Value Creation in Technology-based Firms:

The Role of Bricolage, Ecosystems and Business Models

FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

DEPARTMENT OF INNOVATION, ENTREPRENEURSHIP AND SERVICE MANAGEMENT

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2014

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Submitted at Ghent University
Faculty of Economics and Business Administration
In partial fulfillment of the requirements for the degree of
Doctor in Applied Economics

PhD Series – Ghent University 2014

Faculty of Economics and Business Administration

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"Live as if you were to die tomorrow.
Learn as if you were to live forever."

~ Mahatma Gandhi

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Acknowledgements

Writing a doctoral dissertation is a long journey characterized by ups and downs, disappointment and hope, frustration and excitement. Although this is an individual reward, the doctoral thesis would not have been possible without the support of many people. It gives me great pleasure in expressing my gratitude to all those people who helped me throughout this doctoral journey.

First I would like to express gratitude to my supervisor Prof. Bart Clarysse. Life is about taking chances and seizing opportunities. I am thankful to Bart for giving me the opportunity to do a Ph.D., for his constant guidance, support, motivation and for the interesting opportunities he created for me with respect to data collection, getting to know the right people and teaching. I would also like to thank Bart for giving me ample flexibility which allowed me to simultaneously pursue another Ph.D. on how to handle a baby. I am also indebted to my co-authors Prof. Mike Wright and Prof. David Gann. I consider it my honor to work with them. Their exceptional competence in the field allowed me to learn fast and helped me translate my research into publishable papers.

Deepest appreciation is also due to my guidance committee, Prof. Mirjam Knockaert and Dr. Iris Vanaelst. Their support and guidance was crucial in finishing my Ph.D. Thank you for helping me improve the quality of my research design and your suggestions with respect to the literature and theoretical framing. Thank you Mirjam for introducing me to the academic world and letting me learn from your courses. Listening to presentations in Flemish for two full days in a row was only possible thanks to your company. I cannot thank Iris enough for reading the several versions of my thesis, and commenting also on the nitty-gritty details. Your support, particularly in the last few months in deeply appreciated. "Keep up the good work"- just these few words from you at the end of every conversation we had were enough to keep me going. In your role as my guide, which you took quite seriously, thank you for also guiding me at times to places like Ikea and the train station.

Next I would like to address a word of gratitude to the members of my doctoral committee. Prof. Philippe Mustar, Prof. Evila Piva and Prof. Petra Andries. Despite their busy schedule, they thoroughly reviewed my work and provided me with critical and

high quality feedback and many constructive suggestions which considerably improved the quality of my work.

This Ph.D. would definitely not have been possible without the help of my friendly and cheerful group of colleagues at the department of Management, Innovation and Entrepreneurship. My fellow doctoral students have also provided for many interesting and varied conversations over the years. I would like to thank each of my (ex-) colleagues in the research group: Annelies and Inge for welcoming me to the research group and helping and supporting me during the first uncertain years as a research and teaching assistant; Robin for your company from our first days at the cold Russian Institute until my last day at UGent. Thank you for pioneering the IWT data collection and allowing me to extend it further for my research; Jolien for introducing me to the world of music other than Bollywood, for your positive outlook, and for making sure that I never ate lunch at my desk when you were around; Lien, the offline Wikipedia, for her detailed stories and weird sense of humor; Charlotte- I could always count on you, and chat on just any topic with you. Thank you for our numerous chat sessions in the office which made coming to work more enjoyable; Anneleen for all our discussions ranging from vegan/ vegetarian cooking, the Ph.D. comics to some serious ones on how research needs to be done. Thank you for sharing your knowledge on questions related to qualitative research; Jonas for calmly listening to all our girl talk in the office and sharing your critical comments which led to interesting arguments; Ayna for sharing your Norwegian experiences and increasing the international quotient of the team. Thank you all for all the fun years, the legendary lunch breaks, numerous Friday food meets, and for patiently translating Flemish quotes, jokes, and conversations for me in English.

Thank you Bart L. and Arne for keeping your door open for my statistical questions. I also appreciate Ann De Smaele for her advice, help and motherly support. One person who has always been ready to help me was the ever-cheerful Sofie. She took care of all non-scientific works, including the official procedure and arrangements of this Ph.D. defense. Thank you Sofie for all your support! A word of appreciation is due to Wieland De Caluwe and Anneke van den Sompel for their administrative help in my doctoral defense. A special thanks to Lena De Cock, who was just a phone call away for all my administrative questions. Further I would like to thank Mike J., Gert and Reinout for their help in data collection.

Lastly I would like to thank my family and friends for all their support and encouragement. My mom and dad who have been my role models, thank you for imparting the importance of education and providing my brother and me the best opportunities in life. Mamma taught me to believe in myself and to keep going in tough times. Papa taught me that hard work is the stepping stone to success. My brother Mahesh, thanks for the constant updates of all family events that I missed in the last 8 years. Special thanks to Bhagwat family for welcoming us as a part of their family, and making us feel at home away from home. I would like to thank my friends Himani, Sangeeta and Priyanka for allowing me to put my mind off my Ph.D. at times when I needed it the most.

I would like to end this acknowledgement by thanking the two most important people in my life: my husband Rahul and our son Aaran who helped me in their own way. Thank you Aaran for welcoming me back home every day with your sweet smile. Thank you Rahul for being a loving, supportive and encouraging partner and a very patient and caring father. Without you, this Ph.D. would not have been possible!

Aarti Mahajan, November 2014

Summary

Over the past decade technology has changed at a rapid pace, giving rise to several new technology-based firms (TBFs). Scholars have long studied how and why some firms survive and prosper while others fail to persist. In order to survive, TBFs need to constantly innovate in an environment characterized by fast changes. To gain competitive advantage, firms primarily need to create and maintain value (Conner, 1991; Ireland et al. 2003). Value creation is crucial for TBFs, initially to survive and later to grow. Despite the development of the concept of value creation in management and organization literature, questions remain on the subjective nature of value realized for diverse target users (Lepak et al., 2007). Existing research has conferred several factors that enhance the total value created by the firm, such as new products and services, virtuous ecosystems, talent attraction, resource base, complementary and leveraging technologies etc. (Amit and Zott, 2001; Herskovits et al., 2003). However, the primary source of value creation remains the stock of resources that a firm possesses (Barney, 1991). Scholars further claim that firms need to acquire, develop, incorporate and leverage resources in order to create value (Sirmon et al., 2007). This issue of value creation is of primary importance for new and young TBFs since they operate in technological markets characterized by high uncertainty. In absence of easy access to technological and social capital resources, TBFs find it difficult to innovate and create value. In my doctoral dissertation, I conduct three studies in TBFs to explain how TBFs manage technological and social capital resources to create value by using diverse mechanisms-namely bricolage, ecosystems and business models.

The first study proceeds from the resource based view which underlines the importance of resources for value creation. However, not all firms, particularly new TBFs, have easy access to resources. Baker and Nelson (2005) present Levi-Strauss' (1966) concept of bricolage- "*making do with what is at hand*"- as a mechanism to address resource scarcity. Using bricolage, firms are able to create something from nothing by exploring resources which are overlooked or rejected by other firms. I propose freely available open source software (OSS) as a technological and social capital resource for bricolage in resource-constrained TBFs. Using the strategic lens of ambidexterity (March, 1991), I study how OSS enables bricolage in TBFs subject to resource scarcity within the firm. A detailed case study approach reveals that the degree of bricolage using OSS is contingent

upon the level of resource scarcity within the firm. The study further examines the explorative and exploitative activities during the bricolage process. First, a firm with high resource constraints strongly follows the exploitation process and largely benefits from the software and its user community for formulating their value proposition and reaching their customers. Second, a firm with moderate resource constraints gains speed and flexibility in serving customers through experimentation with OSS by balancing exploration and exploitation. Third, a firm with low resource constraints largely explores the advantage of OSS bricolage to gain credibility and showcase their technological innovation internally to their higher management. The study demonstrates that bricolage using OSS leads to higher value creation in resource-constrained firms that effectively balance exploration and exploitation.

The second study investigates whether the presence of *knowledge and business ecosystems* leads to value creation in young TBFs in Flanders. Innovative start-ups which are located in geographical hotspots, usually centered on universities and public research organizations are proved to be in a beneficial position. These hotspots or knowledge ecosystems play a central role in technological innovation in firms (Jaffe, 1986; Almeida & Kogut, 1999). On the other hand, management literature focusses on business ecosystems as sources of competitive advantage for firms (Moore, 1996). A business ecosystem is seen as a group of companies which simultaneously create value by combining their skills and assets. Following the success of Silicon Valley and the Boston area, practitioners as well as researchers have implicitly assumed that a business ecosystem is a direct consequence of a knowledge ecosystem. However, this question was never addressed in research. To address the co-existence of a knowledge and business ecosystem, I empirically analyze a database of 138 innovative start-ups in the region of Flanders, founded between 2006-2010. A dense knowledge ecosystem in Flanders is observed, with two universities and three public research organizations playing a central role. The financial ecosystem is also prevalent with public investors at the top. Surprisingly enough, a business ecosystem is absent in Flanders. While several dyads exist, the lack of central players confirms the absence of a business ecosystem. The study further investigates whether these ecosystems contribute to the innovative performance and survival of TBFs. Analysis shows that being close to the most central organizations in the knowledge ecosystem has a positive impact on the innovation output of the focal firm. Surprisingly, receiving finance from the more central financial

players in the Flemish network has a negative impact on the venture's innovation output. This indicates that these investors are mainly interested in exploiting the technology rather than further developing the technology portfolios. The business ecosystem literature proposes firm survival as the main performance indicator, especially for innovative start-ups as they operate in markets not yet clearly developed. Interestingly, working together with central partners in the knowledge ecosystem does not impact the survival rate of the innovative start-ups. This finding lends further supports to the hypothesis that a knowledge ecosystem does not automatically lead to a business ecosystem.

The final study departs from the distinguished work of Amit and Zott (2001) which proposes the business model construct as a unifying analysis that captures value creation generated from multiple sources. Open source software (OSS) has long been associated with the concept of 'free' and consequently 'no revenues' or 'no value'. Despite successful OSS companies, research focused on OSS strategies in comparison to closed source software (CSS) is still lacking. Previous studies have compared CSS and OSS firms based on innovativeness, design structure or pricing strategy. A comparison of OSS and CSS firms based on their business model, specific to one sector, is under-researched in management literature. Hence, I depart from the OSS literature (Hecker, 1999; Lerner & Tirole, 2002) and use the business model construct to study how OSS and CSS firms differ. I follow the definition of Teece (2010), aligning it with definition of Osterwalder and Pigneur (2010), to define a business model as a combination of three elements: *value creation*- the value proposition the company offers on the market, *value delivery*- how the value is delivered to the customer, and *value capture*- the financial aspects, namely the revenue and cost model. Focusing on a single industry of content management systems (CMS), 30 qualitative interviews with the management of top CMS companies and founders of community OS CMS were conducted. My analysis shows that CSS companies excel in their innovative value delivery and value capture mechanisms, while OSS companies strongly compete on account of their extrinsic network value, defined by their large installed base. Owing to their popularity among individuals, community OSS enjoy higher social value but low economic value for the community. However, OSS community affiliated businesses benefit from the opportunity space and installed base created by OSS communities. As a result, they pose a serious challenge to OSS and CSS companies.

The three studies underline the importance of using and developing both technological and social capital resources for value creation. Not only does the triad of bricolage, the ecosystem and the business model help the TBFs in pursuing resources, it also facilitates easy adaption of their product development processes contingent on industry expectations in order to innovate and create value for the organization.

These three studies make a number of significant contributions to the entrepreneurship and management literature. The first study primarily contributes to literature on bricolage by discussing the heterogeneity of contexts in which bricolage can occur in firms, and by revealing a link between bricolage and ambidexterity. The second study makes a significant contribution to the literature on ecosystems by arguing that while a successful knowledge ecosystem significantly impacts firm performance, it does not necessarily translate into a business ecosystem. The last study strengthens the literature on OSS by highlighting the opportunity space provided by OSS enriched by the huge community. In addition to literature contributions, this research offers several practical implications for entrepreneurs, investors and policy makers. Policy makers clearly hold the potential to boost the regional innovation systems in Flanders by playing a major role in developing business ecosystems. For entrepreneurs or managers, my research suggests a thorough analysis of OSS before adoption since OSS is certainly not a 'one size fits all' product. Lastly, the study suggests venture capitalists to look beyond the revenue model and open up for investments in (the large installed base of) OSS.

List of publications and conference presentations based on this doctoral research

Articles

Clarysse, B., Wright, M., Bruneel, J., and Mahajan, A. 2014. Creating Value in Ecosystems: Crossing the Chasm between Knowledge and Business Ecosystems. **Research Policy** 43, 1164-1176.

Working Papers

Mahajan, A., Clarysse, B., and Gann, D. How do Proprietary and Open Source Business Models differ? An Analysis of Content Management Systems. *Under Review* for **Long Range Planning**

Mahajan, A., Clarysse, B., and Wright, M. Exploration, Exploitation and Bricolage: Technological Innovation Using Open Source Software.

Conference Proceedings

Mahajan, A., Clarysse, B. 2013. Technological Innovation and Resource Bricolage in Firms: the Role of Open Source Software. Open Source Software: Quality Verification. IFIP Advances in Information and Communication Technology 404, 1-17.

Conference Presentations

Mahajan, A., and Clarysse, B. Technological Resource Bricolage in Firms using Open Source Software. XXIV ISPIM Conference on Innovating in Global Markets: Challenges for Sustainable Growth. Helsinki, Finland. 16-19 June 2013.

Mahajan, A., and Clarysse, B. Technological Innovation and Resource Bricolage in Firms: the Role of Open Source Software. OSS 2013, The Ninth International Conference on Open Source Systems. Koper-Capodistria, Slovenia. 25-28 June 2013.

Mahajan A., and Clarysse, B. How do Proprietary and Open Source Business Models differ? An analysis of Content Management Systems. EURAM 2013, 13th Annual Conference of the European Academy of Management. Istanbul, Turkey. 26-30 June 2013.

Mahajan A., and Clarysse, B. Open Source Software as Bricolage Mechanism for Technological Innovation. EURAM 2013, 13th Annual Conference of the European Academy of Management. Istanbul, Turkey. 26-30 June 2013.

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List of Abbreviations

CMS: Content Management System

CS: Closed Source (Proprietary)

CS CMS: Closed Source Content Management System

CSS: Closed Source Software (Proprietary Software)

FOSS: Free and Open Source Software

GPL: General Public License

OS: Open Source

OS CMS: Open Source Content Management System

OSS: Open Source Software

PRO: Public Research Organization

RBV: Resource-based view

SME: Small and Medium Enterprise

TBF: Technology-based firm

TTO: Technology Transfer Office

VC: Venture Capitalist

1 Introduction

Over the past decade technology has changed at a rapid pace, giving rise to several new technology-based firms (TBFs). Scholars have long studied how and why some firms survive and prosper while others fail to persist. In order to survive, TBFs need to constantly innovate in an environment characterized by fast changes in technology, customers and competition (Danneels, 2002). To gain competitive advantage, firms primarily need to create and maintain value (Conner, 1991; Collis and Montgomery, 1998; Ireland et al., 2003). Schumpeter (1934) established the theory of economic development and new value creation through the process of technological change and innovation. Several authors have discussed the relation between strategies of value creation and the likelihood of profiting from innovation (Lippman and Rumelt, 2003b; Teece, 2005; Jacobides et al., 2006). This doctoral dissertation recognizes the importance assigned to value creation in management literature, and develops it further with three studies on value creation in TBFs.

In this introductory chapter, I begin by presenting the importance of value creation and sources of value creation on which I base the three studies of my doctoral dissertation. In the following section I put forward my research questions of the three studies. The organization of the dissertation is explained in the final section.

1.1 Importance of Value Creation

Value creation is a central concept in management and organization literature. Several scholars have discussed what value creation is and how it can be achieved at both the individual level as well as the organizational level, however not reaching a consensus on the concept of value creation (Lepak et al., 2007). Seth (1990) defines value creation as "a process which involves taking strategic actions to make optimal use of firm's productive resources in the presence of environmental constraints and opportunities". Definitions suggest that value creation is subjective and depends on the relative value realized by several target users (Lepak et al., 2007). Strategic management and entrepreneurship research have discussed value creation for various target users such as organizations (Porter, 1985), stakeholders (Post et al., 2002), customers (Priem, 2007), employees (Wright et al., 2001) as well as society as a whole (Lee et al., 2007).

Studies with an organization as target user of value creation claim that firms create value by new technologies, new products and services, new raw material and inventive methods of doing things. Invention and innovation are thus central to an organization in creating value. Furthermore, scholars claim that firms are more likely to innovate in uncertain environments (Brown and Eisenhardt, 1997), in resource-constrained environments (Van de Ven, et al., 1989), when they have established social networks (Smith et al., 2005), and when they possess the capacity to combine and exchange knowledge (Nahapiet and Ghoshal, 1998). Existing research has conferred several factors that enhance the total value created by the firm, also referred to as value drivers, such as new products and services, virtuous ecosystems, talent attraction, resource base, complementary and leveraging technologies etc. (Amit and Zott, 2001; Herskovits et al., 2003).

Although diverse value drivers have been discussed in management literature, the concept of value creation finds its roots in the resource-based view of a firm (Barney, 1991) which suggests possession of resources as a basis of value creation. While unique and valuable resources may provide competitive advantage to the firm, they do not guarantee value creation (Barney and Arikan, 2001). Scholars argue that in order to realize value, firms need to *manage* their resources in an optimal way. Priem and colleagues (2001) reveal gaps in management literature on theoretical studies to explain how firms transform resources to create value. However, the processes by which firms acquire, develop, incorporate and leverage resources to create and maintain value are not well understood. To clarify the link between the management of resources and the creation of value, scholars have studied the effects of the firm's external environment on managing resources (Sirmon et al., 2007). The noteworthy theoretical work by Sirmon and colleagues (2007) opens avenues for further empirical research on the management of resources and the creation of value.

This research gap in the management of resources for value creation is the outset for this doctoral dissertation. Few studies dealing with value creation for organizations have focused on new and young TBFs. As for established firms, resources are equally important for new and young TBFs. This issue of value creation is very important in hi-tech entrepreneurship, since many firms start up but do not create any value and never make it past the start-up stage. These firms operate in technological markets which are

characterized by high uncertainty. In such an environment, entrepreneurs and managers find it difficult to develop, manage and deploy resources in the most favorable way by virtue of time pressure. More often than not, these TBFs do not possess valuable resources, and neither are they strongly connected in the industry network, which makes it difficult for them to innovate. Hence, value creation is crucial for the development of TBFs as it helps the firm in building a strong reputation (Sanchez and Sottorio, 2007). Within management research, scholars have already studied the acquisition and deployment of certain types of resources in value creation- namely human capital resources (Huselid, 1995; Lepak and Snell, 1999; Hatch and Dyer, 2004) and financial resources (Chebat et al., 1994; Kang, 2000). Entrepreneurs manage financial resources by bootstrapping (Winborg and Landstrom, 2001; Smith, 2009). However, technological and social capital resources, which have a greater impact on value creation in uncertain environments, are more difficult to develop and manage. In my doctoral dissertation, I implement three studies in TBFs to explain how TBFs acquire, develop, incorporate and leverage technological and social capital resources using diverse mechanisms- namely bricolage, ecosystems and business models.

1.2   Sources of Value Creation

My first study departs from the resource-based view of the firm (RBV). RBV suggests that complimentary and specialized resources may lead to value creation (Penrose, 1959; Barney, 1991) through the development of competitive advantage (Ireland et al., 2003; Sirmon et al., 2007). Resources that are rare and lack substitutes provide a superior edge to the firm. But not all firms have easy access to resources which results in firms following 'bricolage'- using resources at hand (Baker and Nelson, 2005). In resource-constrained environments, where firms need to make do with resources that are available, finding rare and valuable resources can pose a challenge. Scholars claim that the combination and the exchange of resources also lead to value creation (Moran and Ghoshal, 1996). I argue that embracing freely available technological resources and incorporating them in novel ways within the firm can also assist value creation in firms. I propose bricolage using the freely available open source Software (OSS) as a technological resource to facilitate the innovation process for value creation in TBFs.

Strategic networks- the important ties between participating firms- have been researched in literature as must-haves for competitive advantage (Dyer and Singh, 1998;

Gulati et al., 2000). Not only do these networks provide access to information, markets and technology, they also facilitate knowledge sharing (Dyer and Nobeoka, 2000). In regional innovation systems, convergence of individual strategic networks of firms can lead to the creation of value networks (Normann and Ramirez, 1993; Eisenhardt and Galunic, 2000). In my second study, I advance from the literature on regional innovation systems to study ecosystems as a source of value creation (Adner and Kapoor, 2010) in the region of Flanders in Belgium. One of the key sources of value creation is the facilitation of the innovation process in individual companies (van der Borgh et al., 2012). I suggest knowledge ecosystems as a technological resource and a facilitator of the innovation process within innovative start-ups in Flanders.

In the third study, I depart from the distinguished work of Amit and Zott (2001) on value creation. Amit and Zott (2001) propose the business model construct as a unifying analysis that captures value creation generated from multiple sources. They observe a business model as a critical source of value creation not only for the firm, but also for its suppliers, partners and customers. I use the business model construct to explore value creation in OSS firms. While practitioners have long associated open source (OS) with 'free' or 'no revenues', I argue that the value in OS lies in the social capital offered by the community and opening up the source code can facilitate the creation of an innovation community which is another source of value creation (van der Borgh et al., 2012).

1.3 Research Questions

In the first study, I focus on the role of technological resources, and specifically OSS, in enabling bricolage in the product or service development. This is an important omission in contexts where technological resources are central to the value proposition of the firm. Value is created by balancing the level of exploration and exploitation (O'Reilly and Tushman, 2008; Teece, 2007; Raisch et al., 2009) that occurs during the bricolage process in firms. Remarkably the potential linkages between bricolage and exploration, and bricolage and exploitation are yet to be studied. Therefore, I address the following research questions: How does OSS enable bricolage in firms, and how do organizations confronted with resource constraints embrace the opportunity provided by OSS? To what extent is the bricolage process contingent on the level of resource scarcity? Does the explorative or exploitative nature of OSS bricolage allow firms to adapt and change

in order to create value through technological innovation? I use a case study approach to address these research questions.

The second study discusses value creation in regional innovation systems. A stream of management research suggests several advantages for innovative start-ups located in dense knowledge ecosystems centered on universities and public research organizations (Pouder and St John, 1996; Van Looy et al., 2003). In contrast, strategic management literature focuses on business ecosystems as sources of competitive advantage for individual companies (Iansiti and Levien, 2004). There is a growing consensus that business ecosystems provide entrepreneurial firms with resources and information to navigate in a constantly changing competitive environment (Zahra and Nambisan, 2012). Quite often, it is implicitly assumed that business ecosystems are the automatic consequence of setting up a knowledge ecosystem. In this study, I explore the question of co-existence of knowledge and business ecosystems, or in other words, the existence of a relation between knowledge ecosystems and business ecosystems. Based on a unique hand-collected database of 138 innovative start-ups in the region of Flanders, I analyze the knowledge ecosystem, the business ecosystem and the financial support network to study their impact on firm performance and survival.

In the third study, I analyze the role of business models in creating value for the firm. Recent studies have identified the business model as a source of competitive advantage for the firm, which contributes to the firm's survival and performance (Teece, 2010; George and Bock, 2011). While OS has been widely accepted as a successful development process in the software industry, the business models in OS still remain unclear. Questions remain as to how companies profit from providing OSS at no cost. Therefore, in this study, I aim to shed light on strategies of OS companies by exploring their business models in depth. I compare the business models of OSS and closed source software (CSS) companies using value creation, value delivery and value capture as three components of their business model. Using in-depth interview data, the study addresses the following research questions: How do business models of OSS and CSS companies differ? How do these OSS and CSS companies adapt their business models in response to industry trends?

1.4 Organization of the Dissertation

The current chapter is the introduction of the doctoral dissertation. In the second chapter, I present my first study on value creation in TBFs through bricolage. In that study, I introduce exploration-exploitation as a strategic lens to study bricolage processes using OSS as a technological resource in resource-constrained firms. Chapter 3 of this dissertation includes my second study on value creation in ecosystems. I draw on the knowledge ecosystem, the business ecosystem and the financial support network in Flanders to study their impact on firm performance. In chapter 4, I compare business models of OSS and CSS companies. Using qualitative data on a single domain of content management systems, I analyze business models of OSS companies in their value creation, value delivery and value capture aspects. Finally, I highlight and summarize the main findings from the three studies in the dissertation in Chapter 5. I also present the implications for management science and practice and discuss the limitations of these studies, which indicate directions for future research.

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2 Exploration, Exploitation and Bricolage: Technological Innovation Using Open Source Software

ABSTRACT

Technological resources have been an important source of innovation in companies. They play a key role in the development of new products and services. However, the upfront investment in technological resources to enable the development of new products and services can be quite high. We argue that the advent of open source software (OSS) creates an opportunity space for companies to build prototypes at a low cost and test their ideas in the market. Little is known about how OSS plays a role in allowing these firms to enhance product development. Using qualitative case studies, the study sheds light on how OSS acts as a bricolage mechanism, a term used in the entrepreneurship literature to refer to low-cost solutions by using resources available at hand, for technological innovation in firms. We further apply the strategic lens of exploration-exploitation to investigate OSS bricolage processes in firms contingent on the level of resource scarcity.

2.1 Introduction

Most firms face substantial resource constraints during firm creation and growth (Shepherd et al., 2000). Several authors have studied resource constraints such as lack of finance (Berchicci and Hulsink, 2006), physical resources constraints (Garud and Karnoe, 2003) and/or technological resources constraints (Stuart et al., 1999). Firms which are resource constrained are unable to make the necessary upfront investments in technical resources to develop new products and services.

Baker and Nelson (2005) present Levi-Strauss' (1966) concept of bricolage- "*making do with what is at hand*" as a mechanism to address resource scarcity. Using bricolage, firms are able to create something from nothing by exploring resources which are overlooked or rejected by other firms (Baker and Nelson, 2005). Firms in resource-poor environments typically engage in bricolage by using resources at hand, or by combining resources for new purposes.

Resources at hand typically include personal knowledge and capabilities, initial investment and personal network. However, technological resources may also play an important role in bricolage. In industries where technological resources are indispensable, considerable investments in the novelty and protection are required in order to access technological resources. A cheaper option for firms is to invest time in developing technology in-house using their technical knowledge and know-how. Open source software[1] (OSS) presents an emerging low-cost alternative to access technology quickly. Free availability of source code, zero cost and access to a knowledgeable community are the major features of OSS which attract firms to adopt OSS (Fitzgerald, 2006). OSS acts as an opportunity space for firms to experiment and manage innovation with technological resources. Moreover, OSS presents several networking opportunities for individuals and firms enabling 'network bricolage' (Baker et al., 2003).

The literature has so far largely ignored the role of technological resources, and specifically OSS, to enable bricolage in the product or service development process. This is an important omission in contexts where technological resources are central to the

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[1] For better readability, the term open source will be used throughout this article, but the study also refers to Libre and Free software, which shares the same technical definition, but is driven by philosophical/moral considerations on freedom rather than technical arguments: see http://www.gnu.org/philiosophy/free-sw.html

value proposition of the firm. The value created by the firm is influenced by the way in which specific processes are performed, and is determined by a healthy balance between the 'exploration' of new capabilities and 'exploitation' of existing resources (March, 1991; O'Reilly and Tushman, 2008; Raisch et al., 2009) that occurs during the bricolage process in firms. In this article, therefore, we address the following research question: How do organizations confronted with resource constraints, embrace the opportunity provided by OSS? Does the explorative or exploitative nature of OSS bricolage process allow firms to adapt and create value and lead to technological innovation?

