Knowledge Sharing in Virtual Organisations: The Case of Open Source Software Communities

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Thesis submitted in fulfilment of the Degree of Doctor Philosophy

Durham University
Durham Business School

2010

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Abstract

The knowledge-based economy, where everything and everybody is just one click away, has formed the foundation for a new organisational form. The term ‘virtual organisation’ (VO) reflects the emergence of a new organisational form with a record of success in the modern business environment, where knowledge has become a key component. Managing knowledge is the main driver in the knowledge-based economy. One of the best examples of such organisational forms with successful knowledge sharing processes is open source software (OSS) communities. This justifies my thesis, which undertakes primary research in OSS communities via qualitative and quantitative studies to find out how and to what extent knowledge is shared in those communities, in order to develop a Model for successful knowledge sharing processes in the VOs.

The following factors in the Model, which influence the level of personal contribution in the OSS communities, were found. The level of personal contribution as an indicator to knowledge sharing for product innovation is a result of a combination of individual factors as well as individual opinion on the organisational factors. Factors such as an education level/explicit knowledge, incentives/benefits for the future and monetary reward do not play a role on their own, but they influence the level of roles and the level of activeness, which in turn influence the level of knowledge sharing, which is important for the level of personal contribution on product innovation. Personal and work related motivations are important factors to successful knowledge sharing inside OSS communities. However, most importantly, the level of personal contribution towards product innovation is a result of the satisfaction of individuals by the management of the OSS communities, identification with these communities and trust inside of these communities. The developed Model shows that organisational factors are more important than individual factors for successful knowledge sharing inside OSS communities from an individual’s perspective.

Declaration

I hereby declare that the material in this thesis has not been previously submitted for a degree in this or any other university. I further declare that this thesis is solely based on my own research.

Zilia Iskoujina

Acknowledgements

I would like to thank everyone who has helped me during my PhD studies. I owe my deepest gratitude to all of you for your patience, knowledge sharing, advice, help, time, and inspiration. This thesis would not have been possible without your help. I offer my regards to all of you: you know who are you.

CHAPTER 1

INTRODUCTION

1.0 Background of This Research

In the middle-late 1980s – early 1990s I attended high school in Ufa, a city of over one million people in the Western Urals, in the Volga region of Russia. The school had four different specialisations: mathematics and physics, English, biology, and sport. I studied in the class where mathematics and physics were taught intensively. We had almost more than double the maths hours of other students studying maths in standard schools. We almost never used textbooks prepared by the Ministry of Education for standard school maths classes. Instead, we were taught a maths programme normally reserved for undergraduate students in their first year of university. During our summer holidays we had to solve a large number of maths problems. We were the first school that offered education on computers and programming in our city, and we were actively involved in various competitions in maths and physics in inter-schools, inter-cities and national levels.

While studying in the high school, my classmates and I also studied by distance learning in Moscow Physics Technical Institute (State University) (MFTI) in a special programme for schoolchildren. Every two weeks I received a large envelope with new maths and physics lessons with problems I had to solve. Because of the Institute's specialisation, I still remember how I tried my best to solve astrophysical problems. I had a supervisor who was managing my progress, programme and helped me to improve my knowledge. All communication was via post. My mother was probably the most frequent visitor to our post office, because she was sending my work back to MFTI every two weeks. This continued for two years.

After ten years of high school and distance learning in MFTI, and a period of university and working in Moscow, I started my postgraduate education (MSc in e-Business) at Robert Gordon University (RGU), Scotland through distance learning. Even though now in 2010 it is funny to remember sounds of a modem connecting to the Internet in 2001-2003, my education by distance learning in high school and after ten years in a Master's programme was very different. During the two years of my postgraduate programme in Scotland, when I was physically located in Moscow, all my education was facilitated through the Internet. I was amazed what kinds of software simulation programmes were available for our educational purposes. It was very interesting to study e-Business through the actual practice of e-business. We had virtual classes, online forums, simulation "games", and chat rooms; we used all the possible information systems that were available to us for our education. During the two years of my Master's programme, I visited Scotland twice for exams and met only three or four of my 'virtual' classmates from a group of more than twenty because most of them had exams at the British Councils in their respective cities. It means I have not met most of my classmates on a face-to-face basis. However, I still remember how close we were during our studies in that programme. When I started to study in RGU, I had no idea that practically I became a member of a Virtual Organisation (VO), our online class, the example of the new organisational form, new classroom in a different medium. Nevertheless, by the end of my studies, such a kind of new organisational form, where main interaction is happening via Internet-based technologies, has become a topic of my interest, and I decided to investigate such organisational forms in detail in my PhD thesis.

1.1 Bird's Eye View

The rapidly, frequently and unpredictably changing global environment has become the norm for developed economies in the 21st century. A stream of complex new technologies, increased knowledge, customer markets which became more demanding and increasingly varied in their needs and preferences, are some of the catalysts for the changing global environment (Cravens, Piercy & Shipp, 1996). Considering the late 1980s, then the late 1990s and now the late 2000s, in the last twenty years we have had enormous changes and one of the most important tools for those changes clearly are Information Technologies (IT).

Even the modest example of distance learning in the late 1980s, then over ten years later in the early 2000s and now in the 2010s, when some innovative educational bodies offer education in the 3D virtual world Second Life (www.secondlife.com), shows us that it is hard to find any other industrial development in history as the recent development of IT, which has entered the lives of such a large population in such a speed. According to recent Internet World statistics[1], the Internet population increased by 362.3% between 2000–2009.

[1] Internet Usage Statistics, http://www.internetworldstats.com/stats.htm, 02 October 2009

IT has grown up phenomenally quickly. History shows us how civilisations discovered the earth and beyond. However, never before have any of the previous civilisations managed to find the whole world in tiny boxes on their desks or even pockets. Communication has never been so fast and so close. If in the past, wanderers might have study-tours all around and collected all new knowledge, whatever they could find, in their travel diaries, now everyone and everything is just one click away. The world has become smaller and smaller, nearer and nearer, and can be invested in bytes and bites.

Our generation is lucky to live through and create the history of IT development. This is a generation whose typing skills are superior to using a pen or a pencil, whose children teach their parents how to use IT tools, where many things happen in reverse order. Our generation experiences a life of both online and offline dimensions, considering we physically attend classes and receive online education, interacting in online social sites and living in the virtual world. It is fascinating to conduct research on the rapidly developing organisational form of Virtual Organisation and discover it from its depth to understand its past and present in order to be ready for the unpredictable online future.

1.2 Why Knowledge Sharing in Virtual Organisations?

In this thesis, recent world developments in technology, which have opened a new era in business for organisational forms, will be considered. 'The new economy', 'the post-industrial economy', 'the service economy', 'the post-capitalist society', 'the digital economy', 'the network economy', 'the knowledge economy' - all of these diverse terms provide an interpretation of one event which resulted from rapid IT development and the globalisation of the economy (OECD[2], 1999). Because this thesis will specialise in issues of knowledge sharing, the term 'knowledge economy' will be used to denote the environment in which knowledge is managed in new organisational forms, which in this thesis will be called "Virtual Organisations"[3].

Although there are plenty of academic studies on the knowledge economy, dealing with its conditions and the new organisational forms associated with it, there is a need to

[2] http://www.oecd.org/dataoecd/42/0/35394025.pdf, 12 May 2008
[3] See Appendix 1 for its definition. VO will be analysed in–depth in Chapter 3.

explore in greater depth a number of issues associated with the phenomena. Working experience in the business environment shows that there is an established body of knowledge about the traditional organisational form of business and its processes, which may include such fields as knowledge management, innovation management, customer relationship management, supply chain management, human resource management, marketing, financial management, and so on. As it will be seen in Chapter 3, Internet-based technologies offer new forms for organisations. This new environment is associated with new business methods. The traditional organisational form has most probably adapted according to the environmental requirements. The Internet provides new requirements for businesses.

From all these business processes, managing knowledge or knowledge management (KM)[4] has gained a new and even more important role than before, because knowledge is the main driver in the knowledge-based economy, where the service sector is dominant and where knowledge based goods and services have replaced industrial goods as the main wealth generators (Hislop, 2009). In the e-medium managing knowledge is vital for gaining a competitive advantage. Knowledge can be considered as the heart of VO (Warner & Witzel, 2004). As will be analysed in detail later, the current academic literature clearly emphasises knowledge as a key component of a VO. In contrast to traditional organisations, where financial capital can be considered as one of the main resources, for VOs networking in the e-medium is the main resource, which is based more on such intangible assets as knowledge and relationships, and technology management (Walters, 2002). According to Renzl (2008), knowledge sharing[5] within organisations and the factors that help knowledge sharing are core questions in managing knowledge. A VO is a network where companies/individuals collaborate to gain a competitive advantage through knowledge sharing. Because of the vitality of managing knowledge and increasing importance of knowledge sharing in the VOs, the role of managing knowledge within such organisations needs to be studied directly.

Although knowledge has been important as long as civilisations have existed, in the knowledge economy, it has taken on a special significance. In the intangible environment of e-business, knowledge replaces inventory (Davidson & Voss, 2002). In some industries of the knowledge economy, especially those producing intangible

[4] See Appendix 1 for its definition. KM will be analysed in–depth in the next Chapter.
[5] See Appendix 1 for its definition. Knowledge sharing will be analysed in–depth in the next Chapter.

products, knowledge sharing has become a means by which firms can gain a competitive advantage. The knowledge economy gives knowledge a greater value than before. Knowledge owners are the most in demand actors in the market. Know-how has become increasingly important and valuable. The knowledge-based economy is based on creating value through knowledge and its sharing. OSS communities are a good example of this, where people – 'knowledge workers' (Hislop, 2009, p.75, 77) share their knowledge, the most valuable asset in the knowledge economy, with others. As a result, there are lots of successful innovative products/services on offer in the market. OSS communities, such as Linux, are a good example of successful knowledge sharing in the VO and creating innovative products.

The knowledge-based economy implies a business performance where it is "possible to deliver anything, anytime, and, anywhere to potential customers" (Malhotra, 2005, p.9). The Internet-based intangible technologies provide not only high-tech innovation products; they also provide intangible online networking, where the VO's main source of gaining a competitive advantage is people and people's knowledge. VO operates in an intangible medium. Intangible knowledge is a driver in an intangible medium and in organisational forms: knowledge sharing in VO is the key issue to understand, in order to understand the success factors in VO. To gain returns on investment VO needs to set up explicit processes to increase collaboration and to assist the flow of knowledge throughout the enterprise (Burn & Ash, 1999).

Knowledge in its origin is intangible. The electronic medium is intangible too. Therefore knowledge has become more important than ever before in e-business, because it is a suitable product in a suitable environment. Knowledge sharing is an important element in gaining a competitive advantage in organisations. Therefore, it is important to understand the existing theory on knowledge and its managing in order to combine that understanding with the current understanding about VO. If knowledge can be considered as a 'motor' and 'lifeblood' in VOs (Warner & Witzel, 2004), by applying knowledge sharing in VO, it is important to find out answers to questions such as how is knowledge shared in virtual software products' organisations such as OSS communities? Why are people motivated to share their knowledge, their know-how in the knowledge-based economy, where knowledge is the value? Why do people give away this value in OSS communities? These questions will be considered in this thesis.

VOs are a response to dynamic market development. In such complex networking, in the web of high-tech space where yesterday's competitors can become today's co-operators, single companies find it hard to compete in a medium where all competitors are just one click away. For example, at Amazon there are a number of small companies who are competitors in real life, but also in virtual life: in the online medium, they are collaborators with each other and with Amazon as well, because it is beneficial for all players to cooperate under one big, globally well known, successful online company to access worldwide markets, earn more profits, etc. Taking into account non-geographical and non-organisational boundaries in VO, the knowledge sharing issues get even more complicated than in 'traditional' organisations. Although knowledge sharing issues were considered in a number of academic works, there are still lots of open areas, which can be studied, in greater depth.

Research Questions in the Thesis

The following three research questions will be investigated in this thesis:

1. What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?
2. What are the characteristics of the communities that affect knowledge sharing in OSS communities?

This is the justification upon which I will build my thesis, which will undertake empirical studies on OSS communities to find out how and to what extent knowledge is shared in OSS communities. The thesis is intended to shed light on knowledge sharing in VOs, and thereby to contribute to our understanding of the role of knowledge sharing in the VO context. The research questions further clarify the aim of this thesis. As it will be seen in Chapter 7, this thesis on knowledge sharing in VO will make contributions to both fields in the current academic literature: knowledge sharing in particular (managing knowledge/KM in general) and OSS communities in particular (VO in general).

1.3 An Outline of Subsequent Chapters

Chapter 2: Literature Review 1: Knowledge

Chapter 2 will investigate the existing literature concerning knowledge sharing and investigated the questions related to this field. The literature review on knowledge started with the asnwer on the question why knowledge and why knowledge sharing in organisations have become a crucial topic especialy in the knowledge-based economy. Definitions of concepts on data, information and knowledge will be analysed. An overview of the understating of explicit knowledge and tacit knowledge, as well as knowledge conversion, ambiguity of tacit knowledge, ambiguity between explicit and tacit knowledge will be discussed. The challenges of knowledge sharing processes in organisations will be procedded further in Chapter 2. Solutions in knowledge sharing in organisations found in the academic literature will be analysed. Chapter 2 will be finished by the questions arising from the literature analysis for the further investigation before moving to the next Chapter.

Chapter 3: Literature Review 2: Virtual Organisations

In Chapter 3 VOs and OSS communities will be examined. Before analysis of VOs, the past anf the present in organisational forms will be discussed. Further Internet as a foundation for new organisational forms and VOs as the new organisational forms will be considered. Later, a detailed overview of VOs will be done, where definitions, terms, type and models, creation of VO, characteristics, features and challenges will be analysed. Literature review will be proceeded by the main point of the thesis: knowledge sharing in VOs. Motivations for sharing knowledge, KM tools to share knowledge, tacit-explicit knowledge sharing, individual knowledge sharing, organisational knowledge sharing will be examined. Section 2 in Chapter 3 will be concentreated on OSS communities. After intorduction to OSS and giving its characteristics, OSS communities will be analysed as an example of virtual space in a wider angle from the current academic literature in terms of knowledge sharing. Motivations for contributing to OSS, roles and responsibilities inside OSS communities, educational level of contributors, trust, coordination and satisfaction with management, identification, and incentives in OSS communities will be examined in detail. The gaps in the these mentioned factors on knowledge sharing in OSS communities will be found, the analysis of which will be done in order to find out open questions and undiscovered aspects of VOs and OSS communities in particular, which require further investigation.

Chapter 4: Theoretical Framework

Section 2 of Chapter 3 laid the foundations for the theoretical framework and propositions to be built within the work and this was based on the outlined research questions, which the work progressed to identify in Chapter 4, which is designed the theoretical framework itself following a clear structure to aid the following empirical research. The research questions will be identified as a conclusion of the literature review for investigation in this thesis in order to fill the gap in the literature. Based on these research questions, in order to find out the answers to the research questions, the stages in developing propositions will be discussed. After that, variables and measurement of the propositions will be discussed. The Model on individual level of the factors influencing sharing of the personal knowledge within OSS community will be designed. Chapter 4 will be finished by clarification how propositions to be investigated would answer the research questions identified.

Chapter 5: Research Methodology

Chapter 5 will outline the research methods in more depth which will be employed within an empirical setting. The Chapter will contain the empirical studies from Phase 1: qualitative research through participant observation and in-depth interviews, and Phase 2: quantitative research. The Chapter will provide information relating to the design of the data collection, such as the online quantitative questionnaire. Furthermore, the measurement tools for the variables used alongside the Model, the pilot studies implemented, the potential bias problems involved in the sampling as well as the data collection results themselves, will be all discussed within Chapter 5.

Chapter 6: Empirical Studies Analysis

Chapter 6 will see the implementation of the empirical studies analysis. Phase 1 will be analysed before the propositions themselves will be tested through Phase 2, with factor analysis, correlation analysis and regression analysis being employed. Discussion of the research questions in the thesis and findings as well as the discussion of the tested propositions will be undertaken in Chapter 6. Main findings on personal factors (research question 1, propositions 1-5), as well as on organisational factors (research question 2 in this thesis, propositions 6-10), and integration of findings on personal factors and organisational factors in the Model (Figure 6.1, Chapter 6) will be discussed in detail.

Chapter 7: Conclusions

This Chapter will formally conclude the thesis. Contributions to knowledge will be considered whilst the methodological contribution will also be discussed. The limitations of the study will be analysed before the thesis is formally finalised with ideas for further investigation of knowledge sharing in OSS communities at the organisational level.

CHAPTER 2

LITERATURE REVIEW 1: KNOWLEDGE

2.1 Why Knowledge?

The title of this thesis is “Knowledge Sharing in Virtual Organisations: The Case of Open Source Software Communities”. This Chapter will embark on an in-depth investigation of knowledge in the current academic literature. The following Chapter, the literature review concerning VO, will take the question ‘why do firms exist?’ as its point of departure and will give an overview of the answer to that question. Grant’s (1996) response to that question relates it with the emerging “knowledge-based view” (Grant, 1996, p.110). According to this view, knowledge is considered “the most strategically important of the firm's resources, it is an outgrowth of the resource-based view” (Grant, 1996, p.110). Knowledge represents a highly valuable organisational resource (Empson, 2001). In addition, as Grant (1996) confirmed, knowledge is central to several diverse research traditions, such as organisational learning, the management of technology, and managerial cognition. Because the base for any theory of the firm is a set of initial grounds that form the basis for the existence of firms, developing a knowledge-based theory of the firm raises the question: What is knowledge? (Grant, 1996)

Philosophers such as Aristotle, Descartes, Locke, Kant, Hegel, Wittgenstein, Heidegger, and Merlau-Ponty have debated about knowledge and its definition for centuries. For example, Plato defined knowledge as “justified true belief”; post-modernists view knowledge as a fundamental truth; anthropologists and other scientists have demonstrated “the significance of situated skills and pragmatic knowledge” (Marr et al., 2003; Gupta et al., 2003; Assudani, 2005 cited in Hicks, Dattero & Galup, 2007). Socrates (469 BC – 399 BC) noted that “there is only one good, knowledge, and one evil, ignorance” and Sir Francis Bacon (1561 – 1626) continued that “knowledge is power”.

The importance of knowledge may have been discussed for a long time, but it has received growing attention in the economy/business since the 1960s (Machlup, 1962; Drucker, 1985; Nonaka and Takeuchi, 1995; Gourlay, 2000). Nevertheless, the idea of managing knowledge seems not to have been seriously considered until the 1990s, the time of the ‘dot com’ revolution, and when managing knowledge emerged as a quickly developing area of business and management both in theory and practice (Gourlay, 2000). For example, between 2000 and 2006 at least 110 articles per year were published on KM (Hislop, 2009, p.2). As already mentioned, knowledge is central to many management research traditions (Grant, 1996), and consequently, managing knowledge in organisations is important for organisational success. The aim of this Chapter is to understand the concept of knowledge and its management before moving to organisational forms, which will be investigated in the next Chapter.

2.2 Why Knowledge Sharing in Organisations?

As mentioned in Chapter 1, knowledge sharing has become a vital element in managing knowledge. Because of such importance, the literature review on this thesis will concentrate only on knowledge sharing processes in the KM literature. Leading journals and books on knowledge, KM and knowledge sharing was a starting point in the literature review (Appendix 9). We begin with the current academic literature on knowledge and knowledge sharing.

There exists a huge amount of the academic literature specialising in knowledge sharing processes and its role in organisations. As the inspiration for such an extensive amount literature, some scholars endorse the idea that knowledge sharing in particular is a vital element for success in almost any organisation (for example, Cabrera & Cabrera, 2005, Renzl, 2008). For instance Renzl (2008) points out that the ability of an organisation's members to exchange knowledge verifies the speed at which new products and services are introduced.

However, as Haas & Hansen (2007) state, as more knowledge sharing does not necessarily mean a guarantee of improved performance, scholars need to move beyond studying facilitators of knowledge sharing to study how an organisation's knowledge resources are developed by task units to improve their performance. This opinion is supported by Grant (1996), who argues that the knowledge acquisition process is individualistic. However, if the creation of production requires the combination of knowledge of individuals between each other, the organisation provides necessary incentives and direction. In this case, it points out that if knowledge is specific to a particular team during the production process, then knowledge creation cannot be split from knowledge application, because both of them occur within a common organisational context (Grant, 1996). Because knowledge flows consist of the creation, sharing and integration of distributed knowledge (Cabrera & Cabrera, 2005), it is important to investigate knowledge sharing processes in organisations and especially if members of those organisations are located worldwide such as in VO. According to Renzl (2008), knowledge sharing within organisations and the factors that help knowledge sharing processes are core questions in managing knowledge.

Why has managing knowledge become such a 'hot' topic especially in recent years? Empson (2001) offers the following answer to this question. According to Empson (2001), at a practical level, the current emphasis on managing knowledge can be recognised in two different but inter-related developments. Firstly, capital and labour-intensive industries have been declining in developed economies, while the importance of information-intensive industries has increased. Secondly, fast progress in IT has created incentives for identifying sources of knowledge within organisations and for developing systematic procedures for knowledge sharing more widely among organisational members. On the other hand, as Empson (2001) continues, at a theoretical level, two parallel developments have added the value to the increased emphasis on knowledge within the management literature. At the time when the resource-based view of the firm identified knowledge as the primary source of a sustainable competitive advantage; post-modern perspectives on organisations argue about the nature and meaning of knowledge within organisations and society as a whole. Empson (2001) finishes that such different perceptions have taken their place in a complex and enduring debate about the role and nature of knowledge in organisations.

In addition to Empson's view (2001), Kalla (2005) continues that managing knowledge has become an important topic in recent years because of the sudden increase of the available information. This has become possible because of dramatically fast innovation in information and communication technologies (Kalla, 2005). Available information and communication have been increased and become more transparent, easier and faster, for example, online communities and more specifically recently popularised social networking websites such as Youtube, Flickr, Facebook, Twitter, amongst others. Kalla (2005, p.303 citing Oliver (1997, p. 64)) provides a definition of communication as "an interchange of ideas, facts and emotions, by two or more persons, with the use of words, letters and symbols based on the technical problem of how accurately the symbols can be transmitted, the semantic problem of how, precisely, the symbols convey the desired meaning, and the effectiveness of how the received meaning affects conduct in the desired way".

This definition shows that communication within an organisation as internal communication is important for knowledge sharing processes, and as a consequence it is fundamental for competitive advantage (Kalla, 2005). Knowledge itself is a sustainable advantage and in the global economy it may be an organisation's greatest competitive advantage (Davenport & Prusak, 2000). Hence, organisations need to be careful how they manage knowledge (Empson, 2001). Communication is therefore important for knowledge sharing processes, which is in turn important for a competitive advantage. Managing knowledge has become one of the most important topics, especially in the last few decades, where knowledge sharing is a core issue. Knowledge sharing processes have been given more chances to flow because of the development of information and communication technologies. All of this is an explanation for why many scholars study an important question, regarding what makes individuals share knowledge effectively with other individuals in organisations (see for example, Barrett, Cappleman, Shoib & Walsham, 2004; MacNeil, 2004; Powers, 2004; Cabrera & Cabrera, 2005; Hansen, Mors and Lovas, 2005; Kalla, 2005; Laycock, 2005; Wasko & Faraj, 2005; Ruuska & Vartiainen, 2005; Chiu, Hsu & Wang, 2006; Huysman & Wulf, 2006; Kuk, 2006; Haas & Hansen, 2007; Renzl, 2008; Wang, Yang & Chou, 2008).

In addition, taking into account that "knowledge is the lifeblood of the virtual organization" (Warner & Witzel, 2004, p.11), meaning that knowledge is a vital key for a competitive advantage in the knowledge-based economy, it begs the following questions: what is a concept of knowledge; and what is a process of knowledge sharing in organisations and particularly with reference to VO? Therefore, before going any further in investigating knowledge sharing processes in organisations and particularly in VO, it is important to understand the concept of knowledge itself.

2.3 Definitions of Concepts

2.3.1 Data – Information – Knowledge

It is important to define data, information, and knowledge in order to move away from an incorrect interpretation of these concepts. Building on these definitions it will be possible to provide an understanding of knowledge sharing issues. The literature review shows that there is lack of agreement in identifying the true meaning of data, information and knowledge. Such confusion of these three terms can provoke financial, operational, or strategic losses. Therefore, it is necessary to identify what data is, what information is, what knowledge is, and how they are related to each other.

Table 2.1 below contains a definition for data, information, and knowledge, which are given by authors who specialise in managing knowledge literature. According to Davenport & Prusak (2000) and Roberts (2001), data is a raw material, dry facts to create information, whereas information makes data different as it gives data a meaningful pattern of value. In this case, knowledge is a constituent of information and human minds, experience, and skills gained from that experience. Nonaka and Takeuchi (1995) find that knowledge is related to beliefs, while information is not; knowledge is related to action, whereas information is not. Knowledge is a collection of information analyses, and knowledge, like information is related to meaning (Table 2.1). Consequently, information and what exists in human minds are not always the same.

Table 2.1: Definitions According to Some Authors

Author	Definition
Data	
Davenport & Prusak, 2000, p.2	"Data is a set of discrete, objective facts about events."
Roberts, 2001, p.100	"A series of observations, measurements, or facts in the form of numbers, words, sound and/or images. Data have no meaning but provide the raw material from which information is produced."
Norris, Mason & Lefrere, 2003, p.2	"A collection of unorganized facts and/or figures"
Information	
Boisot, 1998, p.20	"Information is data that modifies the expectations or the conditional readiness of an observer."
Roberts, 2001, p.100	"Data that have been arranged into a meaningful pattern. Information must relate to a context to have meaning."
Davenport & Prusak, 2000, p.3	"A message, usually in the form of a document or an audible or visible communication…. Think of information as data that makes a difference."

Norris, Mason & Lefrere, 2003, p.2	"Data that has been organized in such way that it achieves meaning, in a generalized way."
Knowledge	
Boisot, 1998, p.20	"Knowledge is the set of expectations that an observer holds with respect to an event. It is disposition to act in a particular way that has to be inferred from behaviour rather than observed directly."
Davenport & Prusak, 2000, p.5-12	"Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routinesm processes, practices, and norms.". "Knowledge derives from minds at work." (p.5). "Knowledge derives from information as information derives from data. If information is to become knowledge, humans must do virtually all the work." (p.6). Knowledge is what makes an organisation go, grow up, develop, and stay alive (p.12). KM process should be "baked" into key knowledge work process. How companies create, gather, store, share, apply knowledge must blend well with how market researchers, scientists, consultants, managers work on a daily basis. (p.2)
Roberts, 2001, p.100	"The application and productive use of information."
Howells & Roberts, 2000, p.19	"Knowledge is what we know."
Clarke, 2001, p.190-192	"Knowledge as a resource causes great confusion for economists, as it is the only resource which increases with use rather than diminishing. Knowledge may be expensive to generate but there is little cost to diffusion. Unlike physical goods that are consumed as they are used, providing decreasing returns over time, knowledge provides increasing returns as it is used. The more it is used, the more valuable it becomes, creating a self-reinforcing cycle" (p.190). "KM provides the means to generate, distribute, and use knowledge in ways that add value to business activity and provide new opportunities for enterprise. However, it is unlikely any of these benefits will be realised without an appropriate knowledge strategy." (p.192).
Nonaka & Takeuchi, 1995, p.58	Knowledge is a result of collaboration. ▪ "Knowledge is "a dynamic human process of justifying personal belief toward the "truth". ▪ Knowledge, unlike information, is related with beliefs and commitment.

	▪ Knowledge is a function of a particular stance, perspective, or intention. ▪ Knowledge, unlike information, is related to action. ▪ It is always knowledge "to some end". ▪ Knowledge, like information, is related to meaning. ▪ Knowledge is contest specific and relational. ▪ Information is a flow of messages. Knowledge is the collection and analysis of that flow of information."
Norris, Mason & Lefrere, 2003, p.2	"Information that is presented within a particular context, yielding insight on application in that context, by members of a community."
Hislop, 2009, p.19	"Knowledge is an entity/object." "Knowledge is derived from an intellectual process."

According to the Organisation for Economic Co-operation and Development (OECD) (1996), knowledge can be "know-what", "know-why", "know-how", and "know-who". Know-what is knowledge about facts and information. Know-why is the scientific knowledge of the principles and laws of nature. Know-how is skills of capability to do something. Know-who is information about who knows what and who knows how to do what (Clarke, 2001; Roberts, Andersen & Hull, 2000). According to Goh (2005), managing knowledge can consist of different kinds of capital – intellectual, structural, human – which can be created from assets, which companies already have such as products, processes, and people. These three kinds of capital can be analogised by categories of knowledge given above: know-what, know-how, and know-who, where know-what is a product of the organisations, know-how is processes within organisations, and know-who is people in the organisations, knowledge workers. It is difficult to separate know-how and know-who (Fahey, Srivastava, Sharon & Smith, 2001), because knowledge workers are those who carry know-how, their knowledge. in other words, know-what is a final knowledge asset, whereas such an asset can be a product of knowledge sharing processes through know-how by knowledge workers or so called 'know-who's. Speaking about knowledge as an asset and knowledge sharing as a process (Empson, 2001), we need to investigate further different types of knowledge, to highlight knowledge as an asset and/or a process.

2.3.2 Explicit Knowledge – Tacit Knowledge (A Descriptive Overview of the Understating These Terminologies)

There is a famous division of knowledge types, proposed by various authors (for instance Polanyi, 1967, 1969; Collins, 1991; Blackler, 1995; Nonaka & Takeuchi, 1995, Grant, 1996; Boisot, 1998; Howells & Roberts, 2000).

Blackler gives five classifications of knowledge: embrained, embodied, encultured, embedded, encoded. Embrained knowledge is the knowledge "that is dependent on conceptual skills and cognitive abilities" (Blackler, 1995, p.1023), in other words, 'know-what'. Embodied knowledge is "an action oriented and is likely to be only partly explicit" (Blackler, 1995, p.1024), which can be called 'know-how'. Encultured knowledge is "the process of achieving shared understandings" (Blackler, 1995, p.1024). Organisational culture can be considered under this classification. Embedded knowledge is "resides in systematic routine", which "explores the significance of relationships and material resources" (Blackler, 1995, p.1024). Embedded knowledge can be analysed in system terms, in the relationships between IT, roles, formal procedures and emergent routines. Finally Blackler (1995) classifies encoded knowledge, which is "information conveyed by signs and symbols" (Blackler, 1995, p.1025). Books and manuals are examples of encoded knowledge, or explicit knowledge.

In this thesis, however, we will concentrate mainly on tacit and explicit knowledge, particularly the individual tacit knowledge of OSS developers shared in OSS communities in order to create innovative products and gain a competitive advantage. In management literature there is an epistemological distinction between knowing how and knowing about that is captured by distinctions between subjective versus objective knowledge, implicit or tacit versus explicit knowledge, personal versus prepositional knowledge, and procedural versus declarative knowledge (Grant 1996). This thesis will not make distinctions between all these different terms of knowledge. It will associate knowing how with tacit knowledge, and knowing about facts and theories with explicit knowledge.

The distinction between explicit and tacit knowledge lies in transferability and the mechanisms for transfer across individuals, across space, and across time (Grant, 1996).

Explicit knowledge is made known by its communication, whereas tacit knowledge is made known through its application, where knowledge sharing involves both transmission and receipt (Grant, 1996). According to Polanyi (1969), “tacit knowing” is the act of integration of the visual perception of objects and the discovery of scientific theories. Gourlay (2000, 2002, 2006 (a, b)) studied tacit-explicit knowledge issues, where he combined a wide range of studies and showed different terms used for tacit and explicit knowledge. In different disciplines, tacit knowledge is synonymous with secret, practical, know-how knowledge; whereas explicit knowledge is synonymous with open, propositional, documented, know-what knowledge.

Nonaka & Takeuchi (1995) find that explicit knowledge is objective; it is the knowledge of rationality, concerned with order and theory, while tacit knowledge is subjective, the knowledge of experience, which can come in real-time, is understood as practice. Tacit knowledge is personal, context specific, hard to formalise and communicate. Tacit knowledge is know-how. Explicit knowledge is contagious in form and it is in formal systematic language. Tacit knowledge can be discovered without being able to recognise what it is what it has to come to know (Polanyi, 1969). According to Howells & Roberts (2000), codified (or explicit) knowledge can be defined as knowledge that can be documented in printed or electronic version, whereas tacit knowledge is intangible know-how, which is collected / shared / discussed through informal ways between individuals or inside companies. Gourlay (2002) notes that explicit knowledge lies within designation and symbol; whereas, tacit knowledge is ‘pre-linguistic modes of human knowing’, tacit knowledge may have difficulties being expressed in words, it is a ‘non-verbal sign-process’. Tacit knowledge is know-how, which is people’s experience and is in people’s minds. Explicit knowledge can be codified.

To summarise, explicit knowledge is codifiable, objective, impersonal, context independent, and easy to share; whereas tacit knowledge is inexpressible in a codifiable form, subjective, personal, context specific, and difficult to share (Hislop, 2009, p.23). However, the difference between tacit and explicit knowledge is not sharply divided (Polanyi, 1969). Tacit knowledge can be possessed by itself, whereas explicit knowledge should “rely on being tacitly understood and applied” (Polanyi, 1969, p.144). This means that all knowledge is either tacit or rooted in tacit knowledge

(Polanyi, 1969, p.144). A wholly explicit knowledge is not thinkable (Polanyi, 1969, p.144), because “tacit and explicit knowledge are inseparable” (Hislop, 2009, p.34).

Collins (2001) gives an overview of tacit knowledge to those “artificial intelligentsia”, who believe that all human skills can be documented. Collins (2001) gives three routes in explaining tacit knowledge: the motor-skills metaphor, the rules-regress model and the forms of life. According to this division, in the first route: the motor-skills metaphor, tacit knowledge is knowing without ability to formulate the rules. In this route Collins gives Polanyi's example of riding a bike, where the skill of riding a bike cannot be formulated in a way, which might satisfy a physicist. In the second route: the rules-regress model, experimental skills are not possible to formulate. Finally, the third route: the forms of life approach, where people from different social groups take different things different according to their social basis.

Boisot (1998) divides tacit knowledge into three different variants. Tacit knowledge, which can be articulated, can be understood and people can “take them for granted” (Boisot, 1998, p.57), knowledge which has been internalised over the years. Another variant of tacit knowledge is the one, which can be fully understood by nobody, which cannot be articulated (Polanyi, 1962). The third variant of tacit knowledge is the one which can be understood by some people, but they cannot “costlessly articulate” (Boisot, 1998, p.57) them (Nonaka & Takeuchi, 1995). Table 2.2 gives a summary of knowledge types and names used in different disciplines.

Table 2.2: Knowledge Types and Names

N	**Discipline**	**Knowledge-how**	**Knowledge -that**
1	Philosophy	Knowledge-how, procedural knowledge, abilities	Knowledge-that, propositional knowledge
2	Philosophy (Polanyi)	Tacit knowing	Explicit knowledge
3	Psychology	Implicit knowledge, tacit abilities, skills	Explicit knowledge, declarative knowledge
4	Management, Education	Tacit knowledge	Explicit knowledge
5	IT studies	Knowledge as process	Knowledge as object
6	KM	Know-how	Know-what
7	Sociology of science	Tacit	Explicit/symbolic

(Adapted from Gourlay, 2006 (b))

The above table leads us to another perspective in knowledge issues. Two broad alternative perceptions on knowledge in organisations have emerged; ‘knowledge as an asset’ and ‘knowing as a process’ (Empson, 2001, p.813).

Research, which adopts the ‘knowledge as an asset’ perspective, seeks to discover valuable knowledge within organisations and to develop mechanisms for managing it effectively. Organisational knowledge is an important source of competitive advantage. Empson (2001) continues that resource-based theorists have conceptualised organisations as mechanisms for creating and utilising knowledge (for example, Grant, 1996). In this context knowledge is often viewed as “an objectively definable commodity, with exchanges of knowledge between individuals being governed by the functioning of an internal market” (for instance, Szulanski, 1996) (Empson, 2001, p.812). The literature on KM is full with literature on organisations transferring knowledge capabilities, renewing knowledge bases, and measuring knowledge assets (e.g. Hansen, Nitin & Tierney, 1999). The ‘knowledge as an asset’ perspective adopts the firm as a unit of analysis, or more specifically the knowledge base and the KM systems of the firm (Empson, 2001).

By contrast, researchers who adopt the ‘knowing as a process’ perspective argue that “knowledge cannot be analysed and understood as an objective reality” (Empson, 2001, p. 813). From this perspective, knowledge is viewed as a “social construct, developed, transmitted and maintained in social situations” (for example Blackler, 1995), (Empson, 2001, p.813). In this situation, “alternative concepts of legitimate knowledge can co-exist within organisations and individuals seek to establish their claims to legitimacy by demonstrating the pre-eminence of their expertise”, where the aim of this research stream is “to understand how knowledge is created, articulated, disseminated and legitimated within organisations” (Empson, 2001, 813).

What does all this mean for this thesis? What is tacit and explicit knowledge? Is knowledge in ‘an asset’ or ‘a process’?

