Open Entrepreneurship

Investigating Entrepreneurship in
Open Source Software Communities

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Source Software Communities

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To
my Family

Foreword

This volume is the result of a research project carried out at the Department of Marketing and Strategy at the Stockholm School of Economics (SSE).

This volume is submitted as a doctoral thesis at SSE. In keeping with the policies of SSE, the author has been entirely free to conduct and present her research in the manner of her choosing as an expression of her own ideas.

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Chapter 1

Introduction

Open source software (OSS) is publically accessible computer software that anyone can modify and share. Over the last decades, software developed by OSS communities has often rivaled proprietary software developed by firms (Benkler et al., 2013). This has led researchers to focus on value creation in such self-organized communities as an alternative to firm-based value creation (Raymond, 1999; Lee & Cole, 2003). Although it is well documented that entrepreneurs can gain economic benefits from participating in OSS, limited attention has been paid to the dynamics and activities through which such benefits are realized and conditioned.

OSS development has been described as a hybrid "private-collective" model of innovation. The "private" element of this model stems from the firm-based model of value creation, which assumes support by private investors who expect to receive returns from private goods. The "collective" element of the model derives from the community model of value creation, in which a public good is produced through collective action (von Hippel & von Krogh, 2003). This hybrid model is characterized by (1) private individuals investing resources but forgoing any direct returns by freely revealing their innovation to the community, and (2) firms basing some or all of their profits on the products or services developed by the community (Dahlander & Magnusson, 2008).

While private individuals and firms formed the initial stakeholder categories in the private-collective model of innovation, a more fine-grained classification of stakeholders in OSS communities has been achieved through

subsequent research, involving hobbyists (Ehls, 2015; Ehls & Herstatt, 2014), large enterprises (Capek et al., 2005; Dahlander & Wallin, 2006), small and medium-sized enterprises (Lundell et al., 2010; Macredie & Mijinyawa, 2011), and public administrations (Rossi et al., 2012). As research has tended to investigated each of these stakeholder groups individually, no clear understanding has been accomplished of their roles and strategies in a dynamic setting of constant interaction between stakeholders and often conflicting goals, norms, and values exists.

The research on value creation in OSS communities intersects with a growing literature on the loosening up of firms' boundaries as they attempt to go beyond their organizations to commercialize new knowledge through collaboration within a loosely coupled network of different actors (Chesbrough, 2003; Dodgson et al., 2006; Kogut, 2000). There are numerous examples of large companies that leverage OSS projects as external resources that complement existing, in-house research and development capabilities (Dahlander & Wallin, 2006). For example, Intel invests resources in OSS communities such as Apache Hadoop and Spark to improve the performance, security, and manageability of the software ecosystem around its offering.[1] In the literature, leveraging such external, complementary resources is described as open innovation (Chesbrough, 2003, 2006). It involves managing the inflows and outflows of resources across permeable organizational boundaries to capture new knowledge and co-create value with outside actors (Chesbrough, 2003, 2006; Huizingh, 2011; West & Bogers, 2014).

If large enterprises like Intel can benefit from OSS projects, could the same be true for entrepreneurial ventures? If so, do entrepreneurs behave differently and approach value creation in OSS differently than large firms?

The OSS literature confirms that entrepreneurs' participation in OSS communities can help them overcome liabilities of newness and smallness (Gruber & Henkel, 2006), a key issue in the population ecology literature emphasizing the negative aspects of an organization's young age and small size (Freeman et al., 1983; Stinchcombe, 1965). While scholars have looked into what entrepreneurs stand to gain from participation in OSS communi-

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[1] https://itpeernetwork.intel.com/intel-invest-open-source-analytics-projects/

ties (Chengalur-Smith et al., 2010; Dahlander, 2007; Lin, 2006; Thistoll, 2011; Widenius & Nyman, 2014), a detailed understanding of how entrepreneurs extract value from OSS projects is, however, absent from the literature. This represents a significant gap because OSS environments have several distinct features that make it far from certain that models and observations of entrepreneurship in other settings also apply in an OSS setting.

Such features of the OSS setting include the fact that entrepreneurs trying to derive value for their ventures from an OSS project need to do so from a collective resource available to anyone, including competitors (Piva et al., 2012). Contributions they make to this collective resource in the form of software code become part of the public domain; the entrepreneurs give up ownership as well as control over something they have invested in (Fitzgerald, 2006; Von Krogh & Haeflinger, 2010; Gruber and Henkel, 2006). Furthermore, in order to influence the direction of development in an OSS project, entrepreneurs need to work through a community that has been described as a "loosely coordinated, distributed system" (Lee & Cole, 2003: 633) with a strong free and open ethos (Coleman, 2004). Even when entrepreneurs are able to influence a community, they cannot managerially command actions as in traditional firms (Dahlander & Wallin, 2006).

Understanding entrepreneurship in OSS requires taking these key characteristics of the OSS environment into consideration. In the light of these special characteristics, my dissertation adopts three theories as lenses to explore entrepreneurship in OSS: stakeholder theory, social capital theory, and collective resource theory. I first study the activities and dynamics of various stakeholder groups in an OSS community to pin down the specific role played by entrepreneurs in resource contribution and social positioning within an OSS community and understand differences between entrepreneurs and other stakeholder groups. I then explore methods that can be used to map the behaviors and agendas of actors within an OSS community. I proceed by qualitatively investigating entrepreneurial approaches within an OSS community as seen from the perspective of OSS entrepreneurs. Through a fourth study, I test a set of hypotheses related to the role of social capital in entrepreneurial approaches in an OSS community. My final study builds a conceptual model of entrepreneurship in OSS by positioning

the phenomenon within streams of literature that deal with key characteristics of OSS. I then investigate the conclusions in the light of empirical evidence from my own research and that of others.

In other words, my dissertation seeks to explore the different stakeholder groups in an OSS community, describe and classify what is observed about entrepreneurs' roles and activities in them, and explain why entrepreneurs behave the way they do. By doing so, it seeks to develop a deeper understanding of entrepreneurship in OSS. I approach this through a single case study of the OpenSimulator community, employing three theories (stakeholder theory, social capital theory, and collective resource theory) as lenses to interpreting my empirical findings. My research starts out explorative, then moves into descriptive, and finally becomes explanatory. Methodological issues concerning my approach are discussed in Chapter 3.

The overarching aim of my thesis is to develop a deeper understanding of entrepreneurship in open source software communities.

1.1. Overview of research purposes

The sustainability of an OSS community is dependent on the ability of the different community actors, the individuals and firms with an interest in the outcomes of the OSS project, to strike a balance between their often conflicting goals, norms, and values. Yet, as the view of OSS communities evolved from that of a collection of technically skilled hobbyists (Ehls, 2015; Ehls & Herstatt, 2014) into that of a complex network of diverse stakeholders combining the pursuit of private interests with the realization of shared goals, the study of these stakeholder dynamics tended to focus on individual stakeholder groups in relation to the general community, especially large enterprises (Capek et al., 2005; Dahlander & Wallin, 2006), small and medium-sized enterprises (Lundell et al., 2010; Macredie & Mijinyawa, 2011), and public administrations (Rossi et al., 2012).

Failure to properly account for the diversity of stakeholders and their interests, functions, and interactions with each other risks limiting our understanding of the organization, value creation, and sustainability of OSS communities. As a starting point, therefore, my dissertation seeks to holisti-

cally explore the different sets of community actors and investigate their interactions and the structures through which they influence decision-making, share power and resources, and self-organize to achieve sustainability. By doing so, through the lens of stakeholder theory, it aims to develop an understanding of how OSS communities achieve continuous benefits for all parties involved in order to sustain their operations. Such an understanding should provide insights to whether entrepreneurs constitute a distinct stakeholder group, different from other stakeholder groups.

Research purpose 1: To identify the stakeholders of an OSS community, examine their interests and positioning within the community, and investigate whether entrepreneurs constitute a distinct stakeholder group.

Considering that the source code of an OSS project is free and accessible to both contributors and non-contributors, entrepreneurs that are active in OSS communities face the dilemma of potentially gaining access to contributions and resources of an entire community on the one hand, but on the other hand being forced to give up their own intellectual property and making their contributions accessible even to their competitors (West & Gallagher, 2006). This dilemma could be resolved either through free riding on the efforts of others, as Olson (1967) suggests is a rational behavior of self-interested actors in collective action projects, or by not participating at all. Yet the empirical evidence from my first study had suggested that entrepreneurs were highly active in the OSS community under study. Understanding entrepreneurial behavior in OSS communities, along with the factors conditioning it, thus became the focus of my continued research.

With regards to the rationale for participation, previous research has found that liabilities of newness and smallness are more easily overcome by new ventures in OSS environments and that they have a higher chance of survival (Gruber & Henkel, 2006). Specifically, ventures in OSS can access community-based resources (Chengalur-Smith et al., 2010) and market insights (Lin, 2006), achieve shorter development times (Dahlander, 2007), receive higher-quality feedback (Schindler, 2007), build offerings on top of code that is kept up-to-date by a community of developers (Gruber & Henkel, 2006), access marketing and sales channels (Thistoll, 2011), and use

open source business models (Widenius & Nyman, 2014). While such re-
search has captured various aspects of what entrepreneurs can gain from
participating in OSS projects, it does not provide an understanding of how
entrepreneurs realize these gains.

While my first research purpose relates to the different stakeholders in
an OSS community and their interactions holistically, my second research
purpose specifically focuses on entrepreneurs in relation to the rest of the
community: how they connect to other community members, how their
networks affect the entrepreneurial activities, and the extent to which they
seek to influence, access, and leverage the resources embedded in the rela-
tionships between the community members.

Social capital theory provides a framework for studying how resources
embedded in the relationships between individuals can be accessed and
mobilized (Lin, 2001). A large body of research exists on the role that social
capital plays in the entrepreneurial process (Batjargal, 2003; Brüderl &
Preisendörfer, 1998; Slotte-Kock & Coviello, 2010; Stam & Elfring 2008;
Stuart et al., 1999). Social capital has also proven useful in understanding
value creation in online communities such as those around OSS develop-
ment, which are characterized by a lack of formal hierarchical structures
and monetary incentives (Raymond, 1999; Stam & Elfring, 2008; Wasko &
Faraj, 2005). Social capital theory is thus a useful lens in approaching my
second research purpose.

*Research purpose 2: To build an understanding of how OSS entrepreneurs are con-
nected to other community members, how their networks affect their entrepreneurial activi-
ties in OSS, and the extent to which they seek to influence, access, and leverage their
OSS community's social capital to develop their ventures.*

Some aspects of entrepreneurship in OSS have been investigated in the
literature on user entrepreneurship. User entrepreneurship is concerned
with commercialization of a product or service by those who are users of
that product or service, a process that is emergent and collective (Shah &
Tripsas, 2007). There are many examples of OSS entrepreneurs who are
user entrepreneurs, starting a business only after being a user of an OSS
product (Gasperson, 2007). However, OSS projects have several character-

istics that have a large impact on the entrepreneurial activities but are absent in the model of user entrepreneurship: reliance on a collective resource for deriving value, restrictions on intellectual property protection, and dependence on a community over which an entrepreneur can exert influence but no control. Thus, user entrepreneurship is not sufficient in explaining entrepreneurial behavior in an OSS environment.

While my second research purpose deals with the relational aspects of entrepreneurship in OSS, my third research purpose strives for a more holistic understanding of entrepreneurship in OSS and how the specific characteristics of OSS condition entrepreneurial activities. This takes into account not only the emergent organizational form of an OSS community but also the collective nature of its resources, most notably the OSS source code. Collective resources have been extensively studied, which has resulted in a large body of literature on collective resource management (Ostrom, 1990). Adding to the lenses of stakeholder theory and social capital theory, for my third research purpose, I add collective resource theory as a lens for understanding entrepreneurship in OSS.

Research purpose 3: To develop a conceptual understanding of how the characteristics of OSS condition entrepreneurial activities and what approaches entrepreneurs use to extract value in OSS.

1.2. Overview of research papers

The five papers that make up my thesis take different angles to achieve the three research purposes within the overarching research aim.

The first paper explores the stakeholder dynamics in an OSS community and investigates whether entrepreneurs constitute a distinct stakeholder group. The second paper investigates the methods available to study stakeholders in an OSS community and methodological issues associated with them. These two papers relate to my first research purpose.

The third paper uses a qualitative interview study to develop a rich understanding of entrepreneurship in OSS from the perspective of OSS entrepreneurs, especially how OSS entrepreneurs connect to other OSS members and leverage social networks. Moving from exploration to hy-

pothesis testing, my fourth study investigates the role of social capital in the value creation of OSS entrepreneurs. These two papers relate to my second research purpose.

The fifth paper seeks to position OSS entrepreneurship within well-established streams of literature in the light of my empirical findings. By doing so, it aims to conceptually describe and explain entrepreneurship in OSS and how it is conditioned by the characteristics of OSS. This paper relates to my third research purpose.

Table 1 provides a brief overview of the five studies making up my thesis and their relation to my research purposes.

In the following chapter, I provide the theoretical background for my thesis and position my research within the literature. Chapter 3 describes my data collection and methods of analysis. In Chapter 4, I outline the studies in my dissertation. In Chapter 5, I interpret my theoretical findings and discuss the contributions of my dissertation as well as the implications of the results for my overarching research aim.