Specifically, based on three case studies, we observe how OSS facilitates technological innovation in firms. When considering OSS bricolage, 'material at hand' is typically the software and the network or the community behind the software. Our cases encompass three contexts. First, a firm with high resource constraints strongly follows the exploitation process and largely benefits from the software and community for formulating their value proposition and reaching their customers. Second, a firm with moderate resource constraints gains speed and flexibility in serving customers through experimentation with OSS by striking a balance between exploration and exploitation. Third, a firm with low resource constraints largely explores the advantage of OSS bricolage to gain credibility and showcase their technological innovation internally to their higher management.

We contribute to the general bricolage literature and the broader emerging resource orchestration literature, by providing insights into how bricolage can be used to access technological resources in rapidly changing resource-constrained environments. We also contribute to the OSS literature by highlighting the heterogeneity of the contexts where it can be applied in technological firms with different resource structure. Moreover, we extend our understanding of the organizational ambidexterity literature and apply the exploration-exploitation framework to investigate OSS bricolage processes.

The article is structured as follows. In the following section we outline the conceptual background on bricolage, OSS adoption and the exploration-exploitation construct. We proceed to analyze the three case studies to examine how OSS as a technological resource facilitates value creation and innovation through experimentation and

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bricolage in firms facing different levels of resource scarcity. Finally we reflect on the findings and discuss the implications and conclusions.

2.2 Theoretical Background

2.2.1 The Concept of Bricolage

The availability of resources presents firms with opportunities to experiment and create value for the firm. Demand and supply gaps lead to opportunity creation, while access to resources confines the choice of opportunities (Thakur, 1999). Availability of resources is highly valuable to young and nascent ventures (Hitt et al., 2001), initially to survive and later to grow (Sirmon and Hitt, 2003; Hoegl et al., 2008). However, financial, technical and human resources are often not available when required (Bruderl et al., 1992). When entrepreneurs discover opportunities and are challenged with resource scarcity, they often make decisions using bricolage (Baker and Nelson, 2005). Bricolage allows these young and nascent ventures to deal with routine problems, and is seen to have a positive effect on innovation in nascent and young firms (Anderson, 2008; Senyard et al., 2011).

Bricolage[2] as a process of resource use and development is conspicuous in firms characterized by resource-poor environments (Baker and Nelson, 2005). Despite these resource constraints, some ventures survive by solving problems and developing opportunities (Mahoney and Michael, 2005). Levi-Strauss (1966) suggested bricolage as a mechanism for opportunity creation by using resources at hand, recombining resources for new purposes, and making do with existing resources. Previous studies on bricolage in SMEs and large organizations have limited its role in facilitating innovation. Few authors have studied the use of bricolage in ICT firms to develop new products or services (Ciborra, 2002; Ferneley and Bell, 2006). Ferneley and Bell (2006) studied the concept of bricolage to integrate business and IT innovation in SMEs. Scholars suggest

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[2] While bricolage discusses opportunity identification, several other theories describe entrepreneurial action. Effectuation, the way of thinking that serves entrepreneurs in the processes of opportunity identification and new venture generation (Sarasvathy, 2001) is a popular theory which argues the importance of resources in the start-up phase. In line with the concept of bricolage, effectuation also discusses the process of using the available resources. However, these two theories have developed independently (Fisher, 2012). While both theories talk about the use of available resources, effectuation is more relevant for new and uncertain environments while bricolage is effective in resource poor environments. Effectuation also enables the entrepreneurs to interpret the resources and clearly predefine the goals, while bricolage allows the bricoleur to take a pre-defined goal and construct the resources in the direction of the goal (Baker and Nelson, 2005).

that SMEs are recognized for their flexibility and ability to respond rapidly to a changing environment, but they are reluctant to adopt information systems, primarily due to lack of strategic planning (Levy et al., 2001) and financial constraints (Foong, 1999). Similarly, multi-national corporations face a number of hurdles which prevents them from reaching their full potential, uncertainty avoidance being the key hurdle (Halme et al., 2012). Halme and colleagues introduced the term intrapreneurial bricolage as entrepreneurial activity within a large organization, characterized by creative bundling of resources, in contexts of resource scarcity (Halme et al., 2012). In order to bricolage, the internal bricoleur, the person who engages in bricolage within an organization, needs organizational space to experiment and innovate (Ferneley and Bell, 2006). For innovation to occur, the internal bricoleur needs access to technology, which managers are often reluctant to invest in.

While the role of bricolage in innovation has been studied, there still exists uncertainty related to the resource configuration of firms engaging in bricolage. Several authors have addressed technological resources as key success factors in high-technology industries (Henderson and Clark, 1990; Zahra, 1996; Autio et al., 1997). Not only do technological resources help in formulating the value proposition in the technology-based firms, they also play a major role in understanding and evaluating the commercial potential of technological advances (Cohen and Levinthal, 1990). Research shows that technological knowledge resources impact firm performance (Lee et al., 2001; Clarysse et al., 2011) and that the quality and diversity of technological resources leads to breakthrough innovation (Srivastava and Gnyawali, 2011). We argue that the type of resource plays a key role in value creation and is a primary source of innovation. We further debate that the availability of technological resources can shape the value proposition of the firm, which in turn can facilitate innovation through bricolage.

2.2.2 Open Source Software

The term open source (OS) has its roots in the ICT industry. In the technology sector, ventures need to keep up with the rapid rate of technological evolution, more so in the ICT industry. Technological resources in ICT industry are protected by intellectual property rights in the form of patents and copyrights with a view to gain market share and obtain investments from venture capitalists (Bell and McNamara, 1991). Firms in resource-scarce environments either need to buy these technological resources

(software, system, platform, etc.) or need to reinvent the wheel and develop the technology in-house. With the rapid changes in the ICT industry, firms find it difficult to invest time and money in the development of technological resources. OS provides a solution for firms to use technology as a resource at hand, and manage innovation through bricolage.

Open source has been widely accepted as a collaborative development process in the software industry. OSS is a software available in source code form, which can be modified by users, and can be redistributed freely even in a modified form without paying the original developers (Riehle, 2009). Development is undertaken by people dispersed all over the world, forming a virtual community via the Internet (Hertel et al., 2003). Prior literature on OSS encompasses motivations and contributions to OSS (e.g. Lerner and Tirole, 2002; von Hippel and von Krogh, 2003; Bonaccorsi and Rossi, 2003), governance and organization of OSS (e.g. van Krogh et al., 2003; Shah, 2006; Lakhani and von Hippel, 2003) and competitive dynamics of OSS (e.g. Bonaccorsi et al., 2006; Economides and Katsamakas, 2006),

Research on OSS suggests that OSS drives innovation and spurs novel business models (von Krogh and von Hippel, 2006; Ebert, 2007). Absence of pricing systems, formal hierarchies and alliance agreements promote innovation with OSS (Osterloh and Rota, 2007). Bonaccorsi and Rossi (2006) observed that a key motivation for OSS entrepreneurial ventures to collaborate with OSS communities is that it allows small and new firms to be innovative. With a robust, high-quality, feature-rich software, and a strong community of developers creating and testing the software, OSS acts as an important source of opportunity for small and large firms. OSS has surpassed the notion of being free software developed by 'techies', and is being extensively embraced by organizations owing to its 'high quality at zero cost' facet. Not only individuals and SMEs, but also large corporations and government organizations show a strong increase in adopting OSS (Hauge et al., 2010). Deploying OSS products in their operation environment as end users has been the most common manner of organizational adoption of OSS (Fitzgerald and Kenny, 2004; Ven et al., 2008). Hague and colleagues argue that adopting OSS is more than simply using OSS products (Hauge et al., 2010). Integrating OSS components into own software is another popular way of organizational adoption of OSS (Ajila and Wu, 2007; Ven and Mannaert, 2008). Participating in OSS

development, providing own OSS products, and using OSS development practices within the organization are other ways in which organizations adopt OSS (Hauge et al., 2010).

These studies on OSS adoption primarily focus on the collaboration process within the communities and its impact on firm performance. However OSS as an opportunity space and as a technological resource that drives value creation and technological innovation tends to be sidelined in existing literature.

2.2.2.1   *OSS Bricolage in firms*

The concepts of OSS and bricolage have been previously discussed by Feller and Fitzgerald (2002). Feller and Fitzgerald (2002) addressed the approach of collaborative development in OSS communities, where developers and users bring together their knowledge resources to develop solutions rapidly. The use of these communities enables a process of bricolage. Scholars have observed communities of users and developers interacting via the Internet to be valuable innovation inputs (Hargrave and Van de Ven, 2006; Piva et al., 2012). Proprietary firms are promoting employees to contribute to OSS in order to insource technical knowledge (Colombo et al., 2013). Participation and/or collaboration with an OSS community can facilitate bricolage in firms. We define OSS bricolage as "making use of OS software or OS platform and the OS community as materials at hand". OSS bricolage may apply to ventures dependent on the ICT industry. Businesses in the ICT sector are more likely to adopt OSS owing to the familiarity with the concept. In contrast, industries such as biotech, pharmaceuticals and manufacturing are less likely to engage in OSS bricolage due to the high importance assigned to intellectual property rights.

Technology and technological services are the key resources in the ICT sector (Melville et al., 2004). While technology can be patented, the CSS code is primarily protected by copyright. On the contrary, OSS code is protected by copyleft which makes it easily available for use under one of the FOSS (Free or OSS) licenses. The free availability of software presents the technical resource to build up the value proposition. Rather than buying expensive licenses on copyright protected software, OSS allows entrepreneurs to experiment and build products and services with freely available software code. Founders of micro firms and developers in large firms can syndicate their technical

knowledge and expertise to work further on the freely available OSS to strengthen and expand their own product and service portfolio.

Several researchers have validated the importance of networks and partnerships for firm performance (Gabbay and Leenders, 1999; Elfring and Hulsink, 2003). Social capital allows firm to build up their resource base with the help of other partners. For young and small firms, the social capital resources provide access to information, technical knowledge, market know-how and complementary resources (Eisenhardt and Schoonhoven 1996; Hitt et al., 2001). The OSS community consists not only of the core developers of the software, but also testers, end users and vendors of the software. Owing to their community participation, members tend to know the working of the software. As a result, most of the community members take a step further to set up start-ups based on OSS by integrating the freely available software within their products and services (Gruber and Henkel, 2006). The community itself acts as the major social capital for these ventures. Moreover, these firms partner with other OSS-based firms in order to reach their end customer. The community not only helps with the development and the testing of the software, it can also act as a primary marketing and distribution tool for these OSS-based firms. Established firms and multinational organizations often allow their developers to work on the development of OSS in order to build up their knowledge and professional network (Dahlander and Magnusson, 2008).

Limited by financial and human resources, firms balance their internal R&D efforts by networking intensively with external third parties that are likely to contribute valuable knowledge and competences (Stuart and Sorenson, 2007). With fairly addressable human and financial resources, entrepreneurial ventures regard OSS primarily as a technological and social capital resource during bricolage. For firms with lower resource constraints, OSS as a technical resource can provide them with a platform to expand their value proposition. Moreover, OSS bricolage in these organizations can pave the way for more resources that are a necessity for higher levels of innovation (Rothaermel and Deeds, 2006). In this study, we present OSS as a key technological and social capital resource in bricolage process in firms.

2.2.3 Exploration and Exploitation

The terms exploration and exploitation have their roots in the vast literature on organizational ambidexterity, the premise of striking a balance between the exploitation of existing resources and exploration of new capabilities which has gained immense attention in management literature since the seminal work of March (1991). The primary argument of organizational ambidexterity is the careful adjustment of short-term *exploitative* capabilities and long-term *exploratory* capabilities in order to achieve a right balance for a particular set of organizational and market conditions (Birkinshaw and Gibson, 2004). March (1991) described exploration as "things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation". Exploitation, on the other hand is illustrated by terms such as "refinement, choice, production, efficiency, selection, implementation, execution". He further stated that "essence of exploration is experimentation with new alternatives" whereas "essence of exploitation is the refinement and extension of existing competences". Applying Levinthal and March's (1993) definition of exploration as "the pursuit of new knowledge, of things that might come to be known" and exploitation as "the use and development of things already known", Rothaermel and Alexandre (2009) explain exploration as "sourcing of new technology" and exploitation as "sourcing of known technology". He and Wong (2004) define exploitative innovation as "technological innovation activities aimed at improving existing product-market domains" and exploratory innovation as "technological innovation aimed at entering new product-market domains." Andriopoulos and Lewis (2009) argue that exploration of existing products enables incremental innovation while exploration of new opportunities fosters more radical innovation.

Further scholars claim that exploration and exploitation need to be recombined to create value (Eisenhardt and Martin, 2000; O'Reilly and Tushman, 2008). Focus on exploitation may result in short-term success, but it might hold back the firms from responding to environmental changes (Ahuja and Lampert, 2001). On the contrary, exploration will allow the firms to strengthen its knowledge base, but it can trap organizations in the endless cycle of search and change (Volberda and Lewin, 2003). Tushman and O'Reilly (1996) state that firms need to excel at both explorative and

exploitative innovation in order to survive and prosper and to achieve long-term firm performance.

Applying the exploration-exploitation lens to organizational behavior (Gibson and Birkinshaw, 2004), organizational learning and adaptation (Levinthal and March, 1993), strategic alliances (Rothaermel and Deeds, 2004; Lavie and Rosenkopf, 2006), knowledge search and knowledge creation (Katila and Ahuja, 2002; Nerkar 2003; Sidhu et al., 2007) and innovation and technology management (Benner and Tushman, 2003; He and Wong, 2004) is well established in literature. These studies view the balance of exploration and exploitation as a necessary condition for organizational success and survival (Raisch and Birkinshaw, 2008). Gibson and Birkinshaw (2004) go a step ahead to analyze the relationship between organizational ambidexterity and firm performance. Recent studies on ambidexterity have discussed relationships between complex antecedents and potential moderators (Auh and Menguc, 2005; Jansen et al., 2006). Remarkably the potential linkages between bricolage and the balance of exploration and exploitation are yet to be explored.

Therefore, we address the following research question: How does OSS enable bricolage in firms, and how do organizations confronted with resource constraints embrace the opportunity provided by OSS? To what extent is the bricolage process contingent on the level of resource scarcity in the firms? Does the explorative or exploitative nature of OSS bricolage process allow firms to adapt and change in order to create value through technological innovation? We address these research questions by using a case-study research.

2.3 Data and Methods

In the absence of prior research on the processes of bricolage associated with OSS in ICT firms, a case study approach seems most appropriate for interpreting these processes (Yin, 1984; Eisenhardt and Graebner, 2007; Leitch et al., 2010). We adopt a case study approach to explore how dependence on OSS and an OSS community helps facilitate technological innovation in firms. In particular, we examine the nature of the resource configuration associated with OSS, and the process of OSS bricolage for value creation.

The choice of the ICT industry was triggered by the familiarity of OSS in the industry. Due to the knowledge of the ICT concept, employees in ICT firms are more likely to

embrace ICT. While a FOSS license enables free download, install and use of OSS, most of these licenses also make it difficult to build commercial products with OSS.

The popularity of OSS has resulted in several small and large, private and public firms adopting OSS. However, there is no official census available for firms that provide OSS based solutions or firms that adopt OSS. Absence of a precise definition of the population does not allow us to extract a representative sample. Hence following Eisenhardt and Graebner (2007) we follow theoretical sampling, more specifically extreme sampling to select the three cases. The selection is based on two extreme criteria; Firstly, the cases are unlike in their level of resource scarcity, each of the cases is either confronted with low, moderate or high level of resource constraints. Secondly, each of the cases adopts a different type of OSS. The uniqueness of the cases is balanced and controlled by the institutional context and age. All three cases are from Benelux and share the same European institutional context. Moreover, all cases were established in the same period 2006-2007.

In order to look at the adoption of the OSS under different degrees of resource scarcity, we studied its use in three contexts: First, an extremely resource-constrained firm, second, a firm which can afford the use of CSS while still being in a constrained environment, and third, a firm with low resource constraints. In each case, we interviewed the founders or the department heads of the product development department. Details of the data collection process are shown in Table 1.

With regards to case with high resource scarcity (Case A), we interviewed the founders of a small Dutch web development company, JWebs. As an initial stage in identifying a suitable case, several firms adopting OSS were interviewed at the first Joomla![3] international conference. JWebs was considered relevant for the research owing to its minimalistic resource base- the two founders had limited technical knowledge, were not part of a relevant network and modest savings as start-up investments.

Case B, Mobixx represents an example of a Belgian SME trying to carve a space for itself in a niche market of mobile web while facing medium level of resource constraints. Interviews were conducted with two founders and four employees of Mobixx. The

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[3] Joomla! is one of the most popular open source content management systems today with a large community consisting of more than 500,000 forum members. Until 2010, Joomla! has been downloaded 25 million times and more there are more than 30 million websites running on Joomla

company contact was obtained through the professional network of one of the authors. Since one of the founders of Mobixx works in close collaboration with the authors, it was easy to obtain access to the company data throughout the company lifecycle.

In search of firms with low resource scarcity, the authors were directed to large firms. Large firms are less likely to face resource constraints in comparison to start-ups or SMEs. OSS adoption in large firms is commonplace in the ICT industry. However, since it is difficult to study company-wide adoption of OSS particularly in large ICT firms, we choose to study OSS adoption in an ICT department in a large non-ICT company. To study OSS adoption in a firm with low resource scarcity, we interviewed the director/ department head of the application management department of Dutch Bank in the Netherlands (Case C). The authors identified this case by interviewing five project leaders of intrapreneurial projects in a large organization. The director had initiated and managed the adoption process from start to finish, and provided the authors with the required information for the case study.

The primary data source is the interviews conducted with the people involved in the bricolage process, namely the founders or department heads. The interview data is complemented by other data sources such as company archives and publicly available data. The details of the analysis are presented in Table 1.

To study the level of exploration and exploitation, we performed a content analysis. Firstly using the extant literature on exploration and exploitation, we coded a list of keywords representing these two notions. Two researchers read the interview notes and the secondary material and coded the keywords and noted their frequency. We further calculated intercoder reliability using Cohen's Kappa (Cohen, 1960), which equaled 0.81, a value within an acceptable range for this kind of analysis. Any disagreements in the coding were resolved by further discussion.

Table 1: Data sources and data analysis methods

	Interviews	Archival Material	Data analysis method
Case A	2 interviews with founder1 ranging 55m-1h35m	Founder conference presentations Company website	Interviews were semi structured with open-ended questions in English. Two authors conducted the interviews, while a third author was not a part of the interviews in order to avoid any confirmatory biases. The interviews were audiotaped and notes were taken. The interviews were transcribed verbatim and the text was read and re-read several times to identify themes.
Case B	6 interviews (2 founders + 4 employees) lasting between 1h and 1h50m	Press releases Company archives including versions of business plans, MoM for board meetings, etc.	
Case C	1h25m interview with director of Application Management department (+ 4 other interviews with other department heads involved in intrapreneurship)	Corporate presentation of the department head at a conference.	

2.4   Analysis

2.4.1   Case A- Bricolage in a firm with high resource scarcity: OSS adoption in a Web Development Company

In this case, founder1 had a degree in computer science and had used his knowledge to control sound and lights in the theatre industry for nearly two decades. After initially working with the .NET framework, he started coding in php in 2007. He founded JWebs in 2007 together with founder2, a creative designer, with a view to build customized websites and applications. Dynamic websites demanded the use of a content management system (CMS) and founder1 initially built a CMS from scratch using .NET and later reworked it in php. He was soon confronted with the difficulties of extending and maintaining the CMS.

> *"If my customers wanted additional features, I had to write extensions specifically for them. All customers had different requirements, and it was quite time consuming to customize the CMS for each one of them."*

Having switched to php from .NET, he was presented with a wide variety of OS CMS to work with. Fascinated by the community and extendibility of Joomla!, he embraced Joomla! in 2008. Joomla! CMS served the purpose of a php-based CMS. Not only was Joomla! easy to work with, there was also a list of free and cheap extensions available and ready-to-use.

> *"When I bumped into Joomla!, I realized that I was reinventing the wheel. With Joomla!, I did not need to write specific extensions for customers any more, I could find it or buy it without spending more time developing them myself. Also I did not need to customize them for different websites; the available extensions were ready-to-use."*

In comparison to php-based OS CMS, very few .NET OS CMS were available in the market at that time. As a result, the extensions for .NET OS CMS were highly priced, and php-based OS CMS was the way to go. Customers of JWebs did not care about the backend and just needed a website that worked. Hence founder1 decided to migrate all his existing websites to Joomla!.

> *"All my customers want a beautiful website, one which can be easily updated. They don't even know what a CMS is."*

Joomla! is supported by a strong and active community of developers and end users. Since Joomla! is backed by a not-for-profit foundation, the decision making rests with the community elected representatives, giving more freedom of opinion to community members. The Joomla! website provides a space for service providers like JWebs to introduce themselves and get noticed.

> *"Getting listed does matter, creates a lot of traffic, people know you and want to try you out. If you are not listed, you are completely dependent of GOOGLE SEARCH and events. Someone contacted me from Norway, through the Joomla Resource Directory (JRD). Since there are not many companies on JRD who provide Flash integrated websites, they contact me."*

The Joomla! community also helps founders to expand their professional network. Activities like Dutch Joomla! days allowed founder1 to meet fellow Joomla! users and developers from the Netherlands.

"People interact here and become friends and partners, rather than competitors. At the end of the day, everyone is limited with the number of (human) resources and cannot commit to all projects."

Not only does Joomla! provide the technological resource for bricolage for JWebs, the large active community of Joomla! also acts as a string social capital resource for JWebs.

"The active community is Joomla!'s biggest strength. Without this community, it would be difficult for me to fulfill my client requirements quickly. If client asks for some features, and they are not available on Joomla! extensions directory, I make a request to the community. In this active community, you always have someone who can develop it for you, or if you are lucky, it will be available in the next build for free."

The founders of JWebs are not keen on growing the company, but rather prefer dealing with new technical challenges in the future. As a result, JWebs did not hire any employees, never considered outsourcing the work to developing countries, and at times even declined projects or passed it on to other developers. JWebs decided to start small, and focus on building up their social network.

"Co-operation with other small companies is essential. When you are a small company, you can do several small projects; but when you are many small companies together, you can do any big project."

To summarize, JWebs adopted OSS due to its ease of use and extendibility. Over the years, Joomla! has become an integral part of their value proposition. Not only does Joomla! provide these resource-constrained individuals with a free platform for use, it also provides micro companies like JWebs with a space to advertise themselves to the target market. OSS like Joomla! presents a huge potential for extension developers and service providers to set up micro businesses and to make profits by exploiting OSS. As founder1 defended the concept of OS:

"One idea of open source is that you don't put any energy in protecting it, otherwise there is less time spent for coding, and more for workarounds."

2.4.2 Case B- Bricolage in firm with moderate resource constraints: OSS adoption in a Small Mobile Internet Company

This case study presents innovation in a Belgian mobile internet company with the help of OSS. Mobixx started in 2006, at the time when the mobile internet market was still in an early stage of development. After a successful pilot project, Mobixx was officially founded in 2007 with two founders, one project manager, three software engineers and four freelance software developers. The value proposition of Mobixx was a technological solution to adapt website content to any mobile device in real time, while adding specific applications like a flexible mobile payment system, location specific information, targeted advertisement, etc. The founders were highly dependent on their strong personal and professional network in order to bring the product to the market. Due to lack of a customer profile, Mobixx was confronted with a range of customers who expected high level customization and experimentation with the technology. As the software engineers mentioned:

"In the beginning the founder just sold projects to customers and we had to make sure we develop what he had sold. We often had to push reality to deliver everything that was promised to the customer." (Interview with SE1, 16 Nov 2007)

"…We basically make whatever the CEO asks us to do. He has the contacts with the customers and he usually overpromises. It is always a challenge for us to realize technically what he wants and especially before the deadline he tends to give us. But I guess that is how it is working in a small start-up." (Interview with SE2, 12 December 2007)

The wide-ranging customer demands were fuelled by the novelty of the value offering. Neither the customers knew what they could get, nor did the company know which products or services the market preferred. The diversity of customer profiles demanded a lot of customization and experimentation with the technology.

Discussion point (Meeting minutes: 24 Feb 2008):

"Choice between serving every customer OR Focus on development of platform. The former (server every customer) asks for a lot of customized software development,

is time consuming and not scalable. If you cannot develop it on time, you need to look for other options- to buy or to outsource."

To meet the customer demands, the company had to be flexible with the technological resources they used. This triggered them to use OS components to build part of their value proposition.

"...The technology platform exists of a device detection database, content fetcher and a transcoder; the device detection database is based upon the open source WURFL mobile device database which is updated continuously. This allows us to keep up with recent developments [at no cost]..." (Interview with SE2, 12 December 2007)

The use of OS components allowed the developers to easily respond to the varied customer requests. At zero costs, and in no time, the components can be downloaded and used with no need to negotiate and buy a license for use. One of the major components of their technology platform- the device detection database- was based on OS WURFL mobile device database which was continuously updated. The use of OS components enabled the company to instantly respond to opportunities with no significant financial commitment.

"The Bazaar Model used by the open source community is the only way to keep abreast of the tidal wave of innovation that characterizes Web technologies. Without a large community, maintaining such a project and pushing its possibilities to its limits is impossible." (Founder1 in Press article, 16 October 2008)

While making use of existing OS database, Mobixx dedicated some time to interact with the community- the contributors for the WURFL database.

"The community acts as our informal business partner. We consult them for what we need, and share whatever extra information we had to keep the WURFL database up to date." (Interview with SE1, 16 Nov 2007)

In addition, one of the venture capitalists (VC) involved in Mobixx had previously invested in some OSS-affiliated companies, instigated by the success story of Red Hat. The VC intended to push the business model of Mobixx in the direction of OSS. As a

result, Mobixx also provided an OS platform at a later stage under a dual license and publicly announced it in the national press and on their company blog:

"..Besides, Mobixx itself largely depends on other open source projects, so it seems only fair to give something back to the community." (Founder1 in Press article, 16 October 2008)

"By making its mobile application gateway available to the open source community of Web builders, Mobixx wishes to further stimulate the use and development of its mobile internet platform for building mobile websites." (Press article, 16 October 2008)

In summary, the evidence from Mobixx suggests that small firms with sufficient resources may be able to benefit from OS in order to widen their value proposition. Moderately resource-constrained firms are often confronted with speed and timing issues in their early stage, and free availability of technological resources can help strengthen their value proposition and meet their market needs. Technological innovation with the help of OS components assists small organizations in nascent markets to compete with incumbents aiming to be fast followers in their industry.

2.4.3 Case C- Bricolage in a firm with low resource constraints: OSS adoption in a ICT department of a large Bank

This case study involves bricolage at the application management department of a large retail bank in the Netherlands. In the recent past, information technology has come to play an important role at the heart of the banking sector. The banking sector has moved from outsourcing IT services to having its own IT department. Dutch Bank has nearly 2000 employees in their offices in the Netherlands. With the radical changes in IT, banks are continuously under pressure to have innovative solutions, while being under cost pressure. In 2007, they realized a sudden drop in customer satisfaction and realized that customer did not care anymore about product specifications and features, but more about the services and easiness. They saw an enormous opportunity for the IT department to contribute to the primary strategy of the organization and hired a new IT head in 2007. The application management department was expected to develop innovative applications in order to offer better customer service. As MVD, the director of application management department, suggests, the narrow focus on application

development at Dutch Bank circumvents the need to be entrepreneurial and look for creative solutions in the outside world.