This thesis uses the ‘knowledge as a process’ perspective, individual tacit knowledge of OSS developers in OSS communities, which cannot be understood “as an objective reality” (Empson, 2001, p. 813), that is a “social construct, developed, transmitted and maintained in social situations" (Empson, 2001, p.813), because such individual tacit knowledge of OSS developers is shared via sharing their know-how by writing beautiful codes and by social interactions. This thesis aims to understand how knowledge is shared within individuals inside VO, OSS communities, so that these communities can produce innovative products as the result of successful individual knowledge sharing processes. Therefore, the thesis will consider tacit knowledge in OSS communities as the personal knowledge; know-how of the software developers in writing the codes beautifully. It is the first step in understanding and investigating knowledge sharing in individual level in OSS communities.

'Knowledge as an asset' can be investigated further at a later stage (Chapter 7) in future research, in order to develop mechanisms for managing valuable knowledge within organisations effectively. The documented version of that process, the documented version of the beautifully written software code can be considered as explicit knowledge, where tacit knowledge in its written/documented format via explicit knowledge becomes as asset of a particular organisation, OSS communities in the case of this thesis.

This is a very short introduction to tacit and explicit knowledge in OSS communities, but this issue will be investigated in more detail later in the Chapter, when a definition of knowledge sharing in this thesis will be given, and also in the next Chapter, where OSS communities will be analysed in detail.

2.3.3 Knowledge Conversion

If most of the knowledge significant to production is tacit, then knowledge sharing processes between organisational members are remarkably difficult (Grant, 1996; Roberts (2000(a)). However, there is a famous model, which offers an idea of how knowledge should be shared. Nonaka & Takeuchi (1995) identify four modes of knowledge conversion, knowledge spiral and contents of knowledge. In order to monitor KM effectively, ideally both explicit and tacit knowledge need to be shared between each other. According to the authors, there are four modes of knowledge conversion.

Socialisation (from tacit to tacit) is a process of sharing experiences and creating tacit knowledge. Externalisation (from tacit to explicit) is a process of articulating tacit knowledge into explicit knowledge. Combination (from explicit to explicit) is a process of systemising concepts into a knowledge system. Internalisation (from explicit to tacit) is a process of learning by doing. It is vital for an organisation to converse in the above four modes. At the same time, according to Nonaka & Takeuchi, there are four very different modes, which can exist and give more value when they are used altogether. Authors underline a very important issue – innovations can emerge only when explicit and tacit knowledge interacts between each other. This type of interaction can be shown as a knowledge spiral, which should move around continuously (Nonaka & Takeuchi, 1995).

2.3.4 Ambiguity of Tacit Knowledge: Unclear Pitfalls in a Clear Picture

The literature review shows that there are some issues in tacit knowledge, which lack clarity (for example, Polanyi, 1962; Boisot, 1998; Baumard, 1999; Norris, Mason & Lefrere, 2003; Gourlay, 2006 (a, b); Hicks, Dattero & Galup, 2007). For instance, Gourlay (2006 (a)) divides tacit knowledge into two main parts: 'articulable' tacit knowledge and 'inarticulable' tacit knowledge, which supports Boisot (1998), mentioned above. The term 'articulable' knowledge implies known things, which can be expressed, or internalised expertise; whereas, 'inarticulable' knowledge is that, either when people feel they know it without needing evidence, or people can do it without the ability to tell because of a habit, cultural knowledge or biology, that is to say innate knowledge. If so, then if 'articulable' knowledge can be expressed, how can 'inarticulable' knowledge be managed? Is there any difference between 'articulable' tacit knowledge and explicit knowledge? How can we differentiate between them?

There is also another question of the differentiation between individual tacit knowledge and organisational tacit knowledge (Baumard, 1999; Gourlay, 2006 (a, b); Hicks, Dattero & Galup, 2007; Hislop, 2009), where individual experience, according to Gourlay, 2006 (a), can be gained through training and learning, personal contact or observation of others, or feelings, as well as individual tacit knowledge already existing biologically in a human being.

If there is a division between individual and organisational tacit knowledge, and if knowledge is one of the important sources in organisations, particularly in VO, then should it not be a combined knowledge of individual knowledge and organisational knowledge? According to Grant (1996), at both the individual and organisational levels, knowledge absorption depends upon the recipient's ability to add new knowledge to existing knowledge, where the ability to share and combine knowledge is a key determinant in organisations. According to Nelson & Winter (1982), an understanding of individual skills sheds light on understanding organisational skills. Individuals use their skills in their roles in organisations as organisational members, which affect the characteristics of organisational capabilities. As Nelson & Winter (1982) point out, “routines are the skills of an organisation” (p.124), in which the effective integration of component subroutines is involved. Such decentralisation in organisations parallels “the skilled individual's ability to perform without attending to the details” (p.125).

Although there is integration between individual and organisational skills, and although it gives some clarification in terms of individual tacit knowledge and organisational tacit knowledge, there is still a need to investigate the use in practice of ‘inarticulable’ individual tacit knowledge inside organisations, and perhaps turn it into ‘inarticulable’ organisational tacit knowledge. If so, it would be useful to understand how all these kinds of complicated tacit knowledge can be managed inside organisations and particularly in dispersed VO.

2.3.5 Ambiguity between Explicit and Tacit Knowledge

As mentioned earlier, explicit knowledge depends on tacit knowledge (Polanyi, 1969). But the distinction between tacit knowledge and explicit knowledge is not always entirely clear. According to Polanyi (1967, p.20), “an explicit integration cannot replace its tacit counterpart”. It is probably because, “we can know more than we can tell” (Polanyi, 1967, p.4).

Gourlay (2006 (a)) argues that there are three main pitfalls in the use of tacit knowledge. Knowledge can be tacit at a time when it is used. Is it still tacit knowledge immediately after being used? If yes, what distinguishes it from any other form of knowledge? If knowledge can be gained through observation of other’s feeling and behaviour, what is the difference between this knowledge and the one, which lacks for such observation of others' feelings? Even if there are observable actions what if actors may not give an account to them as tacit knowledge? To what extent might tacit knowledge be shared with explicit knowledge? Can explicit knowledge be comparable with the original tacit knowledge? To what extent is individual tacit knowledge relevant to what they actually do? It is evident that there are still many unclear aspects regarding the relationship between explicit and tacit knowledge.

However, although there are lots of unclear aspects in the research on knowledge, this thesis will not be able to address all these issues and needs. Instead, it will concentrate on one narrow issue. Let's discover what the above mentioned issues mean for this thesis and how this thesis will contribute to the current academic literature.

2.3.6 What Is Managing Knowledge/Knowledge Management and What Does It Mean in This Thesis?

The above discussion showed the importance of data, information, IT, and knowledge for managing knowledge. In light of these vital components it will be possible to give a definition for managing knowledge/KM in general and what managing knowledge means for this thesis. We will start with KM definitions given by some scholars. According to Mackintosh, Filby & Kingston (1999, p. 551):

> "Knowledge assets are the knowledge regarding markets, products, technologies and organizations, that a business owns or needs to own and which enable its business processes to add value and generate profits. KM is not only about managing these knowledge assets but also managing the processes that act upon the assets. These processes include: developing knowledge; preserving knowledge; using knowledge and sharing knowledge. Therefore, knowledge asset management involves the identification and analysis of available and required knowledge assets and knowledge asset related processes, and the subsequent planning and control of actions to develop both the assets and the processes so as to fulfil organizational objectives."

Hedlund (1994) notes that it is not entirely clear what KM means. Gourlay (2000, p.3) cited Scarborough et. al. (1999) that KM is "any process or practice of creating, acquiring, capturing, sharing and using knowledge ... to enhance learning and performance in organizations"; cited Lank (1997) that KM is "collecting, connecting, creating and applying knowledge for short term and long term sustainability"; cited Myers (1996) that KM is "predicated on the capture and storage of knowledge in organizations' systems, processes, products, rules, and culture".

The KM Community defines KM as "information or data management with the additional practice of capturing the tacit experience of the individual to be shared, used and built upon by the organisation leading to increased productivity" (KM Tool[6]). Further to this definition, KM News adds that KM is "about connecting people to people and people to information to create competitive advantage" (KM News[7]). Norris, Mason & Lefrere (2003, p. 2) identify KM as "the practice of nurturing, collecting, managing, sharing, and updating the knowledge resources of an enterprise".

Hislop (2009, p.59) gives a broad definition of KM as

> "an umbrella term which refers to any deliberate efforts to manage the knowledge of an organization's workforce, which can be achieved via a wide range of methods including directly, through the use of particular types of ICT, or more indirectly through the management of social processes, the structuring of organizations in particular ways via the use of particular culture and people management practices."

Having investigated the data, information and knowledge, some unclear issues have been identified regarding the difference between 'articulable' tacit knowledge and explicit knowledge. Additionally, the relationship between individual and organisational tacit knowledge should be explored in more detail. It will also be useful to explore further why managing knowledge and knowledge sharing specifically are important, especially in the knowledge-based economy. However, before exploring managing knowledge issues in details, and after analysing the literature on data, information, knowledge and managing knowledge definitions, it is important to clarify what managing knowledge and knowledge mean in this thesis.

[6] http://www.kmtool.net/vocabulary.htm, accessed on 7 July 2009
[7] http://www.kmnews.com/Knowledge_Management_Defined.html, accessed on March 2006

After the review of managing knowledge definitions in academic literature (which is given above), it was decided that in this thesis it will be more appropriate to use a more generic definition of managing knowledge, because the thesis specifically concentrates on the issue of knowledge sharing in managing knowledge. This thesis, under this definition of managing knowledge/KM will formulate an instrument to effectively apply data and information by people using their tacit knowledge in order to gain a competitive advantage (the glossary for this thesis is given in Appendix 1). As previously stated, this thesis focuses explicitly on knowledge sharing. With this is mind, what does knowledge and knowledge sharing mean for this thesis?

2.3.7 What Do Knowledge and Knowledge Sharing Mean in This Thesis?

As discussed, we can identify three main islands in knowledge literature. 1) Knowledge can be explicit and tacit. 2) There is articulable and inarticulable, individual and organisational knowledge. 3) Knowledge has two alternative perceptions; it can be considered as an asset and as a process.

1) Tacit vs. Explicit

However, the difference between tacit and explicit knowledge is not sharply divided (Polanyi, 1969). Nevertheless, the definition of explicit and tacit knowledge for this thesis can be summarised by citing Polanyi (1969, p.144) that tacit knowledge can be possessed by itself, whereas explicit knowledge should “rely on being tacitly understood and applied”, which means that all knowledge is either tacit or rooted in tacit knowledge.

If to apply the previously explored definition of explicit knowledge and tacit knowledge to OSS communities and individuals, who are contributing to the OSS development; then explicit knowledge will mean a documented version of the software, which OSS developers write tacitly and share between each other as a process. This means that the skills and experience to write that software masterfully (‘beautifully’, as OSS developers would say) will be the tacit knowledge of those OSS developers. In other words, it is a process (Empson, 2001), where OSS developers use their know-how and share it with others.

This proves Polanyi's idea that all knowledge is either tacit or rooted in tacit knowledge. OSS developers write the software, which means they show by that written software that their knowledge can be codified and that software is explicit knowledge. Nevertheless, the ability and skills to write that software is dependent on tacit knowledge of the OSS developers. Tacit knowledge for OSS developers is their know-how, their skills and personal experience in the writing the software, improving it, sharing it, changing it or correcting it by the members in the OSS communities, who contribute in the development of the OSS. This can be interpreted as OSS developers not directly sharing their tacit knowledge; rather they share their explicit knowledge. It is because not all tacit knowledge is articulable.

2) Articulable vs. Inarticulable

As discussed, if knowledge is articulable and inarticulable as well as individual and organisational (Boisot, 1998; Gourlay, 2006 (a)), then there can be four different types of knowledge; articulable individual, articulable organisational, inarticulable individual and inarticulable organisational. Because of the topic of the thesis, here individual tacit knowledge sharing is investigated. Then, arctulable tacit knowledge which can later be expressed and documented into explicit knowledge as well inarticulable tacit knowledge, can be tested to see if it can be expressed through knowledge sharing processes. This should be studied in depth via empirical studies.

If under the term of articulable knowledge the software, which OSS developers write and share between each other can be understood, then the skills and experience to write that software beautifully will be inarticulable tacit knowledge of those OSS developers. This means that the gap in knowledge sharing, which has been mentioned by different scholars (for example, Sorenson, Rivkin & Fleming, 2006), can be considered as a "non-existent" gap in the case of OSS developers who write the software, which means they show by that software that their knowledge can be codified, and that software is articulable knowledge. They share their software, and the ability and skills to write that software beautifully is kept behind the software. This is one of the reasons for the success of OSS communities.

3) Knowledge as an Asset vs. Knowledge as a Process

The sharing of knowledge in OSS communities does not only happen through sharing the written software, i.e. explicit knowledge. As addressed later in the literature review and in the empirical studies, OSS developers pay attention to networking, communication and interaction between each other, online and offline. Such kind of interactions can be considered as a good basis for sharing tacit knowledge, and such kind of interaction is a good example of OSS communities: online communities, where intensive knowledge sharing processes are implemented: communities of practice[8] (Lave & Wenger, 1991). For OSS communities it is important to use data, information, as well as organisational and individual explicit knowledge effectively, in addition to efficiently manage organisational and individual tacit knowledge in order to gain competitive advantage, because knowledge is a vital key for competitive advantage particularly the extensive influence of IT on the modern world and its current economy.

That is why this thesis adopts knowledge as a process view. The knowledge as an asset perspective adopts the firm as a unit of analysis, the knowledge base and the KM systems of the firm; whereas knowledge from a process perspective looks at knowledge as "an objective reality", a "social construct, developed, transmitted and maintained in social situations" (Empson, 2001, p.813).

This thesis uses the 'knowledge as a process' perspective, the sharing process of individual tacit knowledge of OSS developers in OSS communities; knowledge, which cannot be understood, because such individual tacit knowledge of OSS developers is shared via sharing their know-how not only by writing beautiful software codes but also by social interactions. This thesis aims to understand how knowledge is shared within individuals inside VO, OSS communities, so that later on these communities can produce innovative products as the result of successful individual knowledge sharing processes. Therefore, this thesis considers tacit knowledge in OSS communities as personal knowledge; both articulable and inarticulable; know-how of the software developers in writing software beautifully.

It is the first step in understanding and investigating knowledge sharing at on individual level in OSS communities. 'Knowledge as an asset' can be investigated further at a later stage (Chapter 7) in the future research in order to develop mechanisms for managing valuable knowledge within organisations effectively. The documented version of that process, the documented version of the beautifully written software can be considered as explicit knowledge, where tacit knowledge in its written/documented format via

[8] Communities of practice will be analysed in detail in the next Chapter.

explicit knowledge becomes as asset of a particular organisation, OSS communities in the case of this thesis.

Therefore, sometime in this thesis there can seem some clashes between knowledge as an asset and knowledge as a process. The reason for that confusion can be because knowledge as an asset is a result of knowledge as a process. Knowledge as an asset is the last point in organisational managing of knowledge. However, in order to reach that point, in order organisations can have competitive advantage, individuals in organisations, OSS communities in the case of this thesis, have to have knowledge sharing processes. Because this thesis adopts knowledge as a process view, the further investigation should be considered under such perspective.

2.4 The Challenges of Knowledge Sharing Processes in Organisations

According to Roberts (2000(a)), knowledge sharing occurs when knowledge is diffused from one individual to another, where knowledge can be shared through processes of socialisation, education and learning. Organisations play an important role in knowledge sharing processes. However, the measurement of knowledge sharing is a difficult task (Roberts, 2000 (a)). There is a list of challenges in knowledge sharing in organisations that various scholars have isolated. Hislop (2009) observes the limit of manageability of knowledge.

Mooradian (2005) argues that the concept of tacit knowledge is at the centre of managing knowledge, therefore capturing explicit knowledge should be the central aim of organisations attempting to manage knowledge. Mooradian continues that identifying the relevant tacit knowledge can differ in difficulty on a scale of easy to practically impossible, where some tacit knowledge is easier to express in natural or formal language than other kinds of tacit knowledge. Tacit knowledge has a specific role in managing knowledge: it is a factor in knowledge sharing that explains or predicts the stickiness of the sharing (Mooradian, 2005).

For instance, Hansen, Mors and Lovas (2005) ask what determines the occurrence and effectiveness of knowledge sharing in an organisation, and constructed a literature review, where they found that scholars have examined this question from different viewpoints:

- the problem of sharing tacit and complex knowledge across organisation subunits;
- the nature of informal relationships between two parties in knowledge sharing;
- the problem of searching for knowledge (Hansen, Mors and Lovas, 2005, p. 776).

There is a shortage in terms of the extent to which different factors explain search and sharing knowledge, therefore there is a need for research that "explores the extent to which different properties explain outcomes associated with the various phases of knowledge sharing", where there are three phases: deciding to seek knowledge, searching for knowledge, and sharing knowledge within teams and across subunits in an organisation (Hansen, Mors and Lovas, 2005, p.776). Knowledge sharing "needs to fully incorporate the phase level of knowledge sharing in an organization and the subset level of social networks in order to advance a robust theory of knowledge sharing", where a high average relationship strength between three phases (deciding to seek knowledge, searching for knowledge, and sharing knowledge within teams and across subunits in an organisation) can improve knowledge sharing in an organisation (Hansen, Mors and Lovas, 2005, p. 791).

Haas & Hansen (2007) base their literature review on knowledge search and sharing and identify various barriers to knowledge sharing, including knowledge tacitness (citing Teece, 1986), limited absorptive capacity of knowledge receivers (citing Szulanski, 1996), perceptions of competition by knowledge providers (citing Hansen, Mors, and Lovas, 2005; Tsai, 2002), and lack of trust between providers and receivers (citing Levin and Cross, 2003). In terms of issues related to trust, Renzl (2008) points out that trust in management influences workplace behaviour, such as employees' knowledge sharing behaviour. Further, Renzl (2008) questions how the relationship between trust in management and knowledge sharing works, where he finds that trust in management reduces the fear of losing individual's unique value in the knowledge sharing process.

While some scholars have discussed the issues and problems in knowledge sharing and searching, a number of other scholars, for example Ruuska & Vartiainen (2005) and Renzl (2008) ask how to prevent the reinvention of the wheel and share knowledge gathered in one project with others. This issue can become even more sensible if project teams are temporary, especially in the online environment in VO, where a lot of knowledge may be lost when the projects are finished. As the list of challenges proceeded, so the solutions in knowledge sharing occurred. So what are they?

2.5 Solutions in Knowledge Sharing in Organisations Found in the Academic Literature

Knowledge sharing in organisations can be based on two strategies: the codification strategy and the personalisation strategy (Ruuska & Vartiainen, 2005). The codification strategy is carefully codifying the knowledge and storing it in archives/databases, where it can be assessed and/or reused. In the personalisation strategy, knowledge is closely tied to the people who developed it and is shared by personal face-to-face interaction. Social processes in the personalisation strategy are opposed to the use of IT, where knowledge is codified.

Recalling the four modes of knowledge conversion, knowledge spiral and contents of knowledge offered by Nonaka & Takeuchi (1995), their modes can be analogised by the codification strategy and the personalisation strategy offered by Ruuska & Vartiainen (2005), where socialisation (from tacit to tacit) and internalisation (from explicit to tacit) can be considered as a personalisation strategy, whereas externalisation (from tacit to explicit) and combination (from explicit to explicit) can be considered as the codification strategy. The same differentiation is made by Hislop (2009), where knowledge sharing has two diverse structures: objectivist perspective and practice based perspective. The objectivist perspective focuses on the codification, collection and storing knowledge in order to make knowledge to be searched and accessed. The practice based perspective focuses on interpersonal knowledge sharing through interaction and communication.

Continuing from the personalisation strategy (Ruuska & Vartiainen, 2005) or practice based perspective (Hislop, 2009), for example, Cabrera & Cabrera (2005) propose a set of people management practices to promote knowledge sharing among organisational employees, both core and non-core. According to that proposal, socio-psychological determinants of knowledge sharing include facilitation for knowledge sharing, such as social ties and shared language, and encouraging knowledge sharing, such as trust, group identification, perceived cost, perceived rewards, self-efficacy, and expectations of reciprocity. People management practices for knowledge sharing form from such factors as work design, staffing, training and development, performance appraisal, compensation, culture, and technology. According to Cabrera & Cabrera (2005), socio-psychological determinants of knowledge sharing through those people management practices increase intention to share knowledge in organisations.

In addition to Cabrera & Cabrera (2005) in terms of the personalisation strategy (Ruuska & Vartiainen, 2005; Hislop, 2009), Renzl (2008) finds out that the knowledge sharing result depends on the knowledge to be shared as well as the relationships between the individuals and groups involved in the knowledge sharing process. According to Laycock (2005), for example, in knowledge intensive organisations, knowledge sharing is highly dependent on an effective ongoing collaboration. Across organisations, collaboration should be used for adding value as well as creating new value. Following MacNeil (2004), who is assuming that tacit knowledge and skills can be learned through continuous contact within teams, tacit knowledge and skills could be practiced by the individual employee, using the team as a forum for the creation and sharing of that tacit knowledge (MacNeil, 2004). Thus, MacNeil (2004) summarises that learning gained through the team knowledge sharing process could provide core competence for the organisation.

The research conducted by Haas & Hansen (2007) regarding different types of knowledge sharing may affect task performance differently, and identified three main components of knowledge work productivity: a) two types of knowledge sharing through electronic documents and personal advice; (b) a content and process dimension for each type of knowledge; and (c) three primary task performance outcomes: time savings, work quality, and signal of competence. Haas & Hansen (2007) found that different types of knowledge influence task performance differently. Using high quality electronic documents can increase time savings for certain type of organisations, for instance sales teams in management consulting firms. Whereas drawing on advice from experienced colleagues can improve the quality of teams' work, this may not necessarily save time. The results of their (Haas & Hansen, 2007) study are found that it is a contradicted view of knowledge sharing, where different knowledge types are substitutes for each other.

As seen from the above literature review, in knowledge sharing scholars generally identify different strategies in sharing different types of knowledge. In the codification strategy IT is an important basis for successfully codifying the knowledge and storing it, whereas in the personalisation strategy social interaction and network play an important role. The next Chapter will review the current academic literature on an organisational form, which has emerged together with the development IT: VO, where knowledge sharing in VO will be investigated in detail in order to move further and discover knowledge sharing in a particular form of VO: OSS communities.

2.6 Questions Arising from the Literature Analysis for the Further Investigation before Moving to the Next Chapter

The above literature review created many questions, which can be studied further. However, because of the time and space limitations of this thesis, the following questions will be investigated.

As discussed, although the key element in managing knowledge is knowledge sharing (Nonaka & Takeuchi, 1995), knowledge sharing is one of the most delicate issues. People by nature do not share their knowledge with others (Mooradian, 2005; Lim & Klobas, 2000); nevertheless, they ‘need’ to share tacit knowledge into explicit knowledge, inarticulable knowledge into articulable knowledge. How? What is important so that such knowledge sharing can be implemented? If they ‘need’ to share tacit knowledge, can they really do this? What is the process in knowledge sharing? If the knowledge sharing process includes exchanging existing knowledge and creating new knowledge in collaboration (Maki-Komsi, Poyry & Ropo, 2005), i.e. processing knowledge and as a result having a value, asset from that processing of knowledge, what should organisations provide for tacit knowledge sharing?

On the one hand, knowledge sharing still remains one of those mysterious aspects in human beings, it is still unclear why and how knowledge sharing is happening, because humans are not keen to share what they know. Yet, knowledge sharing is vital for the success of an organisation/ a community despite its all mystery. For instance, individual knowledge sharing is a vital process in order to achieve a competitive advantage. As will be seen in the next Chapter, OSS communities are a good example of successful knowledge sharing processes. In the example of OSS communities, knowledge sharing processes take place among and between individuals in such communities in order to create innovative software, i.e. a competitive advantage. What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities? Since these individuals work together in an organisational form, OSS communities in the case of this thesis, what are the characteristics of the communities that affect knowledge sharing in OSS communities? These two research questions will clarify our investigation on knowledge sharing processes in OSS communities.

Hence, this thesis will investigate knowledge sharing processes in detail and what factors influence successful knowledge sharing in VO. The thesis will concentrate on knowledge sharing as a process in the concrete example of a particular form of the organisations, OSS communities, exploring factors that influence successful knowledge sharing in a concrete and specific example in practice in the real business world, in order to mirror that practice into theory in the academic literature. The next Chapter will firstly analyse organisational forms in general and VO in particular, in order to examine knowledge sharing in an existing example of VO: OSS communities.

CHAPTER 3

LITERATURE REVIEW 2: VIRTUAL ORGANISATIONS

Section 1: Virtual Organisations

3.1.1 Why virtual organisations?

3.1.1.1 Introduction

Before an in-depth analysis of VO as such, because IT has an important impact on VO development, let's investigate how IT has changed organisations over the course of time. Then VO will be analysed in detail, including OSS communities, and finally how knowledge sharing is occurring in today's online organisations, particularly in OSS communities.

3.1.1.2 Historical Context of IT

The chronological development of IT (Marshall, 2007; Preece, Maloney-Krichmar & Abras, 2003; eMarketer, 2008) shows how fast it has developed and what kind of changes we have today. However, the evolution of programming and basis for today's IT started in the nineteenth century with Jacquard's loom, which was invented in 1891 for making carpets and fabrics and decreased the need for skilled human labourers. The first large-scale, electronic, reprogrammable digital computer was developed in the 1940s and took up an entire room. In the 1960s the predecessor to the Internet, the ARPAnet project, began.

Together with the development in hardware and software, academic scholars started publishing papers on aspects of communication (Marshall, 2007; Preece, Maloney-Krichmar & Abras, 2003): such as, a) Kleinrock wrote the first paper on packet switching, "Information flow in large communications nets" in 1961; b) in 1962 Licklider & Clark wrote the first paper on the Internet concept, "On-line man computer communications"; c) in 1964 Baran wrote the first paper on using message blocks to send information across a decentralised network topology "On distributed communications networks".

Together with these academic papers on networking, the first network experiment, where two computers 'talked' to each other using packet-switching technology, took place in October 1965 at the Massachusetts Institute of Technology. Further development of the online network continued in the 1970s by developing email in 1971. The most famous and first widely recognised non-technical online community, "The Whole Earth 'Lectronic Link" (WELL) was created in 1985 (more details can be found in Marshall, 2007; Preece, Maloney-Krichmar & Abras, 2003; eMarketer, 2008). In the 1990s and later in the 2000s after tremendous expanding of the Internet to the wide population, online networking has been experiencing dramatically fast development. The research project "How much information 2003?" found that instant messaging generated five billion messages a day (750GB), or 274 terabytes a year; e-mail generated about 400,000 terabytes of new information each year worldwide (Lyman & Varian, 2003). Clearly IT has played an important role in transferring networking onto online media.

3.1.1.3 Past in Organisational Forms

As has been seen, on one side, there has been tremendous IT development in recent years. However, there is a history of organisational forms, which exist almost from the beginning of human existence, because human nature is social, and human beings live together and work together because they are social animals. The topic of this thesis is knowledge sharing in virtual organisations; however, before considering the virtual form of the organisations, it would be useful to make a short overview of organisational forms and the organisation of firms in general.

According to Grant (1996, p.109), although economists use the term "theory of the firm" in the singular form, there is not only one, multipurpose theory of the firm. Grant (1996) continues that economic theories of the firm are generally interested in predicting the behaviour of firms in external markets; for example, the neoclassical theory of the firm uses partial equilibrium analysis to foresee the firm's purchase decisions in input markets and supply decisions in output markets. Another example is organisational theory, which addresses characteristics of the firm ignored by neoclassical economics; organisational theory analyses the internal structure of the firm and the relationships between its departments (Grant, 1996). Coase says "the firm in modern economic theory is an organization which transforms inputs into outputs" (Coase, 1988, p.5).

There has been a question of why firms exist. Given the fact that most people are employed by firms, there is a massive literature specialising in answering this and similar questions (for this see, for example, Coase, 1937, 1988; Heydebrand, 1989; Romanelli, 1991; Chandler, 1992; Daft & Lewin, 1993; Williamson, 1986, 1996; Grant, 1996; Cravens, Piercy & Shipp, 1996; Lewin, Long & Carroll, 1999; Van den Bosch, Volberda & de Boer, 1999; Swaminathan & Wade, 1999; McKendrick & Carroll, 2001; Hsu & Hannan, 2005).

According to Coase (1988, p.6), firms exist because of 'transaction costs', in other words 'the cost of carrying out a transaction by means of an exchange on the open market'. 'Transaction costs' can be described as 'search and information costs, bargaining and decision costs, policing and enforcement costs' (Dahlman (1979) cited in Coase (1988)). Later Coase (1988) continued that the existence of transaction costs leads players, who are involved in practices, to get a reduction in transaction costs. According to Coase (1988, p.7), "adaptation to the existence of transaction costs is the emergence of the firm". Coase (1937, 1988) found that factors of production between different uses are formulated by the price mechanism, which can vary greatly from one industry to another, from one firm to another. Coase (1937, 1988) argued that a cost of using the price mechanism is the main reason why to establish a firm is profitable. There is also another reason for the existence of a firm: the division of labour (Dobb cited in Coase, 1937, 1988).

However, Grant (1996) argues that the rationale for the existence of the firm can be criticised as being a special case of the Coase/Williamson transaction cost theory of the firm. According to Grant (1996), firms exist because they can avoid the costs related to market transactions. Firms exist because the knowledge-based view is concentrated on the costs associated with a specific type of transaction, which involves knowledge. Hislop (2009) conducts a literature review on the knowledge based theory of the firms, where he argues that such a theory represents the typical perspective of knowledge. Knowledge issues have been investigated in detail in the previous Chapter and will be examined in more detail later when virtual organisations will be explored.

It is evident even from this short overview that organisational forms and the organisation of firms are discussed from many perspectives. This Chapter will examine in depth the technological perspective and how it has changed the organisational forms. Lewin, Long & Carroll (1999) overviewed the forces as a basis for the transition to the post-industrial age and found that IT development, the junction of computing, networks, internet, and video technologies radically affect the socioeconomic system, from global commerce to personal life styles, and have been a factor in forcing the new organisational forms. The major factors for change within and between organisations (key dimensions of intraorganisational and interorganisational forms) are linked to electronic communication technologies: vertical control, horizontal coordination, size of organisation and constituent units, new types of coupling, core product, communication cultures, ownership and control, interorganisational coupling, strategic alliances, and interstitial linking (Fulk & DeSanctis, 1995).

All mentioned issues above can mean that the history of IT and organisational forms have prepared the present for organisational forms. Fast developing IT has influenced the development of organisational forms; it has been the basis for the current development in organisations and the creation of new organisational forms. With this in mind we can explore the present state of organisational forms in detail.

3.1.1.4 The Present of Organisational Forms

According to Fulk & DeSanctis (1995), because communication is an integral part of the organisational form, communication via IT is caught up in a wide range of changes in organisational forms. IT changed organisational forms by offering capabilities to avoid such limitations as time and distance. Fulk & DeSanctis (1995) identify five IT features, which have changed communication in organisations: increase in the speed of communication, reduction in the costs of communication, rise in communication bandwidth, greatly expanded connectivity, and the integration of communication with computing technologies. Such features have created evolutional changes in organisational forms. At the same time there is another issue, which makes an organisation’s assets dynamic, continuously learning. This evolutionary theory of organisations provides an explanation why in the past organisations started through the process of integrating production and distribution; why and how organisations grew/expanded into the new markets (Chandler, 1992).

3.1.1.5 Internet as a Foundation for New Organisational Forms

The Internet and its popularisation have changed business, education, and life style in general. Today the knowledge economy is a worldwide network of companies/individuals connected with each other through the Internet. This economy might be unpredictably changing. If with previously mass production traditional skills were the norm for success, now customers might prefer individualised (mass customisation) and value-added products, which require complex skills in such dynamic markets. (Filos, 2006; Wagner, Botterman, Feijen, Schmidt, Simmons, Hof, Iverson & Laerhoven, 2004).

The Internet is an innovative tool itself but at the same time it is a medium, which provides an environment to produce innovative products/services. In this case, both knowledge and innovation together have gotten 'new importance' in the knowledge economy. On one hand, the outcome of the knowledge creation is innovation; on the other hand, innovation implies more knowledge. This means that knowledge and innovation are two linked values in a chain for competitive advantages, especially in the e-medium, where everything and everybody is just one click away. The e-medium does not have geographical boundaries. It is extremely fast. It has its own time counting, which might be different from traditional time. That is why when her Britain's Got Talent show performance was shared on Youtube, Susan Boyle's song was watched by millions of people during its first week.

Because the e-medium is intangible, it is suitable especially for production/development/distribution of intangible products. For example, to buy software or music which can be listened to online is easier than buying an unknown perfume online, which has not been worn before. It means that especially in the e-medium and especially among intangible producers, innovative companies may become more successful, reach wider markets faster, and as a result can gain a competitive advantage. This is exacerbated by the fact that the e-environment is an ideal market for intangible products/services. For instance, open source software (OSS)[9] is a good example for such intangible products in an intangible medium. As it will be seen from the in-depth analysis of the OSS communities in the next Chapter, they are phenomena in e-business development. In particular, some OSS has shown a real success, such as Apache[10] and Firefox[11]. Indicators of the popularity of OSS include Netcraft's survey of the market share for top servers software which shows that OSS Apache had almost twice the market share of the software giant Microsoft in December 2006.

Another example of the OSS is web browser Mozilla Firefox, which has become a serious competitor for Microsoft Internet Explorer, where as a result has seen a drop in its market share from 91.35% in 2004 to 66.00% in 2009[12] (Figure 3.1(a)). Figures 3.1(b) show the top browser share trend between November 2008 and September 2009. An analysis of Microsoft's latest web browser reveals that its new and useful features have already been successfully implemented by Firefox, demonstrating the important role played by OSS communities in software innovation.

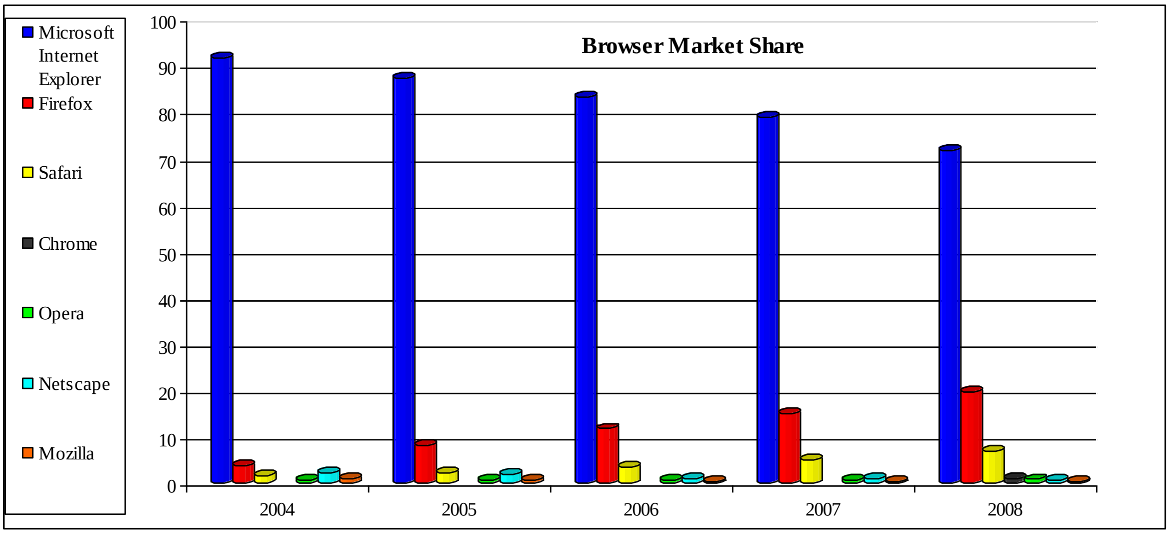
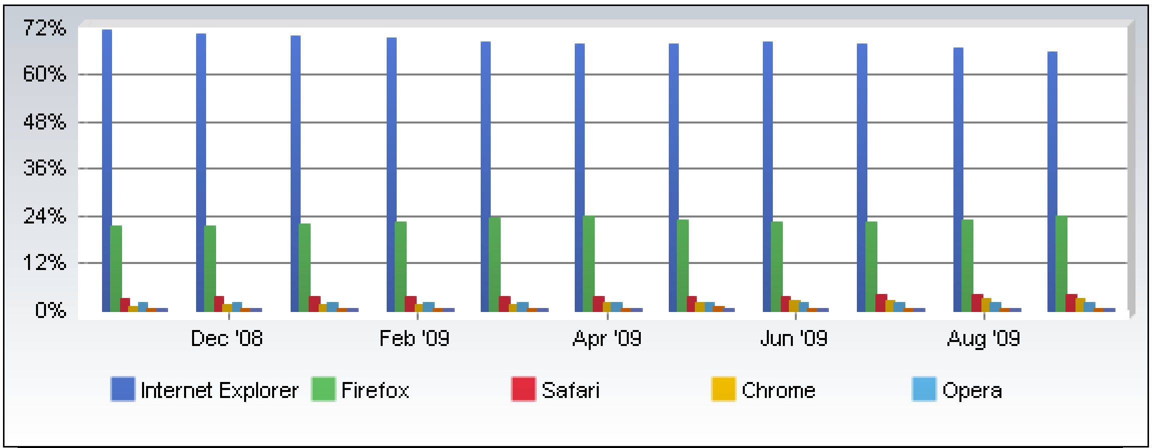


Figure 3.1(a): Browser Market Share[13]

[9] See Appendix 1 for its definition.
[10] Netcraft, http://news.netcraft.com/archives/2008/03/26/march_2008_web_server_survey.html, 10 April 2008
[11] Market Share, http://marketshare.hitslink.com/report.aspx?qprid=0, 27 October 2008
[12] Market Share, http://marketshare.hitslink.com/report.aspx?qprid=0, 03 October 2009
[13] Market Share, http://marketshare.hitslink.com/report.aspx?qprid=0, 27 October 2008



Month	Internet Explorer	Firefox	Safari	Chrome	Opera	Netscape	Other
November, 2008	71.61%	21.21%	3.08%	1.11%	2.17%	0.44%	0.38%
December, 2008	70.50%	21.69%	3.41%	1.40%	2.17%	0.42%	0.41%
January, 2009	69.72%	22.11%	3.62%	1.52%	2.23%	0.43%	0.37%
February, 2009	69.23%	22.58%	3.47%	1.54%	2.19%	0.62%	0.37%
March, 2009	68.46%	23.30%	3.63%	1.62%	2.12%	0.50%	0.37%
April, 2009	67.77%	23.84%	3.53%	1.79%	2.04%	0.64%	0.39%
May, 2009	68.10%	22.75%	3.70%	2.18%	2.06%	0.81%	0.40%
June, 2009	68.32%	22.43%	3.79%	2.40%	2.03%	0.60%	0.42%
July, 2009	67.68%	22.47%	4.07%	2.59%	1.97%	0.67%	0.55%
August, 2009	66.97%	22.98%	4.07%	2.84%	2.04%	0.49%	0.61%
September, 2009	65.71%	23.75%	4.24%	3.17%	2.19%	0.35%	0.59%

Figure 3.1(b): Top Browser Share Trend[14]

Despite the advantages in the e-medium; however, companies in the information era may face more risks than before. In the knowledge economy many firms are finding that operating alone puts them at a competitive disadvantage, and that they need to operate with others (networking) in the new environment (for instance when small players in the market enter online under the umbrella of one big giant such as Amazon.com). The knowledge economy is identified not only within growing importance of the computer hardware and software, but also within the rise of the electronic connectivity. The success of OSS is not only in its nature of being intangible and being stable in the intangible environment, but also in the nature of its production – online communities; communities, where software developers from all around the world work together and create a competitive and successful product. These kinds of OSS communities are examples of Virtual Organisation (VO).