Table 1 – Overview of papers in this thesis

Article	Research question	Research approach	Objective	Theory/Literature	Responsibilities in the article	Dissemination
1. Let's get together: A holistic approach to understanding the stakeholders of an open source software community	Who are the stakeholders of an OSS community, what are their interests, and how do they structure themselves within the community?	Qualitative & quantitative	Exploratory	Stakeholder theory	Third author. Co-authored with R. Teigland and P. M. Di Gangi. Shared responsibility for data collection. Major responsibility for data analysis. Shared responsibility for writing the paper.	Previous version presented at Academy of Management, 2012 and INSNA - International Network of Social Network Analysts Sunbelt Conference, 2012
2. Exploring stakeholders of open source virtual worlds through a multi-method approach	What are the methodological issues related to the study of stakeholders in an open source virtual world community?	Qualitative & quantitative	Exploratory	Stakeholder theory	First author. Co-authored with R. Teigland and P. M. Di Gangi. Shared responsibility for data collection. Major responsibility for data analysis. Major responsibility for writing the paper.	Published in Plesner. U. & Philips, L. (Eds) Researching Virtual Worlds: Methodologies for Studying Emergent Practices. Routledge Studies in New Media and Cyberculture Series London: Routledge, 2013
3. Networked entrepreneurs: How entrepreneurs leverage open source software communities	How are entrepreneurs in an OSS community connected to other community members and how do their networks affect their entrepreneurial processes?	Qualitative	Exploratory	Social capital theory	First author. Co-authored with R. Teigland and O. Dovbysh. Shared responsibility for data collection and data analysis. Major responsibility for writing the paper.	Published in American Behavioral Scientist, Special Issue on Networked Work and Networked Research. 59(4), p. 475-491, 2015
4. Open entrepreneurship: Exploring how entrepreneurs build and utilize social capital in the OpenSimulator community	To what extent do entrepreneurs seek to influence, access, and leverage an OSS community's social capital to develop their ventures?	Qualitative & quantitative	Confirmatory	Social capital theory	First author. Co-authored with P. M. Di Gangi and R. Teigland. Major responsibility for data collection. Full responsibility for data analysis. Major responsibility for writing the paper.	Previous version presented at 10th International Open and User Innovation Workshop, 2012 and IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM), 2012. Under first round review in Information and Organization
5. Towards a theory of open entrepreneurship	How can the approaches that entrepreneurs use to extract value in OSS be understood and explained on a conceptual level?	Qualitative	Conceptual development	Social capital theory, common pool resources, embeddedness	Sole author. Full responsibility for the entire paper.	To be presented at INSNA - International Network of Social Network Analysts Sunbelt Conference, 2017

1.3. Key concepts

This section defines the key concepts in the dissertation. Table 2a and 2b provide lists of, respectively, theoretical and technical concepts and their definitions. The concepts are further discussed in various sections of the dissertation.

One of the most important concepts in this dissertation is that of entrepreneurship in OSS communities. Throughout my dissertation, I use the widely used definition of entrepreneurs by Shane and Venkatraman (2000) as *individuals who found or establish an organization for the purpose of obtaining economic benefits through the sale and/or use of a product and/or service.* This definition does not capture non-monetary purposes that can also be key motivations for individuals who start ventures (Dees, 1998) and does not account for the possibility that some individuals switch between entrepreneurial and non-entrepreneurial roles. In OSS, some members may more closely align with the definition of social entrepreneurship, where a social mission is explicit and central (Dees, 1998). In my dissertation, however, I limit the scope of investigation to individuals who have founded enterprises for the purpose of making monetary gains off an OSS project, regardless of other motivations. The above-mentioned definition by Shane and Venkatraman is thus sufficient and appropriate for the purpose of my research, with the added restriction that the definition should apply in relation to an OSS project; an entrepreneur whose venture does not attempt to make monetary gains off an OSS project is not considered an OSS entrepreneur. In line with previous research on entrepreneurs in OSS (Gruber & Henkel, 2006), in my research I classify as entrepreneurs those OSS community members who have founded ventures that seek economic benefits from the OSS project. The methodological issues and implications of this classification are discussed in Chapter 3.

In this dissertation, two related but distinct terms are used in relation to entrepreneurship in an OSS setting. *OSS entrepreneurship* (interchangeably referred to as *entrepreneurship in OSS*) is a broad term used for any type of OSS-based entrepreneurship satisfying the definition in the previous paragraph. *Open entrepreneurship* is used to describe a specific entrepreneurial ap-

proach within OSS communities, where the entrepreneur becomes socially embedded within the community and is concerned with contributing back to the community to avoiding free riding and excessive resource exploitation. This open mode of entrepreneurship is described in greatest detail in Paper 5 of this dissertation.

Other core theoretical concepts are defined in Table 2a.

Table 2a. Definitions of theoretical concepts used in the dissertation

Theoretical concept	Definition
Common-pool resource (CPR)	A common-pool resource is defined by two characteristics, subtractability and non exclusivity, meaning that exploitation by one reduces the availability of the resource for others, and it is difficult to restrict access to the resource (Ostrom et al., 1999).
Embeddedness	Social embeddedness is related individuals being surrounded by networks of social relationships that substantially influence them (Granovetter, 1985). It is characterized by shared norms and values that reduce the need for monitoring and control and facilitates agreement and the exchange of resources which can be both enabling and constraining (Uzzi, 1997).
Entrepreneurial activities	Entrepreneurial activities related to opportunity identification and realization which includes decision about the usage of the resources that can potentially generate revenues and a profit (Miller & Collier, 2010; Sudhakar, 2013).
Private-collective innovation model	It is the innovation model where innovators privately fund public goods innovations. The private-collective innovation model "contains elements of both the private investment and the collective action models and can offer society the 'best of both worlds' under many conditions" (Gächter et al., 2010; von Hippel & von Krogh, 2003: 209).
Private good	Private goods are defined as goods and services that are excludable and rivalrous in consumption (Cornes & Sandler, 1996).
Public good	"Public goods are characterized by non-rivalry and non-exclusivity in consumption" (Stuermer et al., 2009: 171).
Social capital	Social capital is defined as "resources embedded in a social structure that are accessed and/or mobilized in purposive action" (Lin, 2001: 29), and it is distinguished from other types of capital in that it resides in the social realm of relationships between and among individuals (Burt, 1992; Putnam, 1995).

Stakeholder	Stakeholders are defined as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984: 46).
Sustainability	For the purposes of my dissertation, sustainability is defined as the possibility of an OSS project to program to continue providing benefits for its developers and users over the long term (Butler, 2001: 347; Nyman, 2015).

Given the technical setting of my research setting, Table 2b defines key technical concepts in this dissertation.

Table 2b. Definitions of technical concepts used in the dissertation

Technical concept	Definition
Code commit	"A code commit refers to submitting the latest changes of the source code to a project" (Fan, 2013).
Copyleft	Copyleft is a licensing scheme that facilitates open and decentralized software development. "Its key feature is that once a program is licensed by the inventor, the subsequent programs based on the original must also be licensed similarly" (Mustonen, 2003: 99).
Core developer	Core developers of an open source software community are those who have commit access to the central server of the community and extensively commit code to the project. Contributions made by "non-core" developers will first be reviewed by one or more core developer who has the authority to approve and insert the changes (Fan, 2013).
Forking	Forking is a situation that occurs "when software developers take a copy of the source code from one software package and use it to begin an independent development work" (Nyman & Mikkonen, 2011).
Open source software (OSS)	"Open source designates software that is universally accessible and can be downloaded, used, and modified by anyone "for free". The legal mechanism that makes this possible is Copyleft and similar legal agreements; the technical mechanism is free access to the source code used to create the software" (von Hippel, 2001).
Open source software community	An open source software community is an example of a virtual organization and represents the collective workings of individual developers who voluntarily contribute to developing software and offer programs they have developed to share with other participants. (Stiles & Cui, 2010; Zuo & Panda, 2008)

Open source software license	Open source licenses are licenses that comply with the Open Source definition and "gives the users the freedom to use the software as they see fit, to modify the software and create derived works, and to redistribute the modified software for free or for profit". (Sen et al., 2008: 208)
SourceForge	SourceForge is a web-based service that offers software developers a centralized online location to control and manage free and open-source software projects.
Source code	A source code is the fundamental component of a computer program that is created by a programer, typically written in a programming language and can be read and easily understood by a human being (Wiggins, 1990).

Chapter 2

Theoretical background

This chapter reviews and discusses the different bodies of literature that my dissertation relies and builds upon. I first provide an overview of the literature on OSS communities and the three major research areas within this research field. I subsequently review the literature on the core theme of my dissertation, namely entrepreneurship in OSS communities. This section concludes with a discussion on research gaps. Finally, as a foundation for addressing these gaps in the literature, I expand the theoretical framework by positioning the OSS literature within three bodies of research: stakeholder theory, social capital theory, and collective resource theory. I provide justification for these theories' usefulness as lenses in studying entrepreneurship in OSS.

2.1. Literature on OSS communities

In the last 20 years, scholars from different academic disciplines have studied many different aspects of OSS from a variety of angles. Publications appeared in areas ranging from information systems to management. In other words, OSS does not have a clear academic "home" in the form of a single discipline. In attempting to explain the phenomenon of entrepreneurship in OSS, I therefore seek relevant theoretical lenses rather than grounding my research in one overarching discipline. Appropriate theoretical lenses can only be selected based on a thorough understanding of the characteristics of the OSS setting and the features of that setting that are

likely to have an impact on entrepreneurial logics. In this section, I examine the literature on OSS communities and pinpoint key characteristics that are likely to impact entrepreneurship in OSS.

Scholars have described OSS communities as examples of how innovation can emerge from a group of individuals across the globe, self-organizing online around a shared interest and common practices to create value through sharing knowledge and innovating. Scholars have argued that OSS communities as environments in which knowledge and value are created have challenged the firm-based approach to knowledge creation as the primary mechanism for innovation (Benkler, 2002; Lee & Cole, 2003).

The OSS research field has been categorized into three main areas (Lee, 2012; von Krogh & von Hippel, 2006). The first deals with the motivations of OSS contributors; the second with governance, organization, and the process of innovation in OSS projects; and the third with the competitive dynamics enforced by OSS. Each area is reviewed below.

2.1.1. Motivations for contributing to OSS

Since the early days of research on OSS communities, one of the fundamental questions that scholars have asked has been "Why do thousands of top-notch programmers contribute to OSS when no one pays them to do it?" (Bonaccorsi & Rossi, 2003; Lerner & Tirole, 2002). Motivations for why individuals contribute to OSS projects constitute an important issue in OSS research and some of the early work on the topic listed a wide range of motives such as fun, enjoyment, elevated reputation, better career prospects, learning, access to valuable resources and the private use value of the software being developed (Lakhani et al., 2002; Lakhani & Von Hippel, 2003; Lerner & Tirole, 2002; Hars & Ou, 2002; Hertel et al., 2003; Ghosh et al., 2002; von Krogh & von Hippel, 2006). These motivations were initially categorized under intrinsic (satisfying human needs for competence, control and autonomy) and extrinsic (such as monetary rewards) motivations (Roberts et al., 2006). They were later refined into four kinds of intrinsic motivation (ideology, altruism, kinship amity, and enjoyment/fun), two kinds of extrinsic motivation (career concerns and pecuniary recompense), and four kinds of internalized extrinsic motivation (reputation, reci-

procity/gift economy, learning, and own-use value) (Von Krogh et al., 2012).

Social and political motivations, typically relating to the free and open ethos of OSS and being positioned in opposition to commercial "closed source" software, have been found to have a positive influence on code contributions in OSS communities (Hertel et al., 2003). OSS communities have been described as examples of social movements, as political ideology has been found to be an important motivator for many programmers involved in OSS (Ghosh et al., 2002).

Another motivating factor for contributing to OSS has been found in the control that OSS gives its users, enabling them to reconfigure the software for their own purposes rather than being confined to a predetermined solution, as in the case of commercial software (Stewart & Gosain, 2006; von Krogh et al., 2012).

Investigation has been conducted on the influence of OSS communities and why and how individuals participate in OSS (Bagozzi & Dholakia, 2006). Studies looking at participation in OSS communities in terms of social determinants such as group norms, social identity, and the cognitive determinants of participation have found that a combination of social and psychological variables explains OSS member participation (Bagozzi & Dholakia, 2006; Shen et al., 2010; von Krogh & von Hippel, 2006).

Studies looking at participation in OSS communities in terms of social (identity), affective (positive and negative anticipated emotions), and cognitive (attitudes, perceived behavioral control, and identification with the open source movement) determinants of participation have found that a combination of social and psychological variables explains OSS member participation (Bagozzi & Dholakia, 2006; von Krogh & von Hippel, 2006).

The question of whether intrinsic or extrinsic factors are the main contributing drivers to OSS communities remains unanswered. While one empirically-backed study suggested extrinsic motivations to be most important (Lerner & Tirole, 2002), others have argued that intrinsic motivations, associated with reciprocation and helping behavior within a "gift economy", are the key motivations driving individuals to contribute to OSS projects (Bergquist & Ljungberg, 2001; Kollock, 1998; Lakhani & von Hippel, 2003; Zeitlyn, 2003).

2.1.2. Organization and governance

In attempting to address the working mechanisms of OSS projects, scholars have explored the governance, organization, and innovation processes in such projects. In this context, OSS projects have been conceptualized as a movement (Ljungberg, 2000) that is based on virtual networking on the internet (Hess, 2005). Drawing on transaction cost economics, it has been suggested to provide a "third mode" of production that falls neither into market-based nor hierarchy- or firm-based modes of production (Benkler & Nissenbaum, 2006). This "third mode" has been described as commons-based peer-production taking place in a digitally networked environment (Benkler, 2002). The source code of OSS has been described as a collective resource (O'Mahony, 2003).

The unique features of the organizational structure of OSS projects are captured in the so-called bazaar governance model, which relies on decentralized social structures and distributed development under an open software license (Demil & Lecocq, 2006; Raymond, 1999). The model has been argued to promote the openness and generate strong network externalities (Demil & Lecocq, 2006). A high degree of openness and social interaction within an OSS community has been shown to increase the OSS project's reputation, which in turn increases the aggregate performance of the individuals involved in the project (Mendez-Duron, 2013).

The bazaar model of governance has its unique challenges. While firms pay software developers to contribute and expect them to follow managerial commands, OSS development relies on non-monetary, bottom-up mechanisms for organization, coordination, task distribution, and enforcement (Brabham, 2012; Gulati et al., 2012). Research has shown, however, that OSS communities are not entirely flat; hierarchical social structures tend to emerge within the communities (Nakakoji et al., 2002; O'Mahony & Ferraro, 2007) and network ties of leader-follower and follower-leader type are more beneficial to OSS success than other types of ties (Peng et al., 2013).