> *"Last month, I took a week off together with my boss and signed for a fantastic web conference in California. I had a fantastic week with developers of Yahoo! and Facebook. We would have expected our people that actually do the work (of application development) to be there. But there was nobody. People are so frightened and under cost pressure. No team manager allows his people to fly for a week to the States to actually find out what Yahoo! and Google are doing. I truly think there is a great opportunity but also a great need. If we are not careful, in 10 years people will not see the value of a bank anymore." (MVD, Director Application Management, Dutch Bank)*

After MVD's manager attended a Google conference in 2011, he was impressed by the Android operating system and the opportunities provided by its application development platform. With MVD's previous IT education and expertise, he and his manager started working on the development of a mobile banking application. Although they had the required background, he did not have formal financial support or dedicated resources from the department. To start with, they needed a software platform to build his application on. MVD went back to his roots and thought about OSS. During his Ph.D. years, he was a Java developer. Contributing to Java had helped him to know the language well and comfortably work with it. Along with his manager, MVD decided to start up a Java community and decided to bricolage and use resources at hand. Technological resources were no more an issue. Java was freely available, and they had the knowledge of source code although it was not necessary for the development. To gather human resources, MVD set up a Java community and encouraged people to come together for free pizzas every Tuesday evening, where they would work on developing something cool. This became an enormous success, and 50 people decided to dedicate their free time to the community. With the help of the Java programming language and the Android software development kit, the application code was well under development. Apache Nutch, an OS technology of screen scrapping was used to evoke the requests on mobile phones, which otherwise is done by browsers on desktops. The knowledge pool resulted in a fully-working mobile application in 2.5 months. This

prototype built using OSS met all requirements about the working and feasibility of the application, which normally would not have been possible without resources.

Although they had a fully-working application, the next challenge was to get it into production. Due to several technical reasons, the prototype developed with OSS could not officially advance to production. Additionally, there had been several failures of projects in the past. Thankfully, the prototype proved the success and potential of the mobile application.

> *"We had a fully-working version but that's not the official way to get into production for many technical reasons. Then you see that it really helped, because all the questions- does it work, is it feasible, they are all gone!" (MVD, Director Application Management, Dutch Bank)*

The only problem that MVD still faced was to institutionalize several processes and get it up and running for the bank. They placed an official program in the application development group to replace the version built in their free time using OSS with a formally developed application. The success of the prototype gained them credibility and legitimacy, guaranteed them a budget for the development, and also speeded up the development, which was practically impossible with only a handful of developers.

> *"Everyone saw the prototype and everyone loved it! Instantly we were issued a budget to buy the necessary proprietary software." (MVD, Director Application Management, Dutch Bank)*

Although large organizations are perceived to have several resources at hand, the resources are in fact tightly held which creates several resources constraints. Intrapreneurship or new business creation in large firms is complex and time consuming due to activities involved across multiple levels within the organization (Garvin, 2004). Due to rigid structures and control, employees in large organizations find it difficult to move from their assigned tasks to something creative and entrepreneurial. OSS provides these firms a platform to bricolage and seek resources for technological innovation in order to gain credibility within the boundaries of the firm.

2.5   Discussion and Conclusions

Using qualitative case studies, our aim has been to shed light on how OSS acts as a bricolage mechanism for technological innovation in resource-constrained contexts in firms. The degree of bricolage in firms tends to vary based on the level of resource scarcity. This can be accounted to the difference in the firms' initial resource configuration as well as the growth perspective of the firm. Our analysis suggests there are important strategic differences in the way in which OSS is harnessed in resource-constrained firms. Based on our case study research, these differences concern the intent of bricolage, characteristics of the OSS used, and the extent to which OSS is used for exploration or exploitation activities.

Intent of using OSS for Bricolage

Several ICT firms start up with scarce resources. Mostly these resources consist of the software skills of the founders and their expertise developed from their participation in the OSS community. As a result, they are highly dependent on OSS for technological resources as well as the network. OSS allows them to build their value proposition, while the OSS network provides them with marketing channels and allows them to easily target their customer group. The OSS community helps them build a professional network which opens up possibilities for business partnerships to enable them to work on bigger projects, while still staying small. The regular updates and releases of OSS spurs little innovation opportunities for the service companies, but promises persistence to the firm. For OSS firms engaging in extended product development for OSS, innovation opportunities are higher with every new major release of OSS. The speed of innovation for these firms is driven by an OSS release plan. As a result, firms with high resource constraints are more likely to work with successful OSS, which is under continuous development by an active community. These firms are highly dependent on OSS projects and systems tend to remain small. Rather than ambitious growth in terms of revenues and employees, they emphasize on technical superiority and contributing back to the OSS community.

Firms with moderate resource constraints are in possession of some resources at start up. They have a better insight into market requirements, and the value proposition is already in place at start-up. While software skills and expertise are at hand, these firms

are typically challenged by vague customer demands in a niche market and require more resources due to time constraints. In order to gain competitive advantage in a niche market, these firms need to satisfy customer requirements by competing on their own expertise, rather than collaborating with peers and the OSS community. Speed and timing are crucial in a niche market. As a result, these firms are on a constant lookout for existing technological resources which could strengthen their value proposition to address varied customer requirements. As seen in Case B, the availability of an OS database can be very useful for these firms, which along with resources are also time constrained, and hence cannot reinvent the wheel. While their dependence on OSS is of medium importance, they can benefit from OSS bricolage in order to rapidly adapt their value proposition and expand their customer reach. Free availability of several OSS also allows these firms to experiment and constantly innovate their value proposition. OSS bricolage in turn helps them to display flexibility and allows them to gain access to financial resources.

Low levels of resource scarcity are predominant in large firms where several departments find it difficult to get a hold of resources owing to the hierarchy, control and structure (Damanpour, 1992; Dougherty, 1992; Halme et al., 2012). Consequently, innovation activity in these firms is limited to specific departments. In spite of the existing knowledge and skills prevalent in some departments, the department heads find it difficult to encourage innovation owing to the lack of resources. Innovation activity and access to resources are interdependent, as one is a necessary condition for the other, and vice versa. Such low resource-constrained departments foresee the availability of OSS platforms as a resource-seeking mechanism. As seen in Case C, these departments use OSS platforms to build a working prototype of their products. Working on mature OSS platforms assures high level of security. Building a working prototype using OSS platforms as technological resource allows these departments to gain credibility within the firm and showcase their innovations to higher management in order to seek further resources.

Characteristics of OSS

Although OSS is characterized by free availability, adoption of OSS is influenced by the license under which the OSS is available. The licenses range from weak to strong which in turn determine the possibilities of using OSS for commercial value creation. Highly

resource-constrained firms regard OSS as a cornerstone of their business. Owing to high dependence on the OSS, these firms choose to work with a *developing* OSS with a strong active community. Since OSS contributes heavily to the value creation of the firm, these firms depend on OSS for its *features, usability and extendibility*. Moderately resource-constrained firms, on the other hand, are on a lookout for an OSS which strengthens their value offering. Due to moderate dependence on OSS, these firms mainly look for the *content* of OSS and hence opt for OSS which is completely *developed*. In firms with low resource constraints, use of OSS is temporary, which is reflected by their low to moderate dependence on OSS. As a result, these firms choose *mature* OSS which has long been developed and adopted by the mass market for their *functionality and stability*.

However, while OSS adoption minimizes the costs for technological resources, not all OSS are easy and advantageous to adopt. Although OSS is 'free' to use, there are several implementation and support costs associated with OSS adoption. The choice of OSS should take into account the fit with firms' requirements and budget. The requirements may demand the firms to reuse OSS code in the form of algorithms and methods, single lines of code, or components, which can in turn influence the level of bricolage (Haefliger et al., 2008). The stage of development and the future development potential also play a key role in OSS adoption. Firms are reluctant to embrace software which has been inactive for a long time, or have scarce documentation and inert support forums. Moreover, compatibility of OSS with existing hardware, extent of availability of support and maintenance also determine the choice of OSS. Lastly, the license conditions under which the OSS is released can impact OSS adoption. On the one hand, weak licenses allow users to freely adopt OSS and redistribute it even for commercial purposes. On the other hand, stronger restrictive licenses like GNU GPL prevent users from using the software for commercial purposes, requiring them to share modifications with the community. In spite of the license conditions, research shows that developers engage in selective revealing of OSS code and protecting some of their developments in order to gain benefits from OSS (Henkel, 2006; Bonaccorsi et al., 2006). That being said, firms need to rethink how OSS could confer them competitive advantage, given the fact that everyone else has access to it.

Exploration-Exploitation Lens

JWebs uses OSS as a platform to develop a product ("production"). JWebs' founder extends the current competencies that he or his firm owns and refines them to provide a value offering using OSS. Moreover, JWebs provides a product for a market that already exists, with the help of technology that is already known. The main value offering of JWebs is the development and maintenance of websites. Hence, ensuring customer satisfaction is crucial for JWebs, which is another characteristic of exploitation. To cope with the customer demand, JWebs teams up with partners and builds up alliances. These keywords clearly show that JWebs exhibits high *exploitation* through OSS bricolage. Highly resource-constrained firms like JWebs which innovate through OSS bricolage are risk averse and focus on incremental innovation which can lead to short-term profitability. Since JWebs does not conduct any explorative activities, their long-term survival is questionable. Thus, although OSS allows these companies to easily enter the opportunity space and to get off the ground following a lean start-up philosophy (Reis, 2011), it is difficult for them to monetize on OSS. We expect that this is a typical scenario in highly resource-constrained firms. Only a few OSS start-ups have escaped this through the attraction of venture capital.[4] In our opinion, these firms could benefit from responding to environmental changes and adapting themselves accordingly.

Moderately resource-constrained firms are not deterred from experimenting with either developing or mature OSS. Alongside using OSS for iterating their value proposition, they often tend to be flexible in fulfilling customer requirements in a new product-market domain. As these companies have an installed customer base to which they have sufficient credibility, they can explore OSS components without taking too much risk. With moderate resource constraints, Mobixx demonstrates some level of *explorative* activities alongside *exploitative* activities. In the case of Mobixx, OSS bricolage is primarily used for incremental innovation, but the potential of higher levels of innovation are exhibited in the development of their own OSS. Since these companies typically do not have R&D departments, the OSS community becomes the enlarged R&D department of the company. This implies that these companies also engage in giving

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[4] For a related research, the authors conducted an online questionnaire survey to study the product developers and service providers for Joomla! OS CMS. Out of the 170 firms, as many as 93% of the firms started with less than 3 employees, and 91% of these remained with less than 5 employees within 1-5 years of their founding. None of these 170 firms received any venture capital or external funding.

back to the community while exploring at the same time. These companies are probably the most important sources of innovation for the community. For them, OSS resembles open innovation in a true sense.

Case C exemplifies *exploration* because it allows the firm to search for new technological possibilities and experiment with OSS without any investment or legitimation. The firm also involves risk taking by using OSS in developing a radical innovation for a new market and for a new customer group. Moreover, the adopting process is a bottom-up learning process in which managers are persuaded to abandon old routines and committing to a new course of action (Lubatkin et al., 2006) which is typical of exploration. Although no exploitative activities arise in the OSS bricolage in Dutch Bank, the fact that they proceeded quickly from the prototype to development and further to market launch clearly represents that exploration is not extreme and that the firm is not stuck in the infinite cycle of search and change. For large companies, OSS tools have become a sense-giving instrument to convince the different management layers that a new product or service can be useful. Especially in an environment such as a bank, where new technologies tend to be cognitively distant from the mainstream understanding in the company, it is important to visualize and even prototype new ideas and services. OSS is an ideal fast and low-cost way of prototyping. Without OSS, a traditional business case would have to be made and an upfront investment would be needed. It is unlikely that managers would have been convinced to invest in this.

Table 2 below summarizes the differences in the use of OSS between firms with varying levels of resource scarcity.

Table 2: Differences between the three case studies

	Case A	Case B	Case C
Before Bricolage			
Resources at hand	Software skills	Software skills, professional network	Software skills, professional network, commercial channels, infrastructure
Level of resource scarcity	High	Moderate	Low
Resources needed	Technical, Social	Technical, Financial	Technical, Financial
Bricolage using OSS			
Type of OSS	Developing	Developed	Mature
Dependence on OSS as T.R.*	High	Medium	Low-Medium
Dependence on OSS as S.C.R**	High	Medium-High	Low
Use of OSS	Firm level	Firm level	Department level
After Bricolage			
Reason for bricolage	Value offering, network, marketing channels	Satisfying customer demands, expand market (Speed and timing)	Gaining credibility within firm
Degree of value creation	Low	Medium	High
Level of Exploration	None	Low-Medium	High
Level of Exploitation	High	Medium-High	NA[5]

* T.R. = Technological Resource

** S.C.R = Social Capital Resource

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[5] Exploitative activities are present but are not prevalent in the particular case of OSS bricolage which is studied at department level.

2.5.1 Managerial Implications

The overall pattern of results suggests that balancing exploration and exploitation while engaging in OSS bricolage is challenging. The choice of OSS also impacts the level of OSS adoption and bricolage. Managers should evaluate the use of OSS with care. Quite a number of software start-ups have a value proposition based on OSS. Although we clearly understand why these business models are attractive from a technology exploitation point of view, they might limit or even preempt technology exploration. A start-up with an OSS business model precludes itself from being active on the market for technology where licenses are the main transaction mechanism. Therefore it has to build up complementary assets to play a role on the market for products if it wants to be successful. The latter is a much riskier strategy (Bruneel et al., 2012), which assumes that the companies can raise sufficient funds to build up marketing, sales, etc.

Not surprisingly, OSS provides most opportunities for firms with moderate resource constraints, which tend to have an established customer base. These companies can make use of the OSS community as an external R&D department. However, it also implies that they need to give something back to the community, if not the use will be short-term oriented. As these firms already have complementary assets in place, OSS allows them to speed up the development process and to customize products and services at low cost. The license agreements of OSS tools do not play much of a role as the customers are on the market for products, implying that they buy products or services rather than licenses on the technology. Therefore, OSS provides them with a real open innovation platform without the pitfall of restricted IP.

In large companies, where level of resource scarcity is low, secrecy and protection policies are much stricter. Hence, a true OSS policy is more difficult to implement. These companies cross-license their products and protect their proprietary technology. If necessary, they go to court to make their point as illustrated by visible patent battles such as the Apple vs. Samsung case or the TomTom vs. Garmin case. Still, OSS can play an important role for them. OSS facilitates the making of fast and easy prototypes, which can be tangible artifacts that are used in downstream or upstream communication. The use of these artifacts for prospective sense-making purposes has been illustrated by Stigliani and Ravasi (2012). Prospective sense making is used to convince the constituents of the company of the need to move into a certain opportunity space which

is cognitively distant from the mainstream business. Hence, even in companies with a strict IP policy, OSS can be an important instrument to move in a distant opportunity space.

2.5.2 Conclusions

In summary, in answering the question how OSS acts as a bricolage mechanism for technological innovation in firms, our study makes several contributions. We have shown that OSS creates an opportunity space. However, that opportunity space is contingent upon the level of resource scarcity within the firms. Our case studies show that for start-up, firms with high resource constraints OSS provides an opportunity to exploit, but does not easily translate in exploration. For firms with moderate resource constraints which have an initial customer base, a mix of exploration and exploitation is more likely and OSS becomes a space for open innovation. In less resource-constrained firms, exploration is the most likely objective of the use of OSS tools.

The findings suggest that there is a link between the theories of bricolage and exploration-exploitation. Overall, these findings provide insights suggestive of how bricolage can be used to access and coordinate technological resources in rapidly changing resource-constrained environments. As such, our findings help extend understanding of how different contexts help shape innovative entrepreneurial activity (Zahra and Wright, 2011). We hope that our insights resulting from a focus on analysis of a small number of cases will provide the departure point for future larger studies that encompass further variety in the nature of entrepreneurial ventures adopting OSS.

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3 Creating Value in Ecosystems: Crossing the Chasm between Knowledge and Business Ecosystems

ABSTRACT

Policy makers take initiatives to stimulate knowledge ecosystems in technology hotspots. It is implicitly assumed that these ecosystems will lead to value networks through which the participating companies can realize a competitive advantage. Value networks refer to business ecosystems where the value proposition is offered by a group of companies which are mutually complementary. The strategy literature suggests that business ecosystems lead to competitive advantages for each of the partners in the ecosystem. Based on a unique hand-collected database of 138 innovative start-ups in the region of Flanders, we analyze the knowledge and business ecosystems and the financial support network. We find that the knowledge ecosystem is well structured and concentrated around a number of central actors while the business ecosystem is almost non-existent at the local level. Further, we find that the financial support network is almost 100% publicly backed and fails to bridge the knowledge and business ecosystem. The implications for policy makers who tend to focus on the development of local ecosystems are discussed.

3.1 Introduction

The literature has long recognized the advantages for innovative start-ups to be localized in geographical hotspots, usually centered on leading universities and public research organizations (Link and Scott, 2003; Van Looy et al., 2003; Löfsten and Lindelöf, 2001; Pouder and St John, 1996; Saxenian, 1996, 2006; Zucker and Darby, 2001). The flow of tacit knowledge between companies and the mobility of personnel (Saxenian, 1996, 2006) have been advanced as the main advantages of geographic colocation which characterize these hotspots. Such hotspots have been characterized as knowledge ecosystems where local universities and public research organizations play a central role in advancing technological innovation within the system.

In contrast, the strategic management literature focuses on business ecosystems as sources of competitive advantage for individual companies (Iansiti and Levien, 2004). A business ecosystem finds its roots in the idea of value networks (Normann and Ramirez, 1993) and can be seen as a group of companies, which simultaneously create value by combining their skills and assets (Eisenhardt and Galunic, 2000). Business ecosystems create value for an individual participant only when the participant is not capable of commercializing a product or service relying on its own competences (Lin et al., 2010). Such ecosystems are organized as complex networks of firms whose integrated efforts are focused on addressing the needs of the end customer. There is a growing consensus that business ecosystems provide entrepreneurial firms with resources and information to navigate in a constantly changing competitive environment (Zahra and Nambisan, 2012). Quite often, it is implicitly assumed that business ecosystems are the automatic consequence of setting up a knowledge ecosystem. However, to date, it is not clear whether the success factors that lead to knowledge ecosystems are similar to those for business ecosystems. Companies participating in a knowledge ecosystem which can make use of knowledge available in the region may not necessarily mean that these companies will also participate in the same business ecosystem. Hence, in this study we explore the question of existence of a relation between knowledge and business ecosystems.

This question is of particular interest from a policy perspective as policy makers increasingly invest in regional innovation systems, which foster the creation of innovative start-ups around so-called knowledge hubs, using successful examples such

as Silicon Valley as a benchmark (Engel and del-Palacio, 2011). We focus on whether such a knowledge ecosystem translates into a business ecosystem and draw conclusions for innovation policies aimed at fostering business ecosystems.

We make use of a unique hand collected database of 138 innovative start-ups in the region of Flanders, founded between 2006 and 2010. These companies are those which agreed to collaborate from a total database of 178 companies identified through public innovation advisors as start-ups in this region which could apply for a business plan development grant because they were developing a product or service based on or contingent on novel technologies that did not exist yet in Flanders. Since these innovation advisors receive incentives to identify innovative start-ups and guide them toward channels of public support, we are confident that these companies approximate the total population of innovative start-ups in that period. For each company we constructed the knowledge ecosystem they were embedded in, the business network they participated in, and the financial support network they made use of.

We find that the density of the knowledge ecosystem was much higher than that of the business ecosystem and was dominated by those knowledge institutes which had developed incubator/accelerator facilities and formal tech transfer offices. The business ecosystem's density was extremely sparse with only dyadic relations and a high amount of international partners, indicating that there is no overlap. Also the density of the financial support network was rather sparse, with only 40% of the start-ups participating in that network. It was dominated by public funds which took a central role while the private sector was almost completely absent. We found that working together with the top central actors in the knowledge network has a positive impact on the innovation output of innovative start-ups, but collaborations with average technology partners typically has a negative impact. Further, our findings show that receiving financial support from public funds, typically associated with these knowledge actors, does not help the knowledge production function of these companies at all. Since neither the knowledge ecosystem nor the financial support network directly contributes to short-term survival of innovative start-ups, the lack of a business ecosystem has severe policy implications.

The chapter unfolds as follows. First, we review the literature on knowledge and business ecosystems. We subsequently describe the method we used to collect and

analyze the data. Finally, we discuss the results and their implications for our understanding of knowledge and business ecosystems and the innovation policies developed to support them.

3.2 Literature Review

3.2.1 Knowledge Ecosystems

The knowledge ecosystems literature has explored the mechanisms by which geographically clustered organizations benefit from their locations (Jaffe, 1986; Almeida and Kogut, 1999). This research stream has identified the reduced costs of moving people and ideas as the primary sources of advantage from being located in technological clusters (Clark et al., 2000). In addition to external economies of scale which allow firms in these ecosystems to benefit from collective resources, local spillovers make their technology development efforts more fertile than those of their isolated competitors (Agrawal and Cockburn, 2002). Both linkages among firms and with universities and public research organizations (PRO) as well as intense labor mobility across different players facilitate collective learning and increase the speed of innovation diffusion (Baptista, 1998). As a result, physical proximity to knowledge generators such as PROs, universities and large firms with established R&D departments typically have a positive influence on the focal firm's innovation output (Phelps et al., 2012).

Contemporary literature on knowledge ecosystems has analyzed the extent to which a focal company's centrality in a global research network can substitute for not being part of a local technology hotspot (Owen-Smith and Powell, 2004; Whittington et al., 2009). The main findings show that in a biotech environment, participating in a global research network can partly substitute the lack of geographical proximity to a technology hub in terms of its impact on the innovation output of the focal firm. However, being part of a dense knowledge ecosystem such as the Boston, San Diego and San Francisco Bay areas remains the most important predictor of innovation output of a biotech company (Whittington et al., 2009). In other words, from a policy perspective, creating such a dense knowledge ecosystem remains the best guarantee to spur a high degree of innovation in the area.

Powell et al., (2010) analyzed the critical success factors in developing biotech knowledge ecosystems in the San Francisco Bay area, the Boston and Cambridge, MA area, and Northern San Diego County. They consider two features and one mechanism to be central to the development of knowledge ecosystems: (1) a diversity of organizational forms and (2) the presence of an anchor tenant, and (3) the mechanism of cross-realm transposition. First, a diversity of organizational forms generates divergent standards and multiple kinds of rules, resulting in competing criteria for gauging success (Boltanski and Thévenot, 2006). Including groups of organizations in the different parts of the value chain increases the adaptive capacity of the ecosystems more than if the system is dominated in only one area (Baptista, 1998). The availability of different actors such as universities and PROs, entrepreneurial firms, established companies, and venture capital firms has also been described in contemporary works on regional clusters (Saxenian, 1996). A second crucial feature is the presence of an anchor tenant. Anchor tenants assist in providing access to subsequent connections and field formation and hence actively spur economic growth (Agrawal and Cockburn, 2003). The anchor tenant is not disinterested, in the sense of being neutral, but does not directly compete with the other types of organizations that inhabit the community. Local universities or PROs can fulfill the role of anchor organizations in the knowledge generation process (Agrawal and Cockburn, 2002). These institutions produce basic and applied research and act as catalysts of technological innovation by transferring this to local industry through R&D collaborations. In turn, firms utilize this knowledge for industrial and commercial purposes (Friedman and Silberman, 2003). Diversity and anchor tenants alone are usually not sufficient to spur the emergence of an ecosystem, however. Some form of cross-network alignment is needed in which ideas and models are transposed from one network of organizational forms to another, for instance when the venture capital logic spills-over into the academic community in the context of spin-off ventures (Wright et al., 2006). This mechanism is called cross-realm transposition.

Powell et al.'s. (2010) analysis focuses on the development of knowledge ecosystems in the particular setting of biotechnology. In the biotech industry, the mere presence of innovation output creates immediate economic value. Organizational growth in this industry results mainly from building an IP portfolio which ultimately gets sold to an incumbent company on the market for technology (Clarysse et al., 2011). R&D alliances between biotech firms and other research active organizations dominate in this

environment and are good predictors of exploitative alliances which determine the commercial potential of the biotech company (Rothaermel and Deeds, 2004). As a result, biotech start-ups with a central position in the knowledge creation network of R&D alliances also tend to be successful in setting up exploitative alliances with large pharmaceutical companies to capture the value of their technology.

The implicit assumption made by research in the area of knowledge ecosystems is that they quasi-automatically evolve into business ecosystems. This means that creating a successful knowledge ecosystem is considered to be sufficient to create areas of true economic growth. We focus on (a) whether knowledge ecosystems are developed and (b) whether they lead to business ecosystems.

3.2.2 Business Ecosystems

Industries such as biotech are organized as value chains characterized by a linear knowledge creation – knowledge commercialization process (Gans and Stern, 2003). There is a clear division of innovative labor where entrepreneurial firms are specialized in knowledge creation and large, established firms are specialized in knowledge commercialization. However, business ecosystems do not follow a linear value creation process and many of the players in such ecosystems fall outside the traditional value chain (Iansiti and Levien, 2004). Instead, different companies cooperate to jointly deliver a product or service to a customer. As a result, the value chain is not a linear process with upstream and downstream players, but is a network of companies with many horizontal relations (Moore, 1996). The members of such an ecosystem deliver value to end customers as an interrelated system of interdependent companies rather than as individual companies. Business ecosystems are nested commercial systems where each player contributes a specific component of an overarching solution (Christensen and Rosenbloom, 1995). In a business ecosystem, inter-organizational networks consist of both collaborative and competitive relationships which results in a "coopetition" structure (Moore, 1993). As a result, it is the competition among ecosystems, not individual companies, that largely fuels the next round of innovations. Innovation in business ecosystems goes beyond the focus on technological activity alone which is characteristic of knowledge ecosystems. Business ecosystems introduce the customer (demand) side which is mainly absent in innovation ecosystems (Wright, 2014). Companies collaborate to create and deliver solutions that meet the full package

of value to customers (Moore, 1993). In other words, business ecosystems allow firms to create value which no single firm could create by itself (Adner, 2006). It also involves the creation of new markets and often entails the pursuit of relatively small and poorly defined commercial opportunities. For example, Kahney (2004) describes how Apple leveraged its business ecosystem to develop an easy-to-use MP3 player and music management and purchase software, which resulted in the iPod.

Iansiti and Levien (2004) have described how companies such as Walmart and Microsoft developed competitive advantages by having a strategy to build a business ecosystem around their value proposition. Along the same lines, Gawer and Cusumano (2002) refer to multinationals in the digital economy which are able to manage innovation through their business ecosystem as 'platform leaders'. Birkinshaw and Hill (2005) refer to ecosystem venturing as a strategy used by large companies to build a business ecosystem around the company by incubating and accelerating start-up activities related to the company's innovation strategy.

Through collaboration in a value network, firms exploit their interdependencies and have a competitive advantage over isolated companies which internalize all components of a value chain (Iansiti and Levien, 2004). For start-ups it is therefore important to participate in such a business ecosystem (Zahra and Nambisan, 2012). Companies in a business ecosystem co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Hence, start-ups which can participate in such an ecosystem align their innovation function to the expectation of the leaders and move toward a shared vision (Moore, 1996). Numerous examples describe how start-ups in business ecosystems prosper from investments made by industry leaders to maintain the network (Birkinshaw and Hill, 2005; Kaminsky, 2000).

Iansiti and Levien (2004) put forward two important ingredients that contribute to the success of business ecosystems. First, business ecosystems are characterized by a large number of loosely interconnected participants dependent on each other for their mutual performance. Each participant is specialized in a specific activity and it is the collective efforts of many participants that constitute value, while efforts individually have no value outside the collective effort. Rich networks sharing elements of both cooperation and competition emerge that link companies across products, services, and technologies. A second vital element is the need for a "keystone" company whose role is to ensure that

each member of the ecosystem remains in good health. They consistently invest in and integrate new technological innovations of other participants and encourage the creation of new markets by developing new fundamental infrastructures (Moore, 1993). Keystone companies also create "platforms" such as services, tools, or technologies, which are open for other players in the ecosystems to enhance their own performance (Iansiti and Levien, 2004). Consequently, keystone players are involved with the creation of value within the ecosystems as well as sharing the value with the other participants.