The term 'Virtual Organisation'[15] reflects the emergence of a new organisational form with a record of success in the modern business environment. Although OSS

[14] Market Share, http://marketshare.hitslink.com/report.aspx?qprid=0, 03 October 2009
[15] See Appendix 1 for its definition.

communities represent just a part of VO, as it will be seen from the further discussion in this Chapter, they represent the most developed form of VO. That is why it is useful to investigate them in more detail especially in terms of knowledge sharing issues, because they are not only the most developed form of VO, but also a good example of VO where knowledge sharing is implemented successfully. Therefore it will be useful to examine in detail first VO and then OSS communities in order to investigate knowledge sharing in OSS communities.

3.1.1.6 Virtual Organisations as the New Organisational Forms

The network/VO has existed for a considerable period; however their true content and definition is still limited (Cravens, Piercy & Shipp (1996) cited Gummesson (1994)). However, the more e-business develops especially together with the popularisation of the Internet and its effect on business, the more studies on VO have been carried out, which is necessary in order to understand the constantly changing market requirements and strategies that companies have decided to use in order to reach their competitive advantage. Although there are plenty of studies on VO, as will be evident from the analysis below, due to its wide area and because of the important effect of virtualisation inside organisational forms, it will be useful to investigate VO in its general meaning, to first understand the work processes in it and its benefits and challenges.

As will be analysed later in the Chapter, the organisations may have their representatives in the online medium; some of them choose their existence in e-environment through the basic website; while some others prefer to do their whole business operations online. The term “virtual organisations”, which covers those organisations who find their ‘second life’ or sometimes even their first or primary life in the e-medium, has appeared together with the IT development in highly dynamic environments, which have influenced the formation of the new organisational paradigm. It has been suggested that the network is a promising organisational concept for achieving corporate/entrepreneurial aims in such highly dynamic environments (Cravens, Piercy & Shipp, 1996). As a result, organisations can revise traditional paradigms and develop new organisational forms to adapt new environmental changes and opportunities, relocating in new environments (Cravens, Piercy & Shipp, 1996).

According to the literature review by Cravens, Piercy & Shipp (1996), the network formation process involves vertical disaggregation followed by internal redesign and the formation of alliances. The vertical disaggregation means devolving some business functions to other organisations. It follows by reducing the size of the organisation, eliminating the roles and layers of middle management and pulling down the hierarchy. The flattening of organisational hierarchy can be considered as an internal organisational redesign. The critical difference is that the new organisational forms bring flexibility and are adaptive to new market requirements and customer needs. Network formation in the process of organisational transformation may be connected with conditions of environmental volatility and unpredictability. The new organisational forms can more likely be adopted by entrepreneurs, because of the difficulties faced by traditional, vertically integrated, hierarchical organisations. eBay.com and Amazon.com can be given as examples, where one of them is primarily an online auction and another one is an online marketplace. In both examples all players are actively involved in business processes. Customers can interact with each other and comment on the product/services on the space of eBay or Amazon, where stakeholders can also interact, and competitors can work together under the umbrella of a well known brand and so on and so forth. These two examples show that there is a need for network formation because of highly dynamic environments and its requirements.

One of those requirements is a rivalry in the information age that no longer takes place among single companies, rather it takes place among clusters of companies (who can be competitors in "real life") that act together to increase their profits. Companies need to use them to be able to gain a competitive advantage in the medium, where all competitors are only one click away. Networking, which encourages knowledge sharing among communities, is getting more and more important in the e-medium. Because many innovation processes are interactive, simultaneous networking across multiple organisations on a global scale is required. Internet based technologies can provide the network of links between geographically dispersed companies/individuals, which can facilitate effective knowledge sharing. Knowledge sharing is the key to effective use of knowledge for innovation (Swan, Newell, Scarbrough & Hislop, 1999).

The term 'Virtual Organisations' (VO) has become more and more important and is used in many different ways to guarantee business success. However, 'the virtue of virtualness' is quite limited to explain its application to the business environment

(Katzy & Obozinski, 1999). It is necessary to underline that VO "should not be approached as if it was a panacea, a solution to all business problems" (Warner & Witzel, 2004, p.96). VO has real costs and real challenges. It is complicated. On the other hand, the advantages of VO are also enormous: lowering transaction costs, flexibility, and better ability to manage intangible capital and create value from it. All these are benefits, which can be critical for competitive success in the knowledge economy (Warner & Witzel, 2004). Primary research by Wagner, Botterman, Feijen, Schmidt, Simmons, Hof, Iverson & Laerhoven (2004) shows that VO is more competitive than non-VO.

3.1.1.7 A Short Summary before Detailed Overview of Virtual Organisations

The Internet and its popularisation have changed business, education, and lifestyle in general. The knowledge based economy offers rapid IT development and the globalisation of the economy. IT has changed organisational forms. In the knowledge-based economy, both knowledge and innovation have become more important than ever before for gaining a competitive advantage. Nevertheless, in the knowledge-based economy many organisations find that operating alone may put them at a competitive disadvantage and that they may need to operate with others in networking. Therefore, the term 'Virtual Organisations' (VO) has become more important. It has been used in many different ways but with one meaning: to guarantee business success. However, VO should not be considered a panacea. It is just one of organisational forms in the organisational evolution, which became possible together with IT development. VO does not need be overestimated as well as underestimated. It has its own advantages as well as challenges. VO does not have one single form. It is as numerous as organisations can operate. OSS communities are one of the examples of VO, who have proven the successful side of VO, where knowledge is the basis for innovation in order to gain a competitive advantage in the knowledge based economy. Therefore, the next step will be an in-depth analysis of VO in the example of OSS communities in order to understand knowledge sharing and its managing in VO, in OSS communities.

3.1.2 Virtual organisations: detailed overview

3.1.2.1 Introduction

This section of the Chapter will investigate characteristics, features, drivers, advantages, risks, barriers, models, and work processes of virtual organisations (VO). Terms and definition of VO, types and models of VO, how VO works, characteristics and features of VO will be widely analysed. As an example of VO, open source software (OSS) communities will be chosen. However, before analysing the OSS communities and before the analysis of the topic of the thesis – knowledge sharing and managing knowledge issues, which will be carried out in the next Chapter, below in this Chapter VO will be overviewed in general. After the full understanding of VO and its internal operational processes, it will be possible to construct useful framework for knowledge sharing in virtual software products' organisations. This section will explore VO and prepare for the next Chapter on knowledge sharing in VO and in the OSS communities in particular.

3.1.2.2 Definitions

Since Mowshowitz in 1986 used the term 'Virtual Organisation' for the first time, many other authors have created a variety of different terms and definitions, which describe this new organisational form (Franke, 1999). There are varieties of differences in interpretation of VO from one author to another. Mowshowitz (1999) identified VO as a goal-oriented enterprise, which is operating under metamanagement – the management of a virtually organised task. The European Union[16] sees VO as a network of independent organisations, which to the outside world provide a set of services/functionality, as if they were one organisation. This networking can change/'end its life' with time or it can be more stable. According to Rowley (2002) and Browne & Zhang (1999), VO is a temporary network of independent companies (for example suppliers, customers and sometimes competitors) who are linked by IT to share skills, costs and access to one another's markets. Ariss, Nykodym & Cole-Laramore (2002); and Lin & Lu (2005) note that working together but separately from geographical or organisational boundaries as the main peculiarity of VO. There is an explanation of such kind of differences in VO's definition.

[16] Europa, Gateway to European Union, http://europa.eu.int/ISPO/ecommerce/books/aecev2/2_1.htm, accessed 30 March 2006.

According to Bultje and Wijk (1998) cited in Franke (2001), different interpretations of VO depend on different understandings of the word “virtual”. The word “virtual” has become more popular in 1990s together with the increased popularity of the Internet. In Latin “virtual” means “an intimately personal quality of goodness and power”. More recent meanings of virtual are “not in actual fact” but ‘in essence’, ‘almost like’ and ‘virtual reality’ (Lipnack & Stamps, 1997).

Bultje and Wijk (1998, cited in Franke (2001)) make the following distinctions in their interpretation of the term ‘virtual’. The first meaning of the term virtual is unreal and/or looking real: ‘virtual reality’, which means that VO has the appearance of a traditional company for externals, but in reality this company does not exist, it is only a business of independent network partners. Another meaning is immaterial and/or supported by IT which means that something does not physically exist; it is only created by data. Virtual shopping malls, software, e-newspapers and other products, which do not have any physical appearance, which can exist just online without being presented offline, whose existence is dependent on IT, intangible products can be given as an example of an immaterial / virtual product. The third meaning is potentially present, which means an organisation, which does not really exist, but would have the possibility to exist. Finally the fourth meaning is that it exists but is changing. The organisational unit exists, but the composition of partners is temporary. These kinds of companies exist permanently, but dynamically and progressively. Virtual corporations on the company level and virtual teams on the worker level can be given as examples for the following meaning. Venkatraman and Henderson (1996) cited in Sieber & Swagerman (2001), who define virtualness as the ability of an organisation to constantly manage key competencies through the design of value-adding business processes and mechanisms relating external/internal constituencies to deliver differential, better value in the market place.

Reflecting this range of differences, this thesis will adopt a broader meaning to VO so that it can cover the wide varieties of organisations, who present themselves in the online medium, in order to “give a chance” to all kind of organisations, who use the Internet and e-environment for their business benefits. As a definition of VO (see Appendix 1), this thesis will the use following meaning – a networking of independent companies/individuals, who work together temporarily for one goal without geographical/organisational boundaries linked mainly by Internet based technologies. In this definition, “mainly by Internet based technologies” means that communication between members of VO varies from face-to-face to just online interaction, which also depends on the level of “virtuality” in each particular VO.

3.1.2.3 Terms

Concurrent with different kind of definitions, there are numerous terms used for VO. Warner & Witzel (2004) identify the following terms.

A) Dispersed organisations are the earliest form of VO, the organisation that concentrates its capital in several different locations rather than in one place, such as banks or international trading companies. B) Virtual value chains are used for an extension of the dispersed organisation concept where a product or service transfers from supplier of components to producer of finished products and on to the customer, like most large companies in the automotive and consumer electronic sectors. C) E-commerce VO represents companies such as US online auction eBay.com or British travel and ticket retailer lastminute.com.

D) Virtual webs are collaborations between partners with common interests. Virtual webs can have three different forms: “virtual web platform” – a union of independent companies who agree to cooperate; “virtual corporation” (Franke, 2001) – temporarily created unit which configures on market opportunities and customer needs; and “net broker – as inter-firm network facilitator. E) Hologram organisations are the most complicated form of all where like a hologram, each component of the organisation is a miniature copy of the whole, for example Amazon.com. F) Virtual enterprises are temporary networks of independent companies that cooperate on a short-term basis for a particular project and appear to act as a single unit.

G) Learning organisations are organisations that learn. They are not strictly classified as VO, but widely use virtual elements, for example the World Bank, which developed an intensive global managing knowledge system. H) Hypertext organisations are more complicated forms of learning organisations where the organisation exists on several levels simultaneously. I) Virtual communities are an advanced form of communications networks where a number of different businesses or companies take part on an ongoing basis. They have one of two forms: a) exchange information or knowledge; b) marketing communities where a supplier contacts with a group of customers on a regular basis, such as virtual research consortia set up between universities.

J) Additionally, Davenport (2001) points out online communities of practice as the sites where knowledge is created in organisations, such as Xerox Corporation, where communities of practice were created as levers of new knowledge (Lave & Wenger, 1991; Wenger, 1998; Wenger, McDermott & Snyder, 2002; Amin & Roberts, 2008). Generally communities of practice can be considered as a unit of analysis for looking at work, learning, knowledge, and work identity formation (Ruuska & Vartiainen, 2005), whereas "electronic networks of practice are computer-mediated discussion forums focused on problems of practice that enable individuals to exchange advice and ideas with others based on common interests" (Wasko & Faraj, 2005, p.35). The concept "Community of Practice" (Lave & Wenger, 1991) helps to plan the core of informal and semi-formal structures as communities (Ruuska & Vartiainen, 2005). Hislop (2009, p.167) identifies communities of practice as "a group of people who have a particular activity in common, and as a consequence have some common knowledge, a sense of community identity, and some element of overlapping values".

Despite their formal structures and policies, organisations are increasingly developing communities of practice as strategic tools for knowledge creation and sharing within the organisation as well as across organisational boundaries (Wang, Yang & Chou, 2008). For example, Powers (2004) tells the story of successful knowledge sharing experience in Caterpillar (a manufacturer of construction and mining equipment, engines, and gas turbines) through communities of practice. Managing knowledge at Caterpillar used to rotate around coffee. Generally having a cup of coffee at Caterpillar with colleagues would allow employees to learn anything they needed to know. Such knowledge sharing processes worked for years. In January 1999, Caterpillar launched its Knowledge Network, which was a Web-based system delivered via the Internet to twelve communities of practice.

Powers (2004) continues that in the beginning, these communities of practice collected employees working to improve performance by collaborating and sharing knowledge, where the topics for the first communities were generally related to standards and regulations. Knowledge Network has probably not changed the organization's culture;

but it certainly has supplemented what had already been in place for more than 75 years: a real culture of sharing. Knowledge sharing in Caterpillar now takes place virtually instead of over a cup of coffee. Such practice achieves significant savings along the way. An initiative at Caterpillar evolved into a successful, enterprise-wide process with projected savings of USD 75 million. Caterpillar's Knowledge Network thrives with 3000 specialised communities of practice. Caterpillar measures its managing knowledge success and achieves a 200% ROI for internal communities and more than 700% ROI for its external communities. Many organisations, such as Motorola, HP, IBM, Xerox, Ford, and Shell, have adopted communities of practice as a managing knowledge tool (Wang, Yang & Chou, 2008).

3.1.2.4 Type and Models

Ariss, Nykodym & Cole-Laramore (2002) identify the following three types of VO. They can consist of a group of skilled individuals in a company working via computers, phone, and video conference. Or VO can consist of a group of partnering companies who specialise in a particular industry such as marketing. And finally VO can consist from a large company, which outsource its operations and use ICTs to share knowledge to/among partner companies.

Jansen, Steenbakkers & Jaegers (1999) note that VO can be static – 'seemingly existing'; customers think that they deal with only one company, whereas in reality it includes a network of organisations. In stable ('permanent') VO the collaboration has a more or less permanent character. Usually there is one organisation who is the core player and who identifies the rules for the collaboration. Well-known examples of such VO are Dell and Amazon.com. VO can also be dynamic – 'potentially existing'; where dynamic networks engage in common action at the moment when customers approach them with an order or a problem.

Franke (1999; cited Klein, 1994 and Scholz, 1997) divides VO into two types from a functional and institutional perspective. From a functional perspective, VO is an (intra-) organisational creation such as virtual department or virtual office. In the institutional perspective (inter-) VO is "a frequently co-operating, flexible network of legal independent companies, which uses their resources jointly and in which each company contributes only their strength to the common organization" (p.208) such as virtual markets.

Burn, Marshall & Barnett (2002) identify the models of "virtuality", according to their level of being in the virtual medium (Figure 3.2). It was found that depending on the level of autonomy/substitutability of virtual links and interdependence/strength of organisational links (in terms of collocation, culture, synchronicity, shared risks compared) there can be seven different forms of "virtuality": virtual face, co-alliance, star alliance, value alliance, market alliance, virtual broker and virtual space.

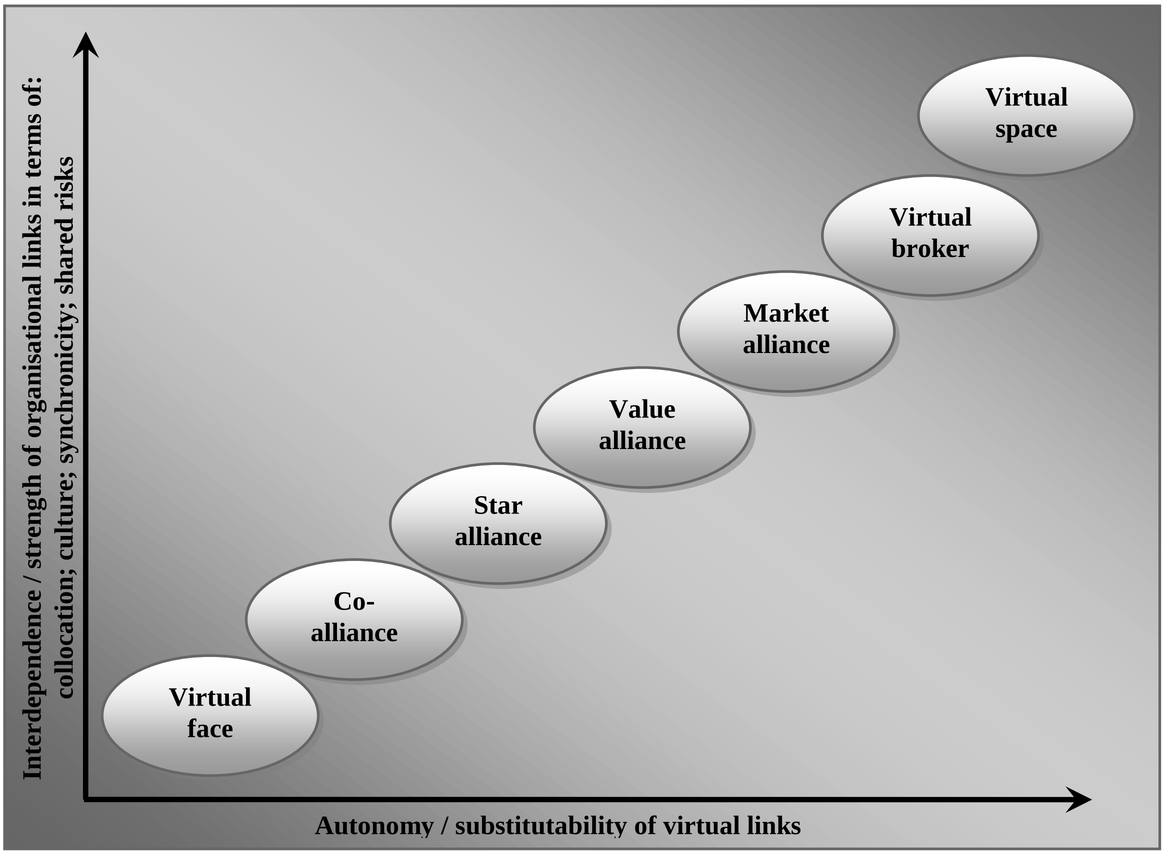


Figure 3.2: Models of Virtual Form

(Source: Burn & Barnett, 2000)

Burn, Marshall & Barnett (2002) give the following clarification to the above mentioned models of virtual forms. Virtual faces are companies that do their business offline and online; they are the cyberspace incarnations of an existing non-VO, who combine the place and the space to gain additional value, such as in marketing. Online transactions, web based versions of TV channels and newspapers are examples of virtual face, like http://www.bbc.co.uk. Co-alliance models are shared partnership in online medium with equal commitment in VO for speed, efficiency, and mutual benefits, for instance collaborative design or engineering, virtual support with a virtual team of consultants. For example, WorldProperties.com is backed by the International Consortium of Real Estate Associations (ICREA), where more than thirty leading national real estate organisations representing two million brokers and agents worldwide for assisting them in marketing and facilitating business in the global marketplace.

The star-alliance model (core or satellite) is a set of coordinated networks with dominant companies – leaders in a market/industry, for example, Recreational Equipment Inc. (http://www.rei.com/) is an outdoor gear and clothing cooperative mail-order business with many brick-and-mortar retail outlets across the USA. Value-alliance models (stars or constellations) bring products and services together in one package and are based on the value or supply chain model, for example Tesco.com. Market-alliance models are companies, which primarily exist in the online medium and depend on their member organisations for the provision of actual products and services, for example Amazon.com.

Virtual brokers are those who are either designers of dynamic networks, third part value added suppliers, web marketing events' organisers, information brokers, or new intermediaries, for example AOL, travel booking systems like Amadeus and Sabre. According to Franke (2001), net-brokers have three main management roles. First of all, they are initiators, where a net-broker searches for companies with criteria of knowledge, core competencies and capabilities, to work in partnership. In this stage the net-broker contacts individuals/companies, brings them together and builds communications between them. The main aim of these of activities is to create trust. The net-broker has to clearly identify aims, mission, vision, rules, and regulations. The net-broker should make pre-qualification criteria for new entrants, or procedures for sharing cost, risks and profits in VO. Then in the second stage net-brokers should perform maintenance: to improve collaboration, a net-broker needs to monitor the performance within VO in order to achieve the required performance, i.e. to have trusted and honest collaboration. The net-broker plays a role of the neutral judge. The net-broker also needs to organise the learning activities inside of VO, special interest groups, seminars, workshops, etc. And the final role is formation where the net-broker knows the resources and core competencies, strengths and weaknesses of the web partners. The net-broker is a leader of independent enterprises in VO (Franke & Hickmann, 1999).

The net-broker is the first and leading member of VO who acts as an information broker, as an initiator, who is the driving force for the formation of VO, who searches and chooses appropriate, competent and complementing partners, defines the business roles of VO members, resolves conflicts between members during the operation of VO and is the primary point of contact for customers of VO. It is important to distinguish the net-broker's roles and duties on the macro and micro-organizational level. On the macro-organizational level the net-broker manages VO, on the micro-organizational level the net-broker acts as facilitator and moderator. The net-broker can be an individual, a group of managers or even a net-broker firm (Franke, 1999; cited Kanet and Faisst, 1997).

Finally, virtual space is made up of communities, who fully exist in online medium, for example open source software communities or the three dimensional virtual world SecondLife.com. A full investigation of virtual space and OSS communities in particular will be carried out later in this Chapter.

3.1.2.5 Creation of VO

According to Katzy, Sung & Serrano (2004) and Hannus (2005) during the start up phase of VO designing and organising vision, goals and core team should be created. Then network business plans should be developed and partners should be selected. And then VO can be operated. VO management consists of project roles and network roles. Project team's responsibilities include bringing partner's competencies together, designing business models, communicating with customers, and the joining together of different players. Network roles require a broker, an auditor, outsourcing, leadership team, and a network coach. (Bremer, Mundim, Michilini, Siqueira & Ortega, 1999; Hannus, 2005).

According to Warner & Witzel (2004), the creation of VO does not mean setting up computer networks and then building a VO around it. First of all virtual space should be created, a space where VO exists. For this aim, 'special' people with 'special' skills are required. It means a space, where knowledge will be created; a well organised and maintained IT systems; and an appropriate organisational culture[17], which identifies how knowledge sharing and what kind of knowledge is used the most. This should be a space where people do research and create innovative new products; a space with knowledge workers. Before creating VO, in order that VOs are successful, a lot of questions should be answered such as what are the needs? Who are the customers? Who will work? Which skills are most required? Who will provide financial needs?

However, it is important to point out that creation of VO should not be considered the same in each particular VO. Its creation is dependent on its form. Some of them can be created from scratch and develop from a creation a virtual space. However, there are plenty of examples of VO that evolve from existing organisations, for instance the BBC, have a physical organisational form and in addition to that created an online presence. The creation of VO can vary according to the types, models and forms of VO mentioned above.

3.1.2.6 Characteristics and features

Although definitions of VO and terms, types and models used for VO vary from one author to another, there are certain key characteristics of VO (Jansen, Steenbakkers & Jaegers, 1999; Katzy & Schuh, 1999; Walters, 2000; Wagner, Botterman, Feijen, Schmidt, Simmons, Hof, Iverson & Laerhoven, 2004; Warner & Witzel, 2004; Loeh, Katzy, Booth, Faughy & Thompson, 2005; Hannus, 2005). The main characteristic of VO is its temporary nature; in other words VO can be built and then 'end' its life after reaching its main aims and objectives[18]: short term for one business opportunity and long term for few or many opportunities. As it is a temporary network, it can often change participants where no geographical boundaries exist. VO is an open and transparent organisation (Jansen, Steenbakkers & Jägers, 1999; Warner & Witzel, 2004). The structure of VO is based on dynamic networks, which can change quickly according to the market requirements. VO is knowledge, relationship, and technology management focused organisation (Walters, 2000). The main power of VO is

[17] The issues related to identification within the online community will be considered in the next Section of this Chapter.
[18] Europa, Gateway to European Union, http://europa.eu.int/ISPO/ecommerce/books/aecev2/2_1.htm, accessed 30 March 2006.

knowledge and skilled specialists, whose relationships are based on cooperation and collaboration and motivated by achieving team goals.

Various literature investigates characteristics and features of VO (for more details, see Jaegers, Jansen & Steenbakkers, 1998; Browne & Zhang, 1999; Jansen, Steenbakkers & Jaegers, 1999; Burn, Marshall & Wild, 1999; Burn & Barnett, 2000; Tayles, Webster & Bramley, 2005; Lin & Lu, 2005; Warner & Witzel; Hannus, 2005). According to the literature, VO is transparent and open; it is flexible; it provides suitable environment for knowledge sharing. VO provides a flexible environment to its members, which is true in some examples, especially for knowledge workers. Members of VO can work while they may be physically far away from the office. The value of the know-how workers is assessed by the value and extend to which they share their knowledge, if even they share their knowledge by being physically located in their houses, if their connection to the world is via an electronic medium.

Although reliance on IT is an important factor in VO, the following Chapter will show that sharing knowledge is a key factor in gaining success and competitive advantage. Therefore it is important to build trust-based communication in VO (Steil, Barcia & Pacheco, 1999; Franks, 1998; Vlachopoulou & Manthou, 2003; Franke, 2001; Lin & Lu, 2005; Browne & Zhang, 1999). The idea of reciprocity is important (Maki-Komsi, Poyry & Ropo, 2005). In VO value is created, not added. The core principle of VO is the fast combination of the core competencies and resources of different companies for a business opportunity, shared profit and gaining competitive advantage in new markets which single companies cannot enter alone (Tayles, Webster & Bramley, 2005; Burn, Marshall & Wild, 1999; Burn & Barnett, 2000; Lin & Lu, 2005; Browne & Zhang, 1999; Jansen, Steenbakkers & Jagers, 1999; Warner & Witzel, 2004).

Such flexibility and responsiveness facilitates the opportunity to provide products and services, which are difficult to implement by single companies. Single companies may no longer be able to provide products or quality to their customers. Creating valuable products for customers is becoming a complex process, which requires a combination of many different types of knowledge. A group of companies needs each other's core competences, in other words they need knowledge to produce products/services, which is formed in VO. Therefore, mass customisation is easier to implement through collaboration in VO. Companies are more efficient in the e-medium where they collaborate with each other to react to the demands of the environment (Lin & Lu, 2005; Browne & Zhang, 1999; Franke, 2001). When companies share their sources, experience and skills, they can increase efficiency and decrease the sensitivity to the strengths of the competitors.

Differentiation, when customers expect their products to be tailored to their own particular circumstances and needs, is an important driver for VO. In contrast to the traditional push approach, the new virtual concept is designed for the pull system. The virtual world through IT innovation can provide services/products upon desires/requests of customers, without pushing, but by pulling such products or services. In this case, tacit knowledge particularly begins to play a more important role than anything else, because tacit knowledge is needed to create specialised products. Tacit knowledge is know-how. Mass customisation is easier to produce by using unique know-how, rather than serial, documented versions of production, which can be produced by using explicit knowledge (detailed analysis will be given in the next Section).

The ability of market players to organise appropriate strategies, to be first on the market to gain competitive advantages over their competitors, who are only one click away, is crucial. Worldwide competition is another driver for VO. International competition is a coin with two sides; one side is of great opportunities worldwide, the other side, increasing rivalry worldwide. In this case companies cannot compete alone and need to unite under one umbrella – VO (Franks, 1998; Franke, 2001; Vlachopoulou & Manthou, 2003).

Considerable amounts of existing literature (for instance, Jaegers, Jansen & Steenbakkers, 1998; Browne & Zhang, 1999; Jansen, Steenbakkers & Jaegers, 1999; Burn, Marshall & Wild, 1999; Burn & Barnett, 2000; Tayles, Webster & Bramley, 2005; Lin & Lu, 2005; Warner & Witzel; Hannus, 2005) note that compared to "old" economy by its old control based culture, in VO it is expected to have partners' "equality game" with equal rights, where everybody plays her/his own role. According to that understanding, the "equality game" provides a good environment for knowledge sharing. However, as will be demonstrated later in the empirical studies in this thesis, VO may also have their own well defined hierarchical levels among workers.

As the difference between companies in “old” economy and VO in the knowledge economy, the opportunity and transparency to share knowledge, the motivations influenced to share knowledge get a competitive advantage in the e-medium. Therefore, particularly in VO knowledge sharing and trust is particularly important. The knowledge-based economy requires knowledge workers, for example in the IT industry. At the same time there is more job rotation with unclear differences among traditional work activities, where more self-managing or autonomous work groups take more responsibility (Burn, Marshall & Wild, 1999).

In fact VO can combine its former competitors in order to gain a competitive advantage together in new markets. Companies can access a wide range of specialised resources and use competencies unavailable internally. On the other hand, individual members retain their independence and continue to develop their core competences. As s consequence, VO can aim for larger, complex, and higher value opportunities than individual companies. At the same time, VO collects necessary competencies from a range of independent external agents through the strategic use of outsourcing mechanisms. Members of VO can more easily access very different markets, including international ones. Case studies by Hannus[19] (2005) show that VO reduced the financial investment of the partner by 50%, overall investment by 20%, cooperation set-up time by 50%, overall time to market by 25%, and increased revenue up to 25%.

3.1.2.7 Challenges

Although there are numerous advantages of VO, providing many benefits to companies, there are some points, which should be considered carefully in order to be successful in the e-medium and/or within VO. Wagner, Botterman, Feijen, Schmidt, Simmons, Hof, Iverson & Laerhoven (2004) search barriers to VO operation in Europe. Even though their outcomes are relevant to VOs in Europe, they can be considered in other parts of the world as well. According to Wagner, Botterman, Feijen, Schmidt, Simmons, Hof, Iverson & Laerhoven (2004), the main limitations to VO operation are financial, tax and law, technological, and logistical barriers. SMEs especially can face such difficulties more sensitively. Trade and tax law barriers such as the hiring of skilled staff, cross border problems; labour tax barriers such as social benefits and long-term contracts

[19] Was accessed in 2006, in April 2009 this article was not found in online sources.

need to be considered at government level. The main point, which is underlined in academic literature regarding risks in VO, is issues related with trust and communication (Steil, Barcia & Pacheco, 1999; Franks, 1998; Vlachopoulou & Manthou, 2003; Franke, 2001; Lin & Lu, 2005; Browne & Zhang, 1999).

The environment of VO is mostly electronic. Staff members, who mainly work differently from face-to-face interaction, may manifest as an obstacle in meeting business partner expectations (Browne & Zhang, 1999). The isolation between managers and staff will sometimes negatively affect productivity. Multiple locations may cause problems related to culture and language differences. Having staff, employed at different times, in different places and under different conditions can generate some difficult group dynamics.

Therefore, VO works better when players are well prepared. VO looks like a team sport. To be a successful team, players ought to know each other and have common tactics and training combinations. When players do not know each other and have not played before together, they will need time before they achieve success. Setting-up and running VO requires successful management (Browne & Zhang, 1999; Franke, 2001; Lin & Lu, 2005; Hannus, 2005). All the mentioned challenges may influence knowledge sharing in VO, which is very important for gaining a competitive advantage in the knowledge-based economy, therefore it is important to study managing knowledge in detail to understand how VO can overcome the problems these challenges may create.

3.1.2.8 A Short Summary before Discussion

As highlighted in the above analysis, IT development has brought evolutionary changes in organisational forms. Mainly together with the Internet, the term “virtual organisations” has gained increased popularity. However, it is important to understand that there are so many varieties of organisational forms. There are numerous business organisations, which operate different, sometimes oppositional forms of businesses. Therefore, they cannot all be considered as one model in the online medium. This is the reason for so many varieties of definitions, terms, models and types of VO, analysed above. Under the term of VO (see Appendix 1), this thesis will use a network of independent companies/individuals, who work together temporarily towards one goal without geographical/organisational boundaries linked mainly by Internet based technologies.

3.1.3 Literature Review on Knowledge Sharing in VO

"If you have knowledge, let others light their candles at it."
Margaret Fuller (1810 - 1850)

3.1.3.1 Introduction

Warner & Witzel (2004) note that knowledge transformation processes lie at the heart of VO management and knowledge sharing is its 'motor' in VO. Knowledge and its sharing is as crucial in online networking as in VO. Knowledge is intangible; therefore, knowledge plays a crucial role in the e-environment, because the nature of the e-environment is also intangible. Practice and further empirical studies, which will be made in this thesis, show that highly qualified people in industries such as IT are knowledge workers, e.g. developers in the OSS communities. People who have knowledge are the most valuable commodity in the knowledge-based economy, where knowledge sharing is power (Davidson & Voss, 2002). At the same time, the biggest challenge in encouraging a VO is the supply of knowledge, explicitly the willingness to share knowledge with other members (Chiu, Hsu & Wang, 2006). Therefore studying knowledge sharing in VO is important.

As discussed earlier, although knowledge sharing is power, one should consider why knowledge workers share their precious value with others, if their know-how is precious in the market. What are the reasons/motivations/intentions behind sharing knowledge? Is it simply altruism? For some of them, perhaps it is. Is it simply peer recognition? For some of them, perhaps it is. If they want to share their knowledge, can they really share it? What exactly are they sharing? The literature review shows that all issues have much deeper reasons, which can be analysed in more detail. It is important to understand knowledge sharing processes, to link them within the new form of organisation in the e-medium, VOs, and analyse how knowledge is shared in OSS communities in order to shed light on innovation processes in VOs. At the moment, there are rather more questions than answers.

The point is that in VO any business processes, including knowledge sharing, which can be applied in a 'traditional' environment, cannot be simply replaced in e-medium. The same application of the same processes in both the non-electronic and electronic worlds can give different results. Face-to-face meetings in traditional organisations with colleagues, for example during daily coffee breaks, or online meetings in VO, for example, Skype conferences with colleagues, who may never meet in real life, can give different results. Therefore, organisations, which enter the virtual world, need to redesign their internal structure and their external relationships. They need to review creating knowledge networks to assist improving the communication of data, information, and knowledge. If we consider managing knowledge processes to be a black box, then it is possible to identify knowledge as inputs, knowledge transformation processes inside of VO as a black box, and value from these processes as outputs. Inside such a black box of knowledge transformation processes, it is possible to identify three stages: knowledge creation and acquisition, knowledge organisation and storage, and knowledge use (Warner & Witzel, 2004). We will now explore the inside of that black box and what scholars have found so far in the topic of knowledge sharing.