A second challenge associated with the governance of OSS projects is the risk of "forking", a situation that occurs when self-interested contributors develop their own versions of the software and leave the project and individuals or firms to patent parts of the software code (Raymond, 2001).

OSS communities deal with this challenge through licenses, legal sanctions, normative tactics, and tactics such as creating a copyright-holding foundation for the software (O'Mahony, 2003).

Licenses protecting the code fall into a spectrum of types with regards to how it can be used, modified, distributed, and protected (Laat, 2005). When it comes to how the software can be protected, the more permissive types give more freedom to developers, for example, by allowing them to protect works derived from the code base (Laurent, 2004; Sen et al., 2011). The more restrictive types, meanwhile, impose constraints on developers, for example, by requiring derivative works to carry the same license as the original source code (Colazo & Fang, 2009; Stallman & Lessig, 2002). When it comes to how the software can be modified and distributed, the more permissive licenses let users use the software as they wish free of charge and developers to modify and distribute it as they wish. The more restrictive licenses tend to limit use, sometimes by imposing fees, and may not allow developers to modify and distribute variations of the software (Lerner & Tirole, 2005). A license can be permissive when it comes to modification and distribution but restrictive when it comes to how modifications can be protected (Laurent, 2004).

The decision about what license to use is driven by a complex set of motivations and shaped by the OSS community as a whole, rather than simply the preference of the licensor itself (Laurent, 2004; Lerner & Tirole, 2005). Research reveals that projects that are geared toward end-users, along with software developed in a corporate setting, are more likely to have licenses that are restrictive in terms of use, modification, and distribution; while projects oriented toward developers are more likely to have more permissive licenses (Lerner & Tirole, 2005).

2.1.3. Competitive dynamics

A considerable number of studies have examined the competitive dynamics of OSS, centered on the question of how firms seek to leverage OSS communities to create and capture value (Lee, 2012; von Krogh & von Hippel, 2006).

The OSS model has been framed as a global sourcing strategy, in which firms utilize OSS communities to supply them with software and support, as well as an open innovation strategy, in which firms and OSS communities collaborate on the development of software of commercial interest to the firm (Agerfalk & Fitzgerald, 2008; Dahlander & Wallin, 2006). Firms have been found to contribute their own software, or parts of it, back to the public domain, eliciting and receiving informal development support from other developers (Henkel, 2006). While doing so, however, they need to reveal part of the software code they have developed and forego ownership of it (Henkel, 2006). Research has shown that firm's specific capabilities play a vital role in capturing and integrating the knowledge created in such communities (Balka et al., 2013; Di Gangi & Wasko, 2009; Flowers, 2008).

While firms have no formal influence over OSS communities, they tend to use different operational means of subtle control to manage their relationships with the communities and seek to influence the direction of their development efforts (Dahlander & Magnusson, 2005). They try to unlock communities as complementary assets, for example, by supporting their employees to become active participants of an OSS community or by sponsoring work within the community (Dahlander & Wallin, 2006). Firms defending proprietary approaches work with OSS project members to achieve their goals and by doing so are able to transform contestation into collaboration (O'Mahony & Bechky, 2008).

How firms seek to interact with OSS communities depends on what complementarities they perceive. Firms with many software trademarks have less involvement with OSS due to fear of devaluation of their brand name and reputation, whereas firms with many hardware trademarks have a higher tendency to engage with OSS (Fosfuri et al., 2008). The latter type of company is believed to have more to gain from OSS solutions as they commoditize the portions of the value chain in which they do not have a competitive advantage (Fosfuri et al., 2008).

The competitive dynamics stream of research has further investigated how OSS competes in an environment dominated by commercial technological standards. Under many plausible conditions, such studies have found, OSS and proprietary software are likely to coexist (Bonaccorsi &

Rossi, 2003). By comparing industry structures around a proprietary platform with those based on OSS, researchers have found that when proprietary applications are based on an open source platform, they tend to be more profitable compared to the entirely proprietary platform (Economides & Katsamakas, 2006).

2.2. Entrepreneurship in OSS

Entrepreneurship in an OSS fits within the competitive dynamics stream of OSS literature, which as discussed above is concerned with how firms, in this case entrepreneurial ventures, seek to leverage OSS communities to create and capture value. Entrepreneurs' involvement in OSS communities poses a puzzle for researchers. Why would profit-maximizing entrepreneurs dedicate time and effort to a project that makes their contribution accessible to anyone, including competitors, and why would they forego control and ownership over the code that they write (Piva et al., 2012; Gruber & Henkel, 2006; West & Gallagher, 2006)? Why would they not instead seek to free ride on the community's effort by taking advantage of the source code? Since they have free access to the source code without contributing to it they could use it and even derive their own proprietary products from it when the software license allows. Such free riding behavior is predicted by traditional models of entrepreneurship, where the profit motivation of entrepreneurs means that they would not engage in actions from which only a small portion of the benefits accrue to themselves while a large portion is provided to others, including competitors (Coleman, 1988).

A solution to the puzzle is provided by what von Hippel and von Krogh (2003) call the private-collective innovation model. By eliminating two fundamental assumptions of the traditional model, they reach the conclusion that private rewards to OSS contributors are significantly stronger than those available to free riders. The two assumptions eliminated are (1) that free revealing of innovations developed with private funds will represent a loss of private profits for the innovator and (2) that free riders have the same access to benefits from the OSS project's collective resource as do project contributors.

This conclusion is supported by empirical work. Scholars have found that new ventures in OSS suffer less than their non-OSS peers from liabilities of newness and smallness and, consequently, that OSS helps entrepreneurial ventures to survive (Gruber & Henkel, 2006). Advantages provided to entrepreneurs by OSS projects identified in the literature span access to developer capacity (Chengalur-Smith et al., 2010), shorter development time and better-quality feedback (Dahlander, 2007), continuous improvements of the code base (Gruber & Henkel, 2006), access to sales and marketing channels (Thistoll, 2011), wider adoption of code (West, 2003), and the ability to undercut competitors by making code freely available (Widenius & Nyman, 2014; Fitzgerald, 2006).

The literature discussed above leads to three issues that any attempt to understand entrepreneurship in OSS needs to deal with. Each of the three issues exposes a gap that has not been addressed in the previous literature and that my dissertation seeks to fill.

First, the literature on entrepreneurship in OSS does not provide conclusive evidence that entrepreneurs are a relevant group to study, distinct from other groups. It could be argued, for example, that entrepreneurs have similar motivations and are likely to adopt similar strategies and approaches as company employees in OSS communities. A framework for studying and comparing stakeholder groups in the context of value creation is present in the literature in the form of stakeholder theory. I thus adopt stakeholder theory as a lens to explore entrepreneurs as a stakeholder group in relation to other groups in OSS.

Second, many of the valuable resources potentially available to entrepreneurs in OSS are socially embedded within the community. This applies to production-side aspects (such as help with testing and bug fixing, access to skills and feedback, and the ability to influence the direction of development in a desired direction) as well as distribution-side aspects (including access to market information, marketing and sales channels, and potential customers within the community). Working with and through people within the decentralized organizational structure of an OSS community, with its many intrinsic and extrinsic motivations and competing agendas, is a challenging task. The fact that monetary rewards and managerial commands tend to be less effective than social status and helping behavior as curren-

cies for getting things done means that entrepreneurs in OSS need to adopt strategies that rely on social interaction. Social capital theory provides a framework for understanding how resources embedded in the relationships between individuals can be accessed and mobilized. I thus adopt social capital theory as a lens for studying strategies taken by entrepreneurs to benefit from socially embedded resources within the diverse and decentralized social structure that is a hallmark of OSS communities.

Third, entrepreneurs in OSS rely on a co-created and collective resource guarded by a more or less restrictive license, limiting its commercial use. Contributions made by an entrepreneur to the code base are given up to the public domain. The stark contrast between the OSS setting and more traditional settings when it comes to the nature of the core resource that value is extracted from suggests a need to further explore this aspect in relation to entrepreneurship in OSS. Thus, I adopt collective resource theory as a lens for exploring entrepreneurial value extraction from the collective resource of OSS communities.

I discuss below the literatures on each of the three theories adopted as lenses to analyze and interpret the empirical findings in my study of entrepreneurship in OSS. As a starting point for discussing my empirical finding, I position OSS within each of the three bodies of literature.

2.3. Expanding the theoretical framework

2.3.1. Positioning OSS within stakeholder theory

Stakeholder theory initially came about as an attempt to introduce a framework for understanding value creation within organizations by synthesizing thinking on stakeholders from economics, strategic management, and organization theory (Freeman, 1984). To date, the literature in this vein of research has tended to focus on stakeholders within traditional organizations or organizations interacting within a network of stakeholders such as suppliers, competitors, distributors, buyers, and investors (Rowley, 1997). The latter perspective, emphasizing the network of relationships between stakeholders affiliated with a focal organization, is the theoretical basis of the small number of studies that have applied stakeholder theory to the

networked community setting of which OSS is an example (Lundell et al., 2010; Rossi et al., 2012; Rowley, 1997). In line with this view, an OSS community can be seen as a network of stakeholders that is emerging around a shared interest to accomplish private goals; an organization less formal and more porous than in the classic case, but one in which social structures emerge and labor is divided, making the stakeholder perspective relevant to understanding value creation (den Besten et al., 2008; Giuri et al., 2008).

Three perspectives, a descriptive, a normative, and an instrumental, are used in stakeholder theory to explain how stakeholders influence the creation of value by an organization (Donaldson & Preston, 1995). The descriptive component holistically identifies the relevant stakeholders, which are tied together through competing and complementary interests (Freeman et al., 2010; Krucken & Meroni, 2006) and who must be viewed within the context of the broader stakeholder network (Freeman et al., 2010; Krishnamurthy & Tripathi, 2009). The normative component relates to the philosophical underpinnings (Donaldson & Preston, 1995), or the vision (Freeman et al., 2010), that determines how an organization will engage within its competitive environment. The instrumental component is concerned with the resources that each stakeholder contributes and how these resources complement each other to achieve performance objectives (Donaldson & Preston, 1995) and the social structures that determine how resources are coordinated, channelled, and used (Freeman et al., 2010).

These three components of stakeholder theory can be discussed in relation to the private-collective model of OSS communities. The descriptive perspective entails identifying the different OSS stakeholder groups and their dynamics. Among the stakeholder groups in OSS communities identified in the literature are large enterprises (Capek et al., 2005; Dahlander & Wallin, 2006), small and medium-sized enterprises (Lundell et al., 2010; Macredie & Mijinyawa, 2011), entrepreneurial ventures (Gruber & Henkel, 2006), and public administrations (Rossi et al., 2012). These all have to be taken into account and their dynamics investigated for a descriptive stakeholder understanding of an OSS community. The normative perspective needs to take into consideration the OSS philosophy, which seeks to advance a robust public commons for consumption by all to create value

(Benkler, 2001; Snidal, 1979; von Hippel & von Krogh, 2003; Weber 2000, 2004). The instrumental perspective can be applied to investigate the resources embedded within an OSS community and contributed by its various stakeholders, as well as the social structures that determine how and by whom they are accessed. Entrepreneurs being one of several stakeholders in OSS communities, stakeholder theory holds potential for understanding the activities and strategies employed by entrepreneurs in OSS.

Against this background, I adopt stakeholder theory as a lens for analyzing and interpreting the empirical findings in my case study.

2.3.2. Positioning OSS within social capital theory

Defined as the "resources embedded in a social structure that are accessed and/or mobilized in purposive action" (Lin, 2001: 29), social capital is distinguished from other types of capital in that it resides in the social realm of relationships between and among individuals (Burt, 1992; Putnam, 1995). On the group level, social capital has been shown to increase the efficiency of action and decrease opportunism and the need for costly monitoring processes, thus reducing transaction costs (Nahapiet & Ghoshal, 1998; Putnam, 1993). On the individual level, it determines the access to resources embedded in social structures, which can be combined with personal skills and knowledge, i.e. human capital (Mendez-Duron & Garcia, 2009).

Scholars have identified structural, relational, and cognitive capital as the three main categories of social capital (Nahapiet & Ghoshal, 1998). Structural capital describes the configuration of relationships between actors in a social network as a whole and is concerned with factors such as the presence and morphology of network ties (Scott, 1991; Wasserman & Faust, 1994). Relational capital relates to trust, norms, expectations, and obligations within a social network (Coleman, 1988; Fukuyama, 1997; Putnam, 1993), attributes that determine the ease of cooperation and willingness to share knowledge (Gulati & Garguilo, 1999; Powell, 1998; Uzzi & Gillespi, 2002). Cognitive capital describes the shared representations, interpretations, and meanings systems among network actors (Cicourel, 1973; Giddens, 1974), involving components such as shared language, codes, and

narratives facilitating communication and collaboration (Nahapiet & Ghoshal, 1998; Liao & Welsch, 2005). Thus, individuals' access to socially embedded resources ultimately depends on their ability to structurally position themselves within their networks, relationally cultivate social ties with other network actors, and cognitively tap into practices within their networks (Liao & Welsch, 2005).

Social capital theory has proven to be a useful framework in studying value creation in online communities such as those around OSS development, which are characterized by a lack of formal hierarchical structures and monetary incentives and rely on emergent patterns of organization (Raymond, 1999; Stam & Elfring, 2008; Wasko & Faraj, 2005). Far from succumbing to opportunism and prohibitively high transaction costs as may be expected from transaction cost theory (Lee, 2012; Williamson, 1981), personal relations and social structures help online communities overcome trust issues and channel resources efficiently (Smith et al., 2017). The usefulness of applying a social capital lens in understanding success in and of OSS projects is demonstrated by studies on the community level, where social capital theory has been used to investigate why projects succeed or fail (Grewal et al., 2006; Singh et al., 2011), as well as on the individual level where it has been used to study how OSS community stakeholders gain a competitive advantage (Stam & Elfring, 2008).

Reinforcing the emphasis on structures that facilitate resource access in stakeholder theory, social capital theory thus holds potential for understanding the entrepreneurial success in OSS. This is not surprising given the large body of research that has demonstrated the role that social capital and network interactions play in the entrepreneurial process in various settings, throughout the phases of identification, evaluation, access, and exploitation of business opportunities (Batjargal, 2003; Brüderl & Preisendörfer, 1998; Slotte-Kock & Coviello, 2010; Stam & Elfring 2008; Stuart et al., 1999). This suggests that in order to access socially embedded resources within an OSS community, entrepreneurs need to build social capital.