Taken together, we observe three important factors in which knowledge and business ecosystems differ. First, the primary activity in knowledge ecosystems is the generation of new knowledge whereas the focus in business ecosystems is on value for customers. Second, players in a knowledge ecosystem are typically connected in a dense, geographically clustered network while business ecosystems are represented by value networks which can be globally dispersed. Third, knowledge ecosystems are centered on a university or PRO whereas large companies are the leaders of business ecosystems. Table 3 below provides an overview of these factors.

Table 3: Overview of differences between knowledge and business ecosystems

Factor	Knowledge ecosystem	Business ecosystem
Focus of activity	Knowledge generation	Customer value
Connectivity of players	Geographically clustered	Value network
Key player	University or PRO	Large company

Policy makers world-wide have sought out the most effective mechanisms to stimulate ecosystem development. Adopting a knowledge ecosystem philosophy, they have established policies giving a crucial role to universities and PROs as engines of regional economic development and drivers of technological innovation (Florida and Cohen, 1999). Universities and PROs are catalysts of innovation, stimulating the production and diffusion of knowledge across regions (Finegold, 1999). Facilitating knowledge transfer via different mechanisms such as contract research and spin-offs became the third mission of these organizations after teaching and research, and they received structural

support from governments to fulfill this role (Debackere and Veugelers, 2005). In addition, governments have also implemented several initiatives specifically geared toward fostering innovative start-ups in the ecosystem, most notably stimulating access to external capital (Wright et al., 2006).

Despite these policy initiatives, there is no guarantee that these knowledge ecosystems will evolve into business ecosystems as the dynamics in both are fundamentally different (Iansiti and Levien, 2004). Still, policy makers expect that the development of a knowledge ecosystem will facilitate the companies embedded in this ecosystem to become part of a larger business ecosystem. This is a strong hypothesis as both ecosystems are considerably different in terms of drivers and characteristics (see Table 3). We will further investigate this hypothesis in the remainder of the chapter.

3.3   Research Setting

To address this issue, we focus on Flanders, a small region in northern Belgium, as an empirical context. Since the regionalization of science, technology and innovation policy in Belgium in 1991, the region autonomously decides on its innovation policy. The region is committed to invest 3% of its GDP (38 billion Euros) on R&D. A wide range of actors and stakeholders are involved in the Flemish Science and Technology Innovation system (Belgian Report on Science, Technology and Innovation, 2010): public administrations and agencies, knowledge institutes and centers, universities and university colleges, scientific institutes, PROs, university hospitals, various collective research centers, incubation centers, private companies, etc. Among these actors, the Flemish Agency of Innovation for Science and Technology (IWT)[6] is the one-stop-shop financing industrial R&D and innovation in Flanders. They offer both direct funding for R&D and innovation and indirect funding through a network of innovation advisors (VIN). In total 1374 people in 220 intermediary organizations, such as knowledge centers, collective research centers and industry federations, provide advice to the local industrial community about new technologies in their sector, new innovative applications, how to finance innovation and how to get subsidies.

Public sector financial support schemes are important for high-tech firms (Wright et al., 2006). In addition to giving R&D grants, innovation support and indirect support

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[6] Agentschap voor aanmoediging van Innovatie door Wetenschap en Technology

through the network of innovation advisors, the government manages through PMV[7] a public risk capital fund (VINNOF), providing seed and early stage capital to innovative start-ups and is a shareholder in GIMV,[8] which provides venture capital (early and later stage) to innovative start-ups. In addition, the government has invested €211mn since 2005 in 12 funds through its ARKIMEDES program, a co-financing scheme for funds committed to invest in innovative start-ups.

In addition to the private sector, universities and PROs play a key role in R&D in Flanders. Six major universities and four major PROs represent the majority of knowledge production (Wright et al., 2008). The universities represent 90% of all non-private scientific output. In 2007, total expenditure in R&D in higher education was € 739mn, of which 15.6% was privately and 84.4% was publicly funded. KULeuven, the largest university in Flanders spent €300mn in 2008 on R&D and has 85 active spin-offs today. Ghent University follows with €200mn R&D spending in 2008 and 60 active spin-offs, while Brussels University (VUB) spent €70mn on R&D. In addition to the universities, there are six major PROs, four of which were founded before 2009 (and are relevant for our study). In 2009, these four centers collectively received an annual grant of €135mn in total. We refer to Table 4 for an overview of the PROs.

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[7] Participatiemaatschappij Vlaanderen
[8] Gewestelijke Investeringsmaatschappij Vlaanderen

Table 4: Overview of PROs

	Research Expertise	Founded in	Operating budget 2008	#researchers	#spin-offs
IMEC	Microelectronics (Research in nanotechnology)	1984	€270mn	2000	26
VIB	Biotechnology	1995	€62.5mn	1200	12
VITO	Technological Research (Environment, Energy, materials and remote sensing)	1991	€73.5mn	600	
IBBT (iMinds)	Broadband Technology	2004	€26.4mn	1000	13

Source: Belgian Report on Science, Technology and Innovation 2010

To analyze the knowledge and business ecosystems, we gathered survey and secondary data to examine the R&D and commercial alliances of new technology-based firms founded in Flanders between 2006 and 2010. We started with a list of 211 new ventures provided by the innovation advisors of the IWT. After consulting the BELFIRST database for the founding year, companies older than 3 years at the time of initial data collection (2009) were eliminated. Of the remaining 185 companies that were contacted, 7 had been acquired or dissolved, leaving us with a sample of 178 companies. 138 of these firms agreed to participate in our study resulting in a response rate of 78%. Non-response analysis did not reveal significant differences between the 40 which did not and those that did participate in terms of age, sector or revenues in 2012. The descriptive statistics of the participating companies are included in Table 5. This database is unique as it involves most of the new ventures created in the region with the specific objective to develop products or services new to the region and that are either based on novel technologies or involve the development of novel technologies.

In the first interview round (118 companies interviewed in 2009 and 20 in 2010), general data about the company, team, founding conditions and activities was collected. This baseline information was collected by using a structured questionnaire during face-to-face interviews which lasted between 30 minutes and 2 hours. These face-to-face interviews were extremely helpful to explain the upcoming longitudinal research design.

Table 5: Descriptive statistics and correlation matrix

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Number of patents	0.92	2.46	1.00									
2. Top TP (dummy)	0.39	0.49	0.226**	1.00								
3. No TP (dummy)	0.38	0.49	-0.10	-0.62***	1.00							
4. Top FP (dummy)	0.19	0.39	-0.04	0.11	-0.11	1.00						
5. No FP (dummy)	0.70	0.46	-0.3***	-0.26**	0.18*	-0.74***	1.00					
6. ICT (dummy)	0.34	0.48	-0.01	-0.04	0.01	0.04	-0.07	1.00				
7. Manufacturing & Engineering (dummy)	0.15	0.36	-0.03	0.07	-0.08	0.16	-0.08	-0.26**	1.00			
8. Company age (in months)	36.51	15.38	0.10	-0.12	-0.06	0.09	-0.13	-0.06	0.07	1.00		
9. Number of employees	5.67	7.14	0.25**	0.15	-0.11	0.03	-0.28***	0.03	-0.06	0.24**	1.00	
10. Failure (dummy)	0.25	0.44	-0.1	-0.13	0.06	0.02	0.09	-0.07	0.26**	0.04	-0.15	1.00

TP: Technology Partner
FP: Financial Partner
n=138
 * p < 0.05, ** p < 0.01, *** p < 0.001

In the two follow-up rounds in 2010 and 2011, we collected data on investments and partnerships using a web-based survey supported by telephonic follow-up. The survey data was strengthened by supporting data collected from IWT, BELFIRST, GRAYDON, VENTUREEXPERT, EPO, Belgian Office Journal and the company websites. In sum, data on ecosystems was collected using several information sources.

3.3.1 The Knowledge Ecosystem

For each company studied, we calculated the alliances they have set up with the universities, PROs and R&D departments of established industrial firms based upon the projects they submitted to the IWT to get co-financing for these collaborations.[9] We used the annual reports of the IWT from 2006 to 2011 to collect information about the requests for support for R&D. These reports contain an overview of the partners involved and the subject of the project. The pre-condition to submit a proposal is that the project should have a technological component and there should be technological uncertainty involved in progressing the project. In other words, the partnerships were mainly R&D focused. Using the IWT database, we identified 177 dyads between 86 innovative start-ups on the one hand (out of 138) and 82 technology partners on the other hand, in the period 2006-2011. The information was used to calculate the symmetric dyad graphs included in Figure 1.

3.3.2 The Business Ecosystem

Further, we asked for information on the commercial co-operations established with other business partners. Commercial co-operations involve relationships with "key customers" with whom they had tested their prototype, further developed their prototype into a commercially viable product or leveraged their prototype into a scalable product and the key "business partners" with which they jointly had developed a business proposition for a common customer. In total, we identified 584 commercial alliances which represent dyads in our analysis between 80 innovative start-ups on the one hand and 547 industrial partners on the other. This information was used to calculate the business ecosystem in Figures 4-6.

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[9] IWT co-finances between 15% and 50% of exploration alliances that are set up between companies or between companies and universities/PROs. Exploration means that the subject of the alliance should be the development of a new technology or a new product based upon a novel technology. New or novel means that it does not exist yet in Flanders

3.3.3 The Financial Support Network

Finally, we also collected information about the financial support network of these innovative start-ups. Powell et al., (2010) argue that financial investors such as venture capitalists (VC) play a prominent role in bridging the gap between the production of new knowledge and the subsequent commercialization of that knowledge. To calculate the financial support network, we asked each start-up whether they had received financial support and from which investor. We cross-checked these answers relating to financial support with the websites of the investors which list the portfolio companies they invest in. Only for the business angels involved in the companies was no further information found. In total, we identified 102 dyads between 41 (out of 138) innovative start-ups receiving financial support on the one hand and 54 financial investors.

3.4 Analysis of the Business and Knowledge Ecosystems and the Financial Support Network

To analyze the knowledge and business ecosystems and the financial support network in the region, we used Ucinet 6.461 as a software program (Borgatti et al., 2002). We calculate Freeman's (1979) degree and normalized degree as measures of centrality. Degree refers to the total number of direct ties the organization has, while normalized degree includes the number of direct ties divided by the total number of ties in the network. In addition we calculated the total network centralization as a measure of equality in the centralization of the total network and network density as an indicator of collaboration activity.

3.4.1 The Knowledge Ecosystem

Figure 1 provides a graphical representation of the knowledge ecosystem which has a network density of 0.007. This implies that a large number of dyads do not exist yet in the network. Two major universities in the region (KULeuven and UGent) and two of the four major PROs (IMEC and IBBT) play a leading role together with Sirris, which is the knowledge center of the major ICT industry federation (Agoria) (see Figure 2 and Figure 3).[10] The two universities, two PROs and the industry specific knowledge center seem to be Anchor-tenants as defined in the Powell et al., (2010) framework. These are the

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[10] Figure 2 and 3 present sub-networks of the complex knowledge ecosystem in Figure 1, and include only the academic partners and the PRO partners respectively.

central knowledge generators in the knowledge ecosystem with a normalized degree > 4%, each. KULeuven has the highest share, which reflects its status as the largest research university in the region. We label these five central partners in the knowledge network as "top knowledge partners". Since almost two out of three innovative start-ups in the ecosystem participate in the knowledge ecosystem, we can conclude that there is a high degree of cooperation among the actors and we can talk of a dense local network, which reflects a technology hotspot.

Figure 1: Knowledge ecosystem in Flanders
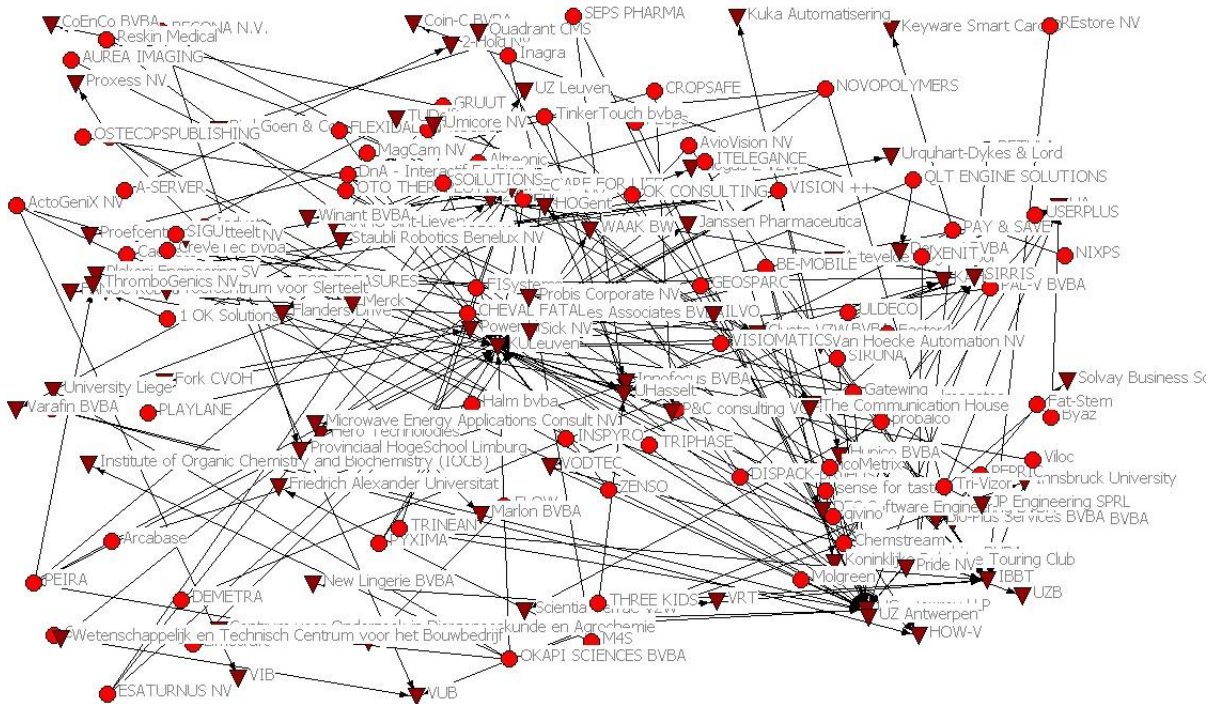
	Type	Degree (centrality)	Norm. Degree (centrality)	Network Centralization	Network Density
Network				11.75%	0.007
KULeuven	University	27	16.265		
UGent	University	20	12.048		
IBBT (iMinds)	PRO	11	6.627		
SIRRIS	PRO	8	4.819		
IMEC	PRO	8	4.819		
UA	University	5	3.012		
UHasselt	University	5	3.012		
HOGent	University	4	2.410		
KAHO Sint-Lieven	University	4	2.410		

Degree (centrality) = number of direct links
Norm. Degree (centrality)= (number of direct links/total number of links)*100
Network Centralization = Centralization= 100* Σ(C*-Ci) / Max Σ(C*-Ci) , where C* is the centrality of the most central actor and Ci, the centrality of all the other I actors
Network Density= Sum of existing ties divided by the number of all possible ties

Figure 2: Knowledge ecosystem in Flanders including only academic partners (universities and university colleges)
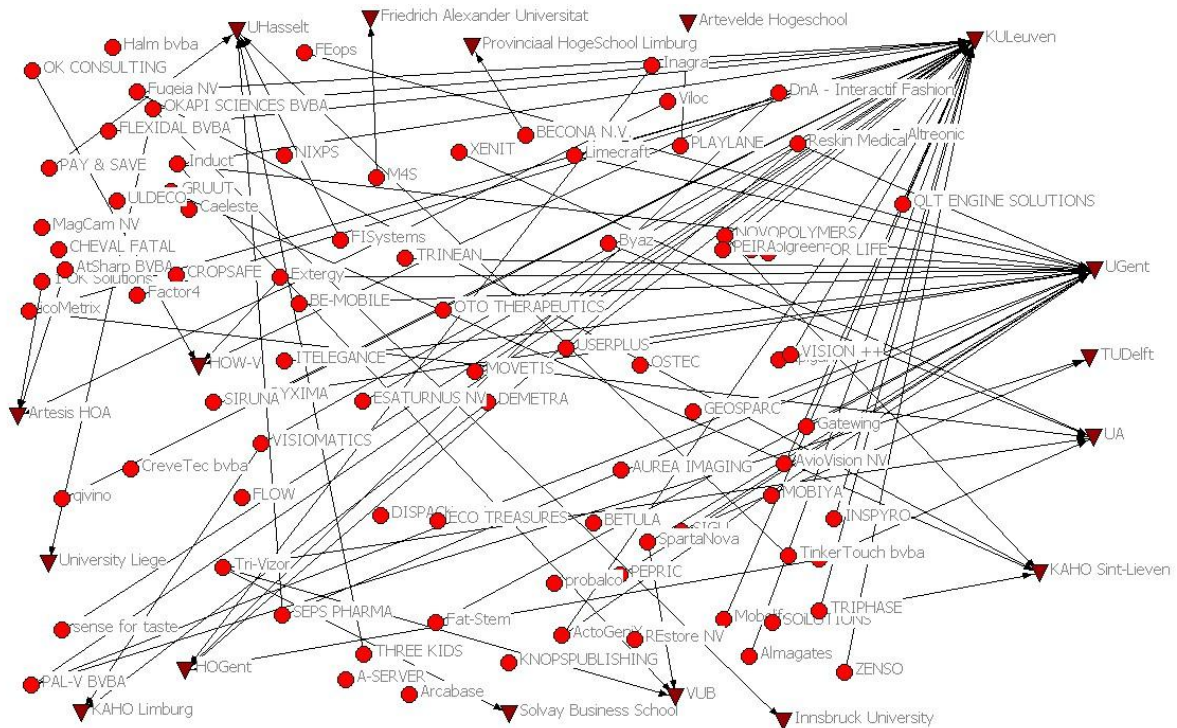
Figure 3: Knowledge ecosystem in Flanders including only PRO partners
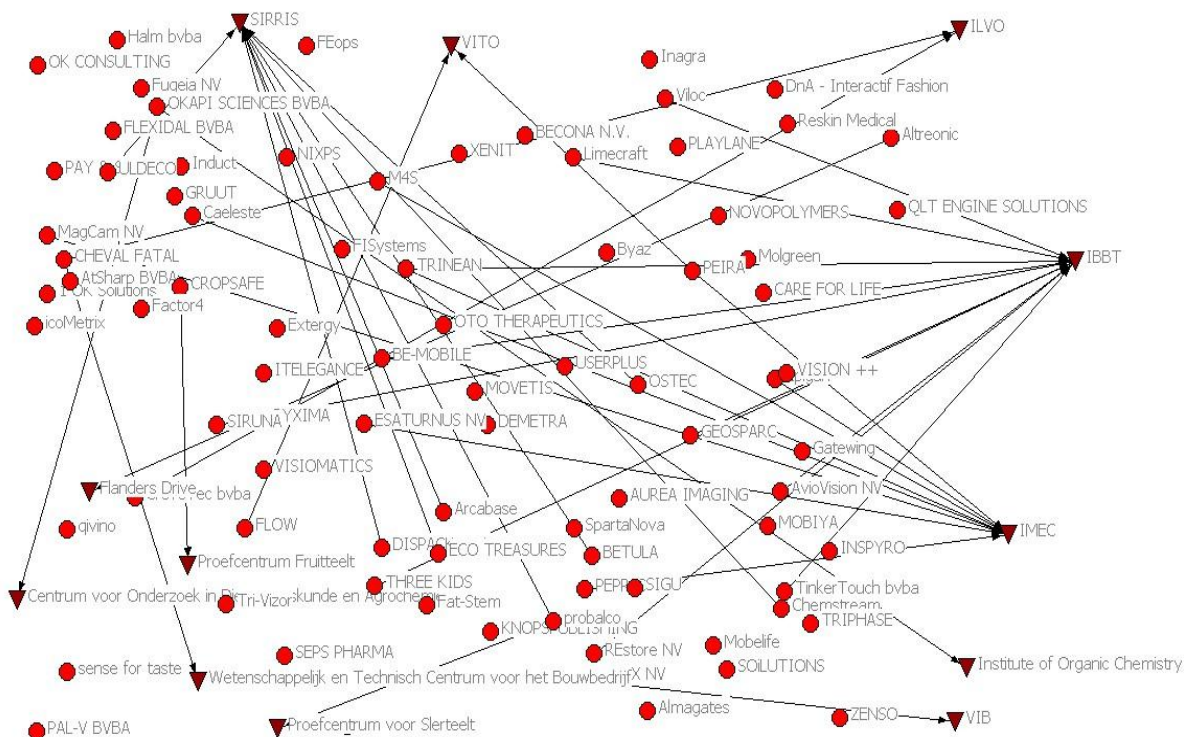
3.4.2 The Business Ecosystem

Figure 4 shows the results and network statistics of the business ecosystem where local and international business partners form a value network in which the innovative start-ups participate.

Figure 4: Business ecosystem in Flanders
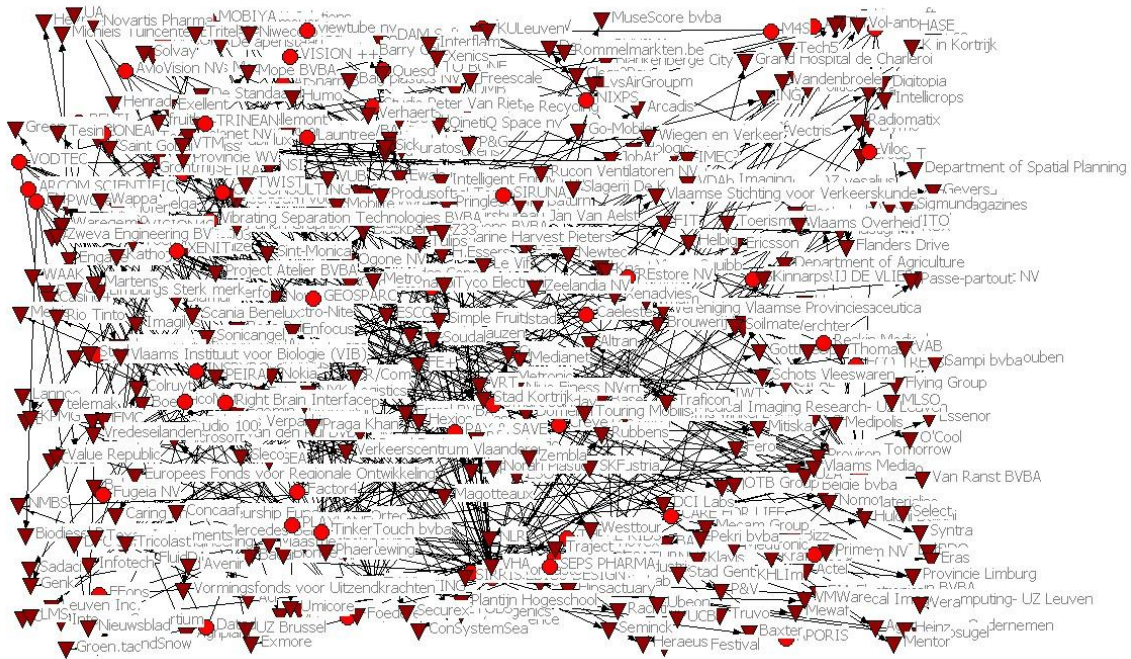
	Degree (centrality)	Norm. Degree (centrality)	Network Centralization	Network Density
Total Network			8.88%	0.002
Microsoft	3	0.482		
Nieuwsblad	3	0.482		
Deloitte	3	0.482		
VRT	3	0.482		
NMBS	3	0.482		

Degree (centrality) = number of direct links
Norm. Degree (centrality)= (number of direct links/total number of links)*100
Network Centralization = Centralization= 100* Σ(C*-Ci) / Max Σ(C*-Ci) , where C* is the centrality of the most central actor and Ci, the centrality of all the other I actors
Network Density= Sum of existing ties divided by the number of all possible ties

It is clear that there are very few overlaps and that no organization takes the lead in the business ecosystem and hence fulfills the role of keystone player. The density of the network drops to 0.002 and the most central organizations only have a degree of 3, which means that they only collaborate with three innovative start-ups in total. Because the innovative start-ups included in Figure 4 are spread over different technological domains and are collaborating with a variety of research organization we took a subsample of the knowledge ecosystem, namely those innovative start-ups that only collaborate with the top-5 central organizations in the knowledge ecosystem (KULeuven, UGent, IBBT, Sirris and IMEC). Among these organizations, we only selected the innovative start-ups in ICT of which we can reasonably expect that there would be similar industrial companies with which these organizations can form partnerships.