3.1.3.2 Motivations for Sharing Knowledge

According to Huysman & Wulf (2006), distributed community members will be more able to connect and use electronic networks when they are a) motivated to share knowledge with others, b) able to share knowledge, and c) have the opportunity to share knowledge. Therefore, it is important to explore why individuals decide whether or not to share knowledge with other community members, when they have the choice. Chiu, Hsu & Wang (2006) also support Huysman & Wulf (2006) and think that finding out the motivations essential for the knowledge sharing behaviour in VO, including online communities, can help to investigate how to stimulate knowledge sharing in online communities in particular and in VO in general.

The empirical studies carried out on one of the forms of VO, online communities of practice, by Ruuska & Vartiainen (2005), show that organisations allocate time for participation in the community. However, this time may be insufficient, and therefore there is more willingness to participate than enabled. The lack of common language around communities may reduce the organisational support. Later, Ruuska & Vartiainen

(2005) conclude their findings by pointing out that communities as systematic knowledge sharing mechanisms call for recognition, where knowledge sharing requires more actual doing work together and policy practices to support the sharing.

Dougherty (1999), as cited in Perez-Araos, Barber, Munive-Hernandez & Eldridge (2007), proposed that knowledge sharing is "about connection not collection" where connection depends on a choice made by individuals. Such a connection may allow for an increase in motivations to share knowledge. Empirical studies made by Maki-Komsi, Poyry & Ropo (2005) show the following as the success factors of knowledge sharing in VO:

- communication of the required information,
- support for informal learning based on colleagues' practical experiences,
- shared work practices within the team or community,
- right group membership (or target group),
- group members' attitudes towards knowledge sharing,
- openness towards knowledge sharing,
- feeling of community with remote colleagues,
- voluntary participation in the knowledge sharing activities,
- shared responsibility for sharing knowledge,
- agility of the tools in use,
- good team leadership coordinating the communication.

As discussed earlier, the ability to share knowledge and motivation/desire to share knowledge are not the same. The ability to share knowledge may not be time and cost effective. Even if it were, the ability to share knowledge might not be always possible or easy to implement. Such ability may vary from organisation to organisation. Some tacit knowledge may be shared, whereas some other tacit knowledge may not be shared. Therefore, the ability to share knowledge issues should be investigated further.

The motivations behind sharing knowledge in VO and particularly in OSS communities will be analysed later in this Chapter, when OSS communities will be explored in detail.

3.1.3.3 KM Tools to Share Knowledge: IT versus Social Networking

By analysing KM tools, Huysman & Wulf (2006) list the design of knowledge-sharing tools that should be considered as the following: the idea that information systems aim to preserve the integrity of the social communities, where knowledge is set in should be avoided. This requires the introduction of socially embedded technologies. The management trap, which implies the introduction of systems that corresponds to the actual needs and requirements of knowledge workers to share knowledge rather than those of management, should also be avoided. This means the social nature of a community should be analysed in order to understand how and why community members share knowledge. It should steer clear of the individual learning trap that requires tools which support social relationships and communities rather than setting up knowledge repository systems and intranets that are designed to support knowledge storage and retrieval (Huysman & Wulf, 2006).

Huysman & Wulf (2006) argue that aids to knowledge sharing (intranets) and knowledge bases that are created for codifying knowledge are not effective enough, because in sharing experiences, people prefer to have support from personal networks rather than from electronic networks to gain knowledge about the knowledge. Such knowledge sharing interaction, which is called ‘metaknowledge’ by Huysman & Wulf (2006) cannot be recorded electronically. Moreover, it requires the support of social personal networks. This means that tacit knowledge does not need to be transformed into explicit knowledge in order to share it with others (Huysman & Wulf, 2006).

3.1.3.4 Tacit-Explicit Knowledge Sharing

Based on Nonaka & Takeuchi’s model (1995) of knowledge conversion (Chapter 2), Steil, Barcia & Pacheco (1999) offer the following way of creating and disseminating of tacit and explicit knowledge in VO (Figure 3.3).

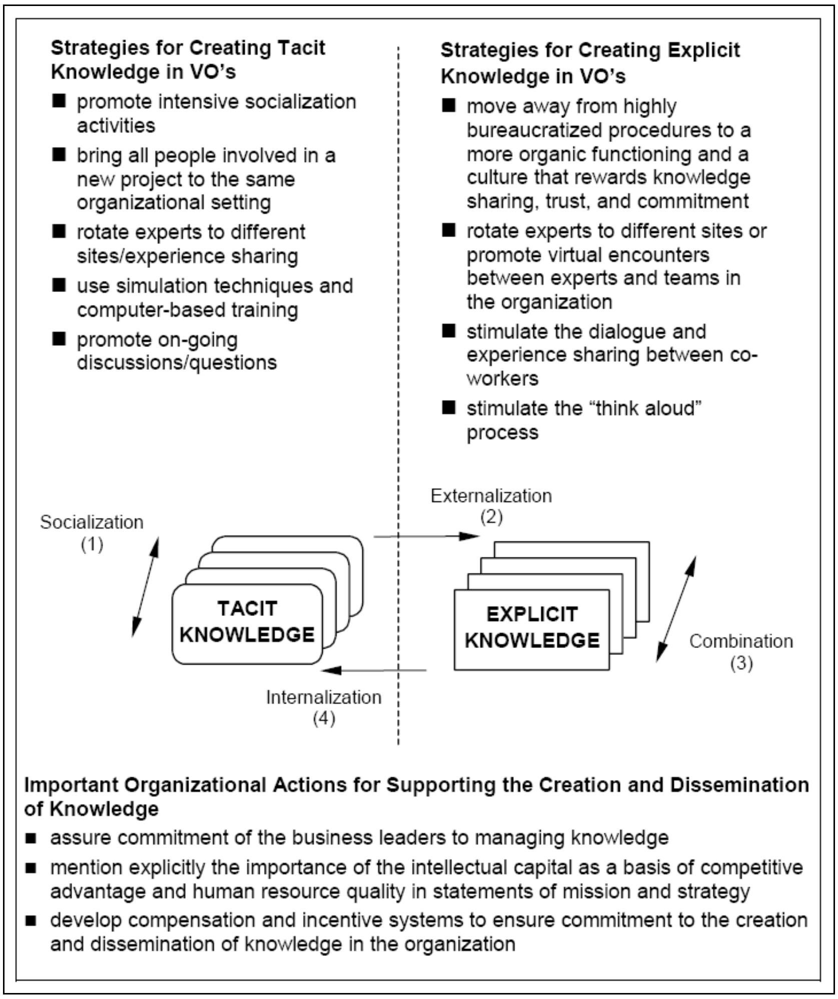


Figure 3.3: Strategies for Creating and Disseminating Knowledge in VOs

(Source: Steil, Barcia & Pacheco, 1999, p. 81)

(a) The Creating and Disseminating of Tacit Knowledge (Figure 3.3)

Socialisation (the transformation of tacit knowledge to new tacit knowledge) depends on the development of empathy between colleagues. The difficulties in creating and disseminating tacit knowledge from existing tacit knowledge in VO can exist for the following reasons. Tacit knowledge is not leveraged by VO as a whole. The absence of physical closeness can result in different understandings of the same thing in different ways (aims/objectives of a project, business aspects, communication, relationships, etc.).

Physical diffusion in VO can damage the spirit of co-operation culture, collaboration, help among colleagues, etc. competitiveness between colleagues in VO can also develop. In internalisation (the transformation of new tacit knowledge from existing explicit knowledge) an individual identifies the knowledge that is relevant for them within the organisational knowledge, and uses this explicit knowledge in their daily work. The main difficulty in creating and disseminating tacit knowledge from existing explicit knowledge in VO is the possible different interpretation of the same event.

In order to successfully implement the creation and dissemination of tacit knowledge either from existing tacit or from explicit knowledge in VO, Steil, Barcia & Pacheco (1999) offer the following strategies: the appropriate environment for tacit knowledge creation and diffusion, for instance bringing all staff involved in a new project to the same organisational setting in order to build the same understanding of the project goals, the role of each group, etc. Such face-to-face interactions strengthen the collaborative relationship between individuals and should therefore be developed. How does this happen in VO? Clearly it depends on the form of virtuality organisations have. For instance, how does this happen in the OSS communities for example? This will be examined by the empirical studies later in this thesis.

Steil, Barcia & Pacheco (1999) argue that promoting intensive socialisation activities, especially for newcomers, in the form of training activities, to build vital trust in knowledge creation and sharing in VO, can be implemented. These training activities include: rotating experts to different sites/experience sharing, vital in VO, as less experienced staff may gain benefits from observation and discussion with expert peers; using simulation techniques and computer-based training, which are useful methods for converting explicit knowledge into tacit knowledge, because they provide a safe environment for using explicit knowledge in staff's daily tasks, are useful; promoting incomplete discussions via digital format, for instance newsgroups, bulletin boards, Internet discussion lists. According to Steil, Barcia & Pacheco (1999) these strategies can be useful for the creation and diffusion of tacit knowledge.

(b) The Creation and Dissemination of Explicit Knowledge (Figure 3.3)

Combinations (conversion of explicit to new explicit knowledge: sorting, adding, re-categorising, and distributing explicit knowledge through computers, groupware, data warehousing, LANs, etc.) seem simple in VO. The difficulties in creating and disseminating explicit knowledge from existing explicit knowledge in VO can arise mainly because of the problem of interoperability.

On the other hand, the difficulties in creating and disseminating explicit knowledge from existing tacit knowledge are the attempt to express the "inexpressible" and the fact that some staff do not want to share their tacit knowledge expertise. Externalisation (converting tacit knowledge to explicit knowledge, which is a key process in any organisation) is difficult to carry out because of the reasons discussed earlier. Additionally, according to Steil, Barcia & Pacheco (1999), tacit knowledge has semiconscious and unconscious scope of which the individual has no awareness. Some types of tacit knowledge are fixed in physical abilities, so it is difficult to explicate and formalise them (see the previously discussed 'inarticulable' knowledge). Another reason is that some people do not like to share their tacit knowledge as they wish to protect their competitive advantage. In this case, Steil, Barcia & Pacheco (1999) suggest building a culture of trust and teamwork.

To successfully implement creating and disseminating of explicit knowledge from tacit knowledge in VO, Steil, Barcia & Pacheco (1999) offer the following strategies. VO needs to move away from bureaucratised procedures to a more organic functioning and a culture for knowledge sharing, trust, and loyalty. VO needs to be based on a culture of flexibility, agility, trust, sharing, and commitment. Rotating experts to different sites or promoting virtual encounters between experts and teams in the organisation opens the best channels to stimulate the exteriorisation and formalisation of tacit knowledge and stimulating dialogue and experience sharing between staff. This is coupled with stimulating the 'think aloud' process in VO as a way of revealing patterns of problem resolution.

3.1.3.5 Individual Knowledge Sharing

Faraj & Wasko (2001) identify two issues for knowledge exchange: perceived knowledge contribution and perceived knowledge acquisition. Successful knowledge sharing is possible by a two-sided relationship, which in practice means individuals should gain new knowledge and contribute with their existing knowledge. For knowledge sharing, authors identify three main factors: motivation, ability and relational capital.

In terms of motivation, authors identify social affiliation and professional affiliation. Social affiliation means the development of personal friendship, the creation of social ties with like-minded people, gaining feeling of belonging, to be socially competent and skilful. Professional affiliation provides support in the form of professional identity, exchanging advice/solutions, helping other people, to be close to innovations/ideas.

The second factor is ability. In the e-medium, knowledge workers are highly valuable. Therefore, to have subject expertise in the community of knowledge skilled people and have tenure in the form of an extended time of participation in a VO (the longer an individual participate in the group, the better s/he understands the sharing language, codes, organizational culture) is important for successful KM in VOs.

The third and final factor is relational capital, which is associated with such sub-factors as obligation, norms, trust, and identification. Obligation is an assessment of the amount of commitment an individual has to the group. A measurement of how much an individual feels responsible to help other people in VOs, how much obligation s/he feels to participate, what s/he feels that other people in VOs expect them to participate. Norms are rules and standards used in a particular Virtual Organisation between members. Trust is one of the critical issues for healthy relations between members in VOs. The more trust that occurs between members, the more knowledge is shared between them. Identification is a measurement of how much an individual relates his personal identity with the identity of VOs. These factors in knowledge sharing will be considered in detail in the section below addressing OSS communities.

3.1.3.6 Organisational Knowledge Sharing

In Figure 3.3, it is still unclear what kind of knowledge that model considered: individual, or organisational, or a combination of both. According to Leonard (1999, cited in Clarke (2001)), knowledge creation and diffusion activities in organisations is possible when external knowledge should be imported into internal knowledge, which should later be integrated and shared within the organisation. Such knowledge sharing will allow the creation of new knowledge based on current knowledge and experimenting with prototyping future capabilities. All these activities need to be carried out on a constant and simultaneous basis. However, can external knowledge be considered as the individual knowledge of the members of VO? If so, then internal knowledge can be considered as organisational knowledge, and the relationship between external and internal knowledge should be investigated further.

Christensen (2007) analysed organisational knowledge sharing and found five problems: the stickiness of knowledge (Nonaka and Takeuchi, 1995; Szulanski, 1996, 2003), no common identity (Brown and Duguid, 2000; Davenport et al., 1998), no relationship between the receiver and sender of knowledge (Davenport and Prusak, 1998; Hansen, 1999), no willingness to share knowledge (Cabrera and Cabrera, 2002, Osterloh and Frey, 2000), no knowledge of knowledge (Borgatti and Cross, 2003; Gupta and Govindarajan, 2000; O'Dell and Grayson, 1998).

Strach & Everett (2006) created a model for knowledge sharing, where they characterise access to knowledge sharing channels, motivation to share knowledge, and the ability to share knowledge as knowledge sharing facilitation factors. The model might be applied to organisational knowledge. According to the model, access to knowledge sharing channels might be considered as IT systems inside/within organisations and well organised access to explicit knowledge. Motivations to share knowledge (which will be considered in detail in the section below: OSS communities) might be obtained via the successful management of knowledge, healthy management in general and a friendly, open atmosphere inside organisations.

3.1.3.7 Summary/Discussion: What Was Found So Far and What Will Be Done Next?

From the definition of VO above (see also Appendix 1), it is clear that this thesis is using the general meaning of VO, which covers almost all forms of VO. There are some additional points, which are necessary to consider. In the above section of this Chapter, the detailed overview of VO was presented. As can be seen, there is extensive literature providing knowledge of different kinds of VO. This Chapter reviewed the current literature on VO to understand online organisational forms better in order to move on to one of the specific forms, virtual space in the form of OSS communities. The next Chapter will review the current literature on knowledge sharing in OSS communities in detail and most importantly the gaps in the current academic literature will be analysed. Therefore, an in-depth analysis of knowledge sharing in VO and in OSS communities in particular will be given after a detailed overview of managing knowledge in OSS communities. Before moving to the next section of this Chapter, the issues found so far should be recalled.

Being virtual in the knowledge economy means to be active online in business processes. It gives considerable advantages to companies in that they can improve their competitive abilities. VO can be considered as temporary, flexible, knowledge and trust-based networks that operate in the online medium. VO offers several benefits for companies. Businesses can gain a competitive advantage in the e-medium through collaboration in VO. By successfully entering the market and by collaboration, companies in VO can increase their profits, productivity, and competitive advantage in addition to reducing transaction costs. These days, it is hard to imagine any organisational forms that would not at least try to consider using the Internet for their benefits.

However, companies may face many challenges using the e-medium. In order to gain competitive success, VOs should find ways where they can turn disadvantages into advantages for themselves. Not all businesses or business processes can be simply replaced by online medium. Moreover, VO is not a panacea (Warner & Witzel, 2004), ‘a drug for all diseases’. VO is evolution, instead of revolution in business development. It is just an extra way to gain a competitive advantage in the knowledge-based economy. VO should not be considered as a solution for problems. In fact, VO can create even more problems; one of the principal problems can be geographically dispersed staff issues (Browne & Zhang, 1999).

The existence of lots of varieties in the definitions, terms, models, forms, and types of VO has arisen from different understandings of the word “virtual” by different scholars (Franke, 2001). It is important to understand that the creation of VO did not materialise out of nothing. The majority of organisations use the online medium as an addition to their offline “normal” business life. As discussed, examples for virtual face, star alliances, co-alliances and so on can be given for such kind of organisations where the online model is an addition to the offline model of the business. Some companies choose a semi-virtual model whereas other companies select a fully virtual existence. Companies choose the level of “virtuality” according to their needs and the nature of their products/services, for example, hotels with physical services cannot be compared with the virtual world Second Life. Online auctions and banks need different levels and different approaches in e-business. Hotels and universities have different needs and expectations for their profits from the online media. In fact, those who produce intangible products, such as OSS, may no longer need physical offices. OSS communities are key examples of virtual space.

The Internet offers many varied opportunities, which can be exploited depending on several factors, the nature of the business, the market requirement, profits, etc. Perhaps that is why there are numerous varieties of different types, models, definitions and terms of VO in the literature, which are used under one umbrella of VO to cover a general understanding of the concept of VO. However, as seen in the literature review, although there is plenty of work regarding VO, the majority of it is concentrated on VO structures, rather than on work processes in VO, which can have its own explanation. The "virtuality" of organisations can vary for different levels, having specific characteristics for each particular organisation, and depending on internal as well external factors, work processes vary from one VO to the next.

Therefore it is more suitable to analyse work processes of VO in particular cases. It would be very difficult or even impossible to consider work processes in different forms of VO under one umbrella definition of VO. Different forms of VO require different work processes. Work processes in the online medium of a hotel are clearly different than work processes of an online shop like Amazon.com. Perhaps this is why there is a shortage in the academic literature on work processes on VO. It is useful to analyse work processes in different VOs separately and to then make analogies or comparisons. At this stage, the thesis will analyse the work processes in the most developed form of VO – virtual space. As an example of virtual space, OSS communities will be considered. The reason for choosing OSS communities will be given in the next Chapter, when OSS communities will be analysed in detail.

As previously mentioned managing knowledge has gained a new and even more important role than before, because knowledge is the main driver in the knowledge-based economy. Knowledge can be considered as a key component in VO, where companies/individuals collaborate to gain a competitive advantage through knowledge sharing. Because of the importance of managing knowledge and increasing importance of knowledge sharing in the VOs, the role of knowledge sharing within VO needs to be studied more specifically. Knowledge sharing issues take an important, if not the most important, role in successful VO. VOs are created on knowledge and an appropriate organisational culture in VO identifies how knowledge sharing and what kind of knowledge is the most used. In VO, knowledge can be considered as the heart of VO (Warner & Witzel, 2004). Therefore it is important to understand knowledge sharing issues in VO.

The main question, which should be analysed later in detail, is how the OSS communities work that allows them successful knowledge sharing inside of these communities? This justifies this thesis, which will carry out empirical studies on OSS communities to find out how and to what extent knowledge is shared in OSS communities. The thesis is intended to shed light on the knowledge sharing processes in the VOs, and thereby constitute to our understanding of the role of knowledge sharing in the VO context. In order to develop a model for successful knowledge sharing processes in the VOs, the thesis will assess how and to what extent knowledge is shared in the OSS communities.

Section 2: Open Source Software Communities

OSS communities were chosen for empirical studies in this thesis because of three main reasons. 1) OSS communities offer intangible products/services: software, which is completely appropriate for the e-medium and answers for today's requirements in a competitive environment. 2) Although non-commercial OSS communities are not necessarily an example of commercial VO, in this thesis OSS communities are considered as an appropriate example of VO because they are the most developed model of the virtual forms – virtual space. In other words, OSS communities in this thesis are an example of VO under the prism of their operation management rather than their financial management. And 3) OSS communities are a good source for studying successful knowledge sharing in VO, because they are an appropriate example of organisational forms, where knowledge sharing processes create successful results such as innovative software, for instance webserver software Apache, Internet browser Firefox.

Studying knowledge sharing in the VO on OSS communities is valuable, as OSS includes rich forms of innovation. Additionally, successful examples of OSS communities show that knowledge can be successfully managed in VO, despite of all the challenges in knowledge sharing processes. This means that OSS is more than just software, it is a global network, an online community: the most developed form of VO, which includes individuals/companies, where knowledge sharing exists intensively. Empirical studies will bring to light how knowledge is shared in OSS communities. However, before the empirical studies, let's investigate the current academic literature specialised on the OSS communities.

3.2.1 Introduction to OSS communities

3.2.1.1 What is Open Source Software (OSS)?

In order to understand the inside working of OSS communities, the OSS movement must firstly be understood. OSS means the source code for software is made open and available for others on the screen. Generally programmers write software in a source code and file it with explanations of how it works. Source codes are compiled in binary form (machine instructions consisting of ones and zeros, for instance "1100011110001010"), which enable the software to work on a computer. Binary code is harder for programmers to read and interpret, compared to the source code. So this is the difference between 'open' and 'closed' software. OSS allows someone to see the source code, interpret, make changes and if needed to compile it and to redistribute. It is different from the proprietary software industry where the source code is protected against modification (Dahlander, 2004).

At the same time there is some confusion between free software and OSS, because they seem to cover the same features and characteristics of the categories in software (Gacek, Lawrie & Arief, 2002). What is the difference between free software and OSS?

3.2.1.2 Open Source Software versus Free Software

Gacek, Lawrie & Arief (2002) clarify the historical background of the free and open source software movement. The idea of creating software, where the source code was made available so that everyone could change/modify/compile and redistribute it, began with the computer operating system GNU project at The Massachusetts Institute of Technology (MIT) in the early 1980s. The aim was to provide 'freedom' in terms of software systems. In 1985, Richard Stallman established the Free Software Foundation (FSF). The FSF defined free software as a program that provides freedoms to its users: freedom to run the program, freedom to adapt the code for personal use, freedom to redistribute the program, freedom to distribute improved/modified versions of the program (Gacek, Lawrie & Arief, 2002).

In early 1998, the term 'Open Source' appeared as a reply to the announcement from Netscape on its plan to provide the source code of its web browser. The Open Source Initiative (OSI) was set up to promote the Open Source Definition (OSD): a guideline to decide whether particular software can be named OSS or not. According to Gacek, Lawrie & Arief (2002, p.2-3), OSD's criteria for OSS are as the following:

- Free distribution
- The availability of the source code
- The right to create similar versions through modification

- The truthfulness of the author's source code should be conserved and changes of the code should be clear to the community
- No discrimination against individuals/groups for providing contributions and for using the software
- No restriction on the usage of the software
- The rights attached to the software concern to all recipients of its (re)distribution
- The license should not be specific to a product, it should apply to all sub-parts within the licensed product
- The license should not infect other software, permitting the distribution of non-OSS along with open source one (Gacek, Lawrie & Arief, 2002, p.2-3)

As a result, Open Source and Free Software can be compared to two political parties within a community, where political parties agree on the basic principles but disagree on practical issues. Open Source and Free Software disagree on the basic principles (commercialism, licensing, etc.), but agree on practical issues (availability of source code and ability of its modification, etc.). There can be found names such as FLOSS: free/libre and open source software (Ghosh, Glott, Krieger & Robles, 2002). Sometimes the name FOSS: free and open source software can be found as well. Hamel (2007) cites Weber (2004) and points that the term FLOSS was developed to moderate the confusion between the terms free as in freedom, and free as in without cost.

According to empirical studies performed by Ghosh, Glott, Krieger & Robles (2002, p.51), although there is clear evidence of a difference between free software and OSS, there is still a share of almost one fifth of the whole sample, that "does not care" if they belong to one party or to the other; 33% that believe they belong to OSS community; and 48% who believe that they are part of Free Software. In the same research, in answer to the question of how software developers understand the differences between the Free Software and the OSS communities, more than half of the sample answered that "the difference between the two communities exists only in principle, while work in both communities is considered the same" (p.52). The same research continues that those who specifically allocate themselves to the Free Software community are determined for a sharp distinction between their community and the OSS community, whereas members of the OSS community have the average distribution of answers (p.53).

This thesis will not use such division between these two groups of Free Source and Open Source. The main idea of this thesis is to find out how knowledge is shared inside virtual communities. Therefore a discussion about the similarities/differences between two mentioned groups will not be formulated and both of them will be considered as a knowledge intensive VO, a virtual space, where knowledge workers share their knowledge in the online medium to create knowledge-based intangible products. This idea is supported by the work mentioned above and carried out by Ghosh, Glott, Krieger & Robles (2002, p.52), where "the difference between the two communities exists only on principle, while work in both communities is considered the same". Therefore, if the work in both communities can be considered the same, then the aim of this thesis is to find out how this work is done so that knowledge workers are keen to share their knowledge in VO to create knowledge based intangible products. However, as a connotative term, used for such communities, this thesis will use the term "OSS communities".

3.2.1.3 Characteristics

There are a number of open source characteristics, which make it unique from both the business and technology points of view. McKelvey (2001) reviews the following characteristics. OSS allows free redistribution without restrictions or fees. The programme needs to include and allow distribution both in source code and in compiled form. Modified and derived works have the same rights of distribution. There is integrity in the author's source code, enabling users to distinguish between base sources (for instance non-modified) and patch files. There is no discrimination against persons or groups and no discrimination against fields of endeavour, for instance against commercial users. At the same time, the distribution of license follows with all redistributions. The license should not be specific to a product i.e. dependent on being part of a software distribution (package) and it should not infect other software or demand that all other software is also open source (McKelvey, 2001).

Regarding licensing, von Krogh and von Hippel (2003, p. 1151) review that Richard Stallman pioneered the idea of using the existing mechanism of copyright law. Software programmers, who were interested in preserving the status of their work as "free" software, could use their own copyright to allow licenses that would guarantee a number of rights to all future users. They could do this "by simply affixing a standard license to their software that conveyed these rights" (von Krogh and von Hippel, 2003, p. 1151). The basic license developed by Stallman to realise this idea was the General Public License (GPL: known as "copyleft", which was a play on the word "copyright"). "Basic rights shared to those possessing a copy of free software include the right to use it at no cost, the right to study its "source code," to modify it, and to distribute modified or unmodified versions to others at no cost. Others developed licenses conveying similar rights, and currently a number of such licenses are used in the open source field." (von Krogh and von Hippel, 2003, p. 1151).

Mulgan, Salem & Steinberg (2005) identify the following as characteristics of OSS communities: transparency, common standards, vetting of participants only after they have become involved, low cost and ease of engagement, a legal structure and enforcement mechanism, leadership, peer review and feedback loops, a shared conception of goals, incrementalism, and powerful non-monetary incentives.

OSS completely changed the philosophy of traditional software organisations, where ideas are kept secret while copyrights and patents are implemented. Transparency has become one of the main factors of attracting contributors worldwide. Another characteristic is common standards. In order to create successful access and maintenance worldwide, OSS projects have common standards, such as IP, UTF-8, and HTML. At the same time, compared with traditional organisations, where in order to involve to any project a candidate should pass recruitment processes and other selection procedures and only after that can join a project, OSS communities have vetting of participants only after they have become involved. In OSS anyone can contribute to a project. The lack of initial vetting does not mean that there is no necessary vetting. This can be carried out by a project leader once a project is submitted.

OSS communities have another specific peculiarity: anyone who has a computer and an Internet connection can join the community. It is easy to join an OSS community at low cost. However, OSS communities have a legal structure and enforcement mechanism. OSS does not mean everything is available free. Open source projects release data freely, but control how they are implemented through licences. Open source has a centralised element, for instance Linus Torvalds in Linux. This can be interpreted as OSS communities having strong leadership, generally by people who invented that particular OSS. Regarding other contributors apart from leaders, it is not important how big the project is. Worldwide contributors provide an immense amount of contributions; therefore peer review and feedback loops take little time. Contributors to OSS communities have shared conceptions of their goals, which make OSS communities more successful. OSS communities provide opportunities to everyone who wants to contribute, because even the small players can still make useful contributions. Lastly Mulgan, Salem & Steinberg (2005) conclude that contributors in OSS projects in fact make their contributions for non-monetary reasons. On the other hand, they have powerful non-monetary incentives[20].

OSS communities therefore have unique peculiarities, which allow them to be successful. According to Raymond (1999), any software project management has five functions: to identify aims/goals and coordinate that everybody keeps pointed in the same direction, to monitor in order that key details do not get skipped, to motivate people to do boring but necessary piece of work, to organise the employment for the best productivity, and to collect resources needed to continue the project. In the case of OSS communities, these functions play more crucial roles, because it is more difficult to coordinate geographically dispersed contributors to keep one goal, direction, productivity, and so on. Therefore, it is important to understand the success factors and the motivations that allow people to contribute to OSS development projects and to investigate the OSS communities internally, first in the current academic literature and then to explore them on a wider scale via empirical studies.

3.2.1.4 So, as a Result, OSS Is …

We can say that OSS is software which is created by a community of knowledgeable people, who come together for one/similar aim/ideology/motivation to work together, to share their knowledge and skills, to produce software, to make it open to others to use/change/modify/redistribute. It is a complicated worldwide web, and it is a fascinating example for researchers from many areas: business/management, computer science, geography, anthropology and many more. Raymond (1999) calls it the Bazaar Model. It is a complex net, which is captivating and difficult to understand (Edwards, 2001). For instance SourceForge.net is the world's largest OSS development website,

[20] Incentives will be analysed in details in the next section of this Chapter.

for in May 2008 it was hosting more than 177 thousand projects and nearly 1 million 853 thousand registered users (SourceForge.net, May 2008). Linux, Apache, Perl, Sendmail, Bind, Mozilla Firefox are just a few examples of OSS. Large commercial corporations also appreciate the success of OSS development. Google has published at least five open source projects on Sourceforge.net: Google mAIM, Core-Dumper, Sparse Hashtable, Perftools, and GoopyFunctional; and Microsoft has released projects such as WiX, WTL and FlexWiki on Sourceforge.net (Krishnamurthy & Tripathi, 2009, p.404). The question is whether OSS is a product or a service. It produces software, but the medium, where these products are created and distributed, is at the same time an “office”, a distribution channel, “a free of charge shop”, a communication channel, and a community place/space. OSS is far from being only a product; it is a service of VO.

Mulgan, Salem & Steinberg (2005) note, although there are many different kinds of OSS they have one similarity. Their source code is available whenever a piece of software is used, distributed or modified. This is almost the opposite of traditional intellectual property systems like patents and copyrights, which aim to keep knowledge restricted to the creators and the people they choose to sell the knowledge to. Open methods and open standards have led to the creation of many of the main basic innovations around the Internet. According to Kogut & Meitu (2000), the success of OSS has made credible the possibility to innovate in a distributed environment, which is opposed to traditional approaches to software development. OSS gives a good demonstration of what the Internet means for the future of work and innovation on a global scale. Kogut & Meitu (2000) name it as ‘e-innovation’.

However, the Internet is not a single technology, but several technologies working in conjunction with one another. According to Prescott and van Slyke (1997), innovation of the Internet is best understood by treating the Internet as a cluster of related IT innovations. This cluster of related IT innovations offers considerable benefits to do business in today’s economy, where the Internet has become the main power. According to Stringer (2000), today e-business allows the ability to commercialise radical innovation as soon as possible. In the age of the Internet, information about new technologies, new applications, new research results, new products, customer experiences and expectations, competitors and their activities are available to everyone. The e-world runs on e-time; therefore speed in the market is measured in days and weeks. The Internet innovation and its innovative products have become the phenomenon. E-innovation has been increasing traditional innovation in two aspects: application and delivery (Lan & Du, 2002; Hargadon & Sutton, 2000; Panne, Beers & Kleinknecht, 2003; Johannessen, Olsen & Lumpkin, 2001). OSS is an excellent example of an innovation in application and in delivery.

3.2.2 OSS Communities as an Example of Virtual Space in a Wider Angle from the Current Academic Literature in Terms of Knowledge Sharing

3.2.2.1 Introduction

As discussed above, OSS communities are a very good example of virtual space, the most developed form of VO, where business processes take place in the online medium with successful innovative outcomes as a result of knowledge sharing. That means that OSS communities are a very good example of successful knowledge sharing and as a result create innovative products. Therefore, it is important to review the academic literature on OSS communities to find out why knowledge is shared, what the factors are that influence participants to join such communities in developing software, contribute to OSS development, share their knowledge, and give away the most precious value in the knowledge-based economy, their know-how. As will be seen below, there are motivations to contribute to OSS communities and share knowledge. After an analysis of the motivations, the study will continue with an analysis of the factors that influence the level of the motivations and how they are related to each other, building the broader concern in relation to knowledge sharing in VO.

This section will include the following subsections:

- Motivations for contributing to OSS communities
- Roles and responsibilities inside OSS communities
- The educational level of contributors to OSS communities
- Trust in OSS communities
- Coordination and satisfaction with management in OSS communities
- Identification within OSS communities
- Incentives in OSS communities

The above mentioned factors were generated after the literature review, which is below and also during the participant observation (Chapter 5 and Chapter 6). The reviewed literature allowed itself to be divided into these factors as it will be seen below. We can investigate these factors in more detail in order to be able to understand them and later build a theoretical framework for the thesis for the further investigation of knowledge sharing in the OSS communities. So what has been found in the current academic literature so far?

3.2.2.2 Motivations for Contributing to OSS Communities

The first and probably most studied factor is motivations behind OSS developers to develop OSS, the motives encouraging knowledge workers to share their knowledge with others. Mikkonen, Vaden & Vainio (2007) notice that in the previous literature two models can be identified for classifying developer motivations: intrinsic and extrinsic motivations. Also Mikkonen, Vaden & Vainio (2007) cite Aalbers (2004) work, who classifies developer motivations into groups of self-enriching, group-enriching and knowledge-enriching.

Bergquist & Ljungberg (2001) underline the reasons why members in online communities share with their knowledge and compare it with other knowledge within academia. According to Bergquist & Ljungberg (2001), in academia a person can give away her/his knowledge, not only because they are altruistic, but also because that is the accepted way of career progression within the academic field. Academics can give away their knowledge in return for status and reputation. By sharing knowledge and being open about results and methods, by responding or by continuing on the published work, pushing the scientific frontier, by writing and publishing papers and by being referred to by others, academics do not only share their knowledge, but also become visible in the academic community. The more other researchers quote each other’s publications, the more the reputation of this person will grow. Such comparison of the OSS development with the academic world can show the motivations of knowledge sharing in OSS communities.

Bonaccorsi & Rossi (2003) and Ulhoi (2004) paint a clear picture of motivations, which can be divided into five parts: economic, psychological, social, intellectual, and technological. Economic drivers can be the probable monetary rewards after finishing the project or gaining a reputation among peers and future career benefits. Improved market value of skills, a feeling of solidarity, altruism and efficiency, and gaining a reputation are among the psychological drivers. On the other hand, social prestige, expectation of reciprocity, fun to program, sense of belonging to the community, and fight against proprietary software are social drivers. Aesthetic qualities, individual needs, learning opportunity are intellectual drivers. Working with "a cutting-edge technology" is a technological driver. Table 3.1 brings together the literature and their findings in terms of motivations in contribution to OSS development. As seen in Table 3.1, all motivations in the literature review were divided into the following categories in order to easily use such categorisation in the further investigation in empirical studies in this thesis:

- Hobbies
- Physiological factors
- Philosophical factors
- Personal needs
- Main work needs
- Network opportunities
- Long term benefits

Table 3.1: Motivations to Contribute to OSS Development

Category	Motivation	Literature
Hobbies	Intrinsic motivations, for instance "fun to program", when a user's direct need for the software and software improvements worked upon enjoyment of the work itself	Lakhani & von Hippel, 2002; Hertel, Niedner & Herrmann, 2003; Mikkonen, Vaden & Vainio, 2007;
Physiological factors	Feeling of solidarity, feeling of altruism and efficiency, reputation	Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006; Mikkonen, Vaden & Vainio, 2007; Schroer & Hertel, 2007;
Philosophical factors	"Fight" against proprietary software	Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006;
Personal needs	Self-determination Altruism Community identification Personal challenges to improve existing software for own needs	Hars & Ou, 2002; Lakhani & von Hippel, 2002; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006;
Main work needs	Needs in the main work	Lakhani & von Hippel, 2002; Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006; Mikkonen, Vaden & Vainio, 2007;
Network opportunities	Learning Social interaction / prestige Reciprocation Peer's respect and recognition Community identification	Faraj & Wasko, 2001; Hars & Ou, 2002; Lakhani & von Hippel, 2002; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006; Schroer & Hertel, 2007;
Long term benefits	Future financial gains, for instance selling products Future career benefits	Bergquist & Ljungberg, 2001; Hars & Ou, 2002; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006; Mikkonen, Vaden & Vainio, 2007;

As can be observed, motivations for the contribution to OSS development are a widely analysed topic in the academic literature. However, there are a few questions.