Against this background, I adopt social capital theory as a lens for analyzing and interpreting the empirical findings in my case study.

2.3.3. Positioning OSS within collective resource theory

With a large number of programmers contributing to OSS projects but no one owning the software or being able to command how it is used or developed, the resulting value creation has been described as emergent peer-production based on a commons (Benkler, 2002). The literature concerned with this understanding of OSS projects deals with how OSS communities manage to avoid the "tragedy of the commons" (Hardin, 1968) in which lack of motivation and failure of collaboration lead to the inability to sustain the commons. The key reasons are that no one will invest in a project if they cannot appropriate its benefits and no one has the power to organize collaboration in the use of the resource (Benkler, 2002). Research into how OSS communities manage to avoid the tragedy of the commons point to strong norms favoring sharing (Bergquist & Ljungberg, 2001; Rolandsson et al., 2011), open castigation of non-conformers (Markus et al., 2000; Raymond, 2001; Sharma et al., 2002; Westenholz, 2012), licenses governing the code base (Bitzer & Schröder, 2006), and the emergence of informal hierarchies and elites within OSS communities (Bird et al., 2008; Garud & Kumaraswamy, 2005; Madey et al., 2002).

Its source code being available for anyone to use, OSS is considered nonexclusive. As an immaterial good safeguarded by a license that allows copying, modification, and distribution, it is also widely regarded as non-subtractable (nonrivalrous in consumption), whereby the use of one individual does not affect the use of it by another individual (Bitzer & Schröder, 2006). The fulfillment of these two conditions leads to the commonly held view that OSS is a public good (Bessen, 2001; Bitzer et al., 2007; Hars & Ou, 2000; Johnson, 2002; Kollack, 1998, 1999; Lerner & Tirole, 2002; Myatt & Wallace, 2002; von Hippel & von Krogh, 2003; Weber, 2000).

This characterization, however, is contested. O'Mahony (2003) notes that an OSS project's availability to all depends on it being protected from proprietary appropriation, something that plenty of anecdotal evidence suggests is far from always a correct assumption. In many OSS projects commercial actors have blocked venues of development by releasing proprietary software that is built on the open source code, something that is

allowed under some licenses (Lerner & Tirole, 2002). When this happens, argues O'Mahony (2003: 1181), the future stream of benefits stemming from the collective resource becomes unavailable to the community. The collective resource literature defines a commons that is nonexclusive but subtractable, i.e. where its exploitation by one reduces its availability to others, as a common-pool resource (Ostrom et al., 1999). Whether an OSS projects takes the characteristics of a public good or a common-pool resource has further been argued to depend on the restrictiveness of the license governing the OSS kernel (Kuk et al., 2014).

Characterizing OSS as a common-pool resource rather than a public good is likely to have implications for value creation and entrepreneurship in OSS. Common-pool resource environments entail, for example, a risk of depletion of the commons as well as the risk of sanctions imposed by the community (Ostrom et al., 1999).

Against this background, I adopt collective resource theory as a lens for analyzing and interpreting the empirical findings in my case study.

Chapter 3

Methodology and research design

This section discusses the research approach as well as different data collection and analysis methods used in the papers comprising my dissertation. It starts with the research approach, discussing ontological and epistemological assumptions and later introduces the empirical context and settings in which my research questions have been investigated. After a detailed discussion on the methods used to carry out the research and the level of analysis throughout the papers, the chapter concludes with a section on how ethical considerations were dealt with.

3.1. Research approach

My ontological and epistemological assumptions align with key elements of critical realism. This entails a view that reality exists independently of its human perception, that it consists of unobservable structures (Archer et al., 1998; Bashkar, 1975). These unobservable structures cause actual events, which in turn generate observable experiences and artifacts. Knowledge derives from uncovering the causal mechanisms connecting the structures in the domain of the real, the events in the domain of the actual, and the experiences and artifacts in the domain of the empirical (Bashkar, 1975; Collier, 1994).

Analysis only deals with the empirical domain and is therefore not sufficient to provide explanations (Collier, 1994; Fleetwood, 2013). To find explanations, during my research I therefore went beyond the empirical

facts and asked what real things might have caused the events to occur as
they did and generated the experiences and artifacts that I was able to ob-
serve. In my dissertation, this involves a mix of qualitative and quantitative
research methods to first explore my phenomenon of study inductively,
then investigate possible explanatory models deductively.

The first three papers in my dissertation use the observable experiences
and artifacts (including code modules, emails, and interviewee statements)
in the empirical domain to explore characteristics, dynamics and methods
in relation to the phenomenon (entrepreneurship) in the social setting (an
OSS community) under study. The two subsequent papers construct mod-
els relating to mechanisms connecting the real with the actual and the ob-
served and investigate the explanatory power of these models in the light of
observable experiences and artifacts in the empirical domain.

Furthermore, in line with critical realism, I consider social systems open
and emergent, continuously changing due to the dynamic nature of human
actions; human activities shape the system, which in turn affects human
activities (Fleetwood, 2013). Therefore, mechanisms in social systems are
not universal but applicable only to a certain setting and timeframe. In my
dissertation, the primary use of theory is therefore for ex post explanations
of the social phenomenon under study, rather than ex ante predictions.
Hypotheses and propositions are limited to the specific case of entrepre-
neurship in OSS communities, with no claim of permanency.

I adopt as the form for my exploration a single case study. Conditions
where single cases are justified or preferred include when the case is (1) par-
ticularly revelatory due to its previous inaccessibility to scientific investiga-
tion, (2) represents a critical investigation of a well-established theory,
and/or (3) is an extreme or unique case (Cavaye, 1996; Keutel et al., 2014;
Walsham, 1995; Yin, 2002, 2010). My study primarily bases its adoption of
a single case on the first condition, as entrepreneurship in OSS is a relative-
ly unexplored phenomenon (see subsequent sections of this chapter for a
more thorough discussion on this). While the drawback of a single case
study is that the particular case, for me the OpenSimulator community, is
not necessarily representative of all OSS communities, I argue that the ap-
proach is justified by the need for in-depth exploration of the relatively new
phenomenon of entrepreneurship in OSS, with little developed theory. Fur-

thermore, I attempt through the last paper in my dissertation to reach theo-
retical generalizability by positioning entrepreneurship in OSS within well-
established bodies of literatures. Justification for the choice of the Open-
Simulator community, as opposed to any other OSS community, is devel-
oped in Chapter 4. More information about the OpenSimulator community
and a comparison to other OSS communities is presented in Section 3.3.

3.2. Open source software

As a background to the methods and sources selected, it is worth consider-
ing the industry setting of my research. OSS is computer software created
collaboratively through the self-organization of developers voluntarily con-
tributing to developing and maintaining the software's source code due to
their shared interest in the software's functionality. The software is available
to the general public to study, change, improve, and re-distribute free of
charge. OSS has gained widespread interest due to success in the produc-
tion of reliable and robust software that often rivals commercial alterna-
tives, with projects like LINUX (computer operating system), MySQL
(relational database management system), Apache (web server software),
and GNOME (desktop environment and graphical user interface) being
only a few significant examples. The growing interest from businesses, gov-
ernments and nonprofit organizations in OSS as a collaborative model of
production has led managers to switch from proprietary standards to open
systems in their own software development (DeLanda, 2001; Schweik,
2009). Well-established companies such as IBM, Oracle, Google, and more
than half of American government agencies are known to have implement-
ed OSS solutions (Chengular-Smith et al., 2010; Gross, 2007).

An important difference between OSS and traditional proprietary soft-
ware is in user and property rights, where more open conditions of use and
more restrictive conditions of ownership are imposed through the use of
software licenses. The demand for such differences has been credited with
triggering the open source movement in the first place; the computer activ-
ists who initiated it challenged Microsoft's domination of the software in-
dustry by supporting Linux, a free and open alternative to the Windows
operating system. The community around Linux organized itself to become

more participatory and democratic in the way it developed its software, setting the standard for open source programming.

3.3. The OpenSimulator community

OpenSimulator is an open source, multi-platform, multi-user 3D application server operating under the Berkeley Software Distribution license that enables individuals and firms across the globe to customize their virtual worlds based on their technology preferences. Founded in January 2007, the community is powered by the efforts of the community members with very diverse backgrounds, who devote their time and energy to the development processes. OpenSimulator is mostly written in C# programming language[2] and runs on Microsoft Windows and the Mono environment in Linux. OpenSimulator has enjoyed an active and long period of sustained participation and growth from developers located across the world, crossing 20 time zones. As of April 2016, 140 developers had committed 55,584 code submissions to the OpenSimulator project resulting in 1,306,853 lines of code. According to the Constructive Cost (COCOMO) model, which is an algorithmic software cost estimation model for estimating effort, cost, and schedule for software projects, OpenSimulator project, to date, took an estimated 366 person-years of effort and an estimated project cost of approximately 20.1 million US dollars.

There are many ways to participate in and contribute to the OpenSimulator project. Apart from code contributions made to the code repository, contributions can be made via IRC (Internet Relay Chat), mailing lists, the Twitter hastag #opensim, Wikipedia, as well as through individual members' websites or blogs. Participants can create their own OpenSimulator-related projects hosted on SourceForge or elsewhere. They can also participate by being active on the community mailing lists, where they can take two distinct roles. First, members who are users of the OpenSimulator platform can pose questions on usage, report bugs, and engage in conversation with likeminded individuals interested in utilizing OpenSimulator either

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[2] As of April 2016, 85% of code contributions to the OpenSimulator project were made in C#, 13% in XML, and 2% in other programming languages.

personally or professionally. Second, members who are developers can participate in the developers' mailing list that discusses technical issues, project updates, and news announcements concerning modules and company actions as well as social communication. As in all open source projects, participants can be both users and developers.

The OpenSimulator community has a large and diverse developer base and has shown continuous growth since its foundation in 2007. It has drawn participation from well-established firms, including IBM and Intel and exhibits a number of characteristics raised in the literature on OSS communities that can accentuate the development of conflict, including issues around intellectual property. The OpenSimulator community involves several entrepreneurial ventures, such as Avination, Kitely, and 3rd Rock Grid. This may in part be due to the project's business-friendly intellectual property license (BSD), allowing for the creation of unique, proprietary software modules and use of the software application for both consulting and commercial ventures. OpenHub.net characterizes Open-Simulator as a *"well-established, mature codebase maintained by a very large development team"*.

The OpenSimulator community is a suitable choice for a case study of entrepreneurship in OSS for several reasons. First, it has been active for a period of many years, showing that it has so far been able to sustain itself despite an evolving developer base and a gradual replacement of core developers. This robustness allows for conclusions about OSS resource sustainability in relation to entrepreneurial activities in the community. Second, the relative longevity of the community means that an abundance of data about activities in the community has accumulated over time, including mailing list messages and code commits. Third, the community's relatively large and diverse developer base makes it more likely to capture many of the dynamics occurring in OSS communities than would be the case in a small community. Fourth, unlike very large communities such as the one around Linux, the OpenSimulator community is sufficiently small to make research of stakeholder group identity of each individual developer possible (one could say the community is large, but not too large). Fifth, the relatively permissive license adopted by the community means that a wide range of ventures are pursuing business opportunities in relation to the OSS project.

Naturally, this raises the question of whether the behaviors observed among entrepreneurs in the OpenSimulator community are applicable to OSS communities with less permissive licenses. A more detailed discussion on the significance of the OSS project's license on the factors that condition entrepreneurship can be found in Paper 5 of my dissertation. Sixth, because one of my co-authors had previously run a project of virtual worlds, it was relatively easy to gain access to key individuals within the community.

3.4. Data sources and methods used

My decision to adopt a case study approach was based on the need to provide a highly contextualized and qualitatively rich description of how stakeholders interact with one another to obtain resources and develop the public good for the entire community (Benbasat et al., 1987; Yin, 1994). Furthermore, because the existing literature did not adequately describe the phenomenon under investigation, theory construction was necessary in order to identify the relevant factors to open source communities (Eisenhardt, 1989).

Several data collection sources and analysis methods were used to conduct a multi-method case study of the OpenSimulator developer community. The data collection fell into three categories. First, interviews were conducted with members of the community. Second, information about community members was manually collected from websites. Third, the entire body of developers' mailing list messages sent between community members (14,145 messages in total for the period August 2007 - July 2015) was collected and data such as dates, sender and receiver information, and email text bodies were retrieved from the messages. Fourth, the full database of code contributions to the source code (totaling 30,899 code commits during the period August 2007 - July 2015) was downloaded and information such as module names, contributors, and dates was retrieved from it. Fifth, kudo rank, a measure of the community's appreciation of a community member, was downloaded for each developer. Table 3 provides an overview of data sources used and the papers in which they were used.

While some interviews were used for several different papers, there was no overlap in content used.

Table 3 – Data sources of the dissertation papers

Data source	Paper
Interviews with entrepreneurs in the OpenSimulator community - 9 unstructured interviews - 11 semi-structured interviews	Primary source in Paper 1, Paper 2, and Paper 3
Interviews with non-entrepreneurs in the OpenSimulator community - 2 unstructured interviews - 6 semi-structured interviews	Primary source in Paper 1, Paper 2, and Paper 3
Developer mailing list - 7,424 messages for the period August 2007 – September 2009 - 2,696 posts for the period October 2009 – October 2011 - 4,025 posts for the period November 2011 – July 2015	Paper 1 (the first two time periods individually), Paper 2 (the first time period), Paper 4 (the three time periods combined)
Code commits made to the OpenSimulator code repository - 30,899 code commits for the period August 2007 – July 2015	Paper 4
Kudo rank given to developers by the OpenSimulator community	Paper 4
Secondary materials such as social media pages and forums, the OpenSimulator Wiki, personal and company websites, and news articles.	Paper 1, Paper 2, Paper 3, and Paper 4.