Figure 5: Business ecosystem in ICT with IBBT, UGent, KULeuven, Sirris and IMEC as central knowledge hubs
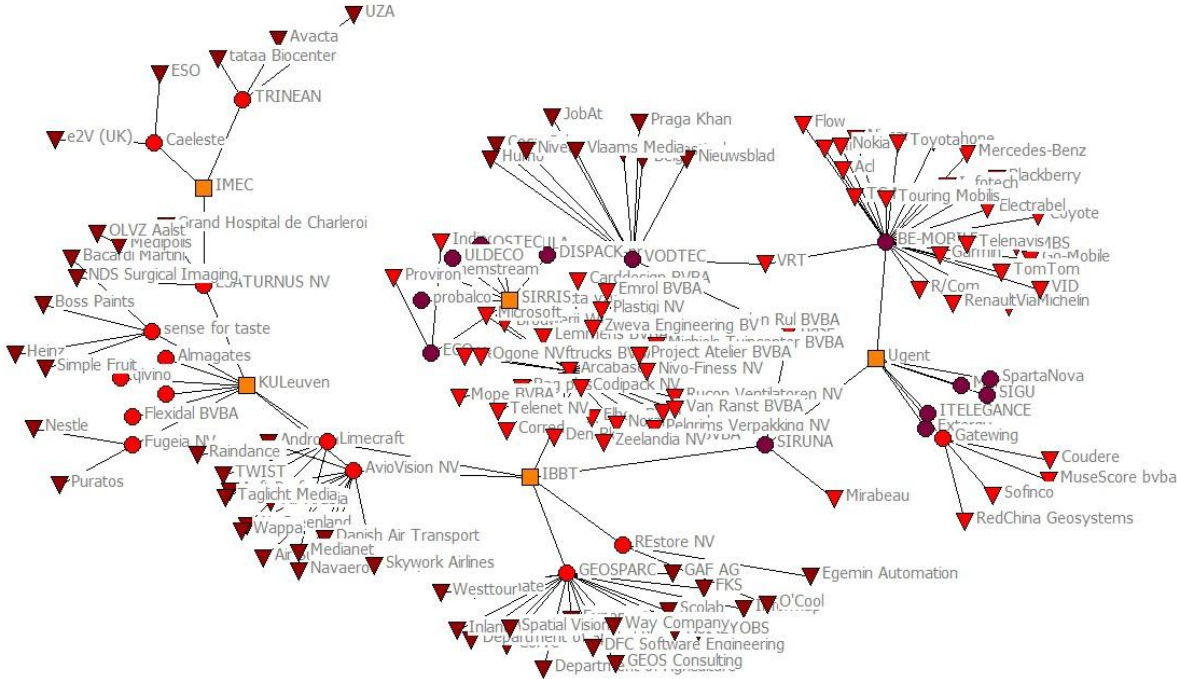
Figure 6: Business ecosystem in ICT with IBBT, iMinds, as central knowledge hub
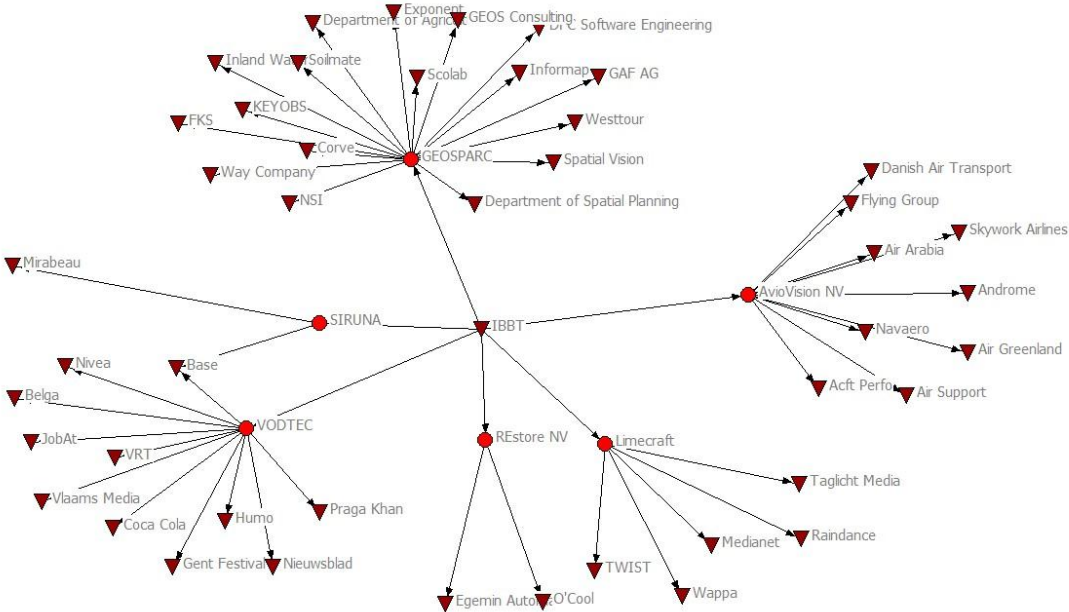
Figure 5 shows the network of all the business partners around the top-5 central organizations. In Figure 6, we show the specific business partnerships of one business network, namely the one around IBBT (iMinds). The results are surprising. We would expect that a number of central "industrial leaders" would take the role of keystone players like the PROs in the knowledge ecosystem. As described in the business ecosystem literature (Gawer and Cusumano, 2002; Iansiti and Levien, 2004), these industrial leaders are companies like Microsoft and Cisco that create ecosystems around their businesses by supporting innovative start-ups. These industry leaders act as lead users (Von Hippel, 1986) which facilitate innovative start-ups to upgrade their prototypes and make them compatible with the expectations of other companies. It is clear that no business ecosystem has developed in the region although a few innovative start-ups that take part in the knowledge ecosystem succeed in integrating into Microsoft's business ecosystem. However, overall, the innovative start-ups collaborate with different partners separately and try to develop an independent network but no industrial organization takes a central role. It is even surprising how scarce the relations are among the different independent start-ups themselves. In sum, our findings indicate that a business ecosystem is non-existent. This finding leads to hypothesize that, in contrast to policy maker expectations set out in Section 3.2, a tight knowledge ecosystem does not automatically lead to the emergence of a business ecosystem.

3.4.3 The Financial Support Network

Following the same logic as above, we map the financial network that supports these innovative start-ups (see Figure 7). The overall network density is about the same as in the knowledge ecosystem. However, only 40% of the innovative start-ups received some form of investment.

Figure 7: Financial support network in Flanders
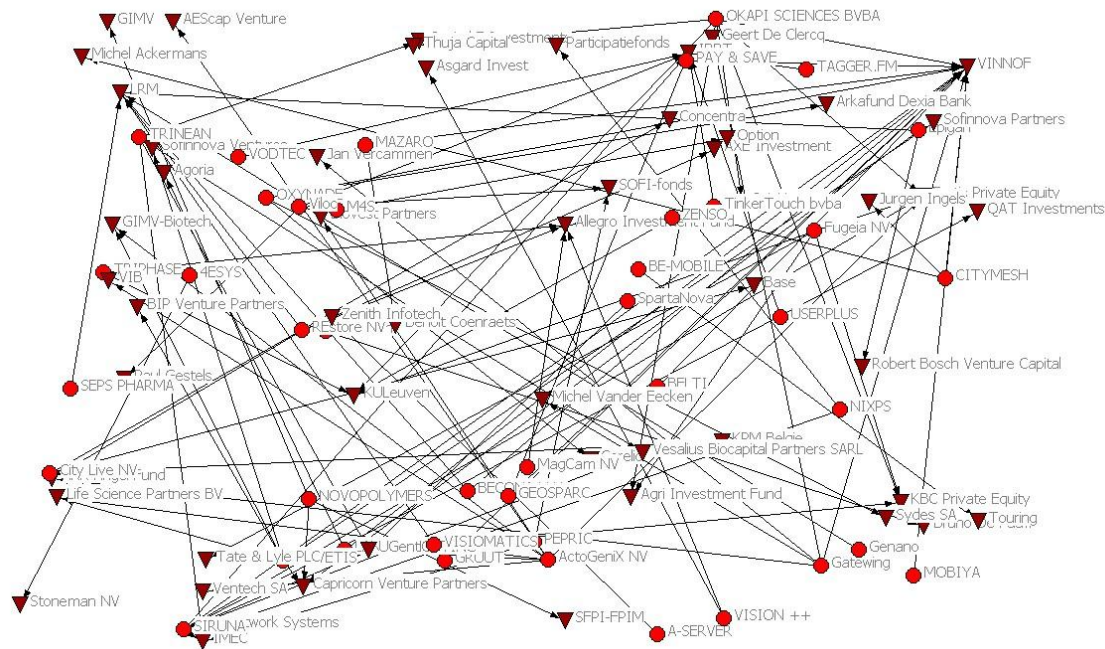
	Type	Degree (centrality)	Norm. Degree (centrality)	Network Centralization	Network Density
Total Network				8.72%	0.006
VINNOF	Public	13	13.83		
IBBT	Incubator	7	7.447		
LRM	Public	6	6.383		
Allegro Investment Fund	Private	5	5.319		
KULeuven/Gemma Frisius Fund	University	4	4.255		
UGent/Baekelandt Fund	University	4	4.255		

Degree (centrality) = number of direct links
Norm. Degree (centrality)= (number of direct links/total number of links)*100
Network Centralization = Centralization= 100* Σ(C*-Ci) / Max Σ(C*-Ci) , where C* is the centrality of the most central actor and Ci, the centrality of all the other I actors
Network Density= Sum of existing ties divided by the number of all possible ties

The network centralization index is higher, which means that centrality is less spread over a number of key actors. In fact, VINNOF (Flemish Innovation Fund) plays the most prominent role. This is the main public fund which targets seed and early stage financing. Also, the other actors in the financial support network are mainly public. LRM is a regional fund in the north of Flanders, which is 100% publicly financed and IBBT (iMinds), KULeuven and UGent are a PRO and two universities, which have their own incubation/university funds that are involved in their spin-offs. The only notable exception is the Allegro Investment Fund, a 100% private fund set up by a few serial entrepreneurs in the region. Similar to the top knowledge partners, we label the top five financial partners in the support network "top financial partners". The lack of private initiatives in the financial support network is remarkable.

Based on the network indices, we conclude that the private sector is only marginally involved in investing in innovative start-ups in Flanders since mostly public financiers play a role in supporting innovative start-ups. Moreover, the majority of the public investors are closely linked to the leading PROs and/or the university. This means that the financial agents in the ecosystem do not form a mechanism of cross realm transposition. This leads us to propose the hypothesis that for a knowledge network to evolve into a business ecosystem, private financial agents should take over the lead of public sector organizations and be the first mechanism of cross realm transposition.

3.5 The Influence of the Knowledge Ecosystem and Financial Support Network on the Performance of Innovative Start-ups

3.5.1 Innovation Output of Innovative Start-ups

The performance indicator in the knowledge ecosystem is the firm's level of innovation output (Powell et al., 2010), measured by the count of patents with the EPO.[11] We analyze whether collaboration with more central research partners had a positive impact on the innovation output, measured by the number of patents, of the focal firm. The mean number of patents was 0.9, while the standard deviation was 2.46, which indicates that over-dispersion might distort the interpretation of other count models such as a Poisson regression (Cameron and Trivedi, 1986). A negative binomial

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[11] As a sensitivity check, we also used more fine-grained measures of innovation output such as the citation weighted EPOs, but this had no impact on our results. We therefore chose to use the simplest measure in the further analysis.

estimation was therefore necessary. Table 6 shows the results of this analysis. In the first stage, we enter only the control variables (age, size, and sector). Firm size is positively associated with the number of patents.

Table 6: Innovation output (Negative binomial regression)

	Model 1	Model 2	Model 3	Model 4	Model 5
Controls					
ICT (dummy)	-0.014	-0.003	0,07	0,046	0,152
	0.35)	(0.336)	(0.32)	(0.315)	(0.318)
Manufacturing & engineering (dummy)	-0.1	-0.031	0.347	0,301	0,415
	(0.466)	(0.46)	(0.428)	(0.423)	(0.422)
Number of employees (log)	0.835***	0.695***	0.439*	0.398*	0.421*
	(0.249)	(0.241)	(0.233)	(0.229)	(0.233)
Company age	-0.005	-0.000	-0.005	-0.000	-0.003
	(0.011)	(0.011)	(0.01)	(0.01)	(0.01)
Predictors					
Top technology partners		1.657***		1.052**	1.065**
		(0.494)		(0.479)	(0.474)
No technology partners		0.884*		0.805*	0.848*
		(0.524)		(0.485)	(0.479)
Top financial partners			-1.696***	-1.482***	-0.893
			(0.494)	(0.491)	(0.584)
No financial partners			-1.999$	-1.717$	-1.193**
			(0.403)	(0.42)	(0.509)
Top technology partners * Top financial partners					-1.747*
					(1.058)
Top technology partners * No financial partners					-1.293
					(0.893)
R²	0.04	0.078	0.11	0.125	0.133
Chi²	14.04**	27.04$	38.12$	43.21$	45.97$
N	138	138	138	138	138

* p<0.10, ** p<0.05, *** p<0.01, $ p<0.001

In model 2, consistent with the extant literature on knowledge ecosystems (Tallman et al., 2004; Boschma, 2005; Whittington et al., 2009), we find that being close to the most central organizations in the knowledge ecosystem has a positive impact on the innovation output of the focal firm. Having no technology partners at all, on the other hand, is better than working with non-central technology partners in the knowledge ecosystem. Hence, collaborating with local strong knowledge providers such as PROs or

universities accelerates the innovation output of the start-ups, but collaborating with technology institutes which have no central role in the knowledge ecosystem has a negative impact. The top institutes in Flanders play their role as anchor organizations in the knowledge ecosystem and have a positive impact on the innovative performance of the start-ups which collaborate with them.

Table 6 also shows the impact of working together with a central financial partner on the innovation output of the innovative start-ups. Surprisingly, we find that receiving finance from the more central financial players in the Flemish network (VINNOF, LRM, Allegro, UGent, and Baekelandt) has a negative impact on the venture's innovation output. This indicates that these investors mainly want to exploit technology rather than further developing technology portfolios to target the market for products or the market for technology (Clarysse et al., 2011). Those innovative ventures which do not attract financial investors have even lower levels of innovation output. However, working together with less embedded financial investors such as GIMV does have a positive impact on the level of innovation output. This suggests that start-ups with the most promising technology opportunities tend to look for investors that are not necessarily very well embedded or that do not necessarily target the local industrial community but are able to attract investors that only play a minor role in the local community. The result, however, is that the most embedded local investors play only a marginal role in helping to sustain the Flemish knowledge ecosystem.

This finding extends Powell et al.'s (2010) view on how clusters develop as they do not distinguish between exogenous entry of agents such as investors into a network versus endogenous initiatives taken by local entrepreneurs or policy makers. In other words, to make a knowledge ecosystem sustainable in itself, a realm transposition needs to take place between the new network (e.g., the financial investors) and the old one (e.g., the knowledge network). The realm assumes that the new network introduces a new modus operandi which is then adopted by the actors in the old network. However, if the public funds are extensions of the knowledge actors in the old network, they do not bring new practices into the ecosystem, but extend the logic of the knowledge actors. This is exactly what we observe here. Most financial investors do not contribute to the start-ups' innovation output. This finding lends further support to the hypothesis proposed in

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Section 3.3.3 that private financial agents play a central role in facilitating the transition from knowledge to business ecosystems.

3.5.2 Survival of Innovative Start-ups

The business ecosystem literature proposes firm survival as the main performance indicator (Iansiti and Levien, 2004), especially for innovative start-ups as they operate in markets not yet clearly developed (Santos and Eisenhardt, 2009). Survival is less industry sensitive than other measures such as revenues.[12] We operationalize firm survival as a dummy variable equaling 1 if the innovative start-up failed during the period under study and 0 otherwise. Failures included completed bankruptcies, completed liquidations, closures based on company request, and merger or acquisition of organizations at risk of bankruptcy (Hannan and Freeman, 1989). We first identified whether a start-up had failed using the Belgian Official Journal. Secondly, we used financial reports from GRAYDON to identify companies experiencing difficulties in fulfilling their financial obligations. The founders of these firms were contacted and coded "1" if the founder confirmed that the company was bankrupt, liquidated or closed. We use survival analysis to examine firm survival (e.g., Dencker et al., 2009; Geroski et al., 2010) and employ a Cox proportional hazard model. The results are presented in Table 7.

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[12] In further sensitivity analysis, we checked with other performance measures we had at hand such as the degree to which the founders of these innovative start-ups perceived themselves to being ahead of or falling behind their initial plans in terms of performance. The use of this performance indicator did not impact our results. Hence, we chose to elaborate our analysis using survival.

Table 7: Cox proportional hazard model

	Model 1	Model 2	Model 3	Model 4
Predictors				
Top technology partners		1,042		0,982
		(0.491)		(0.460)
No technology partners		1,257		1,093
		(0.521)		(0.462)
Top financial partners			2,313	2,293
			(2.526)	(2.512)
No financial partners			3,653	3,541
			(3.919)	(3.831)
Controls				
Number of patents	0,894	0,898	0,974	0,974
	(0.141)	(0.144)	(0.153)	(0.155)
ICT (dummy)	1,421	1,451	1,478	1,488
	(0.597)	(0.613)	(0.629)	(0.635)
Manufacturing & engineering (dummy)	2.956***	3.059***	3.427***	3.446***
	(1.218)	(1.282)	(1.496)	(1.511)
Number of employees (log)	0.566***	0.572***	0.571**	0.576**
	(0.119)	(0.123)	(0.124)	(0.127)
Chi^2	14.61***	14.96**	17.23***	17.31**
N	138	138	138	138

* $p<0.10$, ** $p<0.05$, *** $p<0.01$, \$ $p<0.001$

Interestingly, working together with central partners in the knowledge ecosystem does not impact the survival rate of the innovative start-ups. Even worse, working with centrally embedded financial investors does not improve survival rates. This is surprising as one would expect that if they do not add to the innovation output in the knowledge ecosystem (see Table 6), they would at least add to the economic viability of the start-ups. But this is not the case. This result suggests that the financial investors locally embedded in the ecosystem do not improve the economic viability of that system. This finding lends further supports to the hypothesis proposed in Section 3.4.2 which states that a knowledge ecosystem does not automatically lead to a business ecosystem.

3.6   Discussion and Conclusions

We have analyzed the tension between knowledge and business ecosystems. On the surface, the success factors for the two types of ecosystems look similar: diversity of organizations and anchor/keystone player. However, there are significant differences between the organization and dynamics in knowledge ecosystems versus those in business ecosystems. First, the anchor organizations in the former type of ecosystems are not directly competing within the ecosystem and are typically players such as universities and PROs. In contrast, keystone players in business ecosystems are large, established companies that provide key resources and commercial infrastructures to the different ecosystem niches. Second, knowledge ecosystems are based on value chains where value creation flows from upstream to downstream players. Business ecosystems, on the other hand, are characterized by a non-linear value creation process as groups of firms deliver integrated solutions to end users. Our findings have notable implications for policy which we elaborate below.

3.6.1   Policy Implications

Our analysis suggests that policy has focused too much on bilateral links rather than on an ecosystem approach. Much policy emphasis has been on the commercialization of research on one hand and innovation support to SMEs on the other. We discuss the implications of our research on both of these policy foci.

First, to facilitate commercialization of research, universities have received funding to set up technology transfer offices (TTOs) and seed funds which support spin-offs. The literature on knowledge ecosystems (Powell et al., 2010; Whittington et al., 2009) has already shown that for such an ecosystem to evolve into a viable cluster of organizations there must be anchor organizations facilitating connections between different types of players. We observe in this study that the leading TTOs and PROs play these roles as anchor organizations. However, Powell and colleagues (2010) argue that there needs to be a transfer of logic between the different players in the ecosystem. They label this process of logic shift as cross-realm transposition. It is questionable whether these funds bring a new logic into the ecosystem or whether they are just used to finance companies which follow an academic rather than a commercial logic. If cross-realm transposition takes place in the ecosystem, private VCs should play a much more

prominent role than is the case. This lack of cross-realm transposition is reflected in their negative impact on the level of innovation output of these start-ups and the absence of the impact of financial investors on their survival. Our results suggest that public funds, which tend to be very focused on the regional dimension, can add little value in building a complex network of relationships across different industrial players.

Second, innovation policy typically has focused on creating a network of technology intermediaries to support SMEs and innovative ventures which are not spun off from the large research institutes. We observe that these less central technology institutes do not cooperate with companies with a positive innovation output, nor do they contribute to the survival of these companies. Iansiti and Levien (2004) have shown that leading industrial incumbents play a major role in stimulating these companies thereby creating a business ecosystem which develops a joint value proposition to a common customer. We observe that the business ecosystem in Flanders is completely absent. This means that none of the leading companies in the region plays the role of keystone or anchor company. This is remarkable as it is these large companies which play a major role in the development of US business ecosystems. One could question why even large public companies such as the national (regional) television station and the telecom operator are not encouraged to play more of a leading role in nurturing innovative start-ups in the region. Public procurement policies, such as the SBIR[13] programme in the US, may provide an important stimulus to the creation of a business ecosystem. SBIR programme incentivizes large, established companies to invest part of their budgets in projects with local, innovative start-ups. In Europe, EU policy does not allow such programmes and there is little support, even informally, to work with innovative start-ups at regional level. In contrast, subsidies are given to technology push intermediaries or sector federations, which typically support large, established players in the ecosystem. Alternatively, the question arises as to whether a region might benefit from a university-centered knowledge ecosystem without having a well-defined related business ecosystem or a keystone player. However, the challenges in linking universities and industries are well-known.

It is likely that if the innovation output of the knowledge ecosystem is commercializable through a more global business ecosystem, a business ecosystem in that same region is

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[13] Small Business Innovation Research Programme (SBIR)

not required. If the knowledge is globally commercializable then in the absence of a local business ecosystem, the region needs to develop links to global business players. However, if policymakers see development of a knowledge ecosystem as a mechanism to create local employment, they may need to adopt policies to attract global firms. Overall, this raises questions about the extent to which an innovation policy toward the development of knowledge ecosystems in the absence of a business ecosystem makes sense. One could argue that value is created in the knowledge ecosystem but is captured by a few central players in the business ecosystem (Thomas, 2013). If a region wants to benefit from the value creation which happens within its knowledge ecosystem, it will have to find a way to attract the companies which also capture the value. This can be done either by providing an interesting environment to attract them or, more realistically, by making sure that the innovative start-ups in the knowledge ecosystem also co-capture that value in the business ecosystem. Co-creation does not automatically lead to co-capturing (Thomas, 2013) so facilitation is needed.

In light of these observations, policy may therefore need to develop incentives and mechanisms to enable ecosystem links to develop. There is a need for reconfiguration and reorientation of policy to link knowledge and business ecosystem elements. One key policy challenge is how to bring larger corporations into the ecosystem. Perhaps there is a need to develop boundary spanners who can make the bridge – and develop training mechanisms to enable this. The extant literature on tech hubs and knowledge ecosystems has shown that TTOs at universities and PROs are successful in developing local knowledge networks (Whittington et al., 2009). Policy makers should consider structurally supporting similar functions at large, established companies. Dedicated innovation managers in firms that are critical industry hubs should pay specific attention to their role in the business ecosystems and develop initiatives that promote collaborations with local, innovative start-ups. They should monitor the health of the network of innovative start-ups and stimulate large firms and incumbents to continue investments in technologies and commercial infrastructures which these start-ups can leverage. These managers have to guarantee that the terms of collaboration for innovative start-ups promote sustainable growth, avoiding that large, established players develop into dominators. As put forward by Iansiti and Levien (2004), a healthy business ecosystem requires a healthy keystone as well as healthy innovative start-ups.

The weakness of the financial support network in bridging the knowledge and business ecosystems suggests a need for policy to develop a financial network beyond public sector provision, which is lacking in both the amounts of finance and the specialized strategy support that can be provided. There may be a need for a more differentiated approach to developing financial support networks. Stimulation of business angel and accelerator activity may warrant attention. There may also be a need to stimulate cross-border venture capital provision, which may involve both cross-national and cross-regional borders. For example, a potentially fruitful avenue to address spatial mismatches in equity funding is to consider how to stimulate cross-regional mobility in such funding provision where angel financiers may find it difficult to identify enough sufficiently attractive targets in the regions where they are located (Harrison et al., 2010). Entrepreneurs in investment finance-deficient regions with ventures that may be potentially attractive to venture capital firms and business angels may therefore need to find ways to signal their quality to these financiers located outside their region (Mueller et al., 2012). Policy may therefore need to consider developing incentives and mechanisms to facilitate cross-regional access to angels.

A further option may be to try to attract interest of new financial entrants. For example, a growing trend in the provision of entrepreneurial finance is the development of 'family office' funds, where family firms with surplus cash balances are establishing funds to invest in private equity and venture capital. Perhaps more could be done to incentivize these operations to integrate more with the ecosystems. There may also be a need to explore whether the absence of a financial support network that bridges the gap between knowledge and business is related to demand side or supply side factors (Fraser et al., 2013). To the extent that some entrepreneurs are not interested in growing their firms, and/or maintaining control, they may be reduced demand for external finance. Other sources of finance may need to be stimulated, such as supply chain finance and crowdfunding, but may require policy initiatives to raise awareness, introduce appropriate regulation, etc.

3.6.2 Conclusions

We show that there seems to be a disconnect between the development of knowledge and business ecosystems. Policy makers have primarily supported the creation of knowledge ecosystems assuming that these ecosystems will automatically trigger the development of business ecosystems. However, the value creation processes in knowledge and business ecosystems are fundamentally different, which implies that policies to support each type of ecosystem must be specifically tailored. Supporting large, established companies to fulfill their role as keystone players may be an important way forward. We hope that this study will inspire further research and policy to develop our understanding of different types of ecosystems.

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4 How do Business Models of Closed Source and Open Source companies differ? An Analysis of Content Management Systems

ABSTRACT

While open source (OS) has been widely accepted as a successful development process in the software industry, the business models of open source software (OSS) companies still remain unclear. Questions on how companies adopt OSS remain unanswered. Similarly, how value is created and captured by OSS companies stays understudied. This article uses the context of content management systems (CMS) to analyze the business models of closed source (CS) software and OSS companies with respect to three dimensions: value creation, value delivery and value capture.

The results show that for value creation, CS CMS outperform OS CMS in terms of intrinsic technology value, while in terms of extrinsic network value OS CMS are much more popular as shown by their complementary products and services and the size of their installed base. For CS CMS vendors, value capture is associated with new mechanisms of value delivery. OSS companies do not have sufficient degrees of freedom to adopt innovative value delivery models and hence try to capture value through after-sales services, sometimes accompanied by dual-license fees on proprietary extensions of the OSS.

In contrast to community-backed OS CMS, company-backed OS CMS have been relatively successful in terms of revenues, albeit much less than CS ones. Opening up the code to make it available to the public and building a community around the software are observed to be sources of value creation. The increasing investments in company backed-OS and OS-affiliated businesses, in contrast to the relatively low economic success of OSS, can be explained by the potential investors see in exploiting the relatively large user community.

4.1 Introduction

Over the past decade, open source (OS) has emerged as a mainstream development method in the IT industry. In 1998, Eric Raymond coined the term "open source" referring to distributed, peer-reviewed and transparent software development processes, distinct from "free software". The term "free software" had become associated with a number of negative connotations: vendors presumed this to mean 'no revenue' and customers assumed 'no support' (Hecker, 1999). By contrast, OS refers to making source code freely available. OS software[14] (OSS) is free in the sense that no license fees are charged for use or redistribution of binaries of source code. In addition users have the freedom to modify the source code, create derivative works, and redistribute these works (Hecker, 1999) contingent upon the license under which the software is released.

Questions remain as to how companies profit from providing OSS at no cost. Is OS an ideology or can it be a lucrative business? We contend that OS business models are under researched, resulting in difficulties in explaining the strategy and actions of key players in the sector. For example, why did Red Hat, the distributor of Linux, acquire JBoss' application server for a reputed $350mn in 1996 and release it as open source? What revenue strategy does Oracle follow for their OS database MySQL, acquired in 2009? These companies have been successful not only in terms of revenues, but also in attracting venture capital investment. Since 1997, OSS vendors have successfully attracted investments worth of $4.6bn (Aslett, 2011). What makes OSS an interesting investment for venture capitalists? Why invest in a company that has no intellectual property and gives away free products? Is OSS becoming more attractive than proprietary/closed source software (CSS)?

Recent studies on OSS have discussed the working of OSS communities and specific OSS success stories (Hauge et al., 2010). Researchers have studied the evolution of OS operating systems like Linux, OS database management systems like MySQL, and OS programming languages like PERL. However, the existence of different business models in OSS companies and their limitations have received less attention in management literature. Questions remain unanswered as to how OSS carves a place for itself and

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[14] *Ibid.* 1

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competes strongly in a market predominated by CSS. Although OSS has gained immense popularity as a (product) development process in the past decade, focused research on strategies of OSS in comparison to CSS is lacking. Studies comparing proprietary/closed source (CS) and OS software have studied differences at product level and used the design structure (MacCormak et al., 2006), pricing strategy (Economides and Katsamakas, 2006) and innovativeness (Lamastra, 2009; Boudreau, 2010) as a unit of comparison.

Recent studies on value creation in firms have identified the business model as a source of competitive advantage for the firm, which contributes to the firm's survival and performance (Teece, 2010; George and Bock, 2011). In this study, we aim to shed light on strategies of OSS companies by deeply exploring their business models. Further, we compare this business model with those of CSS companies to understand how they react to competition from OSS. We use the business model approach to analyze *how* OSS companies differ from CSS companies within the context of a very specific industry, namely the Content Management Systems (CMS). The CMS industry provides examples of successful OSS as well as CSS projects. We chose to elaborate one specific industry case in order to draw conclusions from detailed insights rather than general findings. Our analysis of the CMS industry shows the different ways in which CMS companies work and how they achieve success in expanding their user base and revenues.

The article is structured as follows. In the following section, we outline the conceptual background to the article in terms of OSS and business models. We then discuss the methodology- research setting and data collection- that we employed in our study. Next, we present our findings by comparing the business models of CSS and OSS companies with respect to value creation, value delivery and value capture. We proceed to discuss the convergence of business models of OSS and CSS firms by presenting how OSS communities influence the industry. Finally, we reflect on the findings and discuss the implications and conclusions.