Do these motivations influence gaining knowledge or in giving knowledge in knowledge sharing process? According to Sowe, Stamelos & Angelis (2008, p. 432) sharing knowledge in OSS communities is a synergistic process – ''you get more out than you put in''. Knowledge sharing in OSS communities is "all about helping each other and collaboration" (Sowe, Stamelos & Angelis, 2008, p. 432). Knowledge sharing in OSS communities provides such benefit as learning from each other, where the interaction of the participants is archived in the project's mailing from which following participants can learn (Sowe, Stamelos & Angelis, 2008, p. 432). If OSS developers share their perfect codes with others, those other developers can learn from the mastery of those codes, and because of a knowledge-sharing atmosphere those who learnt knowledge earlier can share their skills with the other people as well. This can be characterised as a circle, where knowledge sharing and transforming is taking place on a constant basis (Nonaka & Takeuchi, 1995).

As discussed in the previous section of knowledge sharing in VO, motivations to share knowledge and the ability to share knowledge are not the same thing. Motivations to contribute to OSS development was analysed above. It is now useful to find out what kind of factors influence the level of the motivations, as well as the ability to share knowledge, and how they are related to each other. It will also be useful to find out the level of influence of work related motivations and personal motivations in the contribution to the OSS development. What kind of factors plays a role in increasing motivations? What kind of factors plays a role for the ability to share knowledge? How are they related to each other with motivations? What kind of factors influence motivations, which in turn influence the level of the contribution, the level of creation of innovative products, and the overall success of the OSS communities? These questions need further investigation.

3.2.2.3 Roles and Responsibilities inside OSS Communities

Another important issue current academic literature has concentrated on with regard to OSS communities is the roles and responsibilities in such communities. In other words, after browsing the motivations to contribute, we can explore OSS communities in detail.

Schmidt & Porter (2001) divide success factors from an end-user and software development perspective. From the end-user perspective, OSS is cost effective, as it uses low cost channels for distribution, no license fees. It allows rapid access to source code, which allows the software to progress quickly. Such rapid access at the same time allows modifying, configuring and adapting software as soon as possible to meet changing market requirements. A distribution channel such as the Internet allows access worldwide, which simplifies collaboration. From a software development perspective, OSS development leverages VOs effectively. Compared to traditional closed source software, OSS can improve all mistakes/confusion in a short time, which is important, especially in today's 'time-to-market-driven economy', which has been described by Linus Torvalds' as "given enough eyeballs, all thugs are callow"[21].

Also Schmidt & Porter (2001) argue that OSS has a scalable division of labour. In order to avoid confusion between huge amounts of contributors, OSS communities have core and periphery teams. Core developers are responsible for the inspection of the architectural integrity, fix all mistakes and track day-to-day progress, whereas periphery developers test and debug the software released periodically. At the same time, in successful OSS communities feedback loops between core and periphery teams are frequent; generally it is a matter of minutes and hours. On the other hand, in OSS communities there is not a hierarchy (in its classical well-known form) between core and periphery teams, which can give better motivation for developers and allow a periphery team to contribute as much as possible and share their professional skills at a high level. Moreover, OSS communities make it possible to promote talented periphery developers, who would not be satisfied in playing the role of a tester in a traditional software companies.

Madanmohan & Navelkar (2002, p.8-12) describe what responsibilities members have in online communities and what kind of KM activities they implement: Core Organiser, who organises the community, initiates discussions and groups formations; Expert, who shares with her/his tacit knowledge; Problem poser, who brings problems, poses queries; Implementer/ Bug reporter, who establishes practical validity to the suggestions made, informs limitations/bugs; Integrator, who brings together several rules/suggestions, builds taxonomy/manual; Institutionaliser, who pushes for standardisation and regulatory support.

An important issue to note is that this is unlike traditional organisations, where roles and rewards are formally fixed. Online communities are open and the role behaviour is rather flexible (Madanmohan & Navelkar, 2002). Jensen & Scacchi (2007) show an "onion" diagram representing responsibilities in OSS development process (Figure 3.4).

[21] http://thinkexist.com/quotes/with/keyword/eyeball/, accessed on 17 April 2009.

According to the diagram, OSS communities can have passive users and/or observers, active users, developers, project managers, community managers, and core developers.

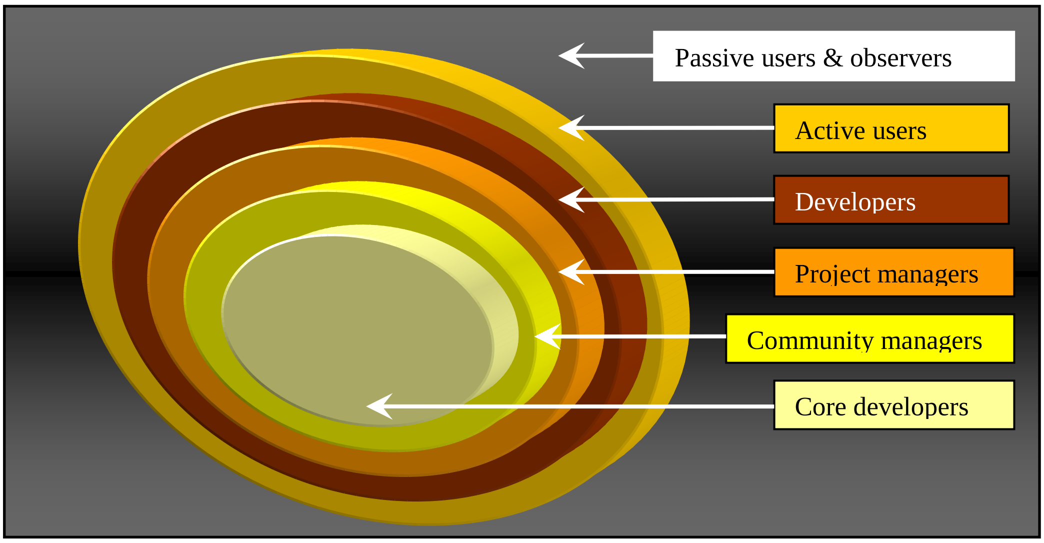


Figure 3.4: "Onion" Diagram of OSS Developers' Responsibilities

(Source: Jensen & Scacchi, 2007)

Gacek, Lawrie & Arief (2002) add to the above diagram that everyone in the OSS communities can be considered as users, who are divided into two main groups: passive (users of OSS) and active (involving in OSS activities: contributors). Active users can be non-developers, whose responsibilities are reporting bugs and/or suggesting new features and there are very active users who are developers of OSS. Developers can be either co-developers, who are suggesting new features for OSS or reviewing the code. Finally, core developers are those who review the code, modify it through fixing bugs and implementing new features and make final decisions.

Jensen & Scacchi (2007) identify role acquisition method in OSS communities. According to the method it is acquired by four types: implicit, earned/granted, elected or appointed/assigned. Implicitly it is acquired by performing a task. The earned/granted method works when an individual or body of authority grants the rank to the community member. This may require the community member to apply for the position, or s/he might be nominated or sponsored by a higher ranking member, possibly involving a vote from the granting body. An individual can be elected by being voted into a position by the community at large or a subcommittee. Finally the appointed/assigned method works when an individual or body of authority appoints the community member to a position.

Hertel, Niedner & Herrmann (2003), with the example of Linux, identify the structural conditions for successful OSS development. Compared with traditional organisations, VOs and especially OSS communities have a culture where authority comes from competence. The knowledge-driven economy appreciates knowledge workers. On the other hand, leadership principles combine with clear responsibilities in OSS development. From a technical perspective, a modular project structure decreases unnecessary complexity, whereas a parallel release policy simultaneously makes possible rapid development and a stable working system. Knowledge, shown through contributions, increases the contributor's supposed merit, which in turn leads to power. If contributors can show their ability (or if they can gain respect from the community), they might be invited into the developer group, where they may have more rights over the code (for instance to incorporate their own modifications into the code base) (Gacek, Arief & Arief, 2004).

The literature on OSS communities concentrates on the roles and responsibilities of the contributors. However, there is still some gap regarding the level of the role/responsibilities in OSS communities and how they influence the intensity of motivations and ability to contribute and share knowledge. This issue needs to be explored more.

3.2.2.4 Educational Level of Contributors to OSS Communities

Because the thesis is investigating knowledge issues, it would be useful to analyse the educational level of the developers and how this educational level might influence the factors of the contribution to OSS communities. According to Blundell, Dearden, Meghir & Sianesi (1999), better-educated workers can be more skilled at responding to technological change. Therefore they may be more productive in high-tech firms. Blundell, Dearden, Meghir & Sianesi (1999) found that some empirical studies confirm strong links between the employment of graduates, for instance professional scientists / engineers, and the adoption / use of high-level technologies in the companies (Blundell, Dearden, Meghir & Sianesi (1999) cited Bosworth and Wilson, 1993; Chapman and Tan, 1990).

Blundell, Dearden, Meghir & Sianesi cited to Bishop (1994) research and mention that education has been found to increase significantly a worker's ability to be innovative in the workplace. For instance, evidence from OECD countries suggests that those countries that expanded their higher education faster during the 1960s had faster growth as well (Blundell, Dearden, Meghir & Sianesi cited Mankiw, Romer and Weil (1992)). In the end Blundell, Dearden, Meghir & Sianesi summarise that positive economic returns to education at the individual level have been always found.

Browsing online sources such as scholar.google.com, web of knowledge, or EBSCO (January 2008) has found only one instance of research, where educational level of OSS developers were investigated. According to research conducted by Ghosh, Glott, Krieger & Robles (2002, p.10) on 2784 Open Source/Free Software developers, OSS developers have a high educational level. 70% of their respondents have an undergraduate degree, 17% of OSS developers - high school degree, and 8% have A-level as their highest educational qualification. A PhD degree does not seem to be a necessary requirement to become an OSS developer. Although there is proof of a strong professional background, for most of the developers OSS is more of a hobby than a profession.

If tacit knowledge is know-how, implicit and not always possible to be documented, and explicit knowledge can be documented, can it be that certified knowledge is explicit knowledge? If so, then can professionally certified knowledge be considered as explicit knowledge? Can educational level be considered as explicit knowledge, especially in knowledge intensive organisations as OSS communities? If so, can the length/intensity of the contribution to the OSS development be considered as tacit knowledge accordingly?

Although no evidence was found from other academic literature, the logic allows the acceptance of this idea to consider explicit knowledge, which can be obtained through educational bodies such as universities, whereas the length/intensity of the contribution can influence the level of tacit experience. In other words, the higher the educational level is, the more the explicit knowledge can be, and the longer/the more intensive the contribution is, the more tacit knowledge the contributors to the OSS development can have. It would be useful to analyse the relationship between the level of education and its impact on the intensity of the contribution to the OSS development, the relationship between individual explicit and individual tacit knowledge. It would also be useful to analyse the impact of the length of the participation to the OSS communities and the level of their knowledge they have gained during the participation, how the tacit knowledge increases during the process of the contribution/participation to the OSS communities, and how individual tacit knowledge can be influenced by other individual tacit knowledge and organisational tacit knowledge.

The further key issues to consider in education level and the length and intensity of the contribution / explicit and tacit knowledge are addressed the following questions. Is there a relationship between the level of education and its impact on the intensity of the contribution to the OSS development i.e. a relationship between individual explicit and individual tacit knowledge? Is there an impact of the length of the participation in the OSS communities on the level of their knowledge they have gained during the participation? How tacit knowledge is increased during the process of contribution/participation to the OSS communities? How can individual tacit knowledge be influenced by other individual tacit knowledge and organisational tacit knowledge?

3.2.2.5 Trust in OSS Communities

Trust, identification and incentives (including monetary reward) are other factors, which can be considered as important in the contribution to OSS communities. According to Faraj & Wasko (2001), trust and identification are attributes for knowledge sharing. Therefore it is important to investigate these attributes in the OSS communities.

Trust in VO is a widely researched field in the current academic literature (Ishaya & Macaulay, 1999; Jarvenpaa & Leidner, 1999; Faraj & Wasko, 2001; Bauer & Koeszegi, 2003; Jarvenpaa, Shaw & Staples, 2004; Roberts, 2003, 2006; Collins & Smith, 2006). Trust is “an efficient mechanism to coordinate exchange relationships characterised by high uncertainty, high interdependence between transaction partners, or when both process and output control are not possible” (Bauer & Koeszegi, 2003, p.28-29). Bauer & Koeszegi (2003) find that trust between the members has a fundamental impact on the success of VOs. Without trust, members of a community of practice may be hesitant to share knowledge (Roberts, 2006).

The existence of the trust between individuals inside communities indicates an ability to share mutual understanding, which is a result of common appreciation of a shared social and cultural context. Trust, familiarity and mutual understanding in social and cultural contexts, are fundamental for the successful sharing of tacit knowledge (Roberts, 2000 (a), 2006). Jarvenpaa & Leidner (1999) ask whether trust exists in global virtual teams. Then they review current academic literature. According to that, a person

> "trusts a group when that person believes that the group "(a) makes a good-faith effort to behave in accordance with any commitments both explicit or implicit, (b) is honest in whatever negotiations preceded such commitments, and (c) does not take excessive advantage of another even when the opportunity is available". (Jarvenpaa & Leidner (1999, p.792) cited Cummings and Bromiley (1996, p.303)).

Jarvenpaa, Shaw & Staples (2004) find the models made by McKnight et al. (1998) on the initial trust formation, by Dirks and Ferrin (2001) on the role of trust in organisational settings, and by Gersick (1988, 1989) on the punctuated equilibrium model. McKnight et al. (1998) developed the initial trust model to clarify high initial trustworthiness and trust in newly formed relationships or in temporary virtual teams. The model by Dirks and Ferrin (2001) builds upon the assumption that trust reduces uncertainty in social perceptions where cooperative or productive activity takes place. Jarvenpaa, Shaw & Staples (2004) find that when there is less uncertainty, the interpretation process becomes unnecessary, reducing the role of trust. Trust effects may not be necessarily direct and linear. Trust provides important benefits for IT-enabled relationships, such as in OSS communities.

High early trust buffered members from the absorbent, incomplete, unpredictable, chaotic processes that are the characteristics of VO interaction. There is an important link between communication early in VO life and early trust. Ishaya & Macaulay (1999) focus on trust as a key factor for successful VOs, where social control is based on self-direction and self-control. Trust is an important factor in any team, and it is much more critical in a virtual team, because of the nature of VO, where face-to-face interactions may happen less than in traditional organisations, or sometimes never happen. In terms of OSS communities, as the most developed form of virtuality, trust inside of OSS communities between contributors and also to management and coordination of the communities is an important factor for success of the OSS communities.

Therefore to find out how trust influences the intensity of the motivations is also important. Another factor, which may influence the intensity of motivations to contribute to the OSS communities, can be identification within the community (Edwards, 2001; Faraj & Wasko, 2001). However, if trust is the most popular field for research in VO, identification within online communities was not found to be a widely researched field.

This section will conclude with a question associated with trust, which is: how does trust influence the intensity of the motivations to share knowledge?

3.2.2.6 Coordination and Satisfaction with Management in OSS Communities

If trust is a popular field for research in VO, satisfaction with management was not found to be a widely researched field. However, there is literature where trust in virtual teams and job satisfaction and satisfaction with management was examined under one umbrella, for instance Staples & Ratnasingham (1998) tested the hypothesis "High levels of trust will lead to higher levels of job satisfaction".

Shin (2004) uses Person-Environment (P-E) fit model in VO between a particular set of person-related attributes and a set of environment-related attributes, for instance the analogy between an individual's competencies and job requirements, where P-E fit is positively related to individuals' career involvement, job satisfaction, organisational commitment, and career success. It can also be negatively related to turnover intentions and behaviour. The personal attributes that are supposed to be essential in VO are "valuing autonomy, flexibility, and diversity highly, willingness to trust, trustworthiness, lateral skills, virtual communication skills, domain knowledge, computer literacy, the ability to work autonomously, and time management skills". Because satisfaction within online communities has not been widely discovered yet, it is important to find out through empirical studies how satisfaction and the intensity of the motivations to share knowledge are related to each other inside OSS communities.

In addition to the factors influencing motivations, there are factors, which should be implemented, in order to make OSS successful (Asklund & Bendix, 2001; Metiu &

Kogut, 2001; Amaratunga & Baldry, 2002; Macbryde & Mendibil, 2003). Asklund & Bendix (2001) divide such factors into three groups: tools, process, and people. Metiu & Kogut (2001) name these factors as communication, coordination, and social context. Technical tools such as servers are vital for e-products such as OSS. All codes of all versions should be stored in the server. However, although on one side technology provides an excellent environment for communication, on the other side, transmitting some kind of knowledge such as tacit experience can be problematic. All developments such as bug fixes and new requirements should refresh old versions. Therefore, coordination plays a crucial role in OSS communities.

According to Metiu & Kogut (2001), coordination in software is an important principle. Metiu & Kogut (2001) use Brook's Law explanation, which formulates that adding personnel is not a solution in solving a problem and increasing speed. Indeed this can be less cost effective because the necessity of training new members and communications are overheads. According to Asklund & Bendix (2001), in OSS communities, a moderator should not play the role of a bottleneck, because such bottlenecks delay the awareness and usability of the application that is developed. However, there is a third factor – social context – that influences members to contribute to open source development, which is 'money free employment'. Members of OSS communities need motivations that encourage them to contribute to OSS development. The management and coordination of geographically dispersed online communities play a crucial role in creating a healthy atmosphere for the contributors to OSS communities so that they can create and share their knowledge and as a result contribute to the success of the OSS communities.

Therefore, the question, which will be considered further in relation to the management and coordination in OSS communities and satisfaction within the management of the OSS communities, will be: how is satisfaction and the intensity of the motivations related to each other inside the OSS communities?

3.2.2.7 Identification within OSS Communities

Wiesenfeld, Raghuram & Garud (2001) find that organisational identification is an important factor in a virtual setting because it may replace/compensate for the loss of aspects of traditional organisations that facilitate co-operation and coordination. Organizational identification is “the strength of members’ psychological link to the organization”, which has been associated motivations when employees need to fulfil organisational goals, their enthusiasm to show “organizational citizenship” (Wiesenfeld, Raghuram & Garud, 2001, p.215). The ability to manage virtual employees may depend on identifying the factors that anticipate their organisational identification.

Wiesenfeld, Raghuram & Garud (2001) find that identification within organisations has specified several predictors of identification, the extent of contact between the individual and the organisation, the visibility of organisational membership, and the attractiveness of the organisational identity. According to Wiesenfeld, Raghuram & Garud (2001), employees in VOs need for connection and the work-based social support are both vital in organizational identification. Managers can strengthen identification among virtual employees who may not be very motivated to identify with the organisation. Because identification within online communities has not been widely discovered yet, it is important to find out through empirical studies how identification and the intensity of motivations are related to each other inside the OSS communities.

Therefore, the question, which will be considered further in identification, will be: how is identification and the intensity of motivations related to each other inside OSS communities?

3.2.2.8 Incentives in OSS communities

How do incentives influence the contribution to OSS communities? (Mikkonen, Vaden & Vainio, 2007). Lerner & Tirole (2000) find that the delayed reward for the activities in OSS communities covers two distinct/hard-to-distinguish incentives: “career concern incentive”(future job offers, shares in commercial open source-based companies, future access to the venture capital market) and “ego gratification incentive” (a desire for peer recognition). Lerner & Tirole (2000) also ask the question “Why do top-notch programmers choose to write code that is released for free?” According to the authors, in addition to the traditional career concerns incentives, programmers are also motivated by a peer recognition motive. According to Lerner & Tirole (2000), most programmers respond to both incentives.

However, from an economic perspective, the incentives are similar in most respects. Because generally OSS communities are considered to be free to join, free to use, free to contribute to, it is important to find out how incentives (benefits for the future) and monetary rewards can influence the level of contribution to OSS communities. In-depth interviews in this thesis (next Chapter) have shown that monetary rewards can be changed from the nature of the OSS community and also to the level of the contribution. Therefore, it will be useful to find out the answer to this issue from the contributors themselves.

The question, which will be considered further in incentives, including monetary rewards, will be: how can incentives, including monetary, reward influence the level of the contribution?

To conclude the above analysed aspects (Sections 3.2.2.2 – 3.2.2.8), the following issues need to be investigated further and it will take place in empirical studies (Chapter 6): motivations behind contributing to OSS communities, roles and responsibilities inside OSS communities, the educational level of contributors to OSS communities, trust in OSS communities, coordination and satisfaction with management in OSS communities, and identification within OSS communities.

3.2.2.9 What is next?

Further investigation of OSS communities will be grouped around the above mentioned aspects (Sections 3.2.2.2 – 3.2.2.8) in order to answer the questions identified in Chapter 2: What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities? And what are the characteristics of the communities that affect knowledge sharing in OSS communities? This investigation will enlighten knowledge sharing processes in OSS communities in detail, and ascertain with factors influence successful knowledge sharing in OSS communities. The next Chapter will be a theoretical framework for future empirical studies.

CHAPTER 4

THEORETICAL FRAMEWORK

4.0 Introduction to Chapter 4

Chapters 2 and 3 outlined the literature review and defined gaps in the current academic literature, which need to be investigated. Now a framework will be built in order to prepare for the further steps in empirical studies.

4.1 Aim and Research Questions as a Conclusion of the Literature Review

The analysis of knowledge sharing (Chapter 2), VO, and OSS communities (Chapter 3) can be summarised in the following two research questions for investigation in this thesis:

3. What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?
4. What are the characteristics of the communities that affect knowledge sharing in OSS communities?

These questions further clarify the aim of this thesis. The following sections of this chapter will explain the steps taken to create the research questions noted above. The questions have been designed to further the aim of the thesis: to assess how/to what extent knowledge is shared in the OSS communities, and to be able to shed light on successful knowledge sharing processes in VO.

4.2 Phases in Developing Propositions

As was mentioned in Chapter 2, this thesis identified gaps in knowledge sharing issues and aims to investigate factors/characteristics that influence successful knowledge sharing in VO; OSS communities. Returning to the Section on OSS communities in Chapter 3 (and specifically on the further study of the OSS communities), the following areas were identified. Also the relationships between the following areas were highlighted for further analysis via creating propositions for their testing through empirical studies. Those issues were identified in the literature review as important factors necessary for successful knowledge flow inside OSS communities. The mentioned factors comprised the following:

- Motivations to contribute to OSS communities
- Roles and responsibilities inside OSS communities
- Educational level of contributors to OSS communities
- Trust in OSS communities
- Coordination and satisfaction with management in OSS communities
- Identification within OSS communities
- Incentives including monetary reward in OSS communities

Analysing these factors, it can be seen that a part of them can be considered as aspects dependent on the individual contributors to the OSS development.

1. The motivations behind contributors to the OSS communities are totally up to the individual contributor. Whether they wish to share their knowledge with others or not is dependent on the contributors themselves.
2. Because the knowledge-based economy is dependent on knowledge, where roles and responsibilities are dependent on the level of knowledge contributors have, the aspect of roles and responsibilities can also be considered as a personal factor.
3. Clearly, the educational level of contributors to OSS communities should be totally dependent on the individual contributors to the OSS communities.

Therefore, motivations to contribute to OSS communities, roles and responsibilities inside OSS communities, and educational level of contributors to OSS communities can be considered as factors on an individual level, influencing knowledge sharing inside OSS communities (Figure 4.1).

Whereas, the final four factors can be considered as factors which are dependent on the success of OSS communities at an organisational level:

4. Trust in OSS communities,
5. Coordination and satisfaction with management in OSS communities,
6. Identification within OSS communities,
7. Incentives including monetary reward in OSS communities,

If a community can create a “healthy” environment, where:

- individuals can trust each other and the organisation,

- identify themselves within the organisation,
- be happy and satisfied within the management of that organisation;
- and where individuals can have benefits for the future, any other kind of incentives, including monetary reward, which can be provided by the organisation,

then those factors are related with the organisational issues within OSS communities. Therefore these four factors can be considered as factors on an organisational level influencing knowledge sharing inside OSS communities (Figure 4.1).

Further study of the seven factors mentioned above, on the personal and organisational level can provide answers to the research questions regarding knowledge sharing inside OSS communities, and can shed light later on knowledge sharing issues, which were identified in Chapter 2.

In order to find answers to the questions regarding knowledge sharing, the following propositions were created as reflections of the research question and qualitative enquiry identified in this thesis. The following propositions will be considered by dividing them into two groups as it was discussed; personal factors and organisational factors. This thesis investigates personal factors and organisational factors (Figure 4.1) as an input for the output of the OSS communities, such as knowledge creation or product innovation. In other words, it investigates how knowledge is shared on an individual level and on an organisational level to create new knowledge, or to use (or even re-use) current knowledge for product innovation. As it is shown in Figure 4.1, the black box shows what kind of factors can be investigated in detail, in order to use them as an input for creating successful output in OSS communities. A detailed explanation of each box will be given below when personal and organisational factors will be analysed accordingly.

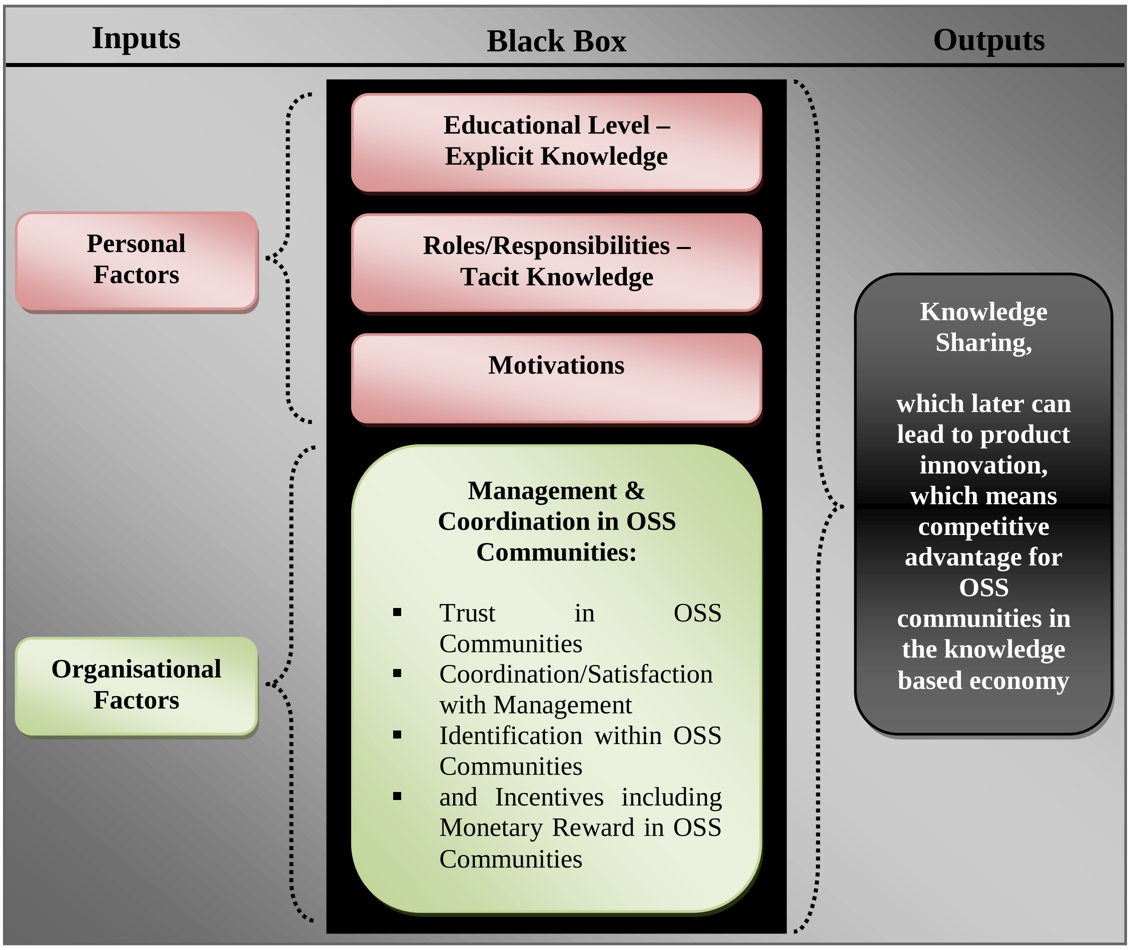


Figure 4.1: Black Box Showing Measurement Factors for Performance

4.2.1 Developing Propositions on Personal Factors

As previously discussed, in the knowledge economy, where knowledge workers are the most valuable actors and where tacit experience of the individuals is the most important driver, the individual level takes special significance. As identified during the literature review (Section 2, Chapter 3), for the individual level the thesis emphasises the most important three factors: individual explicit knowledge, individual tacit knowledge, and motivations encouraging sharing tacit experience with others in order to reach a business aim inside the OSS communities. Without motivations, their interests and personal and professional drivers, individuals are hardly able to fully contribute to the projects.

The current literature has considered a wide range of various motivations (Chapter 3, Table 3.1). Analysing Table 3.1, it is possible to outline that the reviewed motivations in the literature can be divided into two main parts: from a personal and a work related perspective. It will be interesting to analyse work-related and personal-related motivations and discover the connection between the two. It will be remarkable to analyse these two different parts of motivations: personal related and work related, because the overall factors influencing knowledge sharing inside OSS communities are divided into two main parts: personal and organisational. Although there is plenty of academic literature dealing with motivations in terms of contribution to OSS communities, we will still address the subject of motivation in this thesis because motivations to contribute to OSS communities are important drivers that move knowledge workers forward to share their knowledge with others for the success of OSS communities, to create innovative products, which leads to competitive advantage in the knowledge-based economy.

The further the literature review proceeded (Chapters 2 and 3); deeper nuances in terms of factors influencing knowledge sharing in OSS communities became apparent. In Chapters 2 and 3 it was seen that pure motivations are not enough as a single factor to ensure successful contribution to any project, as individuals additionally use their knowledge and skills. The literature review showed that knowledge can be divided into two main parts. There is explicit knowledge of the individuals, who contribute to OSS communities. This explicit knowledge has its root in tacit knowledge of the individuals (Polanyi, 1969). If so, then can explicit knowledge come from the educational level of the individuals? (Chapter 3, Section 2). Can it come from the educational level especially in knowledge-based economy, where knowledge is the main driver? The logic says yes, because the educational level plays a crucial role, since OSS development needs pure software programming skills and certain knowledge, which is in most cases obtained through educational bodies.

Hence, a knowledge-based economy needs knowledge workers. In this case, it seems possible to combine ‘articulable’ individual tacit knowledge with individual explicit knowledge. If individual tacit knowledge can be ‘articulable’, it means it can be expressed/documented (Chapter 2). Documented knowledge can be considered as explicit knowledge. Education gives knowledge to a person, tacit knowledge through explicit knowledge. Explicit knowledge can be taught, it will be digested as tacit knowledge by those who take this education. If this tacit knowledge can be articulated, then it can be considered as explicit knowledge. However, there is also ‘unarticulable’ individual tacit knowledge. In this thesis it will be named as individual tacit knowledge.

Due to the specificity of the contribution to software development, it seems that the higher IT education level people have, the more contributions they may make. On the other hand, their tacit experience plays an even more important role in contributing to the project, because knowledge becomes more valuable and strongly related to tacit experience. In other words, OSS development needs rich theoretical knowledge, wide programming experience and practice. If the knowledge-based economy is based on knowledge, then knowledge workers should be the most valuable ones in a knowledge-based economy. That can mean that roles and responsibilities in OSS communities can be based on the level of tacit knowledge (Chapter 3, Section 2).

As will be discussed in the next Chapter, the empirical studies in this thesis have been obtained via qualitative and quantitative research. Qualitative research was collected through participant observation and in-depth interviews (Chapter 5). Because qualitative research was used as a basis for quantitative research; the results of the participant observation and in-depth interviews were used during the design of the theoretical framework. So according to the participant observation in Qwerty (Chapters 5 and 6), the group committee consisted of four of the most active members, proving as in the academic literature, that the leadership in the OSS communities are appointed upon the level of the contribution to the community, which can be relevant with knowledge in the knowledge-based economy.

This fact is proven also by an in-depth interview with a top leader of a big OSS community (Chapters 5 and 6), where he mentioned that active contribution; active knowledge sharing is the way in which individuals can be officially employed by that OSS community or take higher roles and responsibilities in such communities. So, now it is time to study these factors, which influence individuals to share their valuable know-how with others inside OSS communities, to test them and contribute to current academic knowledge. As a result it is possible to identify the first research question as: What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?

The above mentioned personal factors allow us to go further in the theory and create five propositions to find out how education/explicit knowledge, the length and intensity of the contribution/the fruit for tacit knowledge, the roles and responsibilities/tacit knowledge inside OSS communities, and work related and personal motivations, influence knowledge sharing processes in the OSS communities. All these propositions are constructed in order to answer the first objective of the thesis: to investigate how knowledge is shared in the OSS communities. Answers for this objective will be found out from individuals who have contributed to the OSS development inside of the OSS communities[22]. As is evident in the literature review, there is a limited amount of work done in this specific area and only comparatively limited empirical studies. Therefore, the first five propositions (Figure 4.2) can be constructed as the following.

Propositions on Personal Factors

Proposition 1 – The higher the education level is, the more knowledge contributors share.

Proposition 2 – The longer members participate, the more tacit knowledge they have.

Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.

Proposition 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community.

Proposition 5 – Work related motivations have positive impacts on knowledge sharing in the OSS community.

4.2.2 Developing Propositions on Organisational Factors

The first five propositions were constructed on the frame of the individual level, where knowledge sharing is analysed from a personal perspective. As discussed above, in addition to the individual level of the factors that influence the success inside of OSS communities, there are factors at the organisational level. The OSS communities are a large web of dynamic professionals. Therefore in such communities it is important to find out how the communities manage such a large web of knowledge workers and what communities do for successful knowledge sharing. Inductive research, especially in-depth interviews with three top leaders in three different OSS communities (whose difference is on the size of the communities) showed that management/organisational structure is an important issue inside such a complicated web of OSS communities. Small and large OSS communities, their management or even commercialisation level can show opposite characteristics in the same factors.

[22] More detailed information will be given in the next Chapters.

On the organisational level though there are two main issues to be considered: a) organisational factors for knowledge sharing in OSS communities from an individual contributors' point of view: in other words, how individual contributors assess the management and coordination of OSS communities; and b) organisational factors from the organisation's point of view itself: for example, how the management or top leaders of OSS communities assess management and coordination of OSS communities. Because quantitative data will cover individual contributors and their opinion about knowledge sharing processes in OSS communities, this thesis will concentrate only on point a). The second point (b) will be left for further research in the future. In this thesis it is important to find out how individuals/contributors to the OSS communities find out the 'quality' of the organisational issues inside their communities.

If the first five propositions concentrate on purely personal factors influencing the level of the contribution of the individuals, there are also factors from managerial/organisational perspective, which influence the individuals and their contribution. In Chapter 3, Section 2, satisfaction with management, trust inside of such communities, identification within the communities, and incentives (benefits in the future) including monetary rewards have been identified as factors necessary to successful knowledge sharing from the organisational perspective. The second and last set of the propositions can be constructed to analyse factors that influence knowledge sharing from the organisational perspective, what kind of environment do the communities provide for their members, when motivated and knowledgeable people are joining the communities ready and willing to share their experience. How can the level of contribution therefore be influenced by environment?

Chapter 3, Section 2 analysed these four factors in detail. As demonstrated, satisfaction with management, trust inside such communities, identification within the communities, and incentives (benefits in the future) including monetary rewards are important to investigate further via empirical studies. For example, participant observation in Qwerty and in-depth interviews in qualitative enquiry (Chapter 5) support the idea of further study of the five factors important for building a healthy environment in OSS communities. The literature review showed the importance of the satisfaction with management, trust inside OSS communities and identification within those communities. Therefore there is clear evidence from the literature review proven by empirical studies in this thesis that these four factors should be studied in detail and be explored from the perspective of the individuals who contribute to the OSS development. As a result it is possible to formulate the second research question: What are the characteristics of the communities that affect knowledge sharing in OSS communities?

This question needs to be answered in order to draw a clear picture of management and coordination inside the OSS communities, in other words to see the organisational level by filtering it from individual opinions. Therefore, the next set of five propositions (Figure 4.2) can be identified as:

Propositions on Organisational Factors

Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.

Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.

Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.

Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.

Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

The black box showing the measurement of performance in Figure 4.1 can be developed further and both levels, personal factors and organisational factors, can be added by the propositions in each level, as summarised in Figure 4.2. These questions further clarify the aim of this thesis. The above mentioned two research questions will answer the aim of this thesis: to assess how/to what extent knowledge is shared in the OSS communities to be able to shed light on successful knowledge sharing processes in VO. This integrating issue is a clear gap in the existing literature.