Each source contributed in a distinct way to the research. The interviews provided an opportunity to probe community members and their views and perceptions. The mailing lists helped understand the network of communication between community members, as well as the topics that were discussed in their correspondence. The code contribution data enabled an analysis of patterns of code contribution and knowledge access. Research on online sources was a way to gather information about community members, so that they could be tagged correctly.

The following sections will discuss the methods used in this dissertation in detail. Table 4 provides an overview of methods used and the papers in which they were used.

Table 4 – Methods used in the dissertation papers

Method used	Paper
Interviews	Paper 1, Paper 2, Paper 3 and Paper 4
Qualitative coding	Paper 3
Tagging	Paper 1, Paper 2
Content analysis through "burst analysis"	Paper 1, Paper 2
Social network analysis	Paper 1, Paper 2 and Paper 4
Statistical testing	Paper 4

3.4.1. Interviews and qualitative coding

At the beginning of my thesis work, I conducted interviews with community members of the OpenSimulator community to get an overall understanding of what was going on in the community. As my research questions started to take form, my interviews contained increasingly detailed questions. Over a period of approximately four years, between October 2011 and September 2015, eleven unstructured and seventeen semi-structured interviews were conducted with members of the community, including both entrepreneurs and non-entrepreneurs. While some interviews were used in more than one of my studies, there was no overlap in the content and quotations used between the papers.

These interviews were all conducted virtually through the virtual world Second Life, OpenSimulator, or Skype. Interviewees were selected using the snowballing technique, asking each interviewee to identify additional individuals to interview (Baker, 1988). Questions concerning the roles, resources, and motivations for contributing to the community were included in the interview questionnaire to ensure a rubric to assess resource contributions in the subsequent analysis. Interviews were also used at a later stage as a method to validate and illustrate findings.

The ten interviews used in Paper 3 were further transcribed and coded. The coding scheme was developed using predefined coding categories consisting of four main categories, namely entrepreneurial capacity, entrepreneurial opportunity, work environment, and network position. Under these categories, 12 subcategories, such as opportunity identification,

boundary-spanning activities, and bridging roles, were defined in line with previous studies.

During the process of coding, additional categories were added when meaningful statements did not fit into the predefined categories. This process added one new main coding category, namely benefits, and three new subcategories.

The coding process led to the emergence of a matrix with interviewees as columns and categories and subcategories as rows. Quotations from a certain interviewee that matched a certain theme were placed in the cells. The completed matrix enabled a description of the entrepreneurial activities in the OpenSimulator community from the perspective of the interviewed entrepreneurs. The outcome of the research was validated through collecting and analyzing other online materials, such as content on the entrepreneurs' websites or their ventures.

3.4.2. Tagging

Within the stakeholder literature, an ongoing discussion questions how to identify stakeholders (e.g., Mitchell et al., 1997). In line with previous research (e.g., Corbet et al., 2015; Dahlander & Wallin, 2006; Ehls, 2015), classification schema was based on an individual member's organizational affiliation or lack of affiliation. Thus, an individual was assigned to a specific stakeholder type based on their use of organizational email address and/or signature line within their messages. Names and email addresses were retrieved from the messages in the developer list archive which is publically available on the official website of the OpenSimulator community. This was done using computer software by defining the pattern for the information to be retrieved, so that data could automatically be extracted from all the messages in the mailing lists.

Developers that contributed less than four messages within one year were not coded to a stakeholder group and were assigned the code of *Periphery* to reflect their infrequent contribution behavior within the community.

If a developer could not be clearly assigned to a stakeholder type, we utilized social media profiles (e.g., Facebook, Twitter, and LinkedIn), per-

sonal webpages, OpenSimulator wiki profiles, and other publicly available information to code the stakeholder. If a contradiction occurred between the two sources, the OpenSimulator wiki profile took precedence since the OpenSimulator community maintains it directly. It took, on average, around 15 to 20 minutes to ascertain each member's organizational affiliation.

Because the assignment of members into stakeholder groups was a crucial part of the research, it was imperative that every member was tagged correctly. A second researcher therefore conducted the coding independently of me and we crosschecked each other's work. Based on this coding, we calculated a Cohen's Kappa of 90% indicating excellent agreement between the two coders and a reliable coding procedure (Boyatzis, 1998; Landis & Koch, 1977).

In classifying the different members of the OpenSimulator community, the following organizational affiliations were identified: (1) academic – an individual that develops OSS software as a representative of an educational institution or for academic research purposes (e.g., professor, research/teaching assistant, and IT employee) (Bezroukov, 1999; Raymond, 1999), (2) entrepreneur – an individual that founds an organization for the purpose of commercializing a product and/or service based on the OSS software (Shane & Venkatraman, 2000), (3) hobbyist – an individual that develops the OSS software due to personal interest and does not do so as a main source of income (Jeppesen & Frederiksen, 2006), (4) large firm (>250 employees) employee – an individual that develops the OSS software as a representative for a publicly traded organization (e.g., IBM and Intel) (Lerner & Tirole, 2002), (5) nonprofit employee – an individual that develops the OSS software as a representative of a non-profit organization (Rossi et al., 2012), (6) local public sector employee – an individual that develops the OSS software as a representative of a government agency (Rossi et al., 2012), (7) federal public sector employee – an individual that develops the OSS software as a representative of a government agency (Rossi et al., 2012), and (8) small and medium-sized enterprise (<250 employees) employee – an individual that develops the OSS software as a representative of a firm employing between 10 and 250 people (Radas & Božić, 2009).

Community members in groups 4 through 8 participated in OpenSimu-lator because of responsibilities assigned by their employer. The categorization was far more fine-grained than in previous literature, which has grouped need-based developers into one category or divided members into firms and hobbyists (Dahlander & Wallin, 2006; Henkel, 2006).

In order to avoid circularity, the tagging was done using sources other than those used to study activities within the community, such as mailing lists and code commits. This means, for example, that entrepreneurs were classified as entrepreneurs independently of the information used to investigate their behavior.

It is possible to think of situations where a member has multiple affiliations. In practice, however, such cases are rare. Overlap is least likely for tags that imply employment. Whether the employer is a large firm (4), a non-profit organization (5), a local public sector organization (7), a federal public organization (8), or a small or medium-sized enterprise (8), employed individuals in OpenSimulator are typically assigned by their employers to work with the OpenSimulator project. Thus, these categories did not overlap with those of hobbyists, entrepreneurs, or academics.

With regards to overlap between hobbyists and entrepreneurs, most of the cases were resolved through the definition of an entrepreneur: an individual who is the founder of a venture attempting to make profit from the OpenSimulator project is regarded as an entrepreneur even if is she or he also takes a personal interest in the project. In a few instances, a member started out as a hobbyist and later became an entrepreneur. By using two different time periods in the study of stakeholders (Paper 1), my co-authors and I were able to accommodate for the switching between stakeholder groups by classifying the individuals differently in each time period. In the paper investigating hypotheses related to entrepreneurs' leveraging of social capital (Paper 4), a single time period was used and members were tagged as the category they had been part of for the longest time period.

In one case a developer fit both the definition of an academic and of an entrepreneur. This developer was classified as an academic because her primary interest in the OpenSimulator community was academic and most of her contribution to the project was related to her academic interests.

The reason for classifying according to the most relevant category rather than giving multiple affiliations is that the latter would create artificial ties in the analysis of the community's social network, making it difficult to interpret. Due to the small number of individuals with multiple affiliations, the issue of multiple affiliations is unlikely to have an impact on the results. The methodological issues related to tagging are discussed in further detail in Paper 2 of my dissertation.

I will exemplify the process of tagging with a concrete example. For a specific member of the community, I first did a Google search for her name as it appeared in the information retrieved from the mailing list messages. One of the first things that came up was a link to her LinkedIn profile, which listed her as "founder and director" of a company that I will call "company A", which operates an immersive 3D virtual environment for entertainment, education and commerce, which it charges a fee to use. I then went to the official website of company A and read that its platform is a derivative work based on the OpenSimulator source code, confirming the fact that company A is a venture that seeks to derive economic benefits from the OpenSimulator OSS project. As its founder, the person in question was tagged as an entrepreneur. It was also possible to confirm her classification as entrepreneur through websites such as the official website of the Opensimulator community and Hypergrid Business, an online publication that covers news on immersive virtual reality environments and virtual worlds.

3.4.3. Content analysis through "burst analysis"

To obtain a contextual understanding of the interests of each stakeholder group in the OpenSimulator community, the text bodies of the emails in the developers' mailing list were analyzed using a probabilistic generative model that has been shown by previous research to identify keywords that are overrepresented (or "bursty", which is why the method is sometimes called "burst analysis") in one text body compared to another (Kleinberg, 2006). The strength of the method is that it avoids problems caused by other commonly used methods; comparing absolute frequencies favors

large words, while comparing relative frequencies favors small words (Kleinberg, 2006).

In my research, I used the method to identify the keywords that were overrepresented in emails sent by one stakeholder group compared to another, as well as one time period compared to other time periods. The lists of overrepresented words between stakeholder groups and time periods, combined with in-depth reading of emails containing the overrepresented words, provided a good understanding of the topics that were particularly important to the respective groups.

3.4.4. Social network analysis

The sender and receiver information retrieved from each email in the developers' mailing list was used to map the communication networks between developers. Social network analysis was performed using UCINET version 6.181 (Borgatti et al., 2002) to determine the overall network structure of the OpenSimulator community as well as the structural positioning of different groups of stakeholders within the community.

The social network analysis also helped identify the most central nodes in the network, several of whom were contacted for interviews. The results of the social network analysis were validated through interviews with these and other members of the community.

Network analysis was also applied to the code commit data described under the section *Data sources and methods used*. Rather than examining how individuals in the community are connected through the sending of messages from one person to another, conducting network analysis on code commit data maps how developers are connected through work on the same code modules; working on the same piece of code, if it happens at different points in time, results in a connection between the two developers. This connection implies shared knowledge between developers, as both developers access the knowledge embedded in the particular code module. In the resulting network, a high degree of centrality is associated with working on core code modules, which are modified by many developers. A low degree of centrality, meanwhile, implies working on more peripheral code modules, which do not attract many developers. Some developers are

bridging central and peripheral developers, indicating that they tap into and have the possibility to combine knowledge from code modules that seldom occupy the same people.

Applying network analysis to two different sources, covering different aspects of developers' activities in the OpenSimulator community as described above, made it possible to map patterns in communication as well as code development and knowledge access.

3.4.5. Statistical testing

Statistical analysis was used in Paper 4 of my dissertation, which investigates how entrepreneurs seek to influence, access, and leverage the Open-Simulator community's social capital. The paper formulated eight testable hypotheses based on quantitative measures of various aspects of contribution to and leveraging of social capital. Each hypothesis compared entrepreneurs to non-entrepreneurs. Though described in greater detail under the section on tagging above, it is worth noting here that in order to avoid circularity, an a priori classification into entrepreneurs and non-entrepreneurs was done using sources other than those used to test the hypotheses.

From a statistical testing perspective, this meant that the overall objective was to test whether two independent samples originated from the same population. For this, one might be inclined to employ the classic Student's t-test, which is popular for its simplicity and robustness. However, Student's t-test requires the underlying population to be normally distributed. Analyzing the distribution of the data, I found that all eight variables in the study displayed non-normal distributions, more precisely, excessive positive skews and many extreme observations. I therefore instead used nonparametric statistical testing (Wackerly et al., 2008).

Nonparametric statistical procedures are designed to work under general assumptions about the distributions from which samples are taken and, hence, can be applied to a wide range of data. Wilcoxon's rank-sum test, a nonparametric analog to Student's two-sample t-test was chosen because when assumptions of normality are violated, the Wilcoxon rank-sum test has greater power compared to the t-test for moderate to large samples

(Higgins, 2004). Wilcoxon's rank-sum test also filters out extreme observations, making differences in the central part of the data more easily detected.

The null hypothesis, where entrepreneurs and non-entrepreneurs display identical population distributions, was tested for each variable using the R programming language (R Development Core Team, 2016). R was selected for its advanced algorithm for performing the Wilcoxon Rank Sum procedure.

3.5. Level of analysis

While the individual was taken as the unit of observation in most of my research, the level of analysis tended to shift between that of the individual, stakeholder groups, and the community as a whole. It is common in network theory that the level of analysis shifts between the individual and various network levels (Wasko et al., 2004). In the papers making up my dissertation, the unit of observation and the level of analysis have been combined into four different forms.

First, the individual was the unit of observation as well as the unit of analysis. More specifically, I investigated how the individual interacted with and related to other individuals within the community. This was the case in Paper 3, where I interviewed individual entrepreneurs in order to understand how they act and interact to extract value within the networked setting of an OSS community.

Second, the individual as the unit of observation was combined with stakeholder groups as the level of analysis. My research examined how individuals within stakeholder groups interact with and are different from individuals in other stakeholder groups, used to analyze group level characteristics of stakeholder groups in relation to other stakeholder groups. This individual unit of observation, group level of analysis approach was taken in Paper 1 and Paper 4. In these papers, classification into groups (entrepreneurs, hobbyists, etc.), interviews, mapping of network ties, and collection of information about code commits were all carried out on the individual level. These observations were then used to investigate differences between stakeholder groups.

Third, observations were made on the unit of stakeholder groups for analysis on the same level. This was the case in Paper 1, where the frequencies of terms used in emails were observed directly on the level of stakeholder groups and where this information was used to map differences between stakeholder groups.

Fourth, the interaction between the individual and the community as a whole, understood as a collective rather than as a network, was a perspective taken in Paper 5. In the paper, an OSS community's primary assets are conceptualized as their socialized reservoirs of knowledge and their collaboratively created, collectively maintained code base. These are emergent outcomes of a large set of individual actions and interactions, which however are not necessary to observe for an analysis of how an entrepreneur acts in relation to these resources and how the community reacts to the actions taken.

3.6. Research ethics

Any research in social science raises ethical considerations (Ritchie et al., 2013). It is therefore crucial to conform to a set of principles (Robson, 2002) while conducting research. I tried to address ethical issues in relation to all methods and sources I used.

When classifying community members into stakeholder groups, for example, I was careful to use only openly available online information gathered from websites, blogs, and social networks.