4.2   Conceptual Background

4.2.1   Defining Open Source

The history of OS dates back to the early 1960s when operating systems were developed in academic settings like Berkeley and MIT and code was shared freely (Lerner and

Tirole, 2002). The essence of OSS development is the rapid creation of solutions within a collaborative environment (Fitzgerald, 2006). From the beginning of the 2000s, wider interest and participation in OSS development has resulted in availability of more OSS solutions than their CSS counterparts. The repository Sourceforge.net lists 430,000 OS projects, several of which have been downloaded millions of times. The increasing popularity of OS is partly due to the high quality and reliability of the software, and also due to free availability of complimentary products. Despite this popularity, confusion remains in defining OSS and related approaches such as free software, freemium, freeware, shareware, web 2.0 etc.

LinkedIn, Facebook and Skype are acknowledged success stories in IT. Founded in 2003, LinkedIn, the largest social networking site for professionals, had an IPO valued at $4.3bn in 2011. More than 250 million members have joined LinkedIn in the last ten years. Microsoft acquired Skype in May 2011 for $8.5bn, one of its largest acquisitions till date. Skype was launched in 2003 to facilitate voice over internet communication. By 2011 it had 663 million registered users. With more than 1.3 billion active users since 2004, Facebook has become the most popular social networking site and was valued at $104bn at IPO in 2012. These companies have one distinctive characteristic in common: a huge installed user base. They were set up in the early 2000s in a period when popularity of OSS was at its peak. They are often confused with OSS businesses because they offer users varying degrees of free access.

Open source software (OSS) is defined as a software whose 'source code is made freely available'. The official definition provided by Open Source Initiative goes beyond just the source code access to include detailed conditions of redistribution, modification, derived works and license. It is distinctive from CSS where the software code is developed and protected within the company. Open source stands for the ideology of making the source code available to everyone, thus encouraging collaborative development. Fitzgerald (2006) observes an evolution of OS from its free software origins to a more commercially viable form- referred to as professional OS or commercial OS. The shift sets a basic distinction between community OS and corporate/commercial/professional OS (Riehle, 2009). The key difference in these two lies primarily in the number of stakeholders. Community OSS is software owned by a community of stakeholders, commercial OSS is owned by a single stakeholder, namely the company behind the OSS.

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This stakeholder has the full ownership rights to the code and related intellectual property. Casadesus-Masanell and Llanes (2011) further identify mixed source software as a mix of CSS and OSS, where the owner company makes a choice of releasing the code partly OS and partly CS.

Following Riehle (2009), we provide an overview of different types of software in Figure 8. Based on the development method, software is broadly classified as OSS or CSS. Moreover, within OSS, the ownership and management further classify the OSS in two types. We refer to the company managed software as "*commercial OS*" software and community managed software as "*community OS*" software.

Figure 8: Software Typology
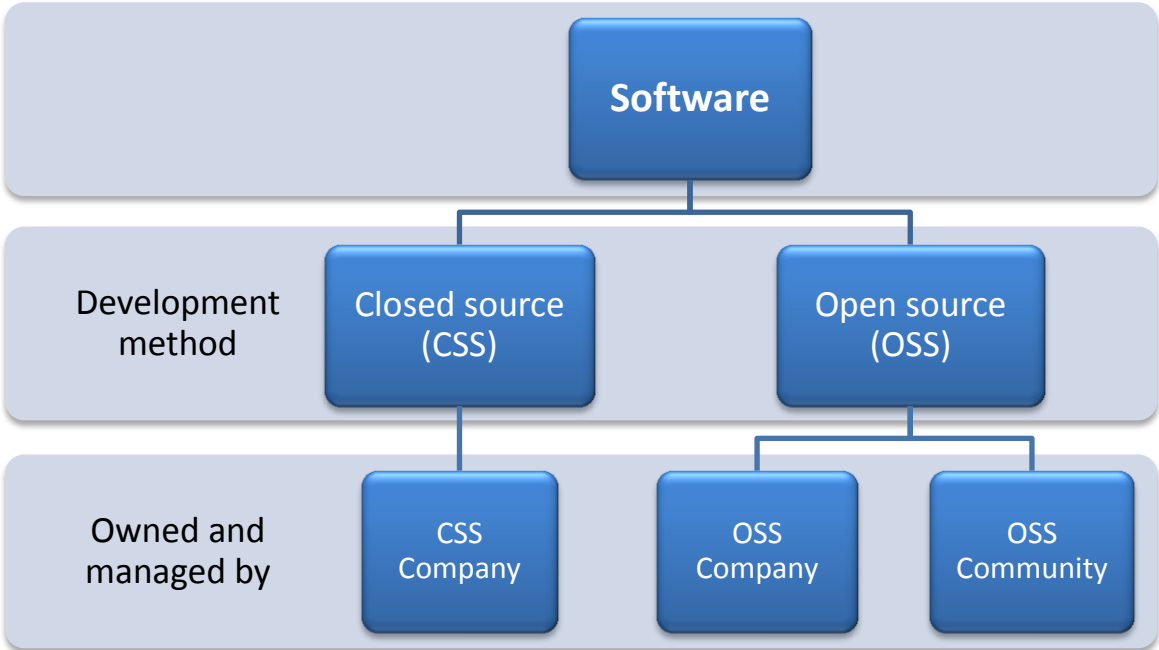
In absence of formal entities behind the community, we consider only commercial OS when comparing business models. We refer to the owner of CSS as "*CSS company*" and that of commercial OS as "*OSS company*" when comparing their business models. Further, we use the term "*OSS community*" as owner of community OS.

In order to study the business model in OSS, we need to clarify the basic classification of OS licenses. In what follows, we will discuss a range of Free and OS (FOSS) licenses and the permissions they allow the users of OSS.

4.2.2 Business Model

In the past few years, the term business model has gained much interest in management research. Nevertheless, scholars have observed a disconnection between management practice and research on business models (Valtakoski and Ronkko, 2010). A few years ago, a good strategy would guarantee success. Things have changed, and now, along with a good strategy, a good business model is essential to every successful organization; be it a new venture or an established player (Magretta, 2002). With the rise in the number of internet users, most of the companies started using a business model as a managerial tool to set up e-businesses (Osterwalder et al., 2005; Osterwalder and Pigneur, 2010). These e-businesses have led to the development of various new ways of making money over the internet which gave rise to e-business models (Afuah and Tucci, 2001). Further, the outsourcing and offshoring of business activities, the emerging knowledge economy and the restructuring of financial services were driving factors in the emergence of the business model concept. While the notion of business models has received significant attention from a lot of researchers, most of the research focuses on the definitions, components and taxonomies of business models or study a specific business model (Hedman and Kalling, 2003). Most of these business model studies have emphasized on value capture (Zott et al., 2011).

The availability of several definitions of a business model in the literature has led to frequent interchangeable use of the terms business model, revenue model and strategy (Morris et al., 2005). The literature refers to business models as explanations of how revenues are generated, for example, Stewart and Zhao (2000) … "a statement of how a firm will make money and sustain its profit stream over time". Rappa (2002) defines a business model as "the method of doing business by which a company can sustain itself". Kim and Mauborgne (2000) also look at the economic view and define business model as an objective of arriving at a pricing structure of a product. According to Chesbrough (2003), the business model serves as an intermediate construct that links the physical domain of technical inputs with the economic domain of outputs. The business model does not only focus on *for how much you sell*, but also incorporates *what you sell* and *how you sell*. Markides (2008) focuses on the strategic view by defining the business model as the positioning of company in a three-dimensional strategic map comprising of *who* - the target group, *what* - the value proposition and *how* - the value delivery system. While the

ultimate goal of a business model is to make money, the revenue model is simply an element of the business model. Amit and Zott (2001) present a very novel perspective by viewing the business model as a source of value creation. Teece (2010) defines the business model as a conceptual model defining the logic of how a business can create and deliver value to its customer, while considering the associated revenues, costs and profits. Teece (2010) distinguishes three value constructs that are important dimensions of a business model: the ways in which a company (a) creates value for its customers; (b) delivers value to its customers, and; (c) captures value from its customers.

Previous studies on business models in OS have considered open source itself as a business model. These business models were associated with the different license policies adopted by the firm. With popularity of General Public License (GPL), some researchers differentiated between GPL and non-GPL models (Krishnamurthy, 2003), others followed in a similar stream by splitting them in GPL, BSD and dual-license models (Onetti and Capobianco, 2005). The licensing policy also gives rise to the traditional models outlined by Hecker, namely the support sellers, loss leader, accessorizing and dual licensing (Hecker, 1999). We argue that OS is not a business model, but a development process and that a business model is not synonymous to a revenue generating mechanism. We adopt one of the four emerging themes outlined by Zott and colleagues (Zott et al., 2011) which suggests focusing on value for studying business models. We follow the definition of Teece (2010) and align it with the definition of Osterwalder and Pigneur (2010), to define a business model as a combination of three dimensions:

- **Value Creation:** How does a company entice customers to pay for value?

Value creation includes the value proposition that a company offers on the market. In addition to the product or service, availability of complimentary products and installed base contribute to value creation.

- **Value Delivery:** How does the company deliver value to the customer?

Value delivery depicts not only how the product or service is delivered, but also how the company builds and maintains strong customer relationships, and equally so with the partners it works with in the process of reaching the customer.

- ***Value Capture:*** How does a company convert payments to profits?

Value capture deals with the financial aspects of the company, in particular, the revenue model and the cost model.

Questions remain as to how companies profit from providing OSS at no cost. Therefore, in this study, we explore the business models of OSS and CSS companies using value creation, value delivery and value capture as three components of their business model. The study addresses the following research question: How do business models of OSS and CSS companies differ? How do these companies adapt their business models in response to industry trends?

4.3   Methodology

4.3.1   Research Setting

OSS is used as background software in all kinds of applications within the ICT industry; it would therefore be difficult to study business models in such a diverse context. Following Zott and colleagues (Zott et al., 2011), we considered one specific context, namely the *content management systems (CMS)* software to study the business models of OSS. A CMS facilitates the creation and deployment of dynamic websites for a variety of users via extranet, internet or intranet (McKeever, 2003).

> *"Linguistically, it means any system that helps you manage content – creating, storing, indexing, archiving, publishing, and distributing content." (K)*[15]

Behind every structured website today lies a CMS, providing easy development and administration without expert technical knowledge. This system helps businesses to design, set up and manage the content of a website and rapidly adapt this in a collaborative environment while maintaining quality (Boiko, 2001). It serves as a template for users to upload content without programming knowledge of scripting languages like PERL, HTML, Java, etc. CMS are used in commercial websites and by individuals for designing personal websites and blogs. Its structure varies according to user and functional requirements. To cope with this varied demand, more and more companies provide CMS in either a closed- or open- source application.

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[15] Letters in ( ) at the end of the quotes refer to interviewees. See Appendix A for an overview.

"A CMS is no longer about just managing a piece of content on your Web site. A CMS should be able to allow a non-technical user to manage any asset on a Web site that they wish to interact with, whether that is a piece of content, a picture, a video or information that is pulled from other sources." (Y)

The decision to study the CMS industry was influenced by several factors. Firstly, high variability is observed within the CMS industry (Vitari et al., 2006). The CMS industry is comprised of several types of software, namely web content management, enterprise content management, document management etc. Secondly, the CMS market is developing rapidly.[16] Wintergreen's research report (2009) valued the entire CMS market at $3.5bn in 2009, and anticipated it to reach $10.3bn by 2015. Web CMS, which is an integral part of most enterprises today, generated $890mn in revenues in recession-hit 2009, and projects $1.4bn for its vendors by 2015. Thirdly, the fraction of websites which use CMS has increased from 16% in 2010 to 30% in 2012 showing a large potential market.[17] With the rise in digital content, companies are finding it necessary to have some form of management process or system in order to structure content (McKeever, 2003). Lastly, OS has been predominant in the CMS industry. The number of OS CMS has been rapidly increasing; 120 OS CMS applications share the CMS market with 72 CS CMS.

Figure 9 provides our analysis of development of the CMS industry. While websites have been around since the early 1990s, structured websites only appeared in the late 1990s. These dynamic websites were characterized by rich content, high interactivity and better structure. Software companies with prior web development knowledge were the first ones to develop CMS, and offered it as an additional service via proprietary license.

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[16] The statistics are presented by Wintergreen Research Inc. in a 2009 report titled "Web Content Management Market Shares Strategies, and Forecasts, Worldwide, 2009-2015". Joab Jackson of IDG News Service shares his views on the growing business of web content management in August 2011 in an article in IT-World titled "Gartner: Web Content Management a billion-dollar business"

[17] W3 Techs Web Technology Surveys provide usage trends of content management system for websites. According to their survey data available for April 2012, 70% of the websites did not use any content management system for their website. The historical usage trends of CMS for websites are available at http://w3techs.com/technologies/history_overview/content_management/all

Figure 9: Development of the CMS industry
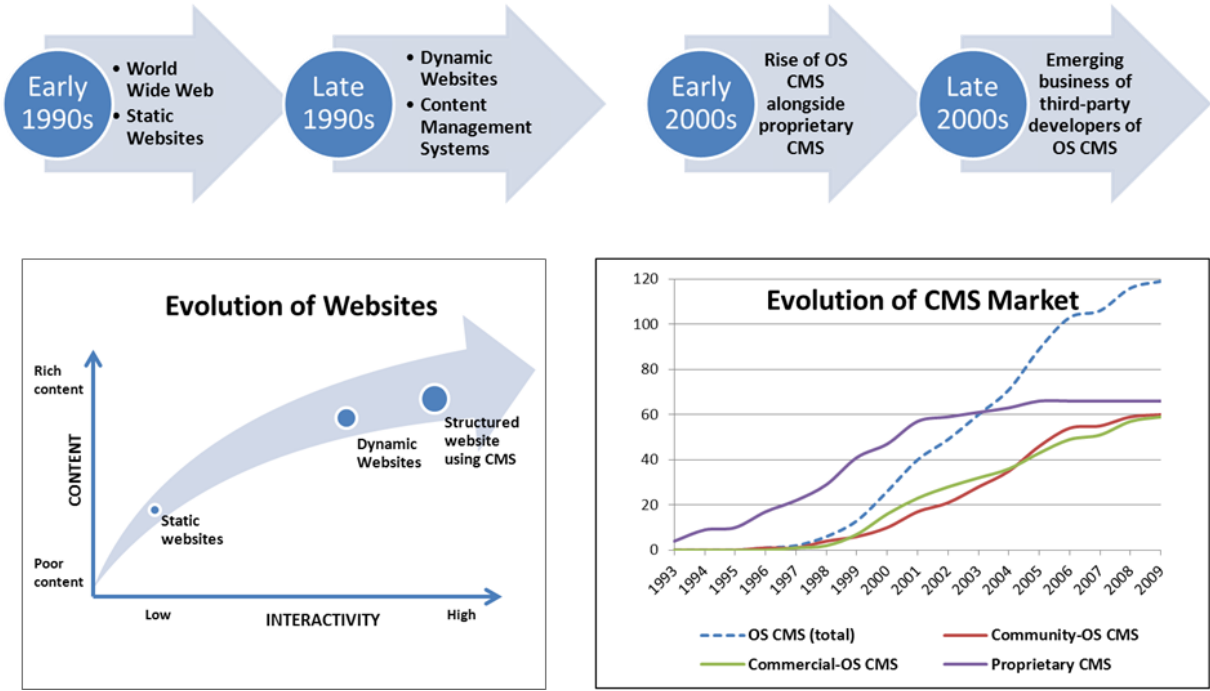
Within a few years several community OS CMS as well as commercial OS CMS were introduced to the market (see Figure 8). In the recent past, independent software vendors have started offering services built over active community OSS, leading to an emerging market of third-party developers of OSS (Dahlander and Magnusson, 2008). The CMS market thus comprises of CS CMS, commercial OS CMS, community OS CMS and several third-party businesses of extension developers and service providers for community OS CMS systems.

4.3.2   Data Collection

As we are interested in explaining *how* business models of OSS companies and CSS companies differ, a qualitative approach seems most appropriate. The research started by building a comprehensive list of existing CMS, using data from CMS research reports by Water & Stone (2008; 2009; 2010; 2011)[18], Wintergreen Research (2009)[19] and Gartner (2013)[20] complimented by data from CMS-related websites CMSWire, CMSCritic, CMSReview etc. The database consisted of 192 CMS, out of which 60 are commercial OS CMS, 60 are community OS CMS and the remaining 72 are CS CMS. Additional secondary

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[18] http://waterandstone.com/
[19] http://wintergreenresearch.com/reports/Web%20Content%20Management.htm
[20] https://www.gartner.com/doc/2565615/magic-quadrant-web-content-management

data on the founding year, platform, number of releases, downloads, licenses, owner company details, product offerings and pricing model was collected through web search. The data from Sourceforge.net was incorporated in the database to study the success of OS CMS based on the ranking and number of downloads. As an indicator of success for CS CMS, financial data was added after consulting Amadeus and Global Reference Solution databases.

In order to study the business models, primary qualitative data was collected using interviews. Based on their popularity and success, the top 15 CMS of each type- community OS, commercial OS and CS CMS were contacted to request an interview. Seven community OS CMS and ten commercial OS CMS companies responded positively. Since a low response was observed from the top 15 CS CMS, additional 15 CS CMS companies were contacted, ultimately resulting in a response from ten CS CMS companies. 30 qualitative interviews with founders and top managers (see Appendix A) of 27 popular CMS (companies) were conducted between January 2009 and June 2012.[21] Due to geographical limitations, most interviews were conducted through Skype and lasted between 30m and 1h45m. Interviews were semi structured with open-ended questions on the CMS industry, the trends in the industry and activities and operations of the companies. One author conducted the interviews, while other authors were not a part of the interviews in order to avoid any confirmatory biases. The interviews were audiotaped and transcribed verbatim and the text was read and re-read several times to identify the themes and sub-themes.

Interview data from OS CMS and CS CMS companies was used to analyze and compare their business models. Interviews with founders of OSS communities were further incorporated in analyzing the competitiveness in the CMS industry. To complement the interview data, secondary data was collected using several sources: (a) extensive archives, including corporate websites, blog articles, financial databases, corporate materials, business publications and press releases; (b) a survey among third-party providers of OS CMS Joomla!, and; (c) information collected through attendance at several international CMS conferences (see Appendix B).

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[21] Mike Johnston, owner of website CMSCritic, has kindly permitted the authors to use his dataset for research purposes.

4.4 Comparing Business Models

As discussed in section 4.2.1 and 4.2.2, every company has a business model which reflects a design of their business operations. To understand how CMS providers make money, we explore the business models of OSS and CSS companies based on the three dimensions outlined by Teece (2010): value creation, value delivery and value capture. Where relevant, our analysis will be complimented with quotes from the interviews in order to deepen our insights. Data on the respondents mentioned at the end of the quotes in ( ) is available in Appendix A.

4.4.1 Value Creation

In technological markets characterized by several players, firms need to continuously improve in order to gain market dominance. In absence of a dominant design, firms strive to create value for their customers in order to create technological lock-in and increase their market share. Value for the customer can be provided in the form of goods and services, knowledge or intangible benefits (Allee, 2000). While acceleration of technological change, the key medium representing value creation is the technology that the firm offers its customers in the form of knowledge embedded in their products and services (Schilling, 2003). Technological superiority or a better technological performance in comparison to competitors can provide a leading edge to firms operating in competitive markets (Suarez, 2004). Thus, the technology or *the technology standalone value* is an important dimension of value. However, technologically superior products can offer less value in absence of network externality effects (Schilling, 1998; Schilling, 2003). Scholars claim that the extent of availability of complementary goods has a significant effect on the consumers' technology adoption (Thum, 1994; Katz and Shapiro, 1986). The adoption of technology is further influenced by the market perception and its popularity which is determined by its installed base, in other words, the number of people who adopt and use the technology (Katz and Shapiro, 1985). Schilling (1998) proposes that *the size of installed base and availability of complementary goods* are highly correlated. The value of the technology is thus enhanced by these external factors- availability of complementary goods and installed base- that result in a network of technology users, of which the effects are visible over time.

In order to study the element of value creation in CMS companies, we follow Schilling (2003) and focus on these two dimensions of value: intrinsic value (technology standalone value) and extrinsic value (network externality value)

Intrinsic value

The *technology standalone value* or technical superiority is controlled by the pure effect of the technology and its performance in comparison with the competition (Suarez, 2004). A radical technology with significant improvement in functionality may surpass the advantages provided by other existing technologies with high external value (Schilling, 2003). The value that a new technology offers can be determined by several drivers, such as the functions it enables the customer to perform, its qualities, features and usability.

The technology of CS CMS, like any other proprietary software, is developed for business purposes and protected through a copyright of the software code and secrecy. Protection from competition allows a clear advantage to CSS firms (Suarez, 2004). Technology development is carried out onsite by a team of managers, developers, designers and testers. The technology tends to provide superior results because structured and centralized approaches are deployed by a dedicated workforce. The structured and centralized approach leads to a clear roadmap and architecture to the development process (Karels, 2003). Moreover, unlike in OSS, CS CMS developers aspire to include all possible functionalities while taking into consideration different customer requirements. The customers are thus presented with a huge list of features which they can choose to use or ignore. Not only is the ultimate software presented to the market secure and thoroughly tested, it also offers stability with development over time.

> "CMS21 is put in place as an investment. As your site grows over the years, you will have a solid product that will only get better over time. Since we are customer driven and focused, our clients feel secure that CMS21 will be their long term needs. This is why we have such a high client retention rate." (W)

CS CMS are mostly active in B2B markets; their customers are business organizations that are highly dependent on IT. These customers prefer to focus on their core activities while outsourcing their IT activities, and hence need a reliable partner for their IT needs. As VP of CMS18 narrated their customers' concern over the use of OSS:

"Our customers have tried to build a business with open source and bumped into various problems, especially when the business was growing to a large size." (T)

In contrast, commercial OS CMS is developed either by the OSS company or by a community of people working voluntarily on the software. In contrast to CSS firms, the development in OS CMS firms is a continuous cycle based on the functionality requested and required by users and developers. The development approach is less centralized and the addition of features is driven by the interests of contributors, rather than end users (Karels, 2003). The development in OSS companies is occasionally steered by a development team, which comprises of developers from within the company or from the community. Since the source code is freely available, bugs are easily identified, reported and fixed swiftly. Research shows that OSS has proven track record of reliability and security (Bonaccorsi et al., 2006). Scholars argue that hiding the source code does not provide higher security. In contrast, opening up the source code enables quickly identification and response to security threats (Boulanger, 2005). In the opinion of CMS13 founder,

"Just as importantly, we feel strongly that open source development leads to faster development, higher quality code, and closer attachment to market needs." (O)

OSS companies that hold the majority of the development in-house are not in a position to benefit from the knowledge inputs of community. An active community of developers is eager to contribute to the development of OSS in an environment where they feel a sense of freedom, ownership, achievement and authority. Moreover, governance in OSS companies, where only the OSS company commits code changes, prevents knowledgeable developers from investing time in commercial OSS development (Shah, 2006). Value creation in OSS companies thus largely depends on the degree of credibility offered to external developers. Empirical evidence on innovativeness of OSS is inadequate (Lamastra, 2009). Tuomi (2005) argues that OSS is not innovative, and tends to re-implement the functionalities of CSS. Unlike in CSS, where a market or customer requirement survey drives the software development, development in OSS is handled by the active contributors who often decide on functionalities that need to be added (Karels, 2003). However, another stream of research claims that OSS solutions are more innovative than CSS solutions (Lamastra, 2009). Studies show that both CSS and OSS are

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equally secure and reliable, and OSS projects are capable of meeting or even exceeding the quality of their CSS equivalents (Boulanger, 2005).

In sum, although OS CMS try to mimic their CS counterparts in features and functionality, CS CMS are usually a step ahead with high-end functionality. Frequent releases of OS CMS often account for more bug fixes rather than more functionality with each new release. Although it is difficult to compare the two with respect to innovativeness, we observe that intrinsic value creation in CS CMS companies tends to be higher than that in OS CMS companies.

Extrinsic value

Network externality or extrinsic value is the value arising from the positive benefits accrued from all adopters of the same product or technology (Thum, 1994). This value is generated by the size of its *installed base* and the *availability of complementary products* (Allee, 2000) which enable or enhance the value of the technology (Teece, 2010).

Many customers select a technology based on the availability of compatible complementary goods. Depending on the capabilities of the firms, firms choose to either provide complementary goods themselves, or depend on other firms for the production of complementary products (Schilling, 1998). Scholars claim that the availability of complementary goods positively influences the consumers' choice of technology (Choi, 1994; Katz and Shapiro, 1986).

Complementary products may provide additional features and functionality to CMS, but are dispensable for the operation of CMS. Examples include add-ons, plug-ins or extensions which constitute supplementary features. The development of complementary products requires knowledge of CMS source code, or at least the structure of the source code. Complementary services include web design services, installation and support services, hosting services, etc., which require little or no knowledge of the source code.

Due to source code protection, there is little possibility for other companies to offer complementary products or services for CS CMS. Only the vendor company usually has the authority to manage the development of complementary products or services, or they adopt complementary products developed by preferred (CS) partners. Proprietary

ownership generally restricts the opportunity of providing third-party services for CS CMS. A remarkable exception in proprietary companies is Apple. Despite being a closed source company, Apple has been successful in creating a large community of application developers. Apple has achieved this by providing a software development kit (SDK) and integrated development environments (IDE), guiding the development of applications, without disclosing the source code. CS CMS generally do not supply such platforms and tools for others to build upon their product. However, CS companies do not seem to assign importance to the availability of complementary goods. As CEO of CMS25 mentions:

> *"We believe that a Web Content Management System should provide marketers and developers with everything they need to achieve their goals on-line. They shouldn't be forced to buy numerous add-on modules, requiring complex or even impossible upgrade paths from multiple vendors, which is quite often the case with open-source CMS systems." (AA)*

OSS companies, on the other hand, try to leverage their lower intrinsic value through a range of complementary products and services. The availability of source code enables external developers, who are often members of the community, to work on extensions and provide services. Since OS licenses are often permissive to the development of complementary products and services, the more popular commercial OS CMS have a large number of extensions available, which are offered at affordable prices, or sometimes at no cost by third-party developers. CMS9, one of the most popular commercial OS CMS hosts nearly 8000 add-ons in the form of apps, modules, skins etc. developed by the community members and offered at low costs. End users of commercial OS CMS are not obliged to use these complementary products since they are supplementary to the working of the CMS. The founder of CMS16 and the CEO of CMS9 openly acknowledge the power of their community members who increase the value of their CMS by developing complementary products- extensions, add-ons, plugins and themes.

> *"I don't think it's any one feature or thing that makes CMS16 different from others, it's the thousands of plugins and themes available for the platform. That community is impossible to duplicate." (R)*

"The big reason for our success is we are an extensible platform with more than 8,000 commercially supported add-ons that plug into our platform. What makes us different and better is our vibrant ecosystem – A vibrant and rich ecosystem of 800 ISVs who provide thousands of commercially supported add-ons at a low cost, hundreds of System Integrators who can help you custom build your web site whether your requirements are simple or complex, and numerous hosting providers who specialize in hosting CMS9." (K)

Although many complementary products and services are available for popular OS CMS, some providing the same functionality, the complementary products need to sell themselves by answering the relevant demands of functionality and robustness. The high technology value of CS CMS might demonstrate that potential complementary products (extensions) are already incorporated in the product itself. On the contrary, value-added complementary services are seen as extrinsic value enhancing options for OS CMS companies.

In addition to the number of complementary products, applications and services, the network externality value of a product is represented by its *installed base*. This is the number of users of a particular product or service. A larger installed base is associated with increased demand and higher rates of adoption for a specific technology (Katz and Shapiro, 1985; Schilling, 1998). The installed base further helps to design future compatible products (Suarez, 2004).