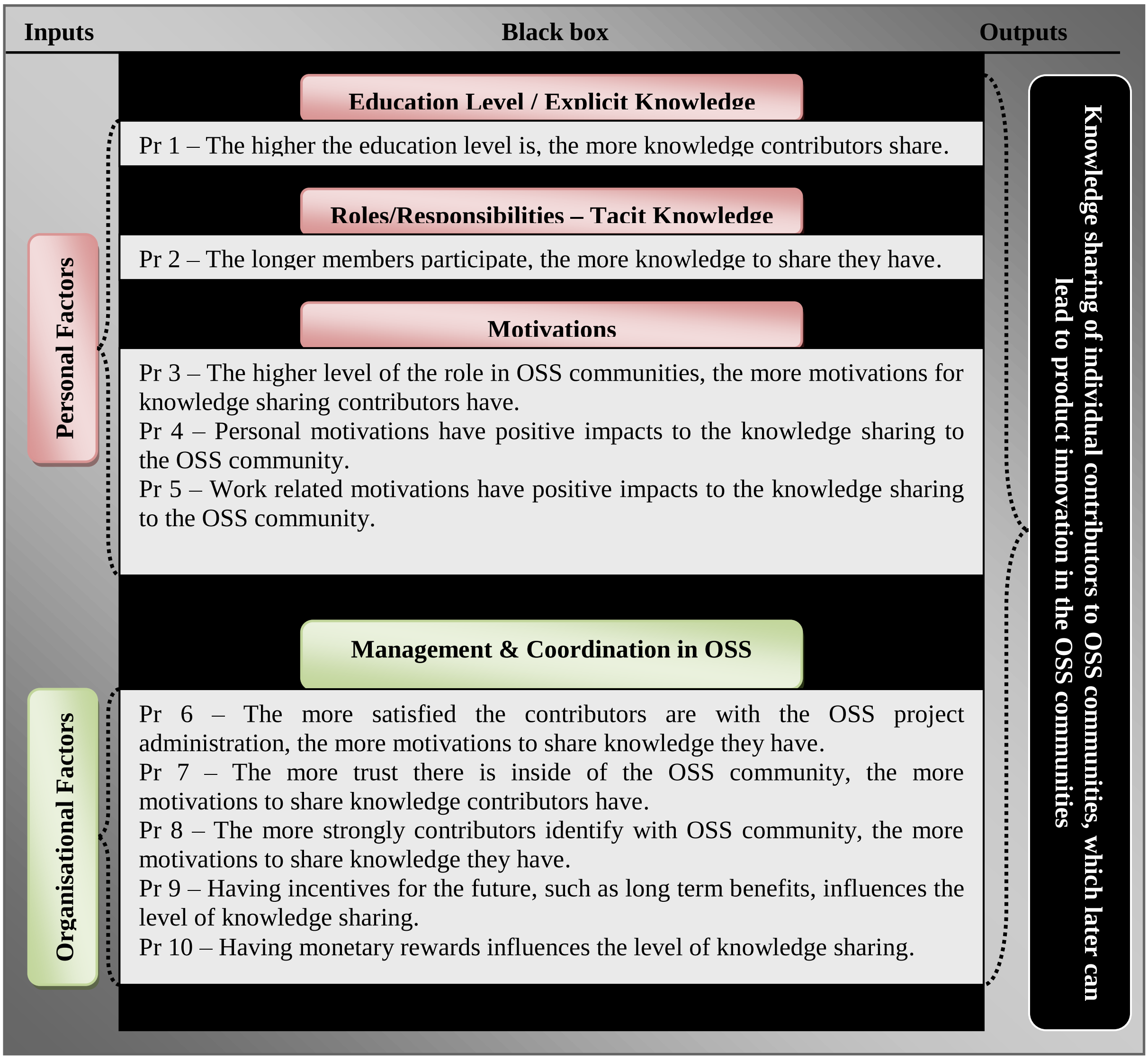


Figure 4.2: Propositions to Be Investigated

4.3 Variables and Measurement

In order to investigate these propositions the thesis will use different variables. The propositions, used in this thesis can more likely be used by dependent and independent variables (Figure 4.3) (Sekaran, 2003). A dependent variable is a variable of interest to this research, depends on independent factors, which can influence it. A result of the relationship between a dependent variable and the independent variables will be an answer to the problem. An independent variable has its own value, which is independent from any factors in a particular problem, and it influences the dependent variables (Sekaran, 2003).

The relationship between dependent and independent variables identified in Propositions is possible to demonstrate as can be seen in Figure 4.3. Knowledge sharing as a dependent variable is dependent on the independent variables identified in Propositions 1, 2, 9 and 10.

- Proposition 1 – The higher the education level is, the more knowledge contributors share.
- Proposition 2 – The longer members participate, the more tacit knowledge they have.
- Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.
- Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

At the same time knowledge sharing as a dependent variable is dependent on the independent variable identified in Propositions 4-5: motivations, which is dependent on Propositions 3, 6, 7, and 8.

- Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.
- Proposition 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community.
- Proposition 5 – Work related motivations have positive impacts on knowledge sharing in the OSS community.
- Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.
- Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.
- Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.

So there are ten propositions. Each proposition has its own measurement. Also there are two sets of variables, which also have their own measurement tools. As will be evident in the research methodology outlined in Chapter, propositions will be tested through quantitative research. Chapter 5 will provide information regarding quantitative research, where all measurements will be provided, including the sources from the current academic literature, which were used in building the quantitative questionnaire, the measurement tools for the propositions and the variables. Therefore, it can be summarised that measurements for the independent variables will be given in Chapters 5 and 6, when the research methodology and its operationalisation will be considered.

It is important to identify a measurement tool for the dependent variable: knowledge sharing, which later can lead to product innovation in the OSS communities. The crucial question in the empirical study is how to measure knowledge sharing of individual contributors to OSS communities? As was discussed in the previous Chapters, successful knowledge sharing can give a fruitful result – creation of innovative products. However, measurements of product innovation do not play a crucial role for this thesis because such measurements are at a company level, at the level of OSS community, who produce new software or publish new releases. Because this thesis is concentrating on individual factors for knowledge sharing in OSS communities, it will focus on how to measure knowledge sharing of individual contributors to OSS communities. However, to explain such a measurement in this Chapter is still too early. It will be explained in detail later after development of a Model. Though what is important in this Chapter is the construction of a Model for successful knowledge sharing in OSS communities upon the discussed factors, variables and propositions.

4.4 A Model – Individual Level: Factors Influencing Sharing of the Personal Knowledge within OSS Community

Figures 4.1 shows that a combination of the personal factors together with the organisational factors develops personal knowledge sharing which can lead to producing innovative products. Ten propositions were created to be tested through quantitative research. A Model (Figure 4.3) was created to visually demonstrate the factors influencing knowledge sharing processes in OSS communities, which were analysed in Chapters 2 and 3 and also in this Chapter 4. The Model can be considered as a finalised version of the theoretical framework, where variables and propositions are gathered together.

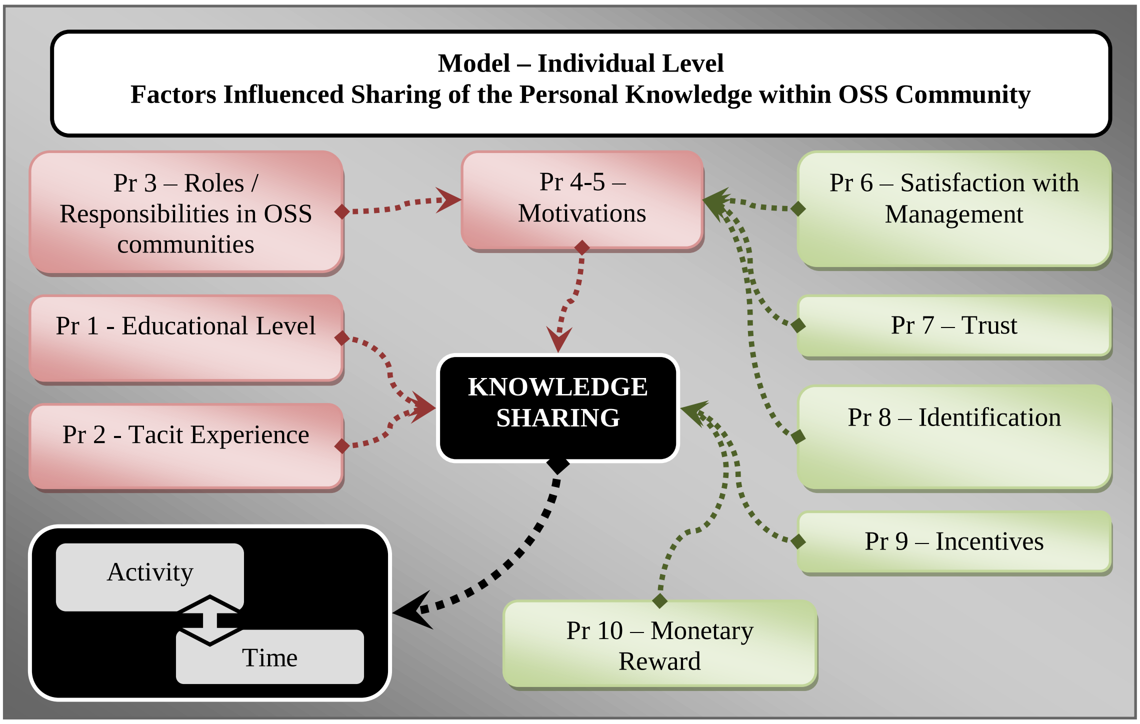


Figure 4.3[23]: Model – Individual Level - Factors which Influenced Sharing of Personal Knowledge within OSS Community

The Model considers the level of personal contribution to product innovation as a result of a combination of the personal factors mentioned above, which include explicit knowledge/educational level, tacit knowledge, roles and responsibilities in OSS, and contribution to OSS communities. At the same time, the level of personal contribution to product innovation seems to be a result of satisfaction of the individuals by the management of the OSS communities, identification with these communities, trust inside of these communities, and incentives both monetary and non-monetary.

The in-depth interviews of the individuals/coordinators of the OSS communities (Chapters 5 and 6, Appendix 2) and also interaction with the individuals during the participant observation Qwerty (Chapters 5 and 6) show that a measurement of the level of personal contribution to product innovation inside of the OSS communities can be a combination of activities and time when these activities take place. In the Model, the level of personal contribution on product innovation will be measured through the level/intensity of activities done at a particular time. This measurement will be described in more detail in the next Chapter, where the quantitative questionnaire will be presented, and where exact questions from the questionnaire will provide answers about the level of activities done by the individual contributors at a certain time.

[23] Pr = Proposition

The Model (Figure 4.3) is the basis of this thesis. The empirical studies in Chapter 6 will be implemented in order to find out answers for the questions created in the Model through testing of the propositions. The tested/final version of the Model will be given in Chapter 6 (Figure 6.1).

4.5 How Propositions to Be Investigated Will Answer the Research Questions Identified in This Thesis

Chapters 2 and 3 analysed knowledge, VO, and OSS communities, and research questions were identified as a result. In this Chapter, the propositions to be investigated are identified. The following Table 4.1 shows which proposition will answer which research question. Therefore at the end of the data analysis, all research questions will be answered and discussed, and will be presented in the final Chapter (7). According to Table 4.1, two main research questions were identified.

Research Question 1: What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?

The first five propositions which examine personal factors in the Model and which will be investigated by testing those propositions will be the answer to Research Question 2. The first five propositions explain the factors necessary for knowledge sharing inside OSS communities. Explicit and tacit knowledge together with motivations to contribute to OSS development were identified as necessary personal factors in the Model. The first five propositions will be tested and the answer for the proposition will shed light on the elements necessary for improving knowledge sharing, for effective knowledge using, and for encouraging knowledge owners to share their knowledge.

Research Question 2: What are the characteristics of the communities that affect knowledge sharing in OSS communities?

Research Question 2 will be answered after testing propositions 6 – 10 on organisational factors in the Model. The individuals who contribute to OSS development will show their views on the question and explain how the OSS community should keep uniqueness of knowledge owners and manage knowledge on time frame effectively. Satisfaction of the individuals by the management of the OSS communities, identification with these communities, trust inside of these communities, and incentives as organisational factors will shed light on Research Question 2 through testing the final five identified propositions.

The Model in Figure 4.3 was created to visualise the factors influencing knowledge sharing processes in OSS communities. The Model investigates the level of personal contribution towards product innovation as a result of a combination of the personal factors and organisational factors. As it was already discussed in Chapter 2 regarding work processes in VO, the Model to be investigated in this thesis through analysis of the propositions at the same time will shed light on work processes inside OSS communities. As discussed, it is challenging to generalise work processes in VO, on account of their wide varieties. The Model will explain how work is organised in OSS communities. Therefore the final version of the Model after data analysis will be the answer to Research Questions 1 and 2.

Thus, by answering these questions and investigating the Model through testing the propositions, the aim of this thesis: to assess how/to what extent knowledge is shared in the OSS communities to be able to shed light on successful knowledge sharing processes in VO will implemented.

Table 4.1: Propositions to Be Investigated and Research Questions

N	Research Questions	Propositions, Which Will Answer Research Questions
1	**What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?**	**Propositions 1-5 on Personal Factors** Proposition 1 – The higher the education level is, the more knowledge contributors share. Proposition 2 – The longer members participate, the more tacit knowledge they have. Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have. Proposition 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community. Proposition 5 – Work related motivations have positive impacts on knowledge sharing in the OSS community.
2	**What are the characteristics of the communities that affect knowledge sharing in OSS communities?**	**Propositions 6 – 10 on Organisational Factors** Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have. Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have. Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have. Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing. Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

4.6 A Summary of Chapter 4

This Chapter built a structure for further empirical research. The variables and propositions to be tested were created. Propositions 1 – 10 will be tested through quantitative data on the individuals – contributors to the OSS communities to analyse the Model and find out the answer for the individual level (Figure 4.3). The operationalisation of the Model through quantitative research will be analysed in the next Chapter. The tested version of the Model in Figure 4.3 will be given in Chapter 6, Figure 6.1.

CHAPTER 5

RESEARCH METHODOLOGY

5.0 Introduction to Chapter 5

In the previous chapters we have reviewed academic literature, identified the research questions, and created a theoretical framework for the empirical studies. In the current Chapter, the research methods, which will be applied to the empirical studies, will be outlined.

5.1 The Multi-Strategy Research Design

This section explains the reason behind the combination of qualitative and quantitative approaches in this thesis and how these two approaches together can add value to the research outcome.

5.1.1 Why Does This Thesis Use a Combination of Qualitative and Quantitative Research Approaches? Academic Evidence from the Current Literature

Black (1999) starts his book with a figure showing the bases of understanding. According to Black, empirical studies are defined as "the information, knowledge and understanding are gathered through experience and direct data collection" (p.3) (Figure 5.1). This thesis is an amalgamation of an intensive and wide literature review combined with qualitative and quantitative empirical studies (Figure 5.1). This thesis, its research questions, ten propositions and their analysis is a product of this intensive literature review, qualitative and quantitative research approaches, as well as logic and inspiration.

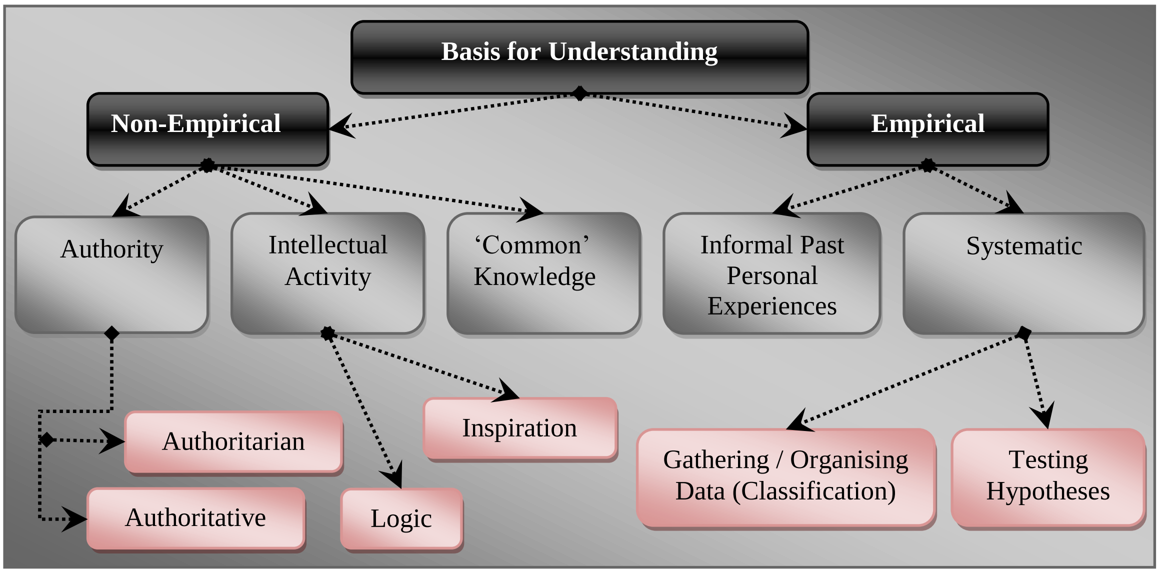


Figure 5.1: Foundations for Understanding

(Source: Black, 1999, p.3)

The research questions presented in this thesis will be addressed through empirical studies, where a combination of qualitative and quantitative research approaches will be used. Qualitative research is used in this thesis as a fundamental element for the quantitative research. The results of the academic literature review and qualitative research approach were used as a basis for the design of the theoretical framework. A quantitative research approach will be used to derive answers to the research questions.

According to Hyde (2000), there are two general approaches to analysis that can create new knowledge: the inductive approach and the deductive approach. The inductive approach is a theory building process, starting with observations on specific examples with the aim of establishing generalisations about the phenomenon under investigation. The Deductive approach is a theory testing process, starting with an established theory/generalisation, which investigates whether the theory can be applied to specific examples. Quantitative investigation generally adopts a deductive process, whereas qualitative investigation generally adopts an inductive process (Hyde, 2000). Traditionally, quantitative research has a "positivist" paradigm, whereas qualitative research has a "relativist" approach (Hyde, 2000). While qualitative research is used, when the question "why" occurs; quantitative research occurs when the question "why" is answered by an uncertain explanation (such as a hypothesis or proposition). Quantitative research is a method for testing hypotheses or propositions (Creswell, 1998; Bryman & Bell, 2003; Sekaran, 2003; Blumberg, 2005).

According to Eisenhardt (1989, p.538), the combination of qualitative and quantitative research can be "highly synergetic":

> "Quantitative evidence can indicate relationships which may not be salient to the researcher. It also can keep researchers from being carried away by vivid, but false, impressions in qualitative data, and it can bolster findings when it corroborates those findings from qualitative evidence. The qualitative data are useful for understanding the rationale or theory underlying relationships revealed in the quantitative data…"

The idea of synergy mentioned by Eisenhardt (1989) is included in this thesis, because qualitative research is a bridge toward the quantitative research. Qualitative and quantitative approaches are a synergy of each other. Perry & Jensen (2001) summarised that it is unlikely for researchers to separate the two methods of induction and deduction. They are generally both involved together and often simultaneously. According to a literature review carried out by Perry and Jensen (2001 cited Richards, 1993; Popper, 1972; Miles & Huberman, 1994; Parkhe, 1987; Patton 1990), induction and deduction are linked research approaches. Pure induction with no prior theory can stop the researcher from benefiting from existing theory. Pure deduction can stop the development of new and useful theory.

Perry and Jensen (2001) cited Parkhe's work (1987), which argues that both extremes are weak and pointless and that the progress of successful theories needs constant interaction between induction and deduction. With this in mind, Perry and Jensen suggest that the usual way of combining induction and deduction in one project is to include two separate studies: the qualitative and the second quantitative. This allows the development of statistical generalisation of the propositions developed in the first study. Nevertheless, following this way can lead to confusion, because qualitative and quantitative research provide answers to different questions, which may not come together to give a single, coherent picture of the situation (Perry and Jensen (2001) cited Patton (1990)). However, sometimes, when time is limited, a combination of the qualitative and quantitative research in a study can be possible.

At the same time, there is academic evidence (for example, Eisenhardt, 1989; Eisenhardt & Graebner, 2007) supporting the reasons for building the theory upon qualitative research. Building theory from case studies is a research strategy, which uses case studies to create theoretical constructs and propositions from case-based, empirical evidence (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). According to Eisenhardt & Graebner (2007), the fundamental conception is to use cases as the basis from which to develop theory inductively. Eisenhardt & Graebner suggest that the main rationale for the popularity and importance of theory building from case studies is that it is one of the best bridging techniques from rich qualitative evidence to mainstream quantitative investigation. “Its emphasis on developing constructs, measures, and testable theoretical propositions makes inductive case research consistent with the emphasis on testable theory within mainstream deductive research.” (Eisenhardt & Graebner, 2007, p.25). Eisenhardt & Graebner continue within the idea that inductive and deductive enquiry logics are “mirrors of one another, with inductive theory building from cases producing new theory from data and deductive theory testing completing the cycle by using data to test theory” (Eisenhardt & Graebner, 2007, p.25).

5.1.2 How Does This Thesis Use Qualitative and Quantitative Research Approaches?

Figure 5.2 demonstrates how this thesis has been produced. After identifying the broad research interests (Chapter 1), an intensive literature review has been completed, leading to the identification of research problems and gaps in the current knowledge (Chapters 2 and 3). Empirical Studies, Phase 1 was implemented via qualitative research and will be discussed in the Chapter 6. As it will be seen, Empirical Studies, Phase 1 had an exploratory purpose and was conducted whilst the generating theoretical framework and prior to the collection quantitative data aimed initially to answer the research questions. During the creation of the theoretical framework (Chapter 4), a series of propositions were generated, which will be tested via quantitative research. Chapter 6 will present the analysis of qualitative and quantitative data, the results of which will be discussed and a conclusion formed. The detailed overview in Figure 5.2 will be examined in more detail as the research methods progress.

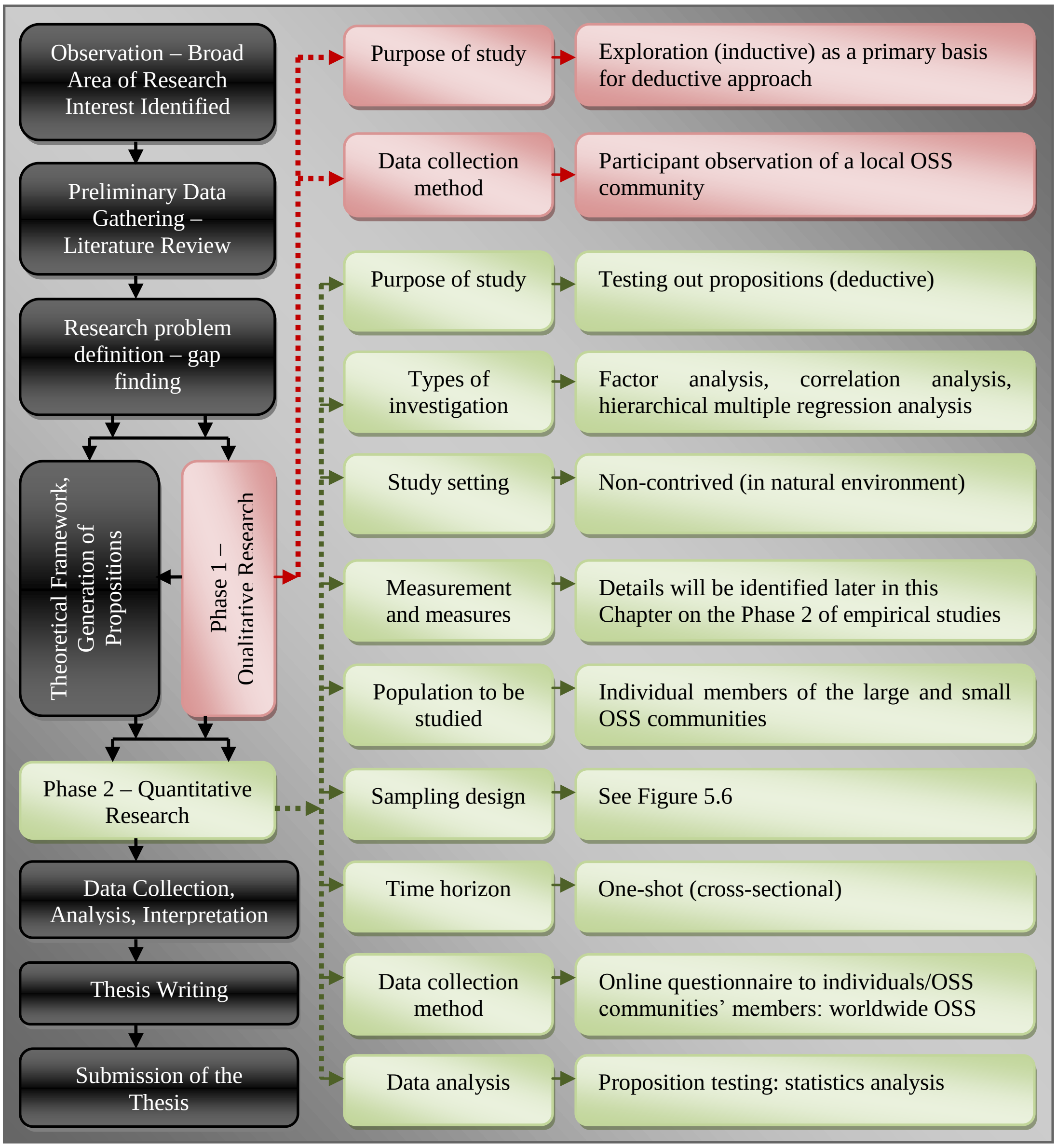


Figure 5.2: Research Methods and Design

(Developed from Sekaran, 2003; Black, 1999)

5.1.3 The Method used in the Combination of Qualitative and Quantitative Research Approaches in This Thesis

Although some scholars use a combination of these two different approaches (qualitative and quantitative) in their research, there are some debates regarding this combination. Bryman and Bell (2003) use Layder's (1993) definition of which combines two approaches into a single research project termed 'multi-strategy research'. John Dewey describes such a combination as the "double movement of reflective thought" (Blumberg, 2005, p. 24). Bryman and Bell (2003) use Hammersley's classification of approaches to multi-strategy research, which uses three methods in multi-strategy research: triangulation, facilitation and complementarity. Triangulation method is used when quantitative research corroborates qualitative research or vice versa. Facilitation is used when one research strategy supports the research by using another strategy. The complementarity is used when two research strategies are employed to dovetail different aspects of the research project.

A combination of two research approaches under the facilitation method will be applied in this thesis to shed light on the research questions (Figure 5.2) due to a number of reasons. The topic of the thesis requires a study of current theoretical knowledge and observing phenomena in e-business through exploratory ethnographical studies. Then, building upon the collected the theoretical knowledge and participant observation, the theoretical framework was formulated. During the designing of the theoretical framework, the thesis used an inductive approach to observe and interpret the research questions though qualitative studies. The results of the inductive research, together with the current literature review assisted in the designing of the theoretical framework. During the development of the theoretical framework, several propositions were identified. These propositions will be tested through a quantitative research approach. Empirical Studies, Phase 2 was developed as a result of the literature review and Phase 1. To summarise, the thesis uses the facilitation method, because qualitative research supports quantitative research. Figure 5.2 above demonstrates how the combined qualitative and quantitative research approaches add value to the thesis. Figure 5.3 below gives a wider idea of how the thesis will be structured in terms of the empirical studies.

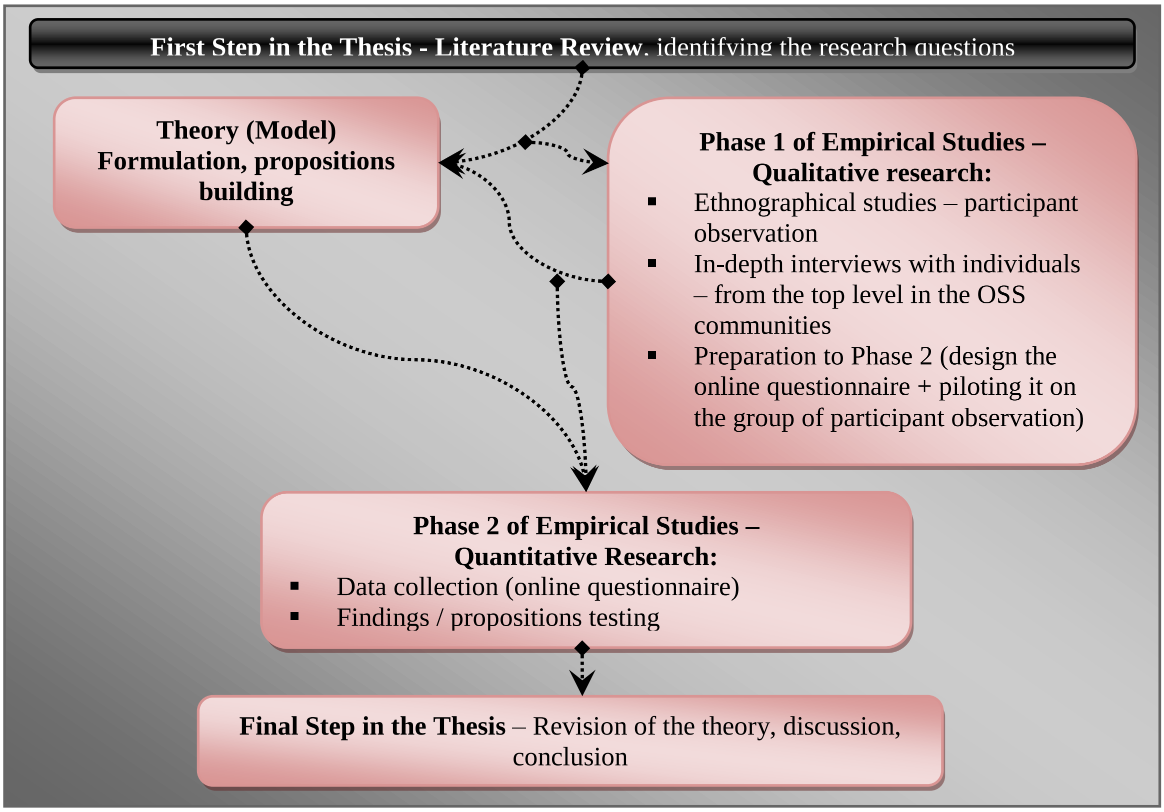


Figure 5.3: Facilitation Approach

(Developed from Bryman & Bell, 2003; Sekaran, 2003)

5.2 Ethical Issues

The empirical studies were implemented according to the ethical guidelines required by Durham University, Durham Business School. This study did not involve participants, who were particularly vulnerable or unable to give informed consent, such as children, people with learning disabilities, or students taught by the author. The participants did not take part in the study without their knowledge and consent at the time. The study did not involve discussion of sensitive topics, such as sexual activity or drug use. No sensitive topics, such as race, religion, sexual orientation, or political preference, were discussed either during the qualitative research or within the quantitative research. No drugs, placebos or other substances (for example, food substances, and vitamins) were administered to the study participants. The study did not involve invasive, intrusive or potentially harmful procedures of any kind. No blood or tissue samples were obtained from participants. No pain or more than mild discomfort was likely to result from the study. The study did not induce psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life. The study did not involve prolonged or repetitive testing.

Both research approaches: qualitative and quantitative, will be presented by adhering to confidentiality rules, by keeping names anonymous. Members of the community for participant observation were aware of the author's participation in their activities. In-depth interviews with three individuals in the OSS communities were implemented. Respondents were informed in advance that all details would be kept highly confidential. All the studies in this thesis will be written without giving the names or identities of people involved in the interviews and participant observation. The quantitative research was conducted through an online questionnaire, where no names or other information regarding identification of the participants was required. The online questionnaire also clearly explained the aim of this study (Appendix 3).

5.3 Empirical Studies, Phase 1 – Operationalisation of the Model through Qualitative Research

5.3.1 Introduction to Phase 1 – Qualitative Research: Theoretical Overview before Starting the Practical Work

As it has been mentioned above, qualitative research in this thesis is the basis for quantitative research. This section will explain how the data for the qualitative research was collected. After the literature review and during the design of the theoretical framework, qualitative research took place to explore the OSS communities more detailed from inside before embarking a quantitative research aspect (Figure 5.2). The data was collected via in-depth interviews and participant observation.

According to Silverman (2000), in qualitative studies, interviews with "open-ended" questions are suitable for small samples; whereas observation is fundamental to understand another culture. Keeping in mind that qualitative research was used as a foundation for the quantitative research, it is possible to underline that ethnographical studies via participant observation was suitable as a basis prior to developing the quantitative questionnaire and after that for its piloting. Also such participant observation was fundamental to understand the culture of the selected OSS communities from an internal perspective. Three in-depth interviews, which were undertaken before the quantitative data collection conducted from a random sample. This was aimed to understand the research questions from inside the OSS communities. Before addressing and analysing the in-depth interviews and participant observation (Chapter 6), some theoretical overview about qualitative enquiry will firstly be explored.

Qualitative research is interpretivist, it is alternative to the positivism, and it provides understanding of the social world through the interpretation of the participants. "Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting." (Creswell, 1998, p.15).

It compliments the differences between people and the objects of the natural sciences. It requires grasping the subjective meaning of social action. The research is driven by human interest and a researcher is a part of what is observed / or actively collaborates in this. Assumptions, which are observed, are interpreted subjectively. Knowledge is developed by "taking a broad and total view of phenomena to detect explanations beyond the current knowledge" (Blumberg, 2005, p.21). Qualitative research "asserts that social phenomena and their meanings are continually being accomplished by social actors. It implies that social phenomena and categories are not only produced through social interaction but they are in a constant state of revision." (Bryman & Bell, 2003, p.20).

Qualitative research methods, such as observation and in-depth interviews, are exploratory in nature and focused on "why" and "how" questions, give a detailed view of the topic (Creswell, 1998; Bryman & Bell, 2003; Sekaran, 2003). Qualitative research is different from quantitative research, because it does not have the relationship between reasons and conclusions in the same level of strength. Qualitative research is a method; where a conclusion is drawn from one or more particular facts/pieces of evidence. "The conclusion explains the facts, and the facts support the conclusion" (Blumberg, 2005, p. 23). Qualitative enquiry generally adopts an inductive process (Hyde, 2000).

There are many reasons why and how qualitative research methods were used in this thesis and more detailed information about the reasons and benefits from using qualitative research methods will be given later, as the thesis progresses further. We will now explore each method in detail, starting with participant observation.

5.3.2 Participant Observation

5.3.2.1 Theory before Practice

“Ethnography is the art and science of describing a group or culture” (Fetterman, 1989, p. 11) and an ethnographer writes about the daily life of individuals. Creswell (1998) identifies ethnographical studies as a report and an interpretation of a social group/system. Creswell suggests using ethnographical studies when description and a high level of detail is required, and when the author is doing “storytelling”. “The ethnographer enters the field with an open mind, not an empty head” (Fetterman, 1989, p. 11), because ethnographical studies allow various interpretations of reality, which requires preliminary knowledge about the topic, research design, etc.

An ethnographical study starts by identifying the problem/research questions; then continues “with a survey period to learn the basics” (Fetterman, 1989, p. 18). Although generally ethnography tests hypotheses/propositions, the research proceeds inductively. Ethnographical studies cover as much territory about culture, programme, and event as possible. The ethnographical studies not only collect information from an internal position, but also should make sense from an external perspective (Fetterman, 1989). Cassel & Symon (2004, cited Burgess, 1984) use four possible identities for participant observation. The participant can be either a complete participant, who operates secretly; or the participant can act as an observer, who participates in activities and makes their aim to observe events transparently; or the observer as participant, who maintains only superficial contacts with the individuals being studied; or finally the complete observer, who simply stands back and observes the events.

In participant observation the ethnographer lives/works in the community for a period of 6 months – 1 year. Participant observation requires long term, close contacts with the individuals who are under study. Interviews as primary data are an important tool for ethnographical studies as well as statistical data and secondary data (Fetterman, 1989). However, the following features make ethnography different from other forms of induction (Hammersley, 1990). People's behaviour is studied in their normal environment, not under experimental conditions prepared/designed by the researcher. Data is gathered from different sources (as in other inductive methods); however, observation is the main focus. Data is collected in a raw form, unstructured from a relatively small group and analysed by interpreting the meanings and functions of people's actions, for example verbal descriptions/explanations, where quantification and statistical analysis take a secondary role (Hammersley, 1990).

5.3.2.2 Benefits from Participant Observation

As was mentioned above, the inductive research plays a fundamental role for the deductive research in this thesis. The qualitative research in this research can be characterised in the following ways: participant observation and in-depth interviews, which served to inform and develop the theoretical framework and later the quantitative questionnaire. The impact of the participant observation on the quantitative questionnaire and the assistance it provided whilst designing the questions will be addressed below, when quantitative research methods will be investigated. Also the focus group, where participant observation took place, was piloted after creating the quantitative questionnaire and this will also be discussed below. However, the most important impact of the participant observation, as will be examined in the next Chapter, is that it was very helpful to experience the atmosphere in the OSS community from the inside. The more concrete benefits of the participant observation will be given later.

5.3.2.3 Participant Observation in Qwerty[24] – Introduction

Immediately after finishing the literature review, participant observation took place within a local network of the OSS community in the web development during the period September 2006 – July 2007. The network subsequently became known as Qwerty. This

[24] All names in the participant observation and in-depth interviews are coded in line with the ethical issues guidelines.

name was chosen randomly in order to keep the anonymity of the network. Qwerty was created in August 2006. A Durham Business School alumni member, who participated in Qwerty meetings, introduced the author to the Qwerty group. The author joined Qwerty as a member from September 2006 (from their second meeting) and attended their monthly meetings till July 2007. From July 2007 until this thesis submission date of this thesis, the author continued receiving emails sent to the group members. However, for the analysis in this thesis, only monthly meetings, which took place in the period between September 2006 and July 2007, will be taken into consideration. The results of the participant observation will be given in the next Chapter.