All interviewees participated in the study voluntarily, without compensation, and were clearly informed beforehand that they should not feel obliged to answer any question they were not comfortable with. In order to process the interview data accurately and to be able to concentrate on the responses form the interviewee (Humphries, 2008), all interviews were recorded. The consent of the interviewee for recording the interview was always taken before beginning the recording. Interview recordings and transcripts were not shared with anyone except my co-authors.

It was also important to make the results of the studies accessible to the participants of the study (Ritchie et al., 2013). The papers were sent to the interviewees who participated in the study and the findings of the papers

were shared with the rest of the OpenSimulator community during a virtual presentation at the annual OpenSimulator Community Conference. Feedback received from the conference was used to validate results and provided new contacts for interviews.

3.7. Collaboration

My dissertation has involved collaboration with other researchers. This section outlines the extent and character of my collaboration with my three co-authors.

Robin Teigland, Professor in Business Administration at the Stockholm School of Economics, Sweden, and my PhD supervisor, was instrumental in setting the research direction and guiding the research for the first two articles in my dissertation. In Paper 3 and Paper 4, she was involved in the work with the research questions and research design.

Paul M. Di Gangi, Associate Professor in Information Systems at the Collat School of Business at the University of Alabama at Birmingham, was responsible for conducting social network analysis in Paper 1 and Paper 2. He was involved in the research designs of Paper 1, Paper 2, and Paper 4.

Olga Dovbysh, at the time of our collaboration a Master's student at the Royal Institute of Technology (KTH), Sweden, assisted with qualitative coding in Paper 3. I co-supervised her Master's thesis work.

Chapter 4

Summaries of the five papers

This chapter provides a summary for each of the five papers that make up my dissertation. The papers are first described "in a nutshell", with special focus on how they fit together.

Paper 1 investigates the stakeholder dynamics in an OSS community and discovers that entrepreneurs are a prominent stakeholder group through their strategic positioning in the community's social network. Drawing on this research, Paper 2 explores methods that can be used to study social phenomena in OSS communities and virtual worlds. The key finding in Paper 1 leads to the need for a deeper understanding of the entrepreneurial activities in relation to OSS. This pursuit starts with Paper 3, a qualitative, explorative interview study to understand entrepreneurial activities in relation to OSS from the perspective of entrepreneurs themselves. Finding that the interviewed entrepreneurs utilize a range of social strategies, Paper 4 seeks to frame these strategies theoretically and validate them through hypothesis testing, using quantitative measures of various aspects of social capital. Paper 5 uses social capital theory and collective resource theory as lenses to conceptually frame entrepreneurship in OSS, and then uses empirical evidence from my own research and previous studies to validate the conclusions.

Paper 1: Let's get together: A holistic approach to understanding the stakeholders of an open source software community

By R. Teigland, P. M. Di Gangi & Z. Yetis-Larsson
Previous version presented at *Academy of Management*, 2012 and *INSNA - International Network of Social Network Analysts Sunbelt Conference*, 2012

The first study of my thesis sets out to investigate who the stakeholders in an OSS community are, how they interact with and complement each other, and what characterizes each stakeholder in terms of roles taken and resources contributed. The paper turns to stakeholder theory for a framework to holistically understand the diverse network of stakeholders in an OSS community, emerging around a shared interest to achieve private goals.

Stakeholder groups were identified from the OSS literature, interviews with community members, and from netnographic research of the community. Each active developer was classified into a stakeholder group based on interviews and reading of the developers' personal and professional webpages and social media profiles. The precise procedure for the tagging is outlined and exemplified in Chapter 3, but it is worth noting here that in order to avoid circularity, the tagging was entirely done using sources other than those used to study activities within the community (mailing lists, code commits, etc). Social network analysis was used to map the networks of interaction between stakeholders, based on sender-receiver information in the community's public mailing list. Finally, content analysis was used to identify topics characterizing each stakeholder group.

The most important finding of the paper is that entrepreneurs have the highest tendency among all the stakeholder groups to bridge different stakeholders, indicated by the fact that they displayed the highest structural hole measure in the community's social network. One interpretation, supported by previous literature, is that entrepreneurs at the individual level seek to maintain diverse relationships to gain access to a variety of infor-

mation and resources for opportunity identification and opportunity realization.

The study also reveals that entrepreneurs have a high tendency to collaborate with other entrepreneurs, indicated by the fact that they have the lowest E-I index in the community's social network, which I speculate serves the purpose of advancing shared agendas within the community as well as collaboratively acting on opportunities identified.

A positive side effect of entrepreneurs' self-interested leveraging of their network positions to combine knowledge into novel combinations is that by doing so, they enhance the combinative capability (Kogut & Zander, 1992) of the community as a whole.

Besides adding to the OSS literature a more fine-grained understanding of stakeholder groups in an OSS community, the study set me on the path of investigating entrepreneurship in an OSS environment by revealing the prominent role that entrepreneurs play in such an environment.

Paper 2: Exploring stakeholders of open source virtual worlds through a multi-method approach

By Z. Yetis Larsson, R. Teigland & P. M. Di Gangi
Published in Plesner. U. & Philips, L. (Eds) Researching Virtual Worlds: Methodologies for Studying Emergent Practices. Routledge Studies in New Media and Cyberculture Series London: Routledge, 2013

The second paper in my thesis, published as a book chapter, is the result of an exploration into methods for studying OSS communities by introducing a methodological framework on both qualitative and quantitative methods. The chapter discusses the methodological issues encountered while studying the stakeholders and social dynamics of the OpenSimulator community. It addresses the following methodological question: "How can open source virtual world communities be investigated using the well-established concepts of stakeholders and resources from stakeholder theory?" Targeting researchers of social dynamics in OSS communities and virtual worlds, the chapter outlines the challenges encountered while conducting the study and provides practical advice on how such challenges can be overcome.

Major methods addressed in the chapter are stakeholder analysis, content analysis, and social network analysis. The chapter demonstrates how these methods can be applied by scholars to study stakeholders of open source communities. Previous uses of each method are reviewed before presenting their applications in the particular case. The chapter discusses at length the steps of data collection, data analysis, and challenges encountered during the process.

One methodological issue highlighted in the paper is that while topic analysis is a useful tool for finding themes associated with the discussion of different stakeholder groups, the output data is highly "noisy", containing many words that are not relevant in the context of my study ("and", "those", and so on). Finding more efficient ways to preprocess and clean the data could therefore speed up the research processes.

With the rise of virtual reality and the growing interest from researchers in social dynamics in such environments, the lessons and suggestions provided by the paper can hopefully play a role in such research.

Because the methods examined in the paper are discussed in further detail in Chapter 3, they will not be elaborated upon here.

Paper 3: Networked entrepreneurs: How entrepreneurs leverage open source software communities

By Z. Yetis Larsson, R. Teigland & O. Dovbysh
Published in *American Behavioral Scientist*, Special Issue on Networked Work and Networked Research. 59(4), p. 475-491, 2015

Having identified entrepreneurs as a prominent stakeholder group in an OSS community, the third paper in my dissertation turns to investigate how entrepreneurs work in and through an OSS community. The research focuses on the entrepreneurial activities associated with identifying, co-creating, and realizing opportunities through sharing of resources and expertise; in other words, how entrepreneurs engage in networked work with other community members to achieve success for their ventures.

The study draws on interviews with entrepreneurs in the OSS community under study. A code scheme was utilized to classify statements by the entrepreneurs into 15 predefined as well as emergent subcategories under the broad categories of entrepreneurial capacity, entrepreneurial opportunity, work environment, network position, and benefits. The resulting interviewee-code matrix, with a number of quotations corresponding to each such combination, enables a rich description of entrepreneurs' activities in the OSS community under study. While the data studied for Paper 1 reveals patterns in activities and interactions within the community, qualitative interviews add to the puzzle the important piece of interactions beyond the OSS community.

The research highlights the large extent to which the entrepreneurs engage in networked work within and beyond the community. They not only bridge different stakeholders as found in Paper 1, but also connect the OSS community with outside actors. Indeed, the entrepreneurs describe themselves as boundary spanners who are able to explore new combinations, exploit synergies, and transfer best practices between environments through working with and for a diverse set of stakeholders within, as well as outside the community, including large firms, public sector organizations, academic institutions, and other entrepreneurs. Working on multiple teams within the community serves the dual purpose of increasing their exposure to new and potentially useful knowledge, while at the same time increasing the likelihood of finding business opportunities.

A second finding is that entrepreneurs tend to take on a mediating role within the community. While the tendency to take a bridging position in the community's emailing network was already highlighted in Paper 1, the interview approach taken in the study enables a more qualitative understanding of the phenomenon. The entrepreneurs interviewed underscore the social role they play in smoothing over conflicts and lowering friction between community members. As one entrepreneur noted: If the community fails, the business fails.

A third finding is that entrepreneurs see themselves as instrumental in creating and maintaining conditions for a sharing environment, thereby helping the community to function more efficiently. By building a reputation for helpfulness and willingness to help, entrepreneurs also become able

to mobilize resources socially embedded in the community for their business needs.

In the context of my dissertation, the study follows up on the quantitative insight in Paper 1 that entrepreneurs position themselves strategically within an OSS community, with a qualitative exploration into the entrepreneurial activities in an OSS community as seen by entrepreneurs themselves. Paper 3 links directly to Paper 4, which seeks to theoretically frame and quantitatively validate its findings.

Paper 4: Open entrepreneurship: Exploring how entrepreneurs build and utilize social capital in the OpenSimulator community

By Z. Yetis Larsson, P. M. Di Gangi & R. Teigland
Previous version presented at *10th International Open and User Innovation Workshop*, 2012 and *IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, 2012
Under first round review in *Information and Organization*

While Paper 3 generates insights into the social strategies taken by entrepreneurs in an OSS community, these findings are in a sense "homeless" as they are the result of an explorative study, not grounded in theory and not validated by quantitative research. The fourth paper in my dissertation therefore seeks a theoretical framework able to accommodate the findings in Paper 3 and to formulate hypotheses to test them quantitatively.

A useful theory is found in social capital literature. Previous research has identified three dimensions of social capital, namely structural, relational, and cognitive, which appears to match the entrepreneurial strategies identified in my previous research. Willingness to help others, for example, has been mentioned in the literature as an aspect associated with relational capital (Chua, 2002); positioning in social networks is in the literature associated with structural capital (Anderson & Jack, 2002); commitment to a collective has in the literature been connected with cognitive capital (Wasko & Faraj, 2005).

Based on social capital theory, testable hypotheses about entrepreneurs' tendency to seek to influence, access, and leverage the social capital of an OSS community along the three dimensions were formulated. This results in eight hypotheses, each using a quantitative measure of a specific aspect of social capital. These range from welcomingness toward new community members (measured by the tendency to answer the first email sent by a new member to the community) to the tendency to work on diverse and seldom bridged code modules (measured by betweenness centrality in the network of code contributions). Each hypothesis is formulated as a comparison between entrepreneurs and non-entrepreneurs. It is here worth repeating that in order to avoid circularity, the classification into entrepreneurs and non-entrepreneurs, described in detail in Chapter 3, was entirely done using sources other than those used to test the hypotheses. These sources included social media profiles and various websites.

Collecting the data needed to test the hypotheses required making use of several of the data sources generated by the OSS community under study. Mailing lists were used to measure developers' patterns of communication and their ways of expressing themselves verbally; the community's code commit repository was used to measure developers' positions in the social network of code contribution as well as the quantity of their contribution; the community's kudos ranking of members provided data for a measurement on the quality of developers' contributions as perceived by the community.

The study finds strong evidence that entrepreneurs contribute more than non-entrepreneurs to the cognitive capital of the community by providing high-quality contributions to the code repository, working on the most central parts of the code base, and bridging diverse parts of the code base. It finds weak evidence that entrepreneurs contribute more than non-entrepreneurs to the community's structural capital by taking central and bridging positions in the emailing network within the community. It finds mixed evidence that entrepreneurs contribute more than non-entrepreneurs to relational capital by being welcoming to newcomers to the community (strong evidence), being opinionated in their emails to the community (weak evidence), and making many commitments to contribute to the code base (strong evidence).

In short, the research reveals building of cognitive capital as a primary value-adding activity among entrepreneurs in the OSS community studied, and building of structural and relational capital as secondary value-adding activities.

Paper 5: Towards a theory of open entrepreneurship

By Z. Yetis Larsson
To be presented at *INSNA - International Network of Social Network Analysts Sunbelt Conference, 2017*

In the fifth and last paper of my dissertation, I use social capital theory and collective resource theory as lenses to explain what entrepreneurs do to extract value in OSS. I validate the conclusions using empirical findings from my own studies and previous literature. The paper proposes a conceptual model of entrepreneurship in OSS.

As the literature on OSS is limited in its understanding of entrepreneurship, the first necessary step was to position OSS within streams of research with stronger connections to entrepreneurship. The OSS literature provides ample material on the key characteristics of OSS to do so. The collective nature of the OSS code base allows for a positioning within collective resources theory and more precisely for a conceptualization of OSS as a common-pool resource. The uneven distribution and social embeddedness of resources in OSS communities enables a positioning within social capital theory, more specifically a conceptualization of an OSS community as a socialized reservoir of knowledge, experiences, and other socially embedded resources. This positioning is further elaborated on in Chapter 2.

I used empirical findings from my own research and existing literature to validate the applicability of these conceptualizations in OSS. The CPR characterization is supported by real examples where entrepreneurial resource extraction from OSS projects eventually leads to resource depletion (see West & Wood, 2014 for an example relating to the Symbian OSS project), and where OSS communities have imposed sanctions due to per-

ceived subtraction without matching replenishment (in the OpenSimulator community, for example, the community reacts strongly to an entrepreneurial venture's attempt to block venues of code development through appropriation). The characterization of an OSS community as a reservoir of unevenly distributed embedded resources is supported by the empirical evidence discussed in Paper 1, Paper 3, and Paper 4 of my dissertation.

Under the two characterizations described above, the literature indicates that entrepreneurs can potentially utilize a spectrum of strategies to derive business value from OSS projects by striking a balance between two sets of counteracting forces.

