study provides a better understanding of what constitutes a project success or a project failure. While the basic argument is that this depends on the perspective taken, the study notes that sustainability and scalability are elementary in achieving capacity development objectives in ICT4D projects. However, the study also warns against focusing too much on the project itself instead of the technology use, which is expected to deliver the capacity development impact in ICT4D projects. A complementary point-of-view deriving from the case project is that while scalability and sustainability issues in the case project were not solved, ICT had a positive influence on the pilot cooperatives, thus signaling the prospects of ICT in capacity development. At the same time, the study also supports the notion that, in the context of developing countries, there are endemic problems such as the poor financial capabilities of the beneficiaries of the capacity development initiative that makes it challenging to solve the problems. The contribution of the study is therefore that it provides a better understanding of the role of ICT4D projects and what can be expected from them.

6.4 Limitations and future research

It is important to understand the nature of this study, what it aimed to accomplish, and what its limitations are. First of all, the study relied on the action case research approach, which aims to contribute both to practical concerns in a real-world problem situation and to research by increasing understanding of the area of concern in the project context. This means that the adopted perspective is to a large extent tied to the context and problem situation at hand. As this study originates from the academic domain of information systems science, the study

does not provide an in-depth discussion of issues that could have been the focus of research in development studies, such as how development is defined in this case, how it is measured or who are the beneficiaries of the development initiative. In addition, the study is exploratory in nature, meaning that it aimed to study an issue that has barely been a subject of research before. This study may therefore only be considered to be an initial step in properly understanding sustainability and scalability issues in ICT4D projects using OSS.

As regards the chosen research approach, the adopted action research approach was limited in that it aimed to research and improve the issues considered important by the project management and the key stakeholders. In the final evaluation period of the research process, it was discovered that many interesting and important aspects were not thoroughly discussed, including the essential goals of the project and its top-to-bottom approach to capacity development. Had a more critical approach been adopted to study these issues, the interests of the donors and the beneficiaries, namely the Kenyan farmers, could perhaps have been better addressed. However, in this case the study adopted the perspective of the project management due to the jointly agreed research framework. A different arrangement could have increased the possibilities of adopting a different method more suited for other purposes. It could be beneficial to study similar projects from a more critical perspective in future research, taking the domain of development studies fully into account.

As regards to the nature of the study as exploratory research on the subject of scalability and sustainability of ICT4D projects using OSS, it would be natural to continue studying the issue in other similar projects in order to find patterns that would evidently lead us closer to generalizable results. Future research could continue addressing the sustainability and scalability problem, as it has been identified as crucial in practice, but it is plausible to assume that it may present itself differently in different projects and contexts. In future studies, it would also be fruitful to apply the conceptual model presented in this study, so that its applicability could be tested and the model further developed. Similarly, future research could adopt the micro-level perspective in studying the possibilities of using OSS in capacity development and in solving sustainability and scalability issues, as clearly the practice is much more complicated than assumed by prior research.

Finally, it must be noted that the research in the context of the case project was carried out during a limited period of time. The collection of empirical evidence was finished in 2008, after which time the author focused on reporting. The software produced in the case project, “CoopWorks”, has continued to live after that. In addition to dairy products, at least one module for the use of coffee producers has been developed with development cooperation funding. The statistics from Sourceforge.net (see Figure 11 below) show that the software has

been downloaded continuously during these years, even if the number of downloads is diminishing and no new versions of the software have been uploaded since 2009.

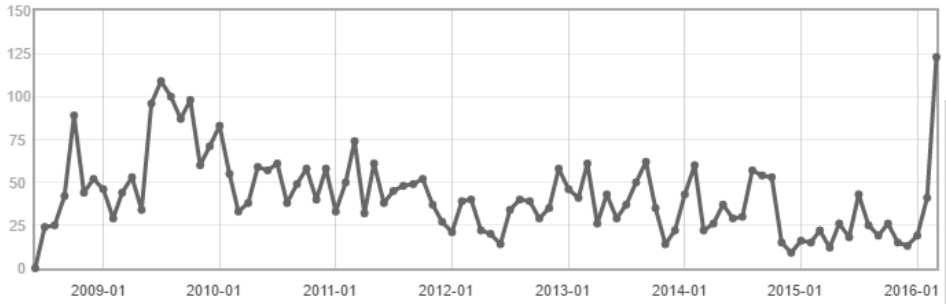

Figure 11: CoopWorks download statistics 2008-2016 from Sourceforge.net

However, a blog post from 2014 claims that "CoopWorks is being upgraded to accept farmers' queries by cell phones messages" (YenKasa Africa 2014), which might boost the use of the software as the use of mobile phones is widespread in Kenya (which might explain the curious spike in the downloads in 2016). It would be interesting to study the recent development of the software and to propose new actions to promote the sustainability and scalability of the CoopWorks technology. This study, like most other studies, was limited to a period of a few years for practical reasons.

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