5.3.3 In-Depth Interviews

5.3.3.1 Theory before Practice

As Kvale (1996) points, conversation is a method of research, through conversation, knowledge is shared in social sciences. Interviewing people has been a source for obtaining knowledge, for example Thucydides interviewed those, who fought in the Peloponnesian Wars, in order to write a history of the wars. Socrates had dialogues for obtaining philosophical knowledge. Kvale (1996) notes that qualitative research interviews are comprised of particular topics neither strictly structured nor completely unstructured, which can bring newness and different outcomes to change the meaning about the topic. The knowledge gained from interviews is a product of interpersonal interaction. King (Cassel & Symon, 2004, p.20-21) mentions the advantages of the interview in qualitative research. According to King, a qualitative research interview is suited to investigating topics where different levels of meaning need to be explored. This is hardly possible to do via quantitative research.

As has been mentioned previously, qualitative research is used as a foundation for quantitative data collection in this thesis. Due to the fact that there are just a few in-depth interviews, this method was suitable because it did not overload high volume of rich data as mentioned by King (Cassel & Symon, 2004). King points out that, interviews can focus on certain aspects of organisational life. In the case of this thesis, it was useful to use in-depth interviews with top leaders in the OSS communities before the collection of the quantitative data from individuals within the OSS communities.

In-depth interviewing of the top leaders gave another perspective, which enabled better understanding of the research questions and allowed a review of the quantitative questionnaire; before this was sent out. Although qualitative research as such does not test the propositions identified in Chapter 4 and does not directly affect the Model (Chapter 4, Figure 4.3), it tests the background for the quantitative data. Quantitative data will be collected to gain information about knowledge creation and circulation from an individual perspective. Because qualitative data is a basis for quantitative data, three in-depth face-to-face interviews took place in the UK before collecting the quantitative data. The interviewed individuals were selected randomly, although one of them was a Durham Business School alumnus and was introduced by a PhD supervisor. Another interviewee was a supervisor for a friend of the author. The third interviewee was introduced by the first interviewee.

5.3.3.2 Individuals Who Were Interviewed[25]

Interviewee 1 is a Professor of Theoretical Chemistry in a European university and is a core coordinator in OSS projects created for chemists. During the interview, as a core coordinator, he gave valuable knowledge about the project he was involved in and the OSS community, which he managed. In the analysis below he will be known as “A”.

Interviewee 2 is the Chief Executive Officer of a commercialised CRM (customer relationship management) OSS project located in UK. In the analysis he will be denoted by the letter “B”. B was interviewed twice: before designing the quantitative questionnaire and after its design, to test it, as well as regarding wider discussion about the thesis topic and research questions. Additionally B introduced the author to the local Qwerty community used for the ethnographical study.

Interviewee 3 is a Technical Development Manager for one of the leading, well known and worldwide famous OSS. In the analysis he will be called by the letter “C”. C was recommended by B. It was a valuable interview with a leading individual in the leading OSS community, the interview was done at the time the quantitative questionnaire was being designed and piloted, therefore the interview considerable impact to the content of

[25] See Appendix 2.

the questionnaire and the general understanding of the OSS communities from their leaders' point of view.

5.3.3.3 Benefits Derived from the Interviews

These interviews are of great value for this research, as all three above mentioned individuals are top managerial people within their communities. Before distributing the quantitative questionnaire, it was helpful to have these interviews to clarify issues with such active OSS developers and take onboard their advice and comments. It was also very useful to meet these top managerial individuals face-to-face to discuss the research questions. It was additionally fruitful to see OSS development from the inside; linking the academic literature with the real world, to better understand the issues/research questions identified during the literature review.

The interviewed individuals were from three different types of OSS communities. One of them is an EU funded, small, non-commercial OSS community, while another is from a large, well known, popular, commercial OSS community. The last one is a small and newborn OSS community. Therefore, it was very useful to meet these individuals, to find out the answers to the questions and compare them from the perspective of the different OSS communities with which they are involved. The analysis of the in-depth interviews will be discussed in the next Chapter.

5.3.4 Summary of Phase 1 – Qualitative Research

Qualitative data was collected through participant observation and three in-depth interviews. During the design of the theoretical framework and prior to the quantitative data collection, three face-to-face in-depth interviews took place with individuals, who are IT professionals and active OSS developers. At the same time, in the period September 2006 – July 2007, participant observation took place within a local OSS community in web development.

Phase 1 of the empirical studies had an exploratory purpose and whilst developing the theoretical framework and before the quantitative data collection, initially try to answer the research questions. Qualitative research in this thesis was the basis for quantitative research, and although qualitative research as such did not test the propositions identified in Chapter 4, it explored the background for the quantitative research. Qualitative research took place to explore the internal aspects of OSS communities in more detail, and helped in understanding whether the designed theoretical framework made sense. Qualitative research in this thesis was a useful tool in designing the theoretical framework and later the quantitative questionnaire.

The group, where participant observation took place, was piloted after creating the quantitative questionnaire. Participant observation was helpful to be able to get used to the atmosphere of the OSS community from the inside. The in-depth interviews have great value for the research, as all three individuals are top managerial people in their OSS communities. It was helpful to clarify issues in the quantitative questionnaire with such knowledgeable OSS developers and to discuss the research questions. Also it was useful in order to experience t OSS development from the inside, linking the academic literature with the real world, to better understand this thesis's research questions as identified during the literature review.

Because qualitative research was a basis for the quantitative research, the influence of the qualitative research on the quantitative research will be analysed later in this Chapter 5: Phase 2 – Operationalisation of the Model 1 through quantitative research.

5.4 Empirical Studies, Phase 2 – Operationalisation of the Model through Quantitative Research

5.4.1 Introduction to Phase 2: Theory before Practice

There are fundamental differences between qualitative and quantitative research approaches in the research in terms of the research strategy (Bryman & Bell, 2003; Blumberg, 2005). Quantitative research is the process, where a reasonable conclusion is taken by logical generalisation of a known fact; while qualitative research is a process, where a conclusion is taken by observation of a certain phenomena, in other words where a general proposition is established by observed facts (Sekaran, 2003). According to Bryman & Bell (2003), quantitative data is collected when there is an absence of interviewer effects. Phenomena can be studied independently from a theory. The quantitative questionnaires are structured and stable. However, scholars found out that in quantitative data collection there is a lack of interpreting a reality; which can be covered by qualitative method (Bryman & Bell, 2003).

The quantitative research approach tests the theory; whereas the qualitative research approach generates theory. Before theory formation, quantitative research observes and gathers preliminary information. After that it tests propositions, collects data, analyses findings and finally revises the theory. Qualitative research starts with theory and a literature review, the observations and findings are implemented, and finally the theory is built. (Bryman & Bell, 2003; Blumberg, 2005).

Quantitative and qualitative methods also can show the difference between different epistemological and ontological positions. Quantitative research generates a natural science model, in particular positivism, which studies social reality. In quantitative research, the research is value-free and a researcher is independent. Assumptions, which are observed, are objective and quantitative based on facts. “Asserts that social phenomena and their meanings have an existence that is independent of social actors. It implies that social phenomena and categories that we use in everyday discourse have an existence that is independent or separate actors.” (Bryman & Bell, 2003, p.19). Knowledge is developed by reducing phenomena to simple elements indicating general laws.

Quantitative data is collected when there is an absence of interviewer effects, which make such research objective (Bryman & Bell, 2003). Quantitative research is a method, where the conclusion should follow the reasons given (Blumberg, 2005). Quantitative questionnaires are highly structured and stable; the measurement of variables is possible and desirable. Phenomena can be studied independently from a theory. However, in quantitative data collection, there is a lack of interpreting reality; a difference of actual behaviour from an observed ‘cause-and-effect’ system, an ‘artificial’ sense of precision. Such disadvantages of quantitative methods can be covered by qualitative methods (Bryman & Bell, 2003).

During the quantitative research in the online questionnaire, all nuances that were identified earlier will be covered carefully. The Model created in the previous Chapter will be studied via the quantitative approach. The quantitative approach is used as the main data collection method, because the Model is focused on personal factors, where the main aim is to find out the answers to the propositions on the individual level from the different level of contributors to the OSS development. That means that quantitative investigation is appropriate to the answer the Model using as many individuals made possible, through quantitative questionnaire.

5.4.2 Design of the Quantitative Questionnaire

Quantitative data was collected through an online questionnaire (URL: http://www.dur.ac.uk/zilia.iskoujina/qq.htm) (Appendix 3, Figure 5.4).

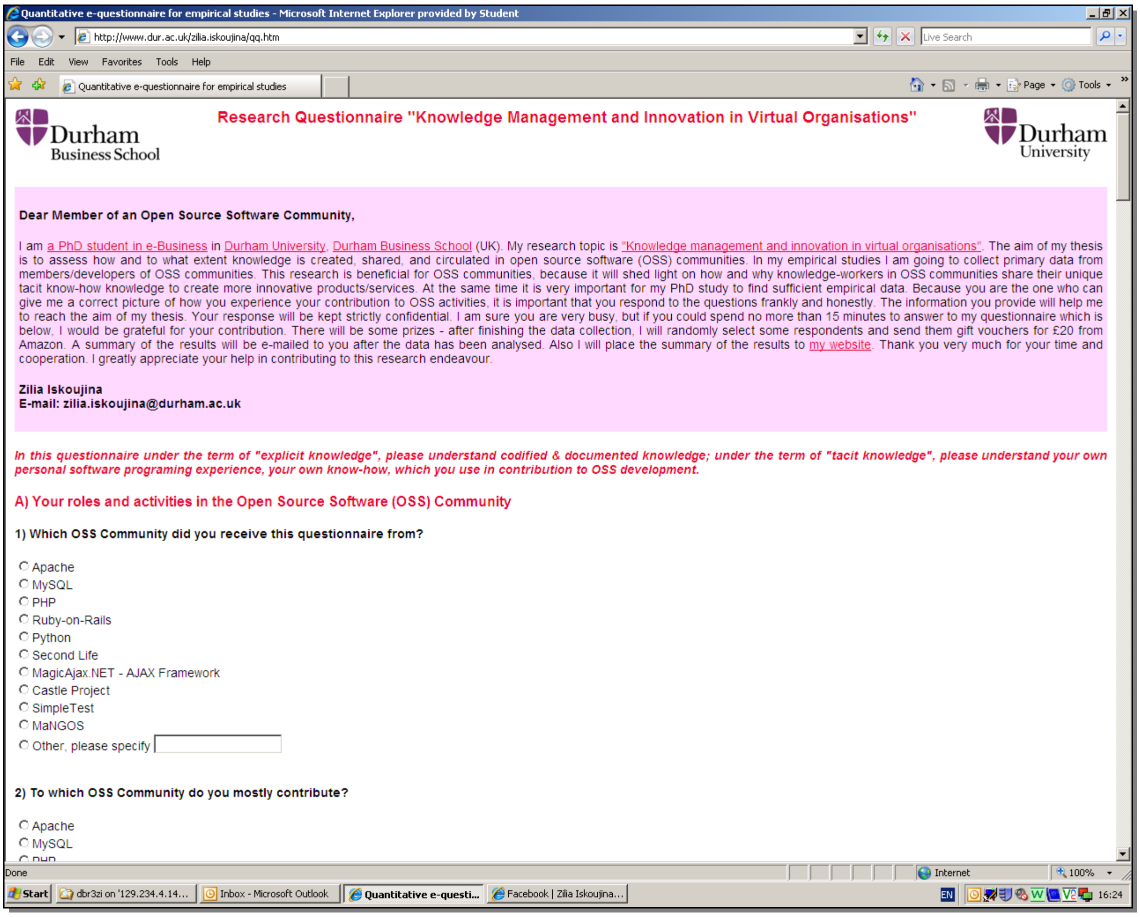


Figure 5.4: Quantitative Questionnaire

The answers were collected using a special webpage (http://www.dur.ac.uk/zilia.iskoujina/php/report-results.php), which created a database of the answers. The OSS for creating dynamic websites called PHP was used for writing codes to transfer data from the questionnaire to the database.

The questionnaire (Appendix 3) was designed to give anonymous responses, so that respondents could give comments without identifying themselves. The most important aim of the questionnaire was to find out the opinions of individual contributors towards OSS communities and toward KM issues.

The information below (Table 5.1) gives details on how academic sources, in-depth interviews and participant observation were used, how the relevant questions developed from the previous questionnaires, and how the academic literature were adapted to the design of this questionnaire (Appendix 3). Additional questions were created during the design and there is also a list of the scales used in the answers for each particular question.

Table 5.1 Online Questionnaire Scales and Sources

N	Questions (Appendix 3)	Sources	Scale
A) Your roles and activities in the Open source software (OSS) Community			
1	Which OSS Community did you receive this questionnaire from?	These two questions came as a result of analysis of the sample and were designed in such format in order to make the data analysis easier.	Nominal scale
2	To which OSS Community do you mostly contribute?		Nominal scale
3	What is your role in the OSS development project in the OSS Community? (please indicate all that apply)	▪ Mikkonen, Vaden & Vaini (2007) ▪ Jensen & Scacchi (2007) ▪ Gacek, Arief & Arief (2004)	Nominal scale
4	What are your activities in the OSS development project and approximately how many times in total have you contributed to these activities? (please indicate all that apply)	▪ Mikkonen, Vaden & Vainio (2007) ▪ Jensen & Scacchi (2007) ▪ Madanmohan & Navelkar (2002) ▪ Lanzara & Morner (2003)	Nominal scale
B) Your participation/contribution to the OSS Community			
5	How do you participate in the OSS Community? (please indicate all that apply)	These questions were created after discussions with individuals involved in the OSS development projects and as a result of analysis of the literature, visiting various websites related with the	Nominal scale
6	How long have you participated in the OSS Community?		Ratio scale

7	How often do you communicate with other members in the OSS Community?	open source development.	Interval scale
8	On average how many hours per week do you contribute to the OSS Community?		Ratio scale
9	What percentage of your participation is related to project development in the OSS Community?		Ratio scale
C) Explicit knowledge obtaining process in the OSS Community			
10	On average how many times a week have you used the following resources to get new / to improve current skills that enabled you to perform new tasks?	This question was created after discussions with individuals involved in the OSS development projects and as a result of analysis of the current literature, visiting various websites related to open source development.	Ratio scale
D) Tacit knowledge obtaining/sharing process in the OSS Community			
11	How often have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?	Faraj & Wasko (2001)	Interval scale
12	To what extent have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?	Faraj & Wasko (2001)	Interval scale
13	How often have you shared your knowledge with other members that enabled them to perform new tasks?	Faraj & Wasko (2001)	Interval scale
14	To what extent have you shared your knowledge with other members that enabled them to perform new tasks?	Faraj & Wasko (2001)	Interval scale
15	I share the information I have with colleagues in the OSS Community.	These questions were created after discussions with individuals involved in the OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
16	I share my skills with colleagues in the OSS Community.		Interval scale
17	Colleagues within the OSS Community tell me what they know when I ask them about it.		Interval scale
18	Colleagues within the OSS Community tell me what their skills are when I ask them about it.		Interval scale

19	Why do you share your knowledge with other members of the OSS Community? (Please write in the box below.)		-
E) Motivations & benefits of contributing to the OSS Community			
20	What is your personal motivation to contribute to the OSS Community?		
	Hobby	Mikkonen, Vaden & Vainio (2007)	Interval scale
	Psychological factors	▪ Mikkonen, Vaden & Vainio (2007) ▪ Schroer & Hertel (2007) ▪ Rullani (2006) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
	Philosophical factors	▪ Rullani (2006) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
21	What is your professional motivation to contribute to the OSS Community?		
	Main work needs	▪ Mikkonen, Vaden & Vainio (2007) ▪ Rullani (2006) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
	Personal needs	▪ Rullani (2006) ▪ This question was created after	Interval scale

		discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	
	Network opportunities	▪ Rullani (2006) ▪ Schroer & Hertel (2007) ▪ Faraj & Wasko (2001) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
22	What are the long-term benefits of contributing to the OSS Community for you?	▪ Bergquist & Ljungberg (2001) ▪ Mikkonen, Vaden & Vainio (2007) ▪ Rullani (2006) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
F) Management in the OSS Community			
23	When you add new code, who accepts it?	▪ Amaratunga & Baldry (2002) ▪ Macbryde & Mendibil (2003) ▪ Mikkonen, Vaden & Vainio (2007) ▪ This question was created after discussions with individuals involved in OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	Interval scale
24	Is there a clearly identifiable person who coordinates your OSS Community?		Nominal scale
25	From the following hierarchical staff, who have you had contact with your OSS project/s? (please indicate all that apply)		Nominal scale
26	Are you satisfied with the management of your OSS Community?		Interval scale
27	I receive on time the information needed to do my job in the OSS Community.		Interval scale
28	The Project Administrator offers guidance for solving job-related problems.		Interval scale

29	I am satisfied with the supervision in the OSS Community.		Interval scale
30	I am satisfied with organisational commitment in the OSS Community.		Interval scale
31	I am satisfied with my co-workers in the OSS Community.		Interval scale
32	Do you gain any monetary rewards for your contribution to the OSS Community?		Nominal scale
33	Who appointed you to your position in the OSS Community?		Nominal scale
34	Are you a formal employee or a volunteer contributor in the OSS Community?		Nominal scale
G) Identification in the OSS Community			
35	Would you feel a loss if you were no longer able to participate in the OSS Community?	▪ Faraj & Wasko (2001) ▪ Edwards (2001)	Nominal scale
36	I strongly identify myself with this OSS Community?		Interval scale
37	I gain a feeling of belonging to the OSS Community.		Interval scale
38	There is a "team spirit" in the OSS Community.		Interval scale
H) Trust in the OSS Community			
39	I trust my peers in the OSS Community.	▪ Roberts (2003) ▪ Roberts (2006) ▪ Jarvenpaa & Leidner (1999) ▪ Jarvenpaa, Shaw & Staples (2004) ▪ Ishaya & Macaulay ▪ Bauer & Koeszegi (2003) ▪ Collins & Smith (2006) ▪ Faraj & Wasko (2001)	Interval scale
40	I trust the quality of information and knowledge provided by group members.		Interval scale
41	If I share my technical problems with the group, I know group members will respond constructively.		Interval scale
42	I think my peers in the OSS Community trust me.		Interval scale
43	We have confidence in one another in the OSS Community.		Interval scale
44	Members in the OSS Community show a great deal of integrity.		Interval scale
I) Personal details		This question was created after discussions with individuals involved in	Nominal scale

	OSS development projects and as a result of analysis of the literature and visiting various websites related to open source development.	

5.4.3 Measurement of the Propositions through Online Questionnaire

As seen above, the questionnaire (Appendix 3) is divided into main sections:

A) Roles and activities in the OSS community

B) Participation/contribution to the OSS community

C) Explicit knowledge obtaining process in the OSS community

D) Tacit knowledge obtaining/sharing process in the OSS community

E) Motivations & benefits of contributing to the OSS community

F) Management in the OSS community & job satisfaction

G) Identification in the OSS community

H) Trust in the OSS community

I) Personal details

Below (Table 5.2) is the list of the propositions (identified previously in Chapter 4) and questions from the questionnaire (Appendix 3), used as measurement tools for the propositions, where questions in the quantitative questionnaire answer each particular proposition.

Table 5.2 Measurement of Propositions through an Online Questionnaire

N	Proposition	Questions in the questionnaire (Appendix 3)
1	Proposition 1 – The higher the education level is, the more knowledge contributors share.	Question 4 Questions 6-9
2	Proposition 2 – The longer members participate, the more tacit knowledge they have.	Question 6 Questions 11-19
3	Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.	Questions 3-4 Questions 20-22
4	Proposition 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community.	Questions 20-22 Question 6-9
5	Proposition 5 – Work related motivations have positive impacts on	

	knowledge sharing in the OSS community.	
6	Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.	Questions 26-31 Questions 20-22
7	Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.	Questions 39-44 Questions 20-22
8	Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.	Questions 35-38 Questions 20-22
9	Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.	Questions 6-9 Question 22
10	Proposition 10 – Having monetary rewards influences the level of knowledge sharing.	Questions 6-9 Question 32

5.4.4 Measurement Tools for the Variables and the Model

It is possible to see that sections in the questionnaire were identified according to the variables in the Model (individual level) (Figure 4.3): motivations, position/roles, educational level/explicit knowledge, tacit experience/knowledge, trust, identification, satisfaction, incentives, and monetary reward. It means that by analysing these factors, propositions 1-10 (Figure 4.2) will be tested.

In addition to the measurement tools used on the propositions (Chapter 5, above Section 5.4.3) and the Model (Figure 4.3), the measurement tools for the variables in the quantitative questionnaire (Appendix 3) can be summarised as the following:

Independent variables: Personal factors, which are measured by questions 1 – 22: educational level/explicit knowledge, tacit knowledge, motivation; and organisational factors, which are measured by questions 23 – 44 in the quantitative questionnaire.

Dependent variable: Product innovation, which can be measured by 3 factors: new product introduction, new releases, and market-share. This measurement was discussed in the previous Chapter 4, where it was mentioned that although product innovation can be measured by these three factors, these measurements are not appropriate for this thesis, because the aim is to investigate the level of personal knowledge sharing on product innovation as identified in the Model (Chapter 4). In the Model the level of personal knowledge sharing on product innovation will be measured through the level/intensity of activities done at a particular time. It will be measured by calculating the level of personal knowledge sharing on product innovation, the level of personal tacit knowledge sharing (Chapter 7), by using one sample chi-square test in order to find out the “goodness to fit” (Pallant, 2005, p.287), where the time of participation of the particular OSS community (Q6 in the online questionnaire) was compared with the percentage of the participation, which is related to project development in the OSS Community (Q9).

Question 6) How long have you participated in the OSS Community?

Question 9) What percentage of your participation is related to project development in the OSS Community?

5.4.5 Pilot Studies

According to the literature, pilot testing should be done in the way it will be used in the real project, for example mail questionnaires should be piloted through the mail (Blumberg, 2005). Pilot studies should ideally be carried out on a different group from the real respondents but can be comparable to members of the population for which sample will be used for the real project (Bryman & Bell, 2003).

During interaction with software developers, IT specialists and other OSS members in the participant observation or in-depth interviews as well as during the review of the academic literature, it was found that OSS developers can be very demanding and tough and require high quality work. Even a small mistake in the questionnaire may discourage them to fill it out. Therefore, the online questionnaire was prepared by paying lot of attention to many nuances, from the researcher’s perspective in order to have reliable data for further analysis and from the respondents’ perspective in order to make the questionnaire easy, user-friendly, understandable and pleasant to fill it. As a consequence, pilot studies were very important for the questionnaire in this thesis.

After design of the quantitative questionnaire, while participant observation took place with the Qwerty OSS network, the quantitative questionnaire was piloted with the Qwerty group members in order to find any biases/shortcoming/weaknesses in the designed questionnaire. The questionnaire was piloted on seven members of this group.

The printed version of the questionnaire was distributed to these members, who later provided answers to the questions in the questionnaire and returned them.

In addition to the Qwerty group, the questionnaire was piloted on two individuals, who were found during networking with people interested in programming and web development. One of them was a PhD student, who was creating a software programme for chemists (OSS project). Another individual was a Chief Technical Officer of one of the British broadband companies, who was an active user of web development packages, such as Apache, MySQL, PHP, and who was a professional programmer. During piloting of the questionnaire with these two individuals, the printed version of the questionnaire was given to them and at the same time, with the author, they discussed each question in detail. Also after creating the questionnaire, a meeting with a lecturer in the Computer Science Department, Durham University, took place, where general issues in the research project were discussed and the questionnaire was analysed from an IT perspective.

That means that the printed version of the questionnaire was piloted in total on ten individuals, who were different from the real respondents, but comparable to members of the population from which the real sample will be taken (Bryman & Bell, 2003). After finalising the questionnaire, its online version was piloted on a group of friends of the author (no more than ten people) who were studying postgraduate programmes with non-IT knowledge to check how the online data from the answered questionnaire was collected in the database in order to avoid any technical problems with data collection during its online transfer the database.

The results of the pilot studies were analysed. According to the comments and answers, further development on the questionnaire was done to it. All in all, the general overview was that the initial version of the questionnaire was nicely prepared, understandable by individuals, and did not consist of technical/IT mistakes. The final version of the questionnaire is the product of some small corrections after the pilot studies, meetings with the professional programmers, and analysis of the current academic literature. These corrections included some technical jargon, rephrasing of some technical words in order to make it more understandable by software developers, as people who have a very technical background. As was already mentioned, the overall design of the questionnaire was prepared to a high quality. The factor analysis (Chapter 6) will show that the data is reliable, because Cronbach's Alpha Reliability Statistics are high (Table 6.2.9). According to Sekaran (2003, p. 307), "the closer Cronbach's alpha is to 1, the higher the internal consistency". Table 6.2.9 in the next Chapter will show that Cronbach's Alpha in all variables of the questionnaire in this thesis is higher than 0.8 (only two variables will have Cronbach's Alpha higher than 0.7).

5.4.6 Potential Sources of Bias

The literature review on research methods show that the following can be considered as potential sources of bias: 1) common method biases, 2) implementing cross-sectional study, and 3) total design method (Podsakoff, MacKenzie, Lee & Podsakoff, 2003; Sekaran, 2003; Bozionelos, 2002; Hoddinott & Bass, 1986; Dillman, Sinclair & Clark; 1993). We can examine each of them in detail and find out how to overcome these sources.

5.4.6.1 Common Method Biases

According to Podsakoff, MacKenzie, Lee & Podsakoff (2003), method biases are a real problem, because they are one of the main sources of measurement error. Podsakoff, Mackenzie, Lee & Podsakoff (2003) cited Bagozzi and Yi (1991) and noted that one of the main sources of systematic measurement error is method variance. Despite its source, systematic error variance can have a serious confusing influence on empirical results. According to Podsakoff, Mackenzie, Lee & Podsakoff (2003), there are potential sources of common method biases: a) measurement context effects, b) item characteristic effects, c) item context effects, and d) common rater effects. According to their list Podsakoff, Mackenzie, Lee & Podsakoff made (2003, p. 882), the mentioned sources can be applied in this thesis and the following steps were implemented in order to avoid the potential sources of biases as much as possible.

A) There can be a bias of 'measurement context effects', which refer to any artifactual covariation formed from the context, where the measures are obtained. Measures of different constructs measured at the same point in time may create artifactual covariance independent of the content of the constructs themselves (predictor and criterion variables measured at the same point in time). Measures of different constructs measured in the same location may create artifactual covariance independent of the content of the constructs themselves (predictor and criterion variables measured in the same location). Measures of different constructs measured with the same medium may create artifactual covariance independent of the content of the constructs themselves (predictor and criterion variables measured using the same medium).

B) Another bias could be 'item characteristic effects', which refer to any artifactual covariance in the questionnaire, when a respondent might put down an item only because of the specific characteristics the item possesses. The items in the questionnaire may be written in such a way as to reflect more socially desirable attitudes, behaviours, or perceptions (item social desirability). The items in the questionnaire may express hidden cues as to how to respond (item demand characteristics). Those items that are unclear and allow respondents to respond to them systematically using their own heuristic, or respond to them randomly (item ambiguity) may be a source for bias. The use of the same scale format (common scale formats) (for example, in this thesis Nominal scale, Ratio scale, Interval scale were used, Appendix 3) on the questionnaire, as well as the repeated use of the same anchor points (for example: always, never, Appendix 3) (common scale anchors) can be sources for bias. In addition the use of positively (negatively) worded items may produce artifactual relationships (positive and negative item wording).

C) Additionally, 'item context effects', which refer to any influence/interpretation, when a respondent might put down an item only because of its relation to the other items making up an instrument, can be considered as bias too. There is no intermixing (or grouping) of items or constructs, because items on the questionnaire were well organised and grouped under themes. The questions on the same scale have the same scale length, however, the first question may encourage a mood for responding to the remainder of the questionnaire (context-induced mood), but this is hard to "count", because of 'common rater effects'.

D) 'Common rater effects' refer to any artifactual covariance between the predictor and criterion variable, when the respondent providing the measure of these variables is the same. This can be a serious source for common method biases and this is outside of the researcher's control. It can happen because of several reasons; firstly respondents may try to maintain consistency in their responses to questions (consistency motif). Respondents may believe in the covariation among particular qualities, behaviours, and/or outcomes (implicit theories and illusory correlations). Some people can respond to items more as a result of their social acceptability than their true feelings (social desirability). Respondents may characterise socially desirable qualities, attitudes, and/or behaviours to someone they know and like than to someone they dislike (leniency biases). Respondents may agree (or disagree) with questionnaire items independent of their content (acquiescence biases). Respondents may be pessimists and view themselves and the world around them in negative terms, or respondents may be optimists and view themselves and the world around them in positive terms. Also recent mood-inducing events faced by the respondents may influence the manner in which respondents view themselves and the world around them (transient mood state). These kinds of mood state (positive or negative affectivity; positive or negative emotionality) can create potential causality for common method biases.

There are some techniques for controlling common method biases (Podsakoff, Mackenzie, Lee & Podsakoff, 2003). These techniques can be applied to this thesis in order to overcome those biases, through obtaining measures of the predictor and criterion variables from different sources, protecting respondent anonymity and reducing evaluation apprehension, counterbalancing question order, and improving scale items (Podsakoff, Mackenzie, Lee & Podsakoff, 2003). As mentioned earlier, the online questionnaire (Appendix 3) was designed by taking into careful consideration all these factors. As discussed above, measures for the questionnaire were obtained via an extensive literature review (Table 5.1) and qualitative research: participant observation and in-depth interviews. The online questionnaire was piloted (on the group, where participant observation took place) and analysed. Questions were counterbalanced by dividing questions into meaningful parts (Appendix 3). The questionnaire was created by providing respondents anonymity (Appendix 3).

Scales were designed by using extensive academic literature, and nominal scale, interval scale, and ratio scale were used. According to Sekaran (2003), the degree of sophistication, when the scales are modified, increases progressively as it moves from the nominal to the ratio scale. The nominal scale was used in order to assign subjects to certain categories, for example, ‘roles inside OSS communities’ in section A in the questionnaire and personal details in section I (Appendix 3). The rest of the questionnaire used an interval scale in order to allow arithmetically operate later in the analysis collected data to test the propositions. Some of the questions used ratio scale, because it "overcomes the disadvantage of the arbitrary origin point of the interval scale" (Sekaran, 2003, p.189). Although the ratio scale is more powerful, all three types of scale were used on particular questions (Appendix 3), because they were used in the previous academic literature and were more appropriate to use on the particular questions.

5.4.6.2 Cross-Sectional Study

According to Bozionelos (2002), causal path modelling is a useful technique for a well-designed description of the relationships between variables, because through such modelling, complex relationships among variables can be depicted with a single model, "that total effects of cause variables on effect variables can be calculated and compared, and that the significance and parsimony of complex models that are based on series of regression analyses or structural equations can be assessed" (Bozionelos, 2002, p.9). Such modelling was used in this thesis during regression analysis and the Model designing. However, the research had been done through cross-sectional studies, when measures had been obtained at the same point in time.

According to Bozionelos (2002, p.7), such type of design does not allow "causality assertions", because "causality in cross-sectional research can be only speculated and tentatively accepted; and needs to be further substantiated with utilization of the other research designs…" According to Bozionelos (2002, p.7), when cross-sectional designs are "utilized certainty on causality is seriously compromised, regardless of the way authors choose to present their findings". Also across sectional study can be considered as a bias in the empirical studies. However, due to the time limit, this thesis had to use a cross-sectional study instead of a longitudinal study.

5.4.6.3 Total Design Method

The Total Design Method (TDM), which has been offered by Dillman, promises a good response rate for mail and telephone surveys (Hoddinott & Bass, 1986). According to

Dillman, Sinclair & Clark (1993), there are four potential influences on mail survey response rates: (1) questionnaire length, (2) respondent-friendly questionnaire design, (3) asking a potentially difficult and/or objectionable question such as social security numbers, and (4) addressing correspondence to the occupant households as opposed to a specific person's name. These factors can be applied in this thesis as the following.

A) Number of questions

According to Dillman, Sinclair & Clark (1993), past research on how the number of survey questions influences response rate is inconclusive. While some studies have demonstrated no effect (for example, Fox, Crask, and Kim 1988; Linsky 1975; Scott 1961), other studies have suggested only a slight negative effect from longer questionnaires (for instance, Dillman 1991; Heberlein and Baumgartner 1978). Dillman, Sinclair & Clark (1993) continue that in 1990 the long census form, which was mailed to 1/6 of all households and asked around 50 more questions for each member of the household than did the short form, obtained a mail-back response rate 6 percentage points lower than the short form.

As can be seen, the questionnaire (Appendix 3) in this thesis is comparatively long. However, it was done at that particular length, in order to have reliable data for analysis, for each factor, a minimum of three different questions was created. Also each proposition should have its own factor for analysis; therefore, the questionnaire was long. However, the analysis of data (next Chapter) showed that the data was reliable; one of its merits is for the length of structure of the questionnaire. At the same time, when the questionnaire was piloted, it was discovered that the respondents did not spend too much time filling it in. Piloted respondents did not complain about its length and questions were systematically ordered and divided into meaningful groups (Appendix 3). The overall design was built in order to make the questionnaire user-friendly, visually pleasant to look at and easily stood.

B) Respondent-friendly questionnaire design

According to Dillman, Sinclair & Clark (1993, cited Dillman (1978)), 'respondent-friendly' design improves mail survey response, although this argument has not been thoroughly tested in past research, perhaps because of the difficulties in testing the effects of this variable due to the lack of agreement on exactly what constitutes respondent-friendly design. According to Dillman, Sinclair & Clark (1993, p.290-291), respondent-friendliness describes “a form that is easy for respondents to complete, avoids confusion about what or how to answer, and results in respondents feeling neutral or positive, as opposed to negative, about the form itself”.

The online questionnaire in this thesis (Appendix 3) was designed in one webpage without complicated multiple webpages, so that respondents can see from the beginning its length and content. The colour consistency is helpful to orientate the webpage and the instructions and the reason behind it is given with a different coloured background to catch attention. The consistency in the design helped to create a ‘respondent-friendly’ design for the online questionnaire.

C) Difficult or objectionable questions

According to Dillman, Sinclair & Clark (1993), to ask difficult or objectionable questions in surveys may cause people to refuse to answer them. Therefore, the online questionnaire in this thesis (Appendix 3) was designed to avoid sensitive or personal questions, and it was kept anonymous, so that respondents could leave any comments freely. The questionnaire was full of technical jargon; however it should not be disadvantage, because of the strong technical background of the respondents, OSS developers.

D) Occupant-addressed correspondence

According to Dillman, Sinclair & Clark (1993), past research on improving the response to mail surveys has focused on correspondence addressed to individual names. However, it seemed hard to implement this in an online questionnaire (Appendix 3), because the questionnaire was distributed widely via different online sources. The details of the questionnaire distribution will be given later in this Chapter (section 5.4.8).

In summary it can be emphasised that the techniques aimed to overcome common method biases as well as total design method were intensively used during the questionnaire design and as a consequence the online questionnaire (Appendix 3) was designed to take into account all these factors. Pilot studies (section 5.4.5 in this Chapter) showed that all these techniques were used appropriately and the questionnaire was designed to a high quality.

5.4.7 Sampling

5.4.7.1 Sample Selection

5.4.7.1a Specialisation of the Selected OSS – Web Development

The reason why OSS communities were chosen as VO for the further studies was explained in the literature review Chapter. The primary data was collected from OSS communities specialising in web development. Reasons for this decision are that the author has a particular level of knowledge in web development; therefore it will be more useful and helpful to perform studies in this field by having certain knowledge about the specialisation of the OSS communities, so was chosen as an appropriate OSS field.

5.4.7.1b Selected Ten OSS Communities

The list of chosen OSS communities in the area of web development is: Apache, MySQL, PHP, Ruby-on-Rails, Python, MagicAjax.NET - AJAX Framework, Castle Project, SimpleTest, MaNGOS, and Second Life. The first five OSS are large OSS communities, while the next four OSS are small OSS communities. There was no specific reason to choose particularly large and small OSS communities, as the selection was done from various OSS communities specialising in web development.