First, depending on their long-term need for resources embedded within the community, they need to decide whether and how to strike a balance between extraction and replenishment. Extracting without sufficient replenishment carries the risk of losing access to resources, such as social capital), embedded in the community or even to the depletion of the resource (Westlund & Bolton, 2015). In cases when a "one-shot game" in relation to the OSS project is sufficient for the entrepreneur, they may choose a strategy that does not involve replenishment. When, on the other hand, the long-term success of the entrepreneur's venture is connected to that of the community, balancing extraction with replenishment is imperative. I refer to this entrepreneurial approach as *open entrepreneurship*.

Second, entrepreneurs need to find the right balance between the enabling and constraining effects of being socially embedded within the community. On the one hand, embedding oneself within the community can give access to human resources and an opportunity to influence the direction of the development of the code base. On the other hand, embeddedness carries the risk of the entrepreneur becoming locked into the emergent technological path of an OSS project, thus restricting the entrepreneur's opportunity search space.

The theoretical aspects of the paper are discussed in further detail in Chapter 2. Since the conceptual model of entrepreneurship in OSS that is the outcome of this paper is of overall importance to my dissertation, it is further discussed in Chapter 5.

Chapter 5

Discussion

This chapter discusses the contributions made by my dissertation as well as the implications for the understanding of entrepreneurship in OSS.

The chapter is structured into sections on the theoretical, empirical, and methodological contributions to the literature on entrepreneurship in relation to OSS, as well as empirical contributions to the literature on stakeholders in OSS.

5.1. Methodological contributions to OSS research

My thesis contributes to the methodological toolbox available to OSS researchers. It introduces three new combinations of sources and methods that have not previously been used in OSS research.

First, while previous studies have tended to use sender-receiver information in mailing lists to map the pattern of communication within OSS communities (Crowston & Howison, 2005; Dahlander & Wallin, 2006), my thesis demonstrates other uses for this information, as well as the value of the rich data contained in the text bodies of messages within OSS mailing lists.

My research shows additional usefulness of sender-receiver information by using it to devise a measure of welcomingness toward new members of the community. It captures a developer's tendency to answer the first email sent to the community by a new member, which in my research was used as an indicator of relational capital.

I further show how mailing list text bodies can be used to quantitatively analyze topics of discussion within the community. The challenge is that text data, unlike sender and receiver information, is unstructured. To perform statistical analysis, the text data first needs to be structured. My contribution introduces methods for topic analysis that have previously been used in other areas (Kleinberg, 2006), into the study of OSS mailing lists. In Paper 1 of my dissertation, I use this method to investigate differences in topics of discussion between different stakeholder groups. In Paper 4 of my dissertation, an analysis of mailing list text bodies gives information about expression of opinion based on the use of opinionated words. The methods I use provide OSS researchers with a tool to obtain a better understanding of what is happening within OSS communities.

Second, the bulk of previous research on social capital in OSS communities has used the pattern of emailing between members of a community as the basis for mapping its social network; a social tie has been considered formed through one member's action of sending an email to another member. My thesis demonstrates how data available for almost any OSS project can be used to create a richer understanding of the community's social capital.

A second social network structure emerges from the pattern of code contribution, where linkages between individuals are understood not as direct communication between them but as work on the same code modules. Even when two developers engage in the coding at different points in time, their work on the same code module represents shared practice and learning and therefore development of cognitive capital (Wasko & Faraj, 2005). Previous research has studied commit activity in OSS projects (Bird et al., 2006) and used patterns of OSS code contribution to map social networks (Lopez-Fernandez et al., 2004; De Souza et al., 2005), but no previous study has applied such measures to the study of social capital in OSS communities.

Third, previous studies have tended to lump different stakeholder groups together, typically into two broad groups: hobbyists and firms (Dahlander & Wallin, 2006; Henkel, 2006). Rather than reflecting the reality of stakeholder groups in OSS communities, this classification is likely a result of the difficulty of obtaining information to help categorize OSS com-

munity members. One study classified members based on their email addresses; individuals with a company email address were classified as company employees, while individuals with a private email address were classified as hobbyists. My research demonstrates that several stakeholder groups are present in OSS communities and that they all have their unique characteristics. For many purposes, it is therefore too simplistic to study OSS communities as made up of only two stakeholder groups. The alternative I offer is qualitative and therefore not suitable for studies of large communities. However, it shows that detailed information is available about individual community members through a variety of channels, most prominently social networking platforms and personal websites, and that this information enables classification of individuals with a higher granularity than has been done previously. There is a tradeoff between quantity and quality that should be considered by researchers.

5.2. Interpretation of empirical results

5.2.1. Entrepreneurs as a stakeholder group in OSS communities

By using stakeholder theory as a lens, my thesis contributes to a more fine-grained understanding of stakeholder groups in OSS communities and shows that entrepreneurs are a group with distinct characteristics. In previous research, groups of OSS project members have tended to be studied individually in relation to the OSS communities they are present within. Such an approach is in contrast to studying groups holistically and dynamically, taking into account how they interact and complement each other in resource contribution. Studies that have considered more than one stakeholder group at a time have tended to classify community members into broad groups such as hobbyists and company employees (Dahlander & Wallin, 2006; West & Gallagher, 2006) or need-driven and hobbyist participants (Shah, 2006).

By tagging each individual in the OSS community under study into fine-grained groups and examining the interplay between them, I provide a more detailed and dynamic understanding of the stakeholder groups in OSS. More precisely, I show that different stakeholder groups play a specif-

ic role in resource contribution and speculate that the complementarity and interplay between them increase the robustness of the community. I also demonstrate that the social structuring of stakeholder groups varies over time, as the community matures. For example, while large firms play a larger role in the critical early phase of the community's development, academics tend to become more central as the community matures and becomes more stable.

Based on this more fine-grained view of stakeholder groups and their role in the community, I identify entrepreneurs as a distinct and particularly interesting stakeholder group. Entrepreneurs play the role of bridging different stakeholders, as indicated by their high structural hole measure in the community's social network, in the community's social network. Seeking to form and maintain diverse relationships on the individual level can serve as a way to gain access to a variety of resources and sales channels for opportunity identification and opportunity realization. The qualitative research in my dissertation further connects the bridging position within the community with the benefits, both to the entrepreneur and the community, of taking a mediating role between actors and fostering a sharing environment within the community. Taking such a role enables the community to operate more smoothly while giving the entrepreneur a more prominent social position.

Entrepreneurs are also the stakeholder group with the highest tendency to collaborate within the group, as indicated by a high E-I index in the social network of the community. A possible interpretation of this result is that coordination improves the ability to advance shared agendas as well as collaboratively acting on identified opportunities.

Using stakeholder theory as a lens thus enables a more fine-grained understanding of stakeholder groups than had previously been presented and demonstrates that entrepreneurs are a stakeholder group with characteristics that are distinct from those of other stakeholder groups. There is therefore a strong argument for studying entrepreneurs as a distinct stakeholder group separate from other stakeholder groups in OSS communities.

5.2.2. Social capital as an enabler in entrepreneurship in OSS

Using social capital theory as a lens for understanding entrepreneurship in OSS, my dissertation highlights the important role of social capital in entrepreneurship in OSS. While the OSS project's source code is available to anyone, resources socially embedded within the community are not. Drawing on the literatures on OSS and social capital, I describe an OSS community as a socialized reservoir of knowledge, experience, and other socially embedded resources. A number of studies offer support for the view that, as a consequence of the formation of informal structures in the self-organizing communities around OSS, resources such as skills, knowledge, and influence are unevenly distributed throughout an open source community (Madey et al., 2002; Bird et al., 2006; Giuri et al., 2008; Garud & Kumaraswamy, 2005; Crowston & Howison, 2005). Access to such resources disproportionately accrues to a small share of community members, which is why entrepreneurs can gain an advantage by systematically cultivating social capital. As noted in the Key concepts section in Chapter 1, doing so in the context of an OSS community amounts to what could be called *open entrepreneurship*.

My research indicates that the strategies entrepreneurs use to seek to influence, access, and leverage a community's social capital mainly relate to the cognitive and relational dimensions of social capital.

Cognitive capital is developed and leveraged by engaging in work on the most central parts of the code base and to bridge otherwise disconnected or loosely connected parts of the code base. Doing so does not only enable entrepreneurs to make use of the most important parts of the code, but also to find new combinations by engaging with dispersed modules of code. Entrepreneurs also provide high-quality code, receiving more appreciation from the community than received by non-entrepreneurs. This enables entrepreneurs to influence the development of the code in their desired direction by leading the way, while at the same time gaining the appreciation of the community, which may carry other benefits.

Relational capital is developed and leveraged by displaying a high degree of welcomingness to newcomers to the community and by being more likely to making commitments of contributions to the source code. Taking

on ambassadorial roles within the community to interact with new members and facilitate integration into the community may be a way for entrepreneurs to establish norms and trust, something previous studies have shown increases the potential for value creation and the willingness of members to engage in cooperation (Luhmann, 1979; Nahapiet & Ghoshal, 1998). By cultivating good relations with other developers, entrepreneurs are more likely to get help with code testing and debugging when needed, and to influence the development agenda of the community. They can also potentially receive valuable information about market needs and gain new customers.

My thesis shows that while building social capital is in the self-interest of entrepreneurs in OSS, it also benefits the community. The activity of building social capital is thus the foundation for the formation of a symbiotic relationship between self-interested entrepreneurs and the OSS communities they are active in. Previous research has already described the relationship between entrepreneurs and OSS communities as a symbiosis (Dahlander & Magnusson, 2005). My research provides a more detailed understanding of the mechanisms that result in a symbiotic relationship. Engaging with an OSS community's social capital may be a way for entrepreneurs to benefit their own ventures, but the strategies they take in doing so generate advantages for the community as well. Cultivating relational capital, for example, helps the community by enabling higher levels of trust and stronger foundations for knowledge sharing, factors found in previous research to facilitate the creation of intellectual capital (Nahapiet & Ghoshal, 1998). By bridging the core and periphery of the source code and developer community, entrepreneurs facilitate information diffusion throughout the community and enable the combination of dispersed, socially embedded knowledge. The interests of entrepreneurs are in these cases aligned with the interests of the community.

While enabling entrepreneurs to access resources, support from research on collaborative technological entrepreneurship (Garud & Karnøe, 2001; Garud & Karnøe, 2003; Kreiner & Tryggestad, 2002; Hughes, 1983; Molina, 1999; Dosi, 1982; Garud & Jain, 1996; Kemp et al., 1988) suggests that there is a flipside: socially embedding oneself into OSS communities carries a risk of becoming locked into the emergent technological path of

the OSS project. Relying on resources that are socially embedded within the community may be effective for entrepreneurial projects that are aligned with the development direction of OSS project, but they can be difficult to utilize for projects that are seen by community members as too different to provide value to the OSS project. Embedded entrepreneurs may also limit their opportunity search to the space around the OSS project's emergent development path, thereby minimizing the cost of compatibility with the code base and the variability of results that experimentation from unfamiliar components and component combinations tend to result in (Fleming, 2001). OSS entrepreneurs thus need to find a balance between the enabling and constraining forces of socially embedding themselves into OSS communities.

Using social capital theory as a lens to understand entrepreneurship in OSS thus provides insights into entrepreneurial strategies for opportunity recognition and realization as well as the outcomes of these activities.

5.2.3. Logics regulating value extraction from the collective resource of an OSS project

Using collective resource theory as a lens to understand entrepreneurship in OSS, I challenge a widely held assumption that OSS is best described as a public good due to its nonexclusivity (the source code is freely available to everyone) and nonsubtractability (the software is an immaterial good, so that the use of the program code by one individual does not affect the use of it by another) (Bessen, 2001; Bitzer et al., 2007; Hars & Ou, 2000; Johnson, 2002; Kollack, 1998, 1999; Lerner & Tirole, 2002; Myatt & Wallace, 2002; von Hippel & von Krogh, 2003; Weber, 2000). I instead conceptualize an OSS project as a common-pool resource by pointing to research showing that there are various circumstances under which the assumption of nonsubtractability does not hold. These include the hijacking by a commercial vendor of an OSS project, making the future stream of benefits stemming from the collective resource unavailable to the community (O'Mahony, 2003). It also includes the diminishing of an OSS project's social capital through the loss or luring away of developers and users (Raymond, 2001). Under a common-pool resource characterization of OSS,

entrepreneurs need to deal with the risk of resource depletion and the risk of sanctions imposed by the community. Doing so involves balancing subtraction from the resource (for example when appropriating an OSS fork or attracting developers and users to a fork) with replenishment (for example by contributing code or facilitating sharing and productivity within the community).

I support the applicability of this conceptualization to entrepreneurship in OSS by using empirical findings from existing literature as well as my own work. The literature provides examples of subtraction that eventually leads to resource depletion through the mechanism of appropriation of, and thereby restriction of access to, derivative works of an OSS, thus blocking future venues of development of the OSS project. One such example is Nokia's closed sourcing of its commercial version of the Symbian open source operating system, triggering a vicious cycle of resource depletion as more and more developers left the open source code base to set up their own mutually incompatible and often closed source alternatives, ending with complete disbandment of the OSS project (West & Wood, 2014). The CPR, in the form of future streams of benefits as well as human capital, had been diverted into many smaller private pools until it was entirely depleted.

In the OpenSimulator project that is the primary setting for my research, the community reacted strongly to attempts by entrepreneurs to appropriate derivate work, as such attempts were perceived as blocking future community-led development of a code base that could otherwise benefit the whole community. As one community member wrote in a plea to the community: "Be careful with what you patent, or you may put yourself out of your business before you even create it by placing obstacles on the way of the infrastructure."[1] Together with other empirical findings, the example supports a CPR characterization of OSS.

The OpenSimulator community further presents an example of the costs of incompatibility that arise as an entrepreneur subtracts from a CPR by creating a private good. One entrepreneur in the community created an initially promising closed source fork of the OSS, which eventually lagged

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[1] http://www.metaverseink.com/blog/opensim/a-personal-plea-on-patents/

behind and lost appeal as the code base continued to evolve while the closed source derivative was unable to keep pace and remain compatible with the code base[2]. The example highlights the potential perils of not adopting a strategy that allows continuous and sustainable resource extraction from the CPR of the OSS project and demonstrates one of the mechanisms in play in restricting the opportunity search space for entrepreneurs whose ventures are linked to the OSS project.