The most vital aspect that a user looks for in a CMS is its functionality - the ability of the CMS to meet user requirements. Besides the technological benefits, a potential user may choose to use a particular CMS based on the number of existing users and their reviews. The choice of CMS depends on the desired complexity of a website. The installed base has a very low influence on the potential customers for CS CMS. Firstly, the customer portfolio of CS CMS companies is rather limited to business customers, hence an installed base does not have much influence on customer decision making. Secondly, these business customers typically outsource all the activities of content management to the vendor company, in turn worrying less about the availability of specific features, and more about satisfying their requirement specifications.

In stark contrast, the installed base plays a major role in the further adoption of OSS (Ajila and Wu, 2007), not only by individuals, but also by developers of commercial applications (Stone, 2002). A majority of commercial OS CMS have been downloaded thousands of times, while five of them have more than a million downloads, showing that the popular commercial OS CMS have a large installed base.[22] The installed base is also referred to as the community in the OS context, and includes the end users, developers and testers. The community is valuable for the OS CMS companies since it keeps the project active by solving issues and answering questions. Amongst others, CMS10 founder defends the unprecedented contribution of the community to the CMS development.

> *"It's that kind of two-way interaction with the community that makes open source work." (L)*

While the intrinsic value of OS CMS companies might be lower, their overall value is leveraged by the network externality, in other words, by the ecosystem that is created around it. However, contribution or participation in CMS development seems to follow the 1% rule observed in the Internet culture (Arthur, 2006). The rule suggests that:

> *"If you get a group of 100 people online then one will create content, 10 will 'interact' with it (commenting or offering improvements) and the other 89 will just view it."*

Within the OS CMS world, very few developers actually help in developing the CMS code. Users download and use CMS in abundance. They return to the forums to ask for support, but there is no evidence of these users actively answering questions or participating in CMS development. Thus, while OSS attracts a lot of users and developers, the best applications are developed only by the active contributors. The number of active contributors in the community, and not the size of the ecosystem, represents the success of OS CMS.

We can conclude that with a dedicated team of full-time developers, CS CMS companies have higher intrinsic value, while the intrinsic value of the OS CMS companies is not as

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[22] The number of downloads were retrieved in October 2010 from open source project repository, Sourceforge.net. The number of downloads or installations is not available for CS CMS. The number of customers listed on the websites of CS CMS is used as a measure for the installed base. Of the popular CS CMS, EpiServer CMS lists the maximum number of customers- 967.

high as one would expect, mainly due to a relatively small number of developers who actively contribute to the development. OS CMS companies excel in extrinsic value, but the value needs to be leveraged by committed developers and contributors, superior quality extensions and higher numbers of users who provide valuable inputs rather than being mere spectators in the CMS development process (Lee et al., 2009). One can conclude that a large user base and an active team of committed developers are the main strengths of OS CMS companies, and they need to leverage this in order to overcome the weaker technological solution they tend to offer.

4.4.2 Value Delivery

The value delivery aspect deals with the ways in which the product or service reaches the end user. In adopting innovative transaction methods, companies need to decide on the parties involved in the transaction process. There are three basic value delivery models in the context of CMS. The first is *traditional on-premise software*, where CMS is installed onsite at the user's facility. On the one hand, users can install the CMS using a license provided by the vendor. This is mostly the case with CS CMS companies and with OS CMS companies providing a professional version of their CMS. Alternatively, users can download OS directly from the Internet. The terms of OS license enable CMS users to freely download, install, use and customize OS CMS according to their requirements. As quoted by several respondents:

> *"Value lies in ease of use-making the software simple- install in one click, and you are all set to go!" (G)*

> *"If CMS15 was exceptionally hard to install and use we wouldn't have the download numbers and the installed user base." (Q)*

> *"We choose the MIT license because it lets you do ANYTHING you want short of suing us. If you're building a start-up, and you want to get a jump on the competition but truly own all the code you write – our MIT license makes that very easy. As a developer you don't have to submit your code back to the project. For all I care you can package CMS8 up exactly as it is today, call it 'cement6' and go sell it on CDs in Walmart." (J)*

The second delivery mechanism is *hosted software*, where the software is hosted by the vendor or a third party as opposed to being installed onsite. This saves end users the high upfront investments of renting the hardware on a subscription basis. The application is accessible over the Internet or private network. The hosted application is usually customized to meet specific user needs. Hosted may imply that the vendor provides technical support, installation, upgrades and support for the CMS. The providers of hosted software have the choice of doing it themselves by being the only vendor of the CMS, or by using their partner network to manage some or all the services as third parties and only restricting their value proposition to the CMS application. This delivery mechanism is used by CS CMS companies as well as OS CMS companies. The third delivery method is *Software as a Service (SaaS)*. SaaS allows the users to access the CMS over the Internet under subscription plans. SaaS is similar to hosted software with regard to saving upfront investment costs. The only difference is that the application delivered via the SaaS model is the same for all users. Hence CMS functionality is limited with respect to customization. The SaaS model is primarily used by CS CMS companies.

Within the last two decades there has been a gradual transition in the way value is delivered. The transition has been from traditional ways of on-premise software and licenses to the more common SaaS and hosted software models. This change can be ascribed to the change in user behavior and requirements. Companies which require a CMS to manage their content are willing to pay an external supplier, rather than reinventing the wheel and developing the CMS in-house. This results in cost savings on hardware and ICT personnel, facilitating companies to work on their core business while outsourcing the complex task of ICT management. Having said that, founders of CMS8 and CMS22 have mixed opinions on the SaaS delivery model:

> *"The traditional model where you charge a big license fee up front and then an ongoing maintenance fee, while not being able to look what is under the hood, that will become hard, because that is going to be replaced with SaaS." (J)*

> *"What I am claiming is that SaaS is only a temporary measure to fill a market need. Eventually organizations need housing at their own facility; eventually all information needs to interrelate. SaaS acts like a band aid to fix a wound rather than cure the disease. Yes there is money to be made, but the longevity of these models is questionable." (X)*

We conclude from the above that the more control a company has over its software, the more novel its value delivery model becomes in order to differentiate itself from its competitors. CS CMS companies appear to be more innovative with their hosting and SaaS delivery model. Adopting a SaaS model may also result in customer lock-in and promises recurring revenues for CS companies. Due to the open nature of its source code, OS CMS companies have limited choice of value delivery mechanisms, and mostly follow the traditional on-premise installation method. A few OSS companies have taken over the hosting approach, and are likely to embrace SaaS in future.

4.4.3 Value Capture

Value capture is determined by the effectiveness of the revenue model. In order to be successful, companies aim to have a continuous stream of royalties from licenses, sell customized services on top of these royalties and have some peripheral revenue streams through advertising, sponsorship or donations. The most common revenue stream for CS CMS companies is through *sale of licenses*. Licenses can be purchased and owned with a one-time payment or can be rented on a monthly/ quarterly/ semi-annually or yearly basis. While the one-time license fee entitles the company to a large amount at one time, the *rental method* promises a continuous revenue stream. The value delivery mechanism (Traditional vs. SaaS) determines the proportion of a one-time license fee against recurring license fees.

A second revenue stream for CS CMS companies is providing services. Different payment options are associated with different types of services. *Installation services* are usually for one-time payments. *Support services* are typically charged per hour or by subscription. Short-term and long-term subscription plans are available for *hosting services*. *Customization and development services* are charged for based on the size of the project or the development man-hours or man-months required. *Upgrade services* are charged at a fixed price. The respondent of CMS18 talks about their business activities with the services revenue model:

> *"People are realizing they need more training, support, hosting and somebody to help them. A company that offers hosting and other services for an open source CMS; that is closer to what we do." (T)*

Within OSS, the distinction in management of the software application is facilitated by a licensing strategy under which the developers make the source code available. A license symbolizes the transfer of rights from the owner to the end user. Software licenses are classified as proprietary licenses and FOSS licenses. Proprietary licenses are available at a cost predetermined by the CMS owner. On the contrary, FOSS licenses are available at no cost, but have a few conditions that need to be taken into account while using the software. In the beginning, FOSS licenses were implemented with the aim to facilitate collaboration and free sharing. Few people started downloading OSS and customizing and using it for professional purposes, without sharing their changes back to the community. It became difficult for the OSS providers to monitor the use of OSS for commercial purposes. Hence, companies formulated the *dual-licensing* strategy (Välimäki, 2003; Gomulkiewicz, 2004). With the dual-licensing strategy, the software could be accessed under two licenses- a FOSS license and a paid commercial license. The free license allows users to download the software for free provided they share the modifications back to the community, while the commercial license permits the buyer to legally customize and use the software according to their own requirements without sharing the modifications with the community. This strategy made it easier to monitor the source code and also to generate revenues from users who wished to use the software for commercial purposes (Watson et al., 2005).

> *"The base product is open-source, distributed as 'CMS17 Community Project' in its bleeding-edge version. The full Experience Management platform is distributed as part of a subscription, packaging all experience management features and services around the powerful content management engine." (S)*

The revenue streams for OS CMS companies are similar to those of CS ones. Within our sample of OS CMS companies, one of the common revenue streams is *dual licensing*. A commercial license allows the customers to access and modify the CMS source code for their own use and further preserves secrecy of the software. As many as 38% of the 60 OS CMS companies release their CMS under a commercial license together with a FOSS license. Other companies prefer to make the CMS purely open source and sell extensions, premium features and templates for a fee.

Services are another popular revenue stream for commercial OS CMS developers. These include customized development and design services, support services, hosting services

and installation services. Next to these services, which are also offered by CS CMS companies, commercial OS CMS companies provide training and consultancy services for their OS CMS. About 75% of OS CMS companies offer at least one of the above mentioned professional services to their customers. According to practitioners, selling services seems to be a successful business model in the OS world. As the co-founder of CMS10 states:

"We're following the tried and tested open source business model. Although anyone can download the core and use it for free, we provide a complete set of commercial services and training surrounding it." (L)

Besides revenue generation, OSS companies achieve profits by reducing costs. CS firms find it difficult to reduce costs, but OS firms explore cost reducing opportunities provided by their community. By virtue of its nature, OSS enjoys minimal personnel and marketing costs. The founders of CMS8 and CMS13 confirm this:

"Honestly, we do not spend a tremendous amount of money on marketing. An enormous advantage of being open source is that you have that huge group of advocates that want to go out and sell for you." (J)

"We also wanted to grow our customer base and knew popularity and proliferation of our software would lead to credibility and drive commercial customers our way." (O)

The intrinsic value is of higher importance in the initial R&D and technical feasibility phase, while the extrinsic value plays an important role in the post-market launch (Suarez, 2004). The main insights of our analysis on the value creation, the value delivery and the value capture of OS and CS CMS companies is assimilated in Table 8. The table stresses the differences in business models of CS and OS CMS companies along their three underlying dimensions. CS CMS companies excel in intrinsic value and are much more diverse in their options to deliver value to their customers. As a result, they have looked into various ways to capture value and generate revenues from their CMS. Most value is captured through license fees which are either paid upfront or on a transaction basis. As a result, the turnover these companies typically generate is much higher than that of OS CMS companies.

Table 8: Business model of OSS vs. CSS companies

	CSS Companies	OSS Companies
Value Creation		
- Intrinsic value	**High**	**Medium**
- Extrinsic value	**Low**	**Extremely High**
	(Absence of installed base)	(Availability of complementary goods and installed base)
Value Delivery	**High**	**Medium**
	(MSP/Hosting and SaaS delivery models in addition to traditional)	(Traditional and hosting)
Value Capture	**High**	**Medium**
	(Licenses, Services)	(Dual Licenses, Services, Extension development, Low development, personnel and marketing costs)

OS CMS companies are more community-driven and aim to create value with the help of network externalities. These CMS have created most value through the community base in which they are installed. Innovative value delivery or value capture mechanisms are less important to them. OS CMS companies deliver value through the classic mechanism of downloading software and capture value mostly by providing dual licenses and support services. OS CMS companies are looking to experiment with new value delivery mechanisms, while pursuing new revenue channels.

4.5   The Role of OSS Communities

Alongside OSS companies that manage commercial OSS, there exist OSS communities that manage community OSS. Besides commercial OS CMS, community OS CMS also hold a significant market share in the CMS market. OS CMS communities are perceived as a severe threat to profitability and revenues streams of OS CMS vendors, and to a minor extent to OS CMS companies. Although questions are raised on security of OSS (Boulanger, 2005), OS CMS communities are confident about the security and robustness of their offering. As the developer of CMS7 suggests:

"Being closed-source doesn't mean that the software is more secure. On the contrary, having more people looking at the source code (in open source) is just that extra benefit." (H)

OSS communities thus take pride in the intrinsic value of their CMS. In addition, OSS communities largely benefit from network externalities. In absence of a company behind the software who steers the development, OSS communities attract more knowledgeable developers than OSS companies (Shah, 2006). The CMS7 developer proudly presents the strong community of developers working on their CMS:

"You've got to be quite a large proprietary company to compensate all the developing hours being done by the developers of a community like ours." (I)

However in practice, the size of the community does not reflect the active development in the two most popular community OS CMS Joomla! and Drupal. Our survey with community members of Joomla! OS CMS shows that 50% of service providers and 35% of extension developers do not contribute back to Joomla! development. Of the ones that contribute, only 12% spend more than 10 hours per week on Joomla! development. In another example, Drupal has nearly 1.1 billion registered users, but only 17,000 registered developers.[23] Consequently, Drupal developers represent merely 1.5% of the community. Undoubtedly, OSS communities tend to overemphasize the strengths of having a community of developers rather than a dedicated internal team of developers.

However, the openness of OS CMS communities indeed attracts a significantly larger installed base. As a result, many of the community members who have been working on CMS development, set up OSS community affiliated firms developing complementary goods for a large installed base. The number of complementary goods, extensions and services provided by these OSS community affiliated firms further increases the intrinsic value of OSS communities. Joomla! lists 9300 extensions, while Drupal lists 15700 modules and 1400 themes.[24] These extensions and services add to the moderate intrinsic technological value of the OS CMS communities.

"A huge community has grown up around CMS1, with thousands of active contributors to the open source project, including nearly 2,000 community-

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[23] Data collected from Drupal website in April 2012.
[24] Statistics available on Joomla! and Drupal websites, accessed in April 2012.

developed modules for extending CMS1 functionality. [....] CMS1's thriving, vibrant ecosystem is the very reason that CMS1 is so successful – it is its greatest strength. The core strength of CMS1 is definitely the open source community that is behind the project. I am constantly amazed by the innovation that comes out of the thousands of dedicated CMS1 contributors." (A)

While providing a free, high-value CMS to the world, OSS communities do not need to worry about value capture. Since they do not have any personnel, marketing or sales costs, they need meager revenues to cover the server costs for hosting their CMS. CMS capture value in terms of the time which developers dedicate to development. Quoting the development coordinator of CMS3 and the co-founder of CMS5:

"We have Google AdSense on our sites, some of them. We get some donations from individuals and we have a great hosting partner that donates so much time and infrastructure. Well the most important donation we can ask for is time" (C)

"The most basic thing people can do to contribute to CMS5 is let us know when something needs to be fixed or improved upon, or by requesting new features in our project tracker." (F)

Thus, while OSS communities do not capture value for themselves, they conquer a huge market share due to the high value they create with their CMS. As a result, they are undoubtedly the first choice for B2C customers, while they also capture some market of B2B customers owing to their stability, security and availability of complementary products and services. The value capture in OSS communities happens with the third party OSS community affiliated businesses that provide complementary products and services for popular OSS communities. Although it is difficult to estimate the amounts, the accumulated revenues generated from these OSS community affiliated businesses are significantly large enough to pose a threat to the revenues of CS CMS and OS CMS companies.

4.6   Converging Business Models

Both OS and CS CMS companies feel the competition from each other as well as from the OS CMS communities. They appear to have adopted the strengths of each other's

business models in order to be competitive and capture a greater market share. We shortly discuss the changes that they foresee in their business models.

4.6.1 Why and how do OS CMS adjust their Business Models?

The real value of OS CMS lies in the installed base and complementary services, while the value of CS CMS lies in the intrinsic technology value and a wide range of delivery systems. The customer can either choose an expensive CS CMS, where the vendor takes care of the website, or a cheaper OS CMS, where the basic structure is for free, and the services or customized development can be outsourced to developers at a comparatively lower price. But what does the customer really value?

The major hurdle to the widespread adoption of OSS in the B2B market is the assurance of continuous development. Since business customers completely rely on external IT support, adoption of OSS asks for the entire IT responsibility to be outsourced. OSS companies can guarantee continuous development when they either have a dedicated development team internally or a strong, active and dependable development team externally as a part of their community. The issue OSS companies face is the dilemma of degree of ownership. While assigning development and ownership of the software to the community can attract a larger installed base, it can limit revenue generation. On the other hand, preserving the ownership can prevent external contribution, signaling the OSS company to be an opportunistic company trying to profit from the efforts of the community. This makes it difficult for OSS companies to move to the CSS way.

OSS communities pose a threat to OSS companies. OSS communities enable the creation of start-ups and provide individuals with opportunities to benefit from OSS (Piva and Rossi-Lamastra, 2012). A number of third-party OSS community affiliated businesses have been created by active OSS community contributors who act as partners for the OSS communities. As the CEO of CMS2 mentions:

> *"Our success lies in the number of websites running on CMS2. Without our service vendors who successfully adopted CMS2 as their core platform for creating websites, this was not possible." (B)*

These OSS community affiliated businesses operate in a similar way as OSS companies, by providing products and services for community OSS. They sell CMS extensions which

are debugged and customized for company needs and guarantee service level agreements (SLAs) which are common in the CS CMS environment. They try to achieve the best of both worlds by positioning themselves in the market of OSS companies. They are evolving to innovative value delivery and revenue generating techniques, which seem to have helped them thrive in the CMS world. But they aim to have high extrinsic value aided by the scale of the community's installed base. The success of OSS community affiliated businesses depends on the complexity of the websites and the technical know-how of the community. For the more complex CMS like Joomla! and Drupal, the community is mostly comprised of techies. WordPress on the other hand is easy to download, install and use, and hence is a favorite among non-techies. As a result, OSS community affiliated businesses of Joomla! and Drupal are primarily set up by business-minded techies who aim to serve the B2B market.

OSS companies are trying to find the right balance between the degree of ownership and fostering an active community. Most of the OSS companies act as third parties for the OSS and provide support services for their commercial OS CMS. The services provided by OSS companies promise support for business customers and ensure continuous development by attracting developers. The larger installed base also ensures availability of complimentary goods. OSS companies are trying to provide a platform to promote these extensions. This is an added advantage for external developers to participate actively in the community. The CEO of CMS9 says about their efforts on promoting the external development of their software:

> *"There are many ways to contribute to the CMS9 project, depending on an individual's skill set and interests. [....] For more technical individuals, they can submit an open source extension to our Forge, they can become a team member on an existing Forge project where they can contribute source code and development assistance, or they can develop and sell their own CMS9 add-ons on Sxxxxxxxxxd.com (CMS9 store)." (K)*

OS CMS companies also take advantage of the contributions they receive from the community together with feedback from commercial users. CMS13 has repeatedly used customer feedback to improve their CMS.

"In the same way a car has a driver and mechanic as distinct roles, we've ensured our product worked for our clients and us, and we've continuously used feedback to ensure both get improvements." (O)

To conclude, the success of OSS is more likely to be determined by the number of active contributors rather than by the number of users, and as such by the size of the ecosystem. OS CMS companies compete with CS CMS companies by excelling in extrinsic value. Since contributors and third-party developers are more likely to be attracted by the ease of use of CMS, a well-structured and well-documented source code can benefit OS CMS companies. Giving higher control to the community for attracting developers, while simultaneously deploying an internal development team to keep the development on track will be a key for OS CMS companies to foster an active community and attract investments to improve value capture mechanisms.

4.6.2 Why and how do CS CMS adjust their Business Models?

CS and OS CMS both face significant challenges. Firstly, with respect to value delivery, CS CMS create the perception among customers that there are high switching costs, creating lock-in. In the case of the hosted value delivery model, the initial license fee is quite high and is a sunk cost, but even if customers opt for the SaaS value delivery model, they lose their content if they wish to switch to another CMS. Secondly, with respect to value capture, CS CMS are confronted with high cost of sales as there is no community available to enable swift adoption.

To address these challenges we observe that CS CMS use freeware, shareware or even hybrid models. Since CMS is the core product for most CS companies, they cannot afford to release it in the form of freeware or shareware unless they adopt a hybrid OS model like CMS8 and CMS13. Both these CMS moved from being a CSS product companies to OSS companies with similar intentions, and have become well-known commercial OS CMS providers. In 2006, CMS13 released their CMS as free under the BSD license, and became successful with their consulting and web development services.

"We wanted to make a bigger difference in the world. We were unexcited by the free and open source offerings and knew if we made our system available to the public we could improve how developers build websites, and how most people manage and update their websites. [....] We've had nothing but positive outcomes that surprised

or exceeded our expectations. Migrating our product to an open source model has worked very well and I'm delighted when I see other companies doing the same thing [....] Its an awful lot of fun and satisfaction knowing a new feature or bug fix shall be enjoyed by tens of thousands of people, rather than a few dozen clients." (O)

"We strongly believe in the power of free information, so after years of pretending we didn't, this complete openness makes us feel great." (J)

Although transitioning to OSS is difficult for CS CMS, these companies are constantly in search of strategies to adapt their business models with a view of increasing their extrinsic value. Other CS CMS companies choose freeware or shareware business models. However, as they do not want to give away their core CMS for free, they release other products as freeware and shareware and use them as branding mechanisms to attract users to their core CMS product. While freeware and shareware seem to be straightforward solutions to increase the installed base, CMS companies find it difficult to modularize their CMS to have basic software released as freeware or shareware. CS CMS could also build extrinsic value by following Apple's strategy - providing users with toolkits and frameworks to develop complementary products. This can be challenging, but offers a viable alternative for CS CMS.

To sum up, there is a need for vendors to boost the extrinsic value of their CS CMS. A few CS CMS companies are taking steps to build closed communities for their products. For instance, Amaxus CMS is making efforts in establishing user groups and communities for their customers. The community allows their customers to communicate and share knowledge, although in a closed environment. Another example is OpenText which also aims to utilize the power of customers by creating discussion groups. The senior management of CMS24 is also trying to build a community with a view of reducing costs:

"By creating a community around your products or services, businesses can empower users to help each other to resolve issues, thus dramatically reducing the support costs." (Z)

Although the success of closed communities is not yet apparent, it is a potential path for CS CMS to increase their extrinsic value by harnessing the power of the crowds.

4.7   Discussion and Conclusions

Despite the clear value of OSS companies in the size of the installed base, OSS companies has not shown convincing results in terms of revenues. Where 10 VC-backed CS CMS companies have been acquired between 2004 and 2010 for prices ranging from $3mn to $1.7bn, only one OS CMS company exited in this period. The biggest acquisition in CMS's history is that of Documentum by ECM which was completed in 2003 for $1.7bn. Three major acquisitions were completed in 2010-2011, which include Open Text-Vignette, Autonomy-Interwoven and Adobe-Day Software. The only acquisition in OSS happened in 2010 when VideoEgg acquired SixApart, the owner of commercial OS CMS MovableType.

Regardless of these successes in the CS CMS world, an increasing number of private organizations are embracing OSS (Stone, 2002). The widespread diffusion of OSS in a market dominated by CSS is evident (Bonaccorsi and Rossi, 2003). California-based Yodlee Inc., provider of online banking solutions, adopted OSS in 2006. Tim O'Brien, senior VP operations, defended their choice of OSS:

> *"It wasn't just the savings that prompted us to go with an open source solution. We also believed we could get an open source solution up and running faster than the proprietary alternatives. We are sure we're missing out on some high-end features by not going with the big guys, but it doesn't really matter. It's like not having a Ferrari; you don't know what it feels like to drive one."[25]*

The popularity is not only limited to the private sector, public organizations seem to follow in the same direction. For instance, the White House uses Drupal CMS and UK government uses Joomla! CMS for their websites. One reason for this is that government and not-for-profit organizations seek social attractiveness and acceptability. While it is difficult for OS communities to make a transition to OS CMS companies, individual developers can set up third-party businesses to increase the intrinsic technology value through screening the extensions and debugging them as well as offering professional SLAs to their customers. OS CMS communities thus open up several opportunities for developers who capture value from the OSS communities. In addition, the perceived

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[25] Tim O'Brien, Senior VP Operations, Yoodle Inc, as quoted in "Open Source lures cost-conscious CIOs" by Shamus McGillicuddy, SearchCIO.com, August 2006.

social value gives OS CMS a competitive edge vis-à-vis the CS CMS vendors. This social recognition drives investors towards OS where they may realize benefits from investing in the community, more than in the product.

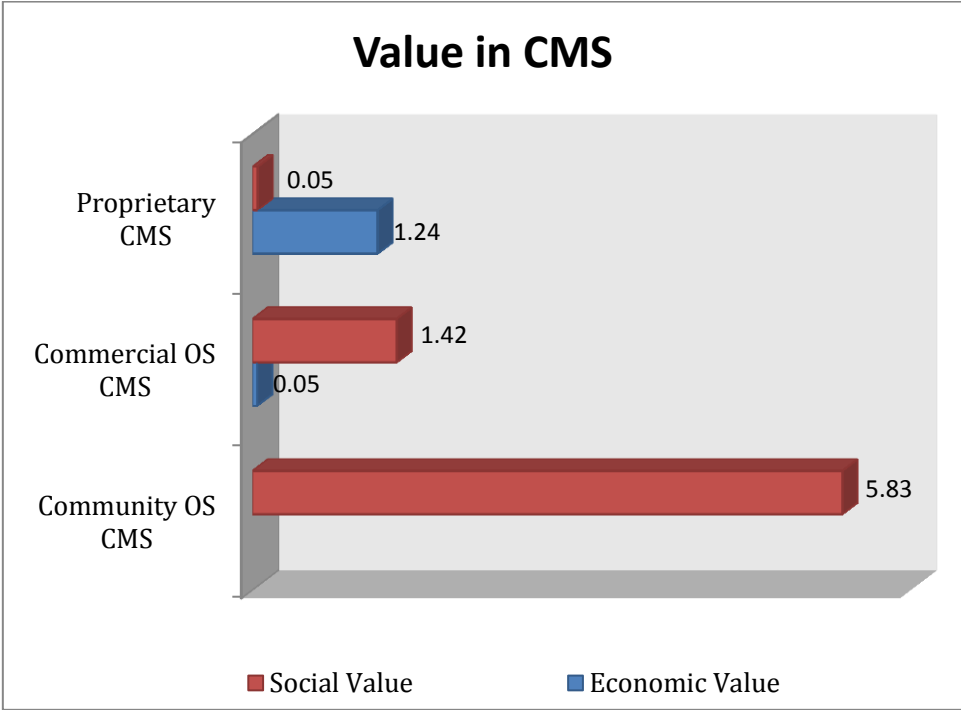**Figure 10: Comparison of value in OS and CS CMS**

Figure 10 shows the value[26] of CS CMS and community OS CMS are orthogonal. The former lies at one extreme with the intent of gaining higher economic value, the later carries an entirely social mission due to its OSS ideology.