Empirical evidence further supports OSS communities' ability to monitor actions and impose sanctions on community members, critical functions of well-organized CPR communities (Sharma et al, 2002). Imposing sanctions comes in the form of flaming, spamming, shunning, and restricting access to socially embedded resources (Markus et al., 2000; Raymond, 2001; Sharma et al., 2002).

Using collective resource theory as a lens to understand entrepreneurship in OSS thus provides insights into the logics that regulate possible and successful entrepreneurial approaches to resource extraction in relation to an OSS project.

5.2.4. An explanatory model for entrepreneurship in OSS

The key contribution of my dissertation is a conceptual model of entrepreneurship in OSS as seen through the lenses of stakeholder theory, social capital theory, and collective resource theory. Stakeholder theory demonstrates the distinctness of entrepreneurs as a stakeholder group in OSS communities. Social capital theory describes and explains the strategies utilized by entrepreneurs for continuous opportunity identification and realization and for gaining competitive advantage in an OSS setting. Collective resource theory captures the logics regulating entrepreneurs' access to the codified and socially embedded resources of an OSS project and the sustainability and interconnectedness of the venture and the collective resource. I demonstrate support for the conceptual model through empirical evidence from my own research of the OpenSimulator community along with empirical findings in other research.

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[2] http://www.hypergridbusiness.com/2012/07/reactiongrid-moves-away-from-opensim/

The conceptual understanding of entrepreneurship in OSS rests on the particular characteristics of the OSS setting and entrepreneurial activity in this setting. This involves the fact that the resource that the entrepreneur seeks to extract value from is a collective one and fits the characteristics of a CPR, giving rise to a need for the entrepreneur to match extraction from the resource with replenishment in the case of continuous extraction. It also includes a set of social relationships between members of the community, regulating access to unevenly distributed, socially embedded resources such as skills, knowledge, and sales channels.

Figure 1: Key features of the setting for open entrepreneurship in OSS. The entrepreneur extracts value from a collective resource, i.e. the OSS source code. It also leverages socially embedded resources in the OSS community by interacting with other community members. To avoid sanctions from the community and the depletion of its collective resource, the entrepreneur needs to match extraction from the commons with replenishment, contributing at least as much value to the project, as perceived by the community, as it is subtracting through its commercial activities
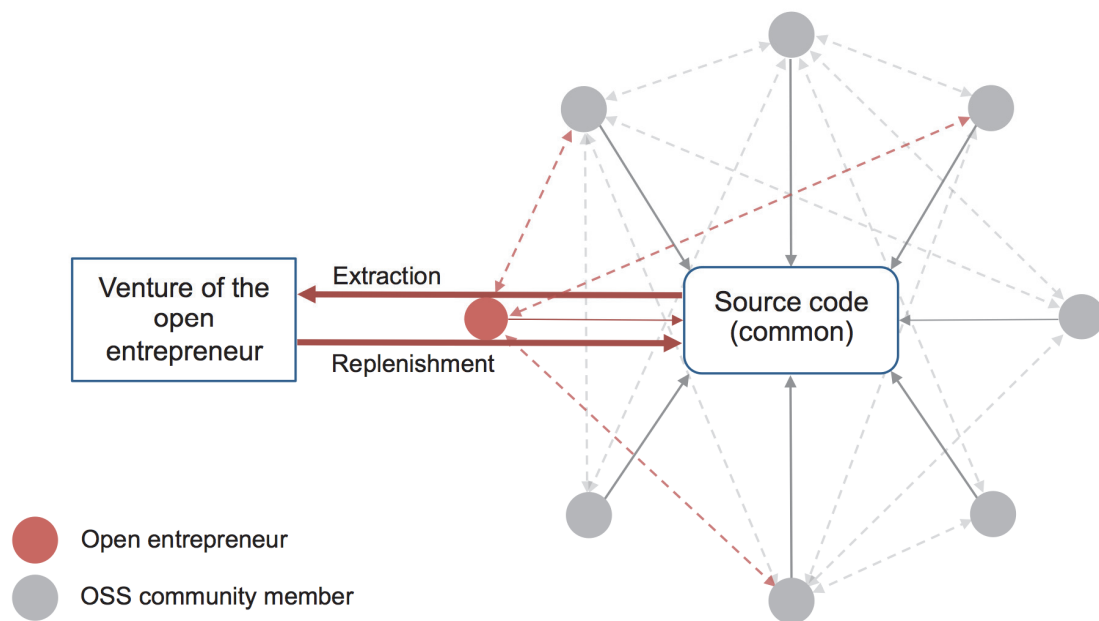

The entrepreneurial activities in OSS can be described as a four-step model, visualized in Figure 2.

Opportunity identification. The process begins with identification of an opportunity within the OSS community. The person identifying an opportunity could be an entrepreneur, who is also a member of the developer community. The person could also, however, be an outsider to the community and could be a user of the OSS, or not. The value identified falls into several categories. First, the entrepreneur may perceive value in directly using parts of the source code of the OSS project. Second, she may seek to improve its software production in terms of speed, cost, and quality. She may hope to accomplish this by using the OSS project's source code and developer capacity. Third, the community's vital resources such as user feedback, market insights, networks, user base and potential customers within the OSS community can profit the entrepreneur's sales and business development effort. Fourth, the entrepreneur might use the OSS project to undercut their competition by making freely available a competitor's functionality or even an equivalent product, seeking revenue from complementary offerings. Fifth, by building an offering that is closely linked with the OSS project, the entrepreneur can link her own success to that of the community, making it more adaptive to external change and resilient to external pressure.

Opportunity realization. The entrepreneur needs to find a balance between subtractive and replenishing components in her value extraction approach dependent on her need. If her need is one-time only, she will more likely choose a free riding approach since an investment of time and precious resources is unnecessary. Conversely, if her venture's progress needs ongoing affiliation with the community's work, she will likely attempt to find a balance between subtraction and replenishment. She must consciously pursue a policy that balances subtractive actions, such as blocking future development venues via patenting and other means, siphoning off the community's human resources, or engaging in closed source implementations of the OSS. These need to be convincingly offset by one of several replenishment actions. First, She can contribute coding resources or other non-monetary resources to the project. Second, she can take positions and roles within the community's social network that will lower the community's overall transaction costs. For instance, she might take on a mediating role, facilitating

Figure 2. Conceptual model of entrepreneurship in OSS
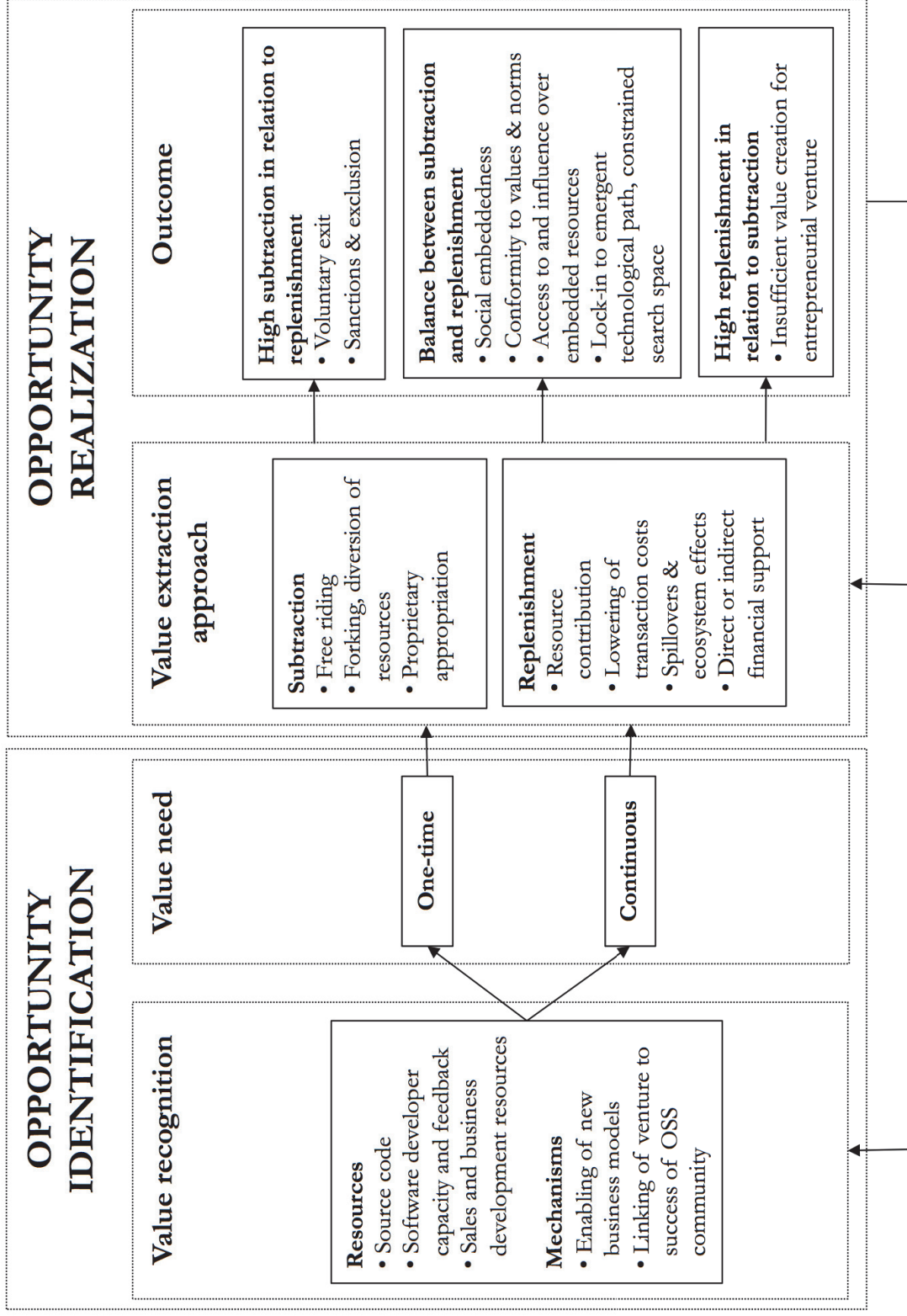
communication and productivity between community stakeholders. Third, her venture can benefit the community as her success directly or indirectly brings new developers and users to the community. Fourth, she may use financial contributions, directly or indirectly, to support the OSS project.

The entrepreneur's mix of subtractive and replenishing actions will determine the outcome of her resource exploitation approach. If she approaches the project with the aim of a one-time need, her high subtraction to replenishment ratio may be quickly followed up by a voluntary exit without further interaction with the project or community. The CPR nature of the collective resource may prompt the community to respond to her not sustained extraction without replenishing by imposing sanctions and excluding her further access to its embedded resources. On the other hand, if she consistently provides more value than she derives, her venture may fail due to weak resource use and insufficient value extraction. A symbiotic relationship can be established in time resulting in the entrepreneur becoming socially embedded in the community if she consciously and effectively combines subtractive and replenishing components to the OSS community's desired levels. This approach means she is both benefitting and contributing to the community's social capital. The access this gives her to the community's social capital can translate to a source of competitive advantage for her venture. Conversely, social embeddedness runs the risk of locking the entrepreneur into the community's emergent technological path, limiting her opportunity search space. Regardless of whether or not the entrepreneur becomes embedded within the OSS community, the process of opportunity realization can lead to further attempts to utilize the resources of an OSS project and to identification of new opportunities.

This conceptual model describes the key features of entrepreneurship in OSS and provides explanatory power with regards to approaches for long-term entrepreneurial success and resource sustainability. To be more precise, as outlined in the discussion above it offers a range of solutions by allowing for different ways of balancing subtraction and replenishment, as well as different ways of balancing the enabling and constraining forces associated with social embeddedness.

5.3. Limitations and venues of future research

While my theoretical work has put observations from my empirical work in a larger context, an important limitation of my empirical studies is the focus on one specific OSS community. Considering the variety of software licenses adopted by OSS communities, the validity of my conclusions in other OSS settings should be investigated.

The conceptual model for entrepreneurship in OSS developed in my thesis rests on two pillars of OSS projects, namely the collective nature of the ownership of OSS and the emergent social structure of OSS communities. From a theoretical perspective, the model should therefore describe entrepreneurship in relation to any setting sharing these two characteristics. Consequently, an interesting venue of further research would be to search for other settings sharing these characteristics and investigate whether the model can be extended to entrepreneurship in these settings.

One such setting might be that of intangible cultural resources, which in the specific study of traditional music was found to be nonexcludable and subject to rivalrous consumption (McCann, 2001). Similar to the case of OSS, the study observed friction between a large community of practitioners sharing the belief that "you can't own this stuff" (McCann, 2001: 3) and a smaller number of individuals copywriting tunes that had been held in common for time immemorial, in order to capture the value of the resource before others could do so. A second parallel to the OSS setting is the study's observation that along with the commercialization of traditional music came the opposite: composition of non-commoditized tunes exchanged through an unarticulated gift economy, creating a collective resource where traditional tunes are modified, developed, and shared within a community of practitioners. The aspects shared with OSS would make it interesting to explore entrepreneurship in the context of intangible cultural heritage such as folk music and handicraft.

The model could potentially be extended to other settings as well. Studies have found that copyleft practices common in the software industry have also been used in areas spanning biotechnology (Pénin & Wack, 2008), medicine (Lang, 2011), nanotechnology (Mushtaq & Pearce, 2012), hardware design (Pearce, 2012; Zhang et al., 2013), and agriculture (Thom-

son & Jakubowski, 2012). In these cases, a community of participants relies on a collective resource, such as blueprints or genetic information, that is available to all, regulated through a license, and can be modified by participants. Typically, participants are allowed to make money off the collective resource, but not to impose private ownership on it (Pénin, 2011). The similarities with the OSS case would make it interesting to investigate whether the model for entrepreneurship in OSS holds in other kinds of open source environments.

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PART II: The articles