The revenues per customer realized by commercial OS are much less than in the CS environment. However, the number of users is much higher so that the total revenues

[26] Economic value is measured as the average of revenues in $mn per customer. Revenues are consulted from financial databases Amadeus and Global Reference Solution, while the number of customers are consulted from the interview data as well as the company website. The data was collected in Jan 2011. Since data is available in Euro, the average value is multiplied by 1.4 to convert the unit of economic value to $mn. The economic value of community OS CMS lies in the revenues that third parties make by providing products and services for community OS CMS, which is difficult to gauge. As a result, this value has not been considered in the graph above.
Social value is measured as the number of downloads of the OS CMS from Sourceforge.net. Unit of social value is the amount in million downloads. Since the number of downloads is not available for CS CMS, the social value is considered as the average number of customers. As almost all of these CS CMS companies provide a B2B solution, the average number of customers is multiplied by 1000- an assumption of the size of their customer base.
The graph consists of average values of the economic value and social value of all CMS of which data are available. Economic value of CS CMS is even higher, considering the fact that only those CS companies that have a flagship CMS product have been considered in the graph

converge with those of CS CMS vendors. In contrast, community OS CMS fail to generate revenues themselves. However community OS affiliated businesses capture a significant share of economic value. In other words, 'going hybrid' by combining OS and CS aspects seems to be the key to success. Individual customers turn to community OSS for their free product. Business organizations have started adopting commercial OSS which show continuous activity and promise support services. OS community affiliated business work in close coordination with OSS communities and act as OSS companies for their community OS CMS, thus increasing the value capture for these CMS.

Nevertheless, increasing interest from VC has been observed in the OS CMS industry. Ten CS CMS received an average VC funding of $20mn. The higher investment in CS CMS can be accounted to the fact that CS CMS companies have a broader portfolio and not all have CMS as their flagship product. On the contrary, four OS CMS companies were successful in seizing VC investments averaging $10mn. Alfresco is one example of a successful OS CMS company. Established in 2005 in London, it started with a hybrid model using a dual-licensing strategy and providing support services. Accel Partners provided Alfresco with a seed investment of $2.2mn in 2005. By 2011, Alfresco seized VC investment of $20mn and had grown to become a much larger player in the CMS industry with revenues of $22mn.

> *"Alfresco continues to demonstrate a bit more edge thinking in the world of ECM than their commercial counterparts IBM, EMC, Oracle, and Open Text."[27] (Kyle McNabb, Principal Analyst, Forrester)*

While no OS CMS communities were able to attract VC funding, OS community affiliated businesses have performed better than CS CMS. An example is Drupal-based Acquia which started in 2007 with a seed capital of $7mn and was successful in acquiring venture capital funding of $67mn by 2012.

This illustrates that VCs are interested in robust good-quality software with low development costs. They consider OSS as a risky investment due to low revenue generating prospects and lack of IP (Aslett, 2009). Investors seem to be interested in OS CMS that show promising revenue generating opportunities, i.e. OS community affiliated

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[27] Kyle McNabb, Principal Analyst, Forrester as quoted on website of Alfresco Software. Online: http://www.alfresco.com/about

businesses and OSS companies. With no prior studies on VC investment is OSS in the management literature, the promising CMS industry opens avenues for further research.

4.7.1 Managerial Implications

OSS is usually developed by students and young graduate engineers. Because of their familiarity with OSS during their education, an increasing number of engineering graduates are acquainted with OSS and stimulate its adoption. However, from a company point of view, one should be clear of the purpose and functionality of the OSS if an OS strategy is chosen. OSS is likely to have more value in a research environment, where people use, reuse and share knowledge and information. The use of OSS and contributions to OSS can flourish in such an environment. Students and researchers have the freedom to build OSS using existing OSS products. This is a preferred manner since they do not need to pay for the software, and they can also improve their knowledge by working on the OSS. Along with self-development, peer recognition motivates individuals in such a research environment. Such a choice of OSS might not be prevalent in the industry context. Many of the OS CMS companies are started by fresh graduates from universities, so their choice for OS CMS can be explained by their familiarity with OSS rather than by a genuine analysis of market opportunities.

However, most of these start-ups quickly find it difficult to generate revenues from a community-driven and community-owned OSS. One of the necessary conditions to adopt a commercial OSS model seems to be that not the community but the newly founded company owns a significant part of the OS CMS. Although converting to a commercial OS CMS significantly decreases the number of users, there are still a significant number of 'users', which can be converted to 'customers' in the commercial OS context. Alfesco, eZ Systems, DotNetNuke have been successful in creating loyal customers for their CMS. OS CMS communities such as Joomla! generated $0.29mn in 2010 on advertisements, merchandising and donations, while Drupal earned $0.8mn in 2010 from conference tickets, advertising, sponsorships, memberships and donations. These revenues are extremely small in contrast to the OS CMS companies which generated on average revenues of $20mn in 2009, mainly through professional services, royalties from dual-license agreements and royalties from proprietary extensions.

Despite the relative success of OS CMS companies, their average revenues of $20mn are significantly below the CS CMS ones of $1.4bn. As discussed above, this might be due to the fact that the perceived intrinsic value of OS CMS is still lower than that of CS CMS. However, it might also indicate that the large ecosystems of users are not fully exploited yet and might still offer a significant amount of expectations to investors. Quoting John Buswell (2009):

> *"Investing in open source is about investing in People instead of investing in a Vendor."*

Among the OS community affiliated businesses, both Acquia (third party behind Drupal) and Automattic (third party behind WordPress), were able to secure investments of more than $30mn each in the last six years, which illustrates the high expectations VCs have from OS community affiliated businesses. This boost in investments can only be explained by the high potential that VCs might see in the large user base of a typical OS CMS.

4.7.2 Conclusions

In this study, we clarify the unclear world of OSS companies and analyze their main business models. The business models are being studied in detail in the specific context in which OSS has been particularly successful: CMS. We explored the business models in the value creation, value delivery and value capture phases, and also studied how both OS and CS CMS companies are trying to come closer by adopting hybrid strategies in their business models. The results show that in terms of value creation, CS CMS companies outperform OS CMS companies in terms of intrinsic value, which immediately explains their popularity in the market. In terms of extrinsic value, OS CMS companies are much more popular as shown by the number of users. We questioned whether OS CMS companies are able to 'capture' network externality value. For CS CMS vendors, value capture is associated with new mechanisms of value delivery. The emergence of cloud computing made it possible to adopt relatively new software models such as SaaS where customers are charged by transaction and thus avoid immediate investments in licenses which are a sunk cost and only pay back if the CMS is used. OS CMS companies do not have sufficient degrees of freedom to adopt innovative value

delivery models and thus try to capture value through after-sales services, sometimes accompanied by dual-license fees on proprietary extensions of the CMS.

We concluded that, third-party or OS community affiliated businesses could secure a part of the intrinsic value. However in those cases, such as Joomla!, where the community rather than a third party orchestrates the developments, this strategy is much more difficult. For example, Joomla! could focus on the quality of the community, rather than on the quantity, to guarantee robust and working software. These OS community affiliated businesses as well as OSS companies have been relatively successful in terms of revenues, albeit much less than CS ones. Despite this relatively low success, the number of investments in these commercial OS CMS companies and OS community affiliated businesses has exponentially increased the last few years. This can partly be explained by the typical option taking behavior of VCs which tend to follow each other and often confuse OSS with successful trade sales of freemium companies, such as Skype or advertising-based companies such as Facebook. However, part of this might also be explained by the potential which VCs see in exploiting the relatively large user communities which OS CMS companies have in comparison to CS CMS companies. These communities might be turned into customers, but the value delivery and value capture models remain unclear and provide new avenues for further research.

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5 Conclusions

This dissertation is a collection of three studies on value creation in technology-based firms (TBFs). The first study addresses the process by which firms use open source software (OSS) as a technological and social capital resource when faced with resource constraints. In this study, I draw on theories on bricolage and ambidexterity and combine them with the literature on OSS. The second study focusses on regional ecosystems for value creation. More specifically, I study the knowledge ecosystem, business ecosystem and financial support network and their impact on firm performance and firm survival. The third study examines how opening up the source code, or going 'open source', leads to value creation. In this study, I depart from the literature on business models and open source (OS) literature and compare business models of OSS and closed source software (CSS) companies.

In this final chapter I summarize the main findings of these three studies. Next, I discuss the most important contributions to management science and provide an overview of implications in practice. Finally, I present an overview of the limitations of my Ph.D. which lead to potential avenues for further research.

5.1 Main Findings

In the first study, a qualitative case study research approach is taken on three firms with different degrees of resource scarcity to study the technological bricolage process in these firms. All these firms bricolage using OSS as a technological and social capital resource, but the dependence on OSS varies contingent on the level of resource scarcity. Highly resource-constrained firms largely depend on OSS, which are under development, and use OSS as a bricolage mechanism to build their value offering and exploit the OSS community as a marketing and networking channel. Moderately resource-constrained firms exhibit a lower degree of dependence on developed OSS and mostly bricolage in order to quickly satisfy unexpected customer demands. Firms with low resource constraints are least dependent on OSS but use mature OSS as a prototyping tool to gain credibility within the firm. Further, a link between bricolage and exploration-exploitation is observed. While bricolage in highly resource-constrained firms is an exploitative process by nature, moderately resource-constrained firms are able to exhibit ambidexterity in the bricolage process. Firms with low resource

constraints are more explorative by nature which confirms their risk taking behavior of using OSS in radical innovations.

In the second study, I challenge the implicit assumption that a knowledge ecosystem leads to a business ecosystem which can empower participating companies with a competitive advantage. This empirical study of regional innovation systems in the region of Flanders in Belgium analyses the knowledge ecosystem, the business ecosystem and the financial support system of 138 innovative start-ups in Flanders. I find that the knowledge ecosystem is strongly developed in Flanders and is concentrated around a number of central actors. The density of the knowledge ecosystem is much higher than that of the business ecosystem and is dominated by knowledge institutes which have developed incubator facilities and formal technology transfer offices. On the contrary, a business ecosystem is non-existent and the financial support system is present but almost 100% publicly backed. Neither the knowledge ecosystem nor the financial support network translates into a business ecosystem at a regional level. Further, it is found that working together with the top central actors in the knowledge ecosystem has a positive impact on the innovation output of innovative start-ups, while collaboration with average technology partners typically has a negative impact. Moreover, receiving financial support from public funds does not impact the innovation output in a positive way. Lastly, neither the knowledge ecosystem nor the financial support network directly contributes to the short-term survival of innovative start-ups.

The third study is a qualitative study of business models in OSS and CSS companies. The business models are compared on three components: value creation, value delivery and value capture. This study extends the literature on business models and OSS by showing how value can be created from an installed base and complementary goods. Opening up the source code and making it (partially) available to the public enables companies to build up a network and to increase their installed base, thereby leading to value creation. It is found that OSS companies excel in value creation while CSS companies excel in value delivery and value capture. The business models of both these types of software companies are converging due to the threat posed by OSS communities which have led to the rise of several OSS community affiliated businesses. Albeit the low economic success, venture capitalists (VC) seem to have noticed the potential of OSS in the magnitude of its installed base. This is confirmed by the increasing VC investments

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in OSS companies. Third-party businesses based on OSS, or OSS community affiliated ventures, are found to be benefiting from the existing OSS community and installed base, and seem to be flourishing by orchestrating the developments in OSS communities.

5.2 Implications

5.2.1 Implications for Management Science

The findings in the first study have important implications for the bricolage literature. Many studies on bricolage have implicitly assumed that bricolage takes place only in the start-up phase where companies face severe resource constraints. My study implies that bricolage occurs irrespective of the level of resource scarcity or the development stage in the company life cycle, and that SMEs, VC-backed firms as well as departments in large firms engage in bricolage. The findings provide insights into how bricolage can be used to access technological resources in rapidly changing resource-constrained environments and into the heterogeneity of these environments with respect to different levels of resource scarcity within the firm. The findings further imply that bricolage occurs in a different stage of the company life cycle with the aim of serving a different purpose in each firms. Secondly, the study extends the emerging OSS literature by presenting OSS as an opportunity space and as a technological and social capital resource for bricolage in resource-constrained firms. The study also contributes to the OSS literature by highlighting the heterogeneity of the contexts in which it can be applied in technological firms. Lastly, the study builds upon the literature on organizational ambidexterity. The main contribution of the study is that it uncovers a link between bricolage and exploration-exploitation.

The second study makes contributions to the literature on ecosystems. It is implicitly assumed that a well-developed knowledge ecosystem leads to a business ecosystem. My results show that this is not true in all cases; the regional innovation system in Flanders has an excellent knowledge ecosystem, while a business ecosystem is completely absent. The findings imply the importance of government policies and incentives to spur regional innovation. While several funds are available for innovative start-ups, government needs to promote participation of large firms in building a business ecosystem. The study further contributes to the knowledge ecosystems literature by confirming the importance of a dense knowledge ecosystem and the positive impact of

the presence of top technology partners on firm performance. Additionally, the study investigates the importance of private VCs as a potential link between the knowledge and business ecosystems. The study implies that cross-regional and cross-border VC investments can help the development of business ecosystem. Finally, the study extends the importance of a value network or a business ecosystem, since neither a technology partner nor a financial partner is able to predict the short-term firm survival.

The results of the third study contribute to the literature on OSS and business models. Business models in OSS have been popular in practice, but have received scant attention in management literature. The findings imply that OSS companies can compete with CSS companies based on the social value they create. The results suggest that the installed base and complementary goods add more value to OSS companies than the intrinsic technology value. The study contributes further to the business model literature by uncovering detailed business models of firms in a specific sector. The study also investigates the evolution of business models towards achieving a best of both worlds. Lastly, the findings contribute to the VC literature where research on potential in OSS has been sidelined. The study suggests VCs to refine their selection criteria and consider investments in OSS taking into account the prospects presented by its installed base.

5.2.2 Implications for Practice

Besides the contributions to management science, this doctoral dissertation also generated some interesting insights for practice. The findings and insights from this doctoral study are useful and relevant for entrepreneurs, managers and investors and reveal some interesting implications for policy makers.

The first study mainly provides guidelines for entrepreneurs and managers. Entrepreneurs setting up start-ups based on OSS should carefully choose OSS, after studying the OSS license conditions. While some licenses allow entire freedom of use of software, other licenses can be quite restrictive in building a proprietary product from OSS. As a result, entrepreneurs are better off offering services, rather than products, for OSS. The installed base serves a potential customer base for these services. Entrepreneurs need to understand that the exploitation of OSS can limit technology exploration leading to short-term success. Responding to environmental changes can prevent them from getting trapped in the exploitation phase. Additionally,

entrepreneurs are more likely to profit from developing an active OSS for which development is less likely to cease abruptly. Managers in SMEs are presented with the most opportunities by OSS. The key to success for managers in SMEs is to balance exploration and exploitation by contributing back to the development of the OSS they embrace in order to gain long-term results from the OSS. Since large organizations cross-license their products and have strong secrecy and IP protection, while incorporating OSS in their products, managers should carefully study the OSS license conditions in order to avoid future lawsuits. They can use OSS as a prototyping tool or an artifact in communication within the organization, also referred to as sense making by Stigliani and Ravasi (2012). While exploring opportunities within OSS, managers should make quick decisions and prevent themselves from trapping in the endless loop of search and change.

The second study, on the other hand, mainly has implications for policy makers. My study claims that anchor organizations which facilitate the connection between different players in the ecosystem (Powell et al., 2010) are absent in Flanders. Universities receive funding in order to set up technology transfer offices to support spin-offs and facilitate commercialization of research. These funds do not seem to transfer logic between the different players in the ecosystem. This is reflected by the absence of an impact by financial partners on innovation output and firm survival. Private VCs can play an important role in bridging this gap, since public funds add little value to building a complex network of relationships across different industry players. Secondly, a business ecosystem is clearly lacking in Flanders. None of the leading companies plays the role of an anchor organization as is the case in USA where anchor organizations help in building a strong business ecosystem. Government should encourage large companies, such as telecom operators and television stations, to play a role in nurturing innovative start-ups in the region. Public procurement policies, such as the SBIR[28] programme in USA which incentivizes large companies to invest part of their budget in regional innovative start-ups, can provide a stimulus to the creation of a business ecosystem. Global firms can also play a key role in business ecosystem creation. Policies to attract global firms will prove advantageous to the regional innovation system. Thirdly, as technology transfer offices and public research organizations are successful

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[28] *Ibid.* 13

in developing a local knowledge ecosystem (Whittington et al., 2009), policy makers should consider supporting similar functions at large established companies. Dedicated innovation managers in large firms can be assigned the task of developing initiatives to promote collaboration with local, innovative start-ups. Such collaboration can promote sustainable growth for start-ups and, as stated by Iansiti and Levien (2004), a healthy business ecosystem needs a healthy keystone and healthy innovative start-ups. Lastly, there is a need for a policy to develop a financial network beyond the public sector. Stimulation of business angels and incubator activity, and cross national or cross-regional venture capital provisions might prove to be successful incentives.

The third study has several implications for entrepreneurs developing OSS or starting-up ventures based on OSS- OSS companies or OSS community affiliated businesses. From a business point of view, entrepreneurs should be clear of the purpose and functionality of OSS, if they choose to follow the OS way. OSS is likely to have more value and is more likely to flourish in research environments, where people use, reuse and share knowledge and information. Entrepreneurs can benefit from a thorough market analysis before starting-up OSS community affiliated businesses. The study also suggests developers of OSS software to be careful when choosing to set up OSS companies. Contributors are reluctant to contribute to the development of software which is owned by a company. Thus, in order to create an installed base, developers should clearly think of a better revenue model other than dual licensing where part of the code might be available only to paying customers. Lastly, the study also has implications for VCs and investors. While VCs invest in companies with promising cash flows, they need to look beyond economic value and focus on social value. Facebook, LinkedIn, Skype etc. have already accentuated the power of the installed base and networks. Similarly, the power of OSS lies in the community behind it. Therefore, VCs should not only look at the potential of the revenue model, but also at the breadth of the installed base.

5.3 Limitations and Directions for Further Research

As any doctoral dissertation, this study not only provided answers to the research questions posed but also led to additional research questions and avenues for further research. Our first study contains a number of limitations that open the door for future research. Firstly, although detailed, the number of case studies can limit the generalization of results across all firms. It would be valuable to explore the bricolage

process for a broader sample in a longitudinal study across the entire life cycle of the firm, as it can strengthen the research on exploration-exploitation during the bricolage process. The challenge here is to identify firms with lower resource constraints that bricolage using OSS and openly acknowledge their use of OSS. In a similar way, a detailed study of OSS adoption across all departments within large firms can shed light on the level of bricolage and exploration-exploitation across the firm, which can help us fine tune our results. We are also in deep need of an understanding of the factors that clearly differentiate exploration and exploitation in highly resource-constrained firms. The bricolage process is more prevalent in these firms since they face resource scarcity at start up. Resource constraints persuade these firms to use and leverage OSS to innovate and create value. Given that OSS is easily available in the market, to explain whether and how differences in usage of OSS can create differences in innovation and value proposition in highly resource-constrained firms can be a critical question for future research. Developing key constructs to measure how these firms capture value can also be an interesting research avenue.

Limitations in our second study on value creation in ecosystems present several opportunities for further research. First, our context is related to a small region in one country, which may not be representative of all types of regions. As spatial context may have an important influence on entrepreneurial and innovative ecosystems (Zahra and Wright, 2011). Further research is needed both to compare similar regions in other countries and also to compare our findings with different contexts. For example, future studies might consider matched pairs of research intensive regions in Europe (Clarysse et al., 2005) to revisit the ecosystem questions addressed in this study. Further, from a national perspective, different geographical locations may involve different ecosystems some of which are local while some have cross-regional and cross-country elements. Second, social contexts for entrepreneurship and innovation are heterogeneous (Wright, 2014). The structure and dynamics of knowledge and business ecosystems may differ both across sectors and the phases of the life-cycle of the development of innovation start-ups. Further, as these start-ups emerge, they may need to enter and disrupt pre-existing ecosystems. As yet, little is known about how these processes work. Third, I use very simple measures of innovation output and economic performance. Future research might explore these into more depth by looking at a mix of short-term and long-term measures. Innovation outputs can be further refined by adding a citation impact as a

long-term quality measure, while economic performance can be further developed into measures of long-term success such as IPO, profitability and sustainable growth (de Saint-Georges and van Pottelsberghe de la Potterie, 2013; van Pottelsberghe de la Potterie, 2011). However, survival is the short-term focus of most innovative start-ups and it is the most straightforward performance measure. By controlling for the industry and the availability of venture capital, I overcome the most important cross-sectorial differences in survival rates. Hence, our analysis of the determinants becomes stronger. Finally, I included universities as part of the knowledge ecosystem but further research might focus on examining the circumstances under which a university could be considered as an ecosystem and how this interacts with knowledge and business ecosystems. The literature on universities as research partners suggests an important role for universities in creating basic research awareness and its challenges in public-private funded projects at the pre-commercial stage (Hall et al., 2003). The related academic engagement literature covers a wide-range of activities between academics and industry partners and tends to emphasize individual and department level engagement (Perkmann et al., 2013). The links between pre-commercialization engagement (knowledge) and subsequent commercialization (business) and the challenges in developing them to create an ecosystem have, however, been neglected. Studies could attempt to identify and analyze cases where universities operate as such ecosystems and, for example, develop a typology of the kind of knowledge and commercialization that lends itself to different types of ecosystems.

The last study on business models is limited to a single domain of content management systems. Although the focus on a single domain helps in in-depth research, questions remain whether the results can be generalized for other domains and industries. While OSS has had more than its share of popularity in ICT sector, an interesting research avenue would be to study how OSS is embraced in other industries. Moreover, the most successful OSS cases with respect to VC investments have been Red Hat Linux, MySQL, SugarCRM, not to forget Acquia and Alfresco in the area of content management systems. With fragmented research on VC investment in OSS, additional research with VCs could help shed light on their search and selection strategy and their expectations from investments in OSS.

5.4 Discussion

The resource-based view of a firm has been dominant in explaining the importance of resources for creating competitive advantage for a firm (Barney, 1991). While possession of rare and valuable resources can be advantageous, the resources are insignificant if not managed in an optimal way (Barney and Arikan, 2001). Firms need to acquire, develop, incorporate and leverage resources to create and maintain value. In absence of valuable resources at start-up or initial growth phase, value creation is crucial for the development of TBFs in order for them to innovate and survive (Ireland et al., 2003). The three studies of my doctoral dissertation depict diverse mechanisms using which TBFs acquire, use, develop and manage their resources in a fine way to create value for the firm.

The first mechanism of bricolage discusses acquisition and use of freely-available resources for value creation. Ecosystems emphasize the strength of partner networks in developing resources in order to create value. Lastly, studying the business model allows for the development of technological and network value using the power of community. This triad comprising of bricolage, an ecosystem and a business model focusses attention on managing resources for value creation in TBFs. These three studies build up the understanding of processes that TBFs can implement to start with value creation for the organization, and then proceed further to create value for its employees, stakeholders, society and environment.

Bricolage using OSS as a resource provides TBFs with the access to technology to develop their products or services or to enhance their existing product portfolio. This is crucial in uncertain environments where TBFs are constantly constrained with time and money. The OSS also acts as a social capital by connecting the TBFs to a pool of like-minded knowledgeable people in the community which acts as an informal partner for supporting their technology. The use of OSS as technological and social capital resource functions as an importance source of value creation.

Further, regional innovation systems benefit new and young TBFs more than established competitors. The presence of a strong knowledge ecosystem clearly signals the importance of research and development within the region. Knowledge ecosystems are breeding grounds for technology, and the presence of reputed universities and PROs

provides TBFs with multiple technological resources. The presence of a business ecosystem may pave the way for potential social capital resources that TBFs seek. The current alternative for a business ecosystem as a social capital resource is the university-industry collaboration which presents certain networking opportunities, although still in its infancy.

Lastly, the business model is a tool that allows a firm to reflect on its existing capabilities and resources. For new and young TBFS, business models are unclear and are subject to constant change pertaining to the rapid changes in technology. My study shows that not only the standalone value of the technology but also the social network value enhances the value creation for TBFs. This underlines the importance of using and developing both technological and social capital resources for value creation.

These three mechanisms allow the firm to seek and develop the resources that they might need to cope with the drastic changes in the industry. Not only does the triad of bricolage, the ecosystem and the business model help the TBFs in pursuing resources, it also facilitates easy adaption of their product development processes contingent on industry expectations in order to innovate and create value for the organization. Value can be created from both incremental and radical innovation, however TBFs need to efficiently manage and explore resources for innovation, taking into account the risks involved. As a general conclusion for this dissertation, we propose further research on this triad with respect to resource management and value creation for TBFs.

5.5   References

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Appendix A: Characteristics of Interview Data

Interviewee	CMS Name	Founding year	Type of CMS	Based in	Position
A	CMS1	2001	Community OS		Founder
B	CMS2	2009	Community OS		Founder
C	CMS3	2005	Community OS		Development coordinator
D	CMS3	2005	Community OS		President
E	CMS4	2008	Community OS		Co-founder
F	CMS5	2004	Community OS		Co-founder
G	CMS6	2001	Community OS		Founder
H	CMS7	2001	Community OS		Board of Director and Developer
I	CMS7	2001	Community OS		Core Developer
J	CMS8*	2003	Commercial OS	USA	Founder
K	CMS9	2006	Commercial OS	USA	CEO
L	CMS10	2005	Commercial OS	UK	Co-founder
M	CMS11	2004	Commercial OS	USA	CEO
N	CMS12	2006	Commercial OS	France	CMO
O	CMS13*	2000	Commercial OS	New Zealand	Founder
P	CMS14	2006	Commercial OS	Germany	CEO
Q	CMS15	2005	Commercial OS	Denmark	Lead Developer
R	CMS16	2003	Commercial OS	USA	Founder
S	CMS17	1999	Commercial OS	Norway	VP Community
T	CMS18	2001	CS	USA	VP Communications
U	CMS19**	2004	CS	USA	Director Product Management
V	CMS20	2006	CS	USA	Co-founder
W	CMS21	2001	CS	USA	Sales Manager
X	CMS22	2000	CS	USA	Founder
Y	CMS23	2001	CS	USA	Founder
Z	CMS24	2005	CS	Germany	VP Global Marketing
AA	CMS25	2004	CS	Czech Republic	CEO
AB	CMS26	2000	CS	USA	President
AC	CMS27	2001	CS	Denmark	Regional Sales Director
AD	CMS27	2001	CS	Denmark	CEO

*started as CS, moved to OS

** acquired in 2010

Appendix B: List of Data Sources

Extensive Archives

Variable	Source
Acquisition data	Factiva Database (Press releases), Corporates websites, Zephyr Database
Capital Investment data	Factiva Database (Press releases), Corporate Websites, VentureSource Database
Data on OSS projects and Licenses	Sourceforge.net
Financial Data (Revenues, IPO)	Amadeus Database, Global Reference Solution Database, Corporate Websites
List of content management systems (CMS)	Websites such as CMS Review, CMS wire, CMS Matrix, CMS Match
	Market Reports from Gartner, RealStory Group and Water & Stone
CMS ownership	Corporate websites, archives
CMS downloads	Sourceforge.net, Corporate websites
CMS founding and activity	Corporate websites
CMS Licensing information	Corporate websites
Product/Service portfolio	Corporate websites
Customer portfolio	Corporate websites
Value capture/ revenue generation mechanisms	Corporate websites, Factiva Database (Press releases)

Survey

An online survey was distributed via Joomla! portal, blog posts, and Joomla! forums to address extension developers and service providers of Joomla! OS CMS. Amongst others, questions regarding the value proposition, contribution to Joomla! and/or other OSS, marketing channels, distribution methods and revenue models were addressed. The exact response rate is difficult to calculate for such a sample as it is difficult to know the precise population size. The survey yielded 171 valid responses, including 57 responses from extension developers and 114 service providers.

Conferences

- The Next Web Conference, Amsterdam, April 2009

- DrupalCon, Paris, September 2009

- Joomla!® Day, New York, October 2009

- DrupalCon, San Francisco, April 2010

- CMS Expo, Chicago, May 2010

- J & Beyond, 1st International Joomla!® conference, Wiesbaden, Germany, June 2010.

"Arise! Awake! And stop not until the goal is reached."

~ Swami Vivekananda