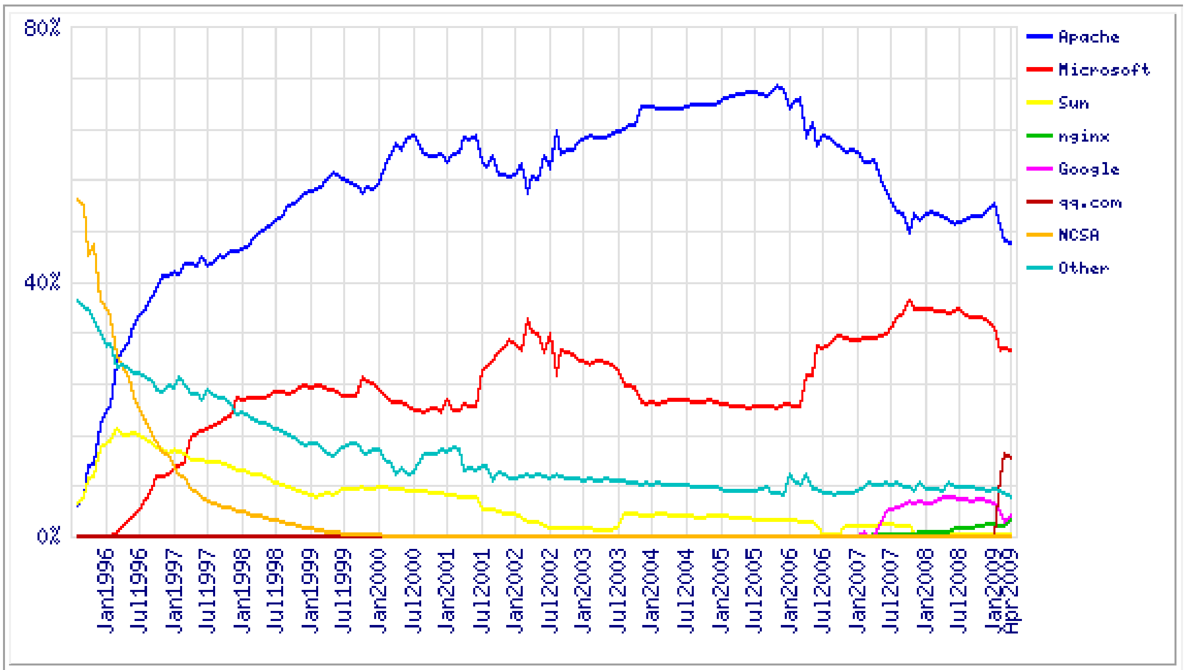
5.4.7.1c Large OSS Communities

Web server software Apache, database MySQL, dynamic web languages such as PHP, Ruby-on-Rails, and Python were chosen as large OSS communities because of their popularity and success. There is a well known and successful complex of the OSS known as “LAMP”[26] which is an abbreviation of Linux, Apache, MySQL, and PHP. Because Linux was a pioneer in the OSS movement, a wide range of the studies have

[26] See for example: Precision, a provider of IT consulting and implementation services, http://www.pretechno.com/i/php-mysql-apache-linux-lamp-windows-web-development-programming-solutions.html, 18 May 2009; or Developer.com, http://www.developer.com/open/article.php/3560296, 18 May 2009

been done on that particular phenomena (for example Raymond, 1999; Mckelvey, 2001; Hertel, Niedner & Herrmann, 2003; Modica, 2003; Mustonen, 2003; Miller, 2006); therefore this thesis was not going to use the Linux community for its empirical studies. However, in the later stage of data collection (see below); Linux developers were also approached and asked to fill in the questionnaire.

The questionnaire was distributed to Apache (web-server software), MySQL (database), and PHP (a language for dynamic websites' creation). Indicators of the popularity of OSS include Netcraft's survey of the market share for top server software, which shows that OSS Apache had almost twice the market share of the software giant Microsoft in April 2009 (Figure 5.5).



Developer	March 2009	Percent	April 2009	Percent	Change
Apache	104,178,852	46.35%	106,368,727	45.95%	-0.41
Microsoft	66,229,250	29.47%	67,767,928	29.27%	-0.20
qq.com	28,905,129	12.86%	28,905,133	12.49%	-0.38
Google	5,403,930	2.40%	7,229,033	3.12%	0.72
nginx	3,838,784	1.71%	6,100,424	2.64%	0.93

Figure 5.5: Market Share for Top Server Software across All Domains August 1995 – April 2009[27]

The questionnaire was distributed to Ruby-on-Rails and Python software programs because they are developed for creating dynamic websites. Therefore it will be an

[27] Netcraft, http://news.netcraft.com/, http://news.netcraft.com/archives/2009/04/06/april_2009_web_server_survey.html, 18 May 2009

interesting combination of PHP, Ruby-on-Rails, and Python. Also because the local group Qwerty, used for participant observation, was interested in Ruby-on-Rails, it will be interesting to find out more information from a wider audience about Ruby-on-Rails. Nevertheless, these three communities were selected randomly from those large OSS communities in web development. The TIOBE (The Coding Standard Company) gives statistics on popularity and position of the programming languages. Table 5.3 shows the position of the first eleven programming languages for October 2007 and October 2006. According to the table, programming languages of such OSS communities as PHP, Python and Ruby are one of popular programming languages.

Table 5.3: The TIOBE Statistics on Popularity and Position of the Programming Languages[28]

Position	**Position**	**Programming Language**	**Ratings**	**Delta**
Oct-07	**Oct-06**		**Oct-07**	**Oct-06**
1	1	Java	21.62%	0.44%
2	2	C	14.59%	-3.07%
3	5	(Visual) Basic	11.17%	1.44%
4	3	C++	9.58%	-1.48%
5	**4**	**PHP**	**9.50%**	**-0.36%**
6	6	Perl	5.35%	-0.12%
7	8	C#	3.74%	0.68%
8	**7**	**Python**	**3.43%**	**-0.03%**
9	9	JavaScript	2.69%	0.48%
10	**13**	**Ruby**	**2.39%**	**1.30%**
11	12	PL/SQL	1.97%	0.87%

So for the distribution of the online questionnaire, the following large OSS communities were selected: Apache, MySQL, PHP, Ruby-on-Rails, and Python. Because of the recent popularity of Second Life (McCarthy, (2007) and Jones (2006)), it was attempted to distribute the questionnaire to its developers. Second Life is “a 3-D virtual world entirely created by its residents. Since opening to the public in 2003, it has grown explosively and today is inhabited by millions of residents from around the globe.”[29] The software developers and contributors to this community were targeted.

[28] TIOBE Programming Community Index for October 2007, http://www.tiobe.com/tpci.htm
[29] http://secondlife.com/whatis/, January 2009

5.4.7.1d Small OSS Communities

The small OSS communities specialising in web development were chosen from SourceForge.net, which is the one of the world's largest OSS development websites and during the summer of 2007 hosted more than 142 thousands projects and nearly 1.5 million registered users. For quantitative data four small OSS communities were chosen from the most downloaded software in web development, MagicAjax.NET - AJAX Framework, Castle Project, SimpleTest, and MaNGOS.

In SourceForge.net[30], from the whole project topics (Appendix 4) “software development” applications were chosen. This particular topic consisted of 29578 projects. In the “software development” section “object oriented” subsection was chosen, because it was related to web development. “Object oriented software development” consisted of 1130 projects (Appendix 4). After that, in SourceForge.net, in “object oriented software development” subsection, “web development” software was searched. 174 projects were displayed in total. Four communities were chosen who had the most members (Appendix 5). For May 2007, the largest number of members in the smaller OSS communities was 21 people. The most downloaded first 4 OSS projects, which at the same time had more members than others, were selected: MANGOS, MagicAjax.NET - AJAX Framework, Castle Project, and SimpleTest.

So, in summary it can be concluded that the participants for the collection of quantitative data were chosen from large and small OSS communities (Figure 5.2). From the large OSS communities Apache, MySQL, PHP, Python, Ruby-on-Rails, Second Life were chosen. From the small OSS communities MANGOS, MagicAjax.NET - AJAX Framework, Castle Project and SimpleTest were chosen.

5.4.7.2 Sampling Design

Figure 5.6 shows the steps made in sample design. Following this representativeness of the sample is critical for this study, because those who will respond the questionnaire

[30]https://sourceforge.net/softwaremap/trove_list.php?stquery=web+development&sort=num_downloads&sortdir=desc&offset=0&form_cat=562, 9 May 2007

are contributors to OSS development, the topic of this thesis. Therefore, in selecting OSS communities and in approaching them, probability sampling design should be chosen (Figure 5.6), because the representativeness of the sample is critical for the study.

5.4.7.2a Identifying OSS Communities

In identifying OSS communities the stratified random was used, because random sample from identifiable groups of large and small OSS communities in web development was selected (Pink Boxes in Figure 5.6). The analysis of the data will be made after defining segments of the communities using the responsibilities of the respondents inside of the communities. The questionnaire will be sent to the OSS members/contributors: project leader, core member, active developer, peripheral developer, bug fixer, bug reporter reader, passive user (these kinds of contributors were found earlier in the literature review in Chapters 2 and 3). Population of the selected communities (see above) will be divided into meaningful segments by their taken positions and responsibilities, therefore stratified random sampling is chosen. Because the chosen OSS communities are both large and small, and because it is not clear at the moment the hierarchy of the communities, and because this can be too large in large communities and too small in small communities, disproportionate sampling is chosen. (Sekaran, 2003) (Pink Boxes in Figure 5.6).

5.4.7.2b Inside the Defined OSS Communities

Inside defined OSS communities, because all members will be selected, simple random sampling will be used (Green Box in Figure 5.6) (Sekaran, 2003; Black 1999), which will be generalised the view in OSS communities. The questionnaire will be sent to contributors in the software development projects via the coordinators of the OSS communities. Also the contributors will be contacted “directly” through various online forums they are participating in. The coordinators will distribute the questionnaire to their contributors and/or contributors will have an opportunity to see the questionnaire in online forum webpages, which means that 100% of the members will receive the questionnaire and all of them have the same right to fill the questionnaire and have a

100% probability of responding. Therefore the sampling is probability with simple random sampling design (Green Boxes in Figure 5.6).

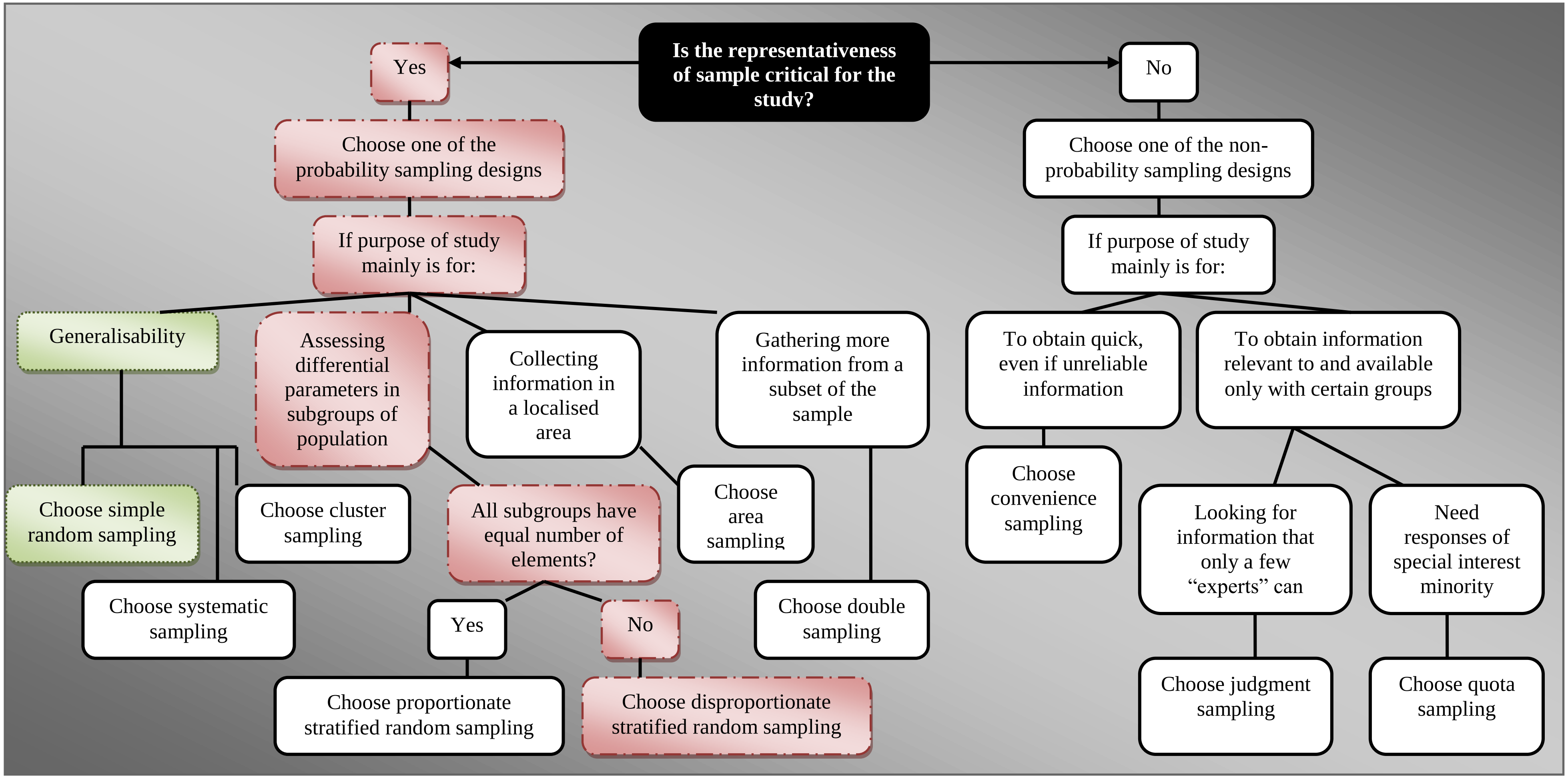


Figure 5.6: Choice Points in Sample Design

(adapted from Sekaran, 2003, p.281)

5.4.7.3 Sample Size

As discussed (this Chapter, Section 5.4.7), respondents for the quantitative questionnaire were chosen from large and small OSS communities. As it was mentioned above (this Chapter, Section 5.4.6), total design method (Hoddinott & Bass, 1986; Dillman, Sinclair & Clark, 1993) was used in order to increase the response rate. We will now explore what happened in reality in terms of the response rate and sample size. For 9 May 2007, the population of the small OSS communities was found to be the following (Appendix 5): MagicAjax.NET - AJAX Framework – 7 members, Castle Project – 7 members, SimpleTest – 10 members, and MaNGOS – 21 members. Information regarding the population of the large OSS communities is difficult to obtain. In forums of the large OSS communities there are huge numbers of participants, which does not necessarily mean that all/most of those participants are real developers, but not just passive users of those software programmes. To find out the exact number of particular communities from the large OSS communities seems impossible even by accessing the top managerial people in those communities.

The in-depth interview with one of the interviewees (Chapter 6, Appendix 2) proved this. Nobody, including the top level of leaders in the large OSS communities, can give the exact number or even the approximate number of all contributors. The interviewee could give the number of the officially employed contributors; however, the total population of the OSS communities is hard, perhaps impossible to count. As mentioned, SourceForge.net, the one of the world's largest OSS development websites, hosted more than 142 thousands projects and nearly 1.5 million registered users in summer 2007. This gives a general idea about the current situation in the OSS market; however, it was not possible to find a clear picture regarding the population of the OSS larger communities.

The challenging issue is to try to count determining minimum returned sample size for a given population size for continuous and categorical data, because in this thesis, there is no clear picture of the population size. However, we can look at the academic literature and the advice regarding sample size and what can be done in this thesis in order to be able to fit the thesis to the required academic criteria in terms of sample size.

The ideal sample size should be no less than 500 individuals – members of OSS communities for the quantitative data. According to Krejcie and Morgan (1970) (cited in Sekaran, 2003, p.293-294), the sample size can be counted by a variety of formulas. Sekaran (2003) gives a generalised scientific guideline for sample size decisions. According to that guideline, the sample size of a given population of 1.000.000 should be 384. Sekaran (2003) also uses the method mentioned by Roscoe (1975), where a sample size larger than 30 and less than 500 is appropriate for most research. At the same time Roscoe wrote that in multivariate research the sample size preferably should be 10 times as large as the number of variables. Tabachnick and Fidell (2007, has been cited in Pallant, 2007) gave a formula to calculate sample size $N > 50 + 8m$, where m = number of independent variables.

Taking into consideration the hard task of discovering even the approximate population of OSS communities, and the advised points mentioned above regarding sample size in the literature, this thesis will try to achieve a sample size as large as possible. As it will be seen from the quantitative data analysis in the next Chapter, the sample size in this thesis is appropriate to the above mentioned calculations and formulas. For example according to the formula given by Tabachnick and Fidell (2007), there are ten propositions in this thesis and one independent variable in each proposition, which means ten independent variables. Therefore the sample size N should be bigger than 50 + 8x10, which means bigger than 130. Additional evidence is Roscoe's opinion (1975, cited in Sekaran, 2003) that sample size should be larger than 30 and less than 500 for most research projects. The next section will explain how the data was collected and what kind of challenges occurred in the data collection and sample size.

5.4.8 Data Collection

5.4.8.1 Response Rate

It was naively expected to receive responses in a quite short time. Unfortunately the expected numbers of respondents was much higher than those which were received in reality. As discussed (this Chapter, Section 5.4.6), total design method (Hoddinott & Bass, 1986; Dillman, Sinclair & Clark, 1993) was used in order to increase the response rate, during the period 21 May 2007 – 31 July 2007, in total 275 email exchanges were made with individuals or communities or groups of people related to OSS development (Detailed information is given below and in Appendix 6). During those three months (May-July 207) after an extensive amount of email exchanges, after joining lots of online discussion boards/forums, after contacting potential respondents and academic staff who specialise in the OSS communities, in total 142 responses were received. At the same time, it is impossible to count the response rate; because of the unknown number of individuals which received the questionnaire proved during the in-depth interview with C, Appendix 2.

The size of the sample in this thesis, which is 142 responses, can be considered as comparatively small. However, the author of the thesis believes that in order to reach OSS developers and to increase the response rate, all possible attempts have been made to approach the individuals in the OSS communities. Even though the sample size is not ideal, the author believes that it is representative of the active developers. As can be seen from the next Chapter around 80% of the respondents are active developers, who are involved in OSS development processes. This means that the collected data can be considered as representative, because most of its respondents are those who contribute to knowledge sharing in the OSS development. The description of the respondents as well as data analysis will be presented the next Chapter.

5.4.8.2 Cover Letter during Questionnaire Distribution

The cover letter included in the questionnaire is presented below.

> *Dear Member of an Open Source Software Community,*
>
> *I am a PhD student in e-Business in Durham University, Durham Business School (UK). My research topic is "Knowledge management and innovation in virtual organisations"[31]. The aim of my thesis is to assess how and to what extent knowledge is created, shared, and circulated in open source software (OSS) communities. In my empirical studies I am going to collect primary data from members/developers of OSS communities. This research is beneficial for OSS communities, because it will shed light on how and why knowledge-workers in OSS communities share their unique tacit know-how knowledge to create more innovative products/services. At the same time it is very important for my PhD study to find sufficient empirical data. Because you are the one who can give me a correct picture of how you experience your contribution to OSS*

[31] http://www.dur.ac.uk/zilia.iskoujina/research-abstract.htm

activities, it is important that you respond to the questions frankly and honestly. The information you provide will help me to reach the aim of my thesis. Your response will be kept strictly confidential. I am sure you are very busy, but if you could spend no more than 15 minutes to answer to my questionnaire which is below, I would be grateful for your contribution. There will be some prizes - after finishing the data collection, I will randomly select some respondents and send them gift vouchers for £20 from Amazon. A summary of the results will be e-mailed to you after the data has been analysed. Also I will place the summary of the results to my website[32]. Thank you very much for your time and cooperation. I greatly appreciate your help in contributing to this research endeavour.

Zilia Iskoujina
E-mail: zilia.iskoujina@durham.ac.uk

5.4.8.3 Distributing the Questionnaire

The potential respondents were approached via the following organisations and individuals (a more detailed list of the organisations and individuals who were approached to either complete the questionnaire or to distribute it is given in Appendix 6):

- SourgeForge.net (small OSS communities in web development)
- Main sites of the targeted OSS communities: Apache, MySQL, PHP, Ruby-on-Rails, Python, MagicAjax.NET - AJAX Framework, Castle Project, SimpleTest, MaNGOS, Second Life
- Source Forge itself and its partners
- Discussion boards/ developers' online forums
- Google groups of the OSS communities
- OSS Gurus
- Academics who in specialise in the research of OSS communities
- The groups in Facebook specialised in OSS development
- 22 most active projects in SourceForge.net
- Randomly chosen other OSS communities
- The Developers Group
- W3C (World Wide Web Consortium)
- Open Source Initiative
- Open Source Software Institute (OSSI)

[32] http://www.dur.ac.uk/zilia.iskoujina

- British Computer Society's Open Source Specialist Group
- OASIS (Organization for the Advancement of Structured Information Standards)
- Conferences specialised on the OSS development
- OSDC (The Open Source Developers' Club)

5.4.8.4 Distributing the Questionnaire to Small OSS Communities

Small OSS communities, which were found in SourgeForge.net in the web development sector, were approached by sending an individual email to each contributor (Appendix 5); it was possible to find out their contact details on their webpages in SourgeForge.net. The request to complete the online questionnaire was sent to all 20 members in MaNGOS and 2 respondents completed the questionnaire. The request to SimpleTest was sent to all 10 members and 2 respondents completed the questionnaire. The request to Castle Project was sent to all 7 members and none replied. The request to MagicAjax.NET was sent to all 7 AJAX Framework contributors and 1 respondent completed the questionnaire.

5.4.8.5 Distributing the Questionnaire through Source Forge, ThinkGeek and FreshMeat

The next step was sending the request to distribute the questionnaire to the management of Source Forge. The 20 email addresses of the related individuals were found on the Source Forge website and they were sent a request to distribute the questionnaire. One of them replied and promised to check how he could help ("I've forwarded this along to our operations manager to see if/how we can help you out. I'll let you know."). The final answer informed that it was impossible to help, due to privacy issues.

> "He said we don't typically respond to these kinds of inquiries for privacy reasons. But he did forward your request on to one of our user support guys, so you could still get another answer from one of them.". "We have no mechanism to distribute or provide a survey to the end-users without causing the target audience to get upset with us. We get several requests like this a month, and our users would grow tired of us if we forwarded them all on to our community.
>
> We do like to help researchers when possible, but unless access to some raw SourceForge.net data is of use, you'll need to find a way to get your survey out the door without our assistance. Is

there a conference coming up in your area soon? If so, you could print out copies of your survey and ask folks to fill them out there. I think that would get a better reception than sending it out via email or some other method.”).

The next step was contacting SourgeForge partners ThinkGeek and FreshMeat. The request was sent to their general email addresses. No reply was received.

5.4.8.6 Distributing the Questionnaire through the Websites of Selected Large OSS Communities

The next step in approaching OSS communities was contacting them via the main websites of the targeted groups. Apache was contacted via apache@apache.org and human-response@Apache.Org. The request was sent to their general email address. The automatic reply was received and confirmed that “mail *will* be read by a human being.” From Apache, 1 respondent completed the questionnaire. The email for developers of the Second Life community was sent to SLDev@lists.secondlife.com. Also the same request was sent to 4 relevant individuals from the list of contributors. 1 respondent completed the questionnaire. MySQL was approached via MySQL contact and questions online form. The following reply was received “Thank you for using the MySQL AB contact form. We will contact you concerning your inquiry as soon as possible.” 10 respondents completed the questionnaire.

PHP was contacted via info@phpdeveloper.org, and 6 respondents completed the questionnaire. Ruby was contacted via ruby-talk-admin@ruby-lang.org and ruby-core-admin@ruby-lang.org, and no reply from the main site was received. Python was approached via addresses taken from http://www.python.org/psf/committees/ - committees, conferences, developers, http://news.gmane.org/gmane.comp.python.devel - developers, http://www.python.org/community/sigs/ - special interest groups. Because no reply was received the second time request was sent to the email addresses of moderators, organisers, developer groups. 9 respondents completed the questionnaire.

5.4.8.7 Distributing the Questionnaire through Special Interest Groups on Facebook

As the next step, the online community Facebook was searched to locate special interest groups in OSS development. The request was sent to administrators and main pages of the following groups in Facebook: “Linux, BSD, Free OS's, Software and the Open Source” community – 24 members; “MySQL - The world's most popular open source database” – 243 members; “LAMP Linux Apache MySQL PHP” – 270 members; “PHP” – 485 members; “The Web Designer Index” – 3333 members; “Open Source Developers” – 21 members; “Python Developers” – 40 members; “Django Web Framework” – 57 members; “UK Rails Developers” – 30 members. Administrators of the groups kindly distributed the request to the members of the group. 5 respondents completed the questionnaire from receiving the request from Facebook groups.

5.4.8.8 Distributing the Questionnaire through Other Various Organisations and Academic Staff

Organisations such as “The Developers Group”, “World Wide Web Consortium”, and “Open Source Initiative” were contacted through their main email addresses. No reply was received. After that, the current academic literature was reviewed once again and relevant academics were located. The request was sent to 14 different groups of academics. Brian Fitzgerald promised to distribute the questionnaire in Ireland at one of the OSS conferences. Juan Carlos Fernandez-Ramil, Lecturer in Computing Department, The Open University gave advice for research.

Cornelia Boldyreff, Professor of Software Engineering in the Department of Computing and Informatics within the Faculty of Technology at the University of Lincoln advised the author to contact the British Computer Society's Open Source Specialist Group and get the questionnaire circulated through them. The chairman of the British Computer Society's Open Source Specialist Group Paul Adams was contacted later on. An invitation to conferences in OSS in Birmingham and Cambridge was received. However, due to the financial issues, it was not possible to attend the conferences. This is one of the weaknesses of this research. If it would be possible to attend such OSS conferences, it would be much easier to gain a bigger sample size for the quantitative data collection.

5.4.8.9 Distributing the Questionnaire through Online Forums

A developers' forum (http://forums.devshed.com/) was approached and PHP Development, Python Programming, Ruby Programming, MySQL Help, Apache Development online forums were found. After sending requests to discussion boards, the author's access to the www.devshed.com online forum was banned permanently. The next step was approaching the OSS individual contributors via discussion boards of other online forums. Although initially Linux was not in the list for the distribution of the questionnaire, the Linux forum was approached. The request was seen 110 times for 19 October 2007 by the individuals. The number of the completed questionnaire by those viewers is not known.

Developers' network was the other online forum to be approached. For 19 October 2007 there were 350 views of the message regarding the questionnaire. Also there were two replies: "Wow this is cool. Shame the only open-source projects I've ever worked on either wasn't programming or I was the sole member…" and "That was an interesting survey. A little vague and hard to follow in some areas, but interesting none the less." Also the group Qwerty was approached, which was studied for participant observation for qualitative data collection. The number of the completed questionnaire is not known. Python forum was approached by sending email to an administrator. There were 228 views. The number of the completed questionnaire by those viewers is not known.

Also the request was sent to Ubuntu developers by subscribing to the Ubuntu developers email list. The request was sent to online forums of the communities Ruby forum, Developers' papers, Slashdots, PHP, Linux, Mozilla, Firefox, Thunderbird, Webtools, Bryght, Open Source Think Tank, Pligg forum CRM, and Drupal. The request was sent to the Google groups of Ruby-on-Rails, Python, MySQL, Apache, PHP, and Second Life. The request was sent to the subscribers in OASIS (Organization for the Advancement of Structured Information Standards which is a not-for-profit, international consortium) that drives the development, convergence, and adoption of e-business standards. The request was sent to the general email of the conferences on OSS: the Holland Open Software Platform, Conference in Lumerick, FOSDEM.The number of the completed questionnaire is not known.

5.4.8.10 Distributing the Questionnaire among the Most Active Project in Source Forge

The next step was to contact the most active projects (http://sourceforge.net/top/mostactive.php) in SourceForge.net. They were WebCalendar, 6 members; SourceForge.net, 32 members; Crystal Space, 62 members; Pidgin, 26 members; the Python programming language, 75 members; PhpWiki, 16 members; phpBB, 8 members; phpWebSite, 13 members; The JBoss/Server, 77 members. One of the reply was received was “Sorry, I get so many of these OSS survey requests now I don't do them anymore.” This post explains low response rate.

5.4.8.11 Distributing the Questionnaire among OSS Gurus

Also the request was sent to the Open Source Software Institute (OSSI) Board of Directors. OSSI Executive Director John M. Weathersby asked for the research abstract and then distributed the request to its members. Also the Internet was browsed and such leaders were found and the request was sent to them as well:

1. Eric Raymond, a programmer, author and open source software consultant;
2. Richard Stallman, a software freedom activist, hacker, and software developer;
3. McCool, an author of the original NCSA HTTPd web server, later known as the Apache HTTP Server;
4. Brian Behlendorf, a technologist, computer programmer, and an important figure in the open-source software movement;
5. Dr David Mertz, an author and columnist for IBM's developerWorks, Intel Developer Services, O'Reilly's ONLamp, and other online publications;
6. Roy T. Fielding, Chief Scientist, Day Software, Co-founder and member, The Apache Software Foundation;
7. Mitchel Baker, Mozilla CEO;
8. Jono Bacon, Ubuntu Community Manager, Canonical;
9. Daniel Berlin, Google, Google's Open Source Program Office;
10. Aaron Boodman, Google, Inc.;
11. Danese Cooper, Open Source Diva, Intel and Open Source Initiative;
12. Chris DiBona, Open Source Programs Manager, Google, Inc.;

13. Mark-Jason Dominus, Chief Programmer, Plover Systems Co.;
14. Justin Erenkrantz, Senior Software Engineer at Joost, a Director for The Apache Software Foundation;
15. Schuyler Erle, a free software developer and activist;
16. Brad Fitzpatrick President, CTO, LiveJournal.com, founder and CTO of Danga Interactive, best known for the popular community blogging and social networking site LiveJournal.com;
17. Brian W. Fitzpatrick, Software Engineer, Google, Inc.;
18. David Goodger, Director & Secretary, Python Software Foundation;
19. Ted Leung, Senior Engineer, OSAF;
20. Timothy Miller, Founder, Open Graphics Project;
21. Eric Pugh, Principal, OpenSource Connections;
22. Sam Ramji, Director, Open Source Software Lab, Microsoft;
23. Mark Shuttleworth, Founder, Ubuntu/Canonical Ltd.;
24. Nathan Torkington, Conference Chair, O'Reilly Media, Inc.; Nat Torkington, a consultant on open source and startup strategies, writes for O'Reilly Radar, and co-chairs the Open Source Convention OSCON;
25. Simon Wardley, COO, Fotango;
26. Andrei Zmievski, Chief Architect, Outspark Inc.;
27. Ruby founder Yukihiro Matsumoto;
28. David Heinemeier Hansson, an inventor of Ruby on Rails.

5.4.8.12 Main Point in Quantitative Data Collection

The result of all above mentioned efforts ended successfully, when an inventor of Ruby-on-Rails David Heinemeier Hansson published a request to the Ruby-on-Rails website's blog.

> **"PhD study on innovation with open source**
> Posted by David July 01, 2007 @ 11:58 PM
> Zilia Iskoujina is a PhD student from the UK who's doing research on Knowledge management in virtual organisations. As part of that, a questionnaire for people working in open source has been created. If you have 15 minutes, consider filling it out."

This publishing was the main source of receiving the responses for the questionnaire and helped most in collecting the data. After his request to his community, the quantitative questionnaire was responded comparatively quickly and it is the main basis of the whole data. Generally people, who were asked for help in distributing the questionnaire, were positively approached toward the request. However, it was observed that because of huge amount of similar requests, OSS developers might simply ignore such kind of requests to complete the questionnaire. Also on the case of D. H. Hansson and Ruby-on-Rails, it was clearly seen that the authoritative person in the community has more influence on his colleagues. As a result for the future, in approaching the OSS contributors, it would better to join some big conferences where it is possible network and then distribute the online questionnaire among attendants to such conferences and/or to colleagues of those attendants.

5.4.9 Data Collection Results

142 respondents completed the questionnaire during the period May – July 2007, which will be used for data analysis. As 5 responses had a lot of missing data, only 137 responses will be used. These respondents received the questionnaire from the following OSS communities: Apache, Facebook, Facebook MySQL Group, Java, Jboss, JBossESB, KDE, LAMP, linuxforum.com, MagicAjax.NET – AJAX, MaNGOS, Mozilla, MySQL, OpenLogic, Perl, PHP, Pligg, Python, Red Hat, Reddit, Ruby, SecondLife, SimpleTest, SourceForge, Ubuntu (Table 5.4). However, in order to keep consistency in analysis, to find out answers to questions from the respondents according to their main activities in OSS development, for the analysis of the data communities where contributors mostly contribute to: .net, Apache, AROS, Bzr, Castle Project, Gnome Desktop, GNU, grass gis, Inkscape / lib2geom, Java, JBoss, KDE, Latex, Linux, MaNGOS, mirthproject.org, MOGRE 3D Engine, Mozilla, Stic, MySQL, NASA World Wind, Nmap, OpenACS, Perl, PHP, Pligg, Python, Ruby[33], SecondLife, Semantic Web, SimpleTest, Ubuntu,YAWE will be used (Table 5.5). The majority of the responses were from Ruby on Rails (RoR), PHP, and Python, which are 3 different languages in web development for creating active websites. As it was discussed earlier, that the majority of responses received from RoR (67 out of 137), because of the message from the creator of RoR David Heinemeier Hansson in the main blog of the RoR website.

[33] For the data analysis Ruby and Ruby-on-Rails will be marked as RoR.

Table 5.4: Question 1 “Which OSS Community did you receive this questionnaire from?”

	Frequency	Percent	Valid Percent	Cumulative Percent
	2	1.5	1.5	1.5
Apache	1	.7	.7	2.2
“Contacted directly”	1	.7	.7	2.9
“direct to me personally”	1	.7	.7	3.6
Facebook	3	2.2	2.2	5.8
Facebook MySQL Group	2	1.5	1.5	7.3
Java	1	.7	.7	8.0
Jboss	1	.7	.7	8.8
JBossESB	1	.7	.7	9.5
KDE	1	.7	.7	10.2
LAMP	1	.7	.7	10.9
linuxforum.com	1	.7	.7	11.7
MagicAjax.NET - AJAX	1	.7	.7	12.4
MaNGOS	2	1.5	1.5	13.9
Mozilla	2	1.5	1.5	15.3
MySQL	10	7.3	7.3	22.6
OpenLogic	1	.7	.7	23.4
Perl	1	.7	.7	24.1
PHP	6	4.4	4.4	28.5
Pligg	6	4.4	4.4	32.8
Python	9	6.6	6.6	39.4
Red Hat	1	.7	.7	40.1
Reddit	4	2.9	2.9	43.1
Ruby	**67**	**48.9**	**48.9**	**92.0**
SecondLife	1	.7	.7	92.7
SimpleTest	2	1.5	1.5	94.2
SourceForge	2	1.5	1.5	95.6
Ubuntu	5	3.6	3.6	99.3
Other	1	.7	.7	100.0
Total	**137**	**100.0**	**100.0**	

Table 5.5: Question 2 "To which OSS Community do you mostly contribute?"

	Frequency	Percent	Valid Percent	Cumulative Percent
	5	3.6	3.6	3.6
.net	1	.7	.7	4.4
Apache	3	2.2	2.2	6.6
AROS	1	.7	.7	7.3
bzr	1	.7	.7	8.0
Castle Project	1	.7	.7	8.8
Gnome Desktop	1	.7	.7	9.5
GNU	1	.7	.7	10.2
grass gis	1	.7	.7	10.9
Inkscape / lib2geom	1	.7	.7	11.7
Java	3	2.2	2.2	13.9
JBoss	3	2.2	2.2	16.1
KDE	1	.7	.7	16.8
Latex	1	.7	.7	17.5
Linux	3	2.2	2.2	19.7
MaNGOS	1	.7	.7	20.4
mirthproject.org	1	.7	.7	21.2
MOGRE 3D Engine	1	.7	.7	21.9
Mozilla	3	2.2	2.2	24.1
My own project Stic	1	.7	.7	24.8
MySQL	2	1.5	1.5	26.3
NASA World Wind	1	.7	.7	27.0
Nmap	1	.7	.7	27.7
OpenACS	1	.7	.7	28.5
Perl	2	1.5	1.5	29.9
PHP	**16**	**11.7**	**11.7**	**41.6**
Pligg	6	4.4	4.4	46.0
Python	**10**	**7.3**	**7.3**	**53.3**
Ruby	**51**	**37.2**	**37.2**	**90.5**
SecondLife	2	1.5	1.5	92.0
Semantic Web	1	.7	.7	92.7
several OSS projects	1	.7	.7	93.4
SimpleTest	2	1.5	1.5	94.9
Ubuntu	6	4.4	4.4	99.3
YAWE	1	.7	.7	100.0
Total	**137**	**100.0**	**100.0**	

5.4.9.1 Sample Size: Final Look

As was mentioned earlier in this Chapter, the sample size can be calculated by Tabachnick and Fidell's formula (Pallant, 2007) N>50+8m, where m = number of independent variables. Taking into consideration the difficult task of finding out even the approximate population of the OSS communities, and the advised points mentioned above regarding sample size in the research from other scholars, this thesis tried to have the sample size as large as possible. According to the formula given by Tabachnick and Fidell, there are ten propositions and an independent variable in each proposition, i.e. 10 independent variables. Therefore the sample size N should be bigger than 50+8x10, i.e. bigger than 130.

For achieving the statistical significance in data analysis (Hair, Black, Babin, Anderson & Tatham, 2007), the statistical power of the sample size is important, although this thesis uses a comparatively small sample size, the author believes that the sample size is good enough for further data analysis and to test the propositions, because of the flowing reasons:

A) The sample size is 137, i.e. larger than 130.
B) The sample is "filtered" and it has the right respondents, i.e. as it will be seen below, the real contributors to the OSS communities were the ones who completed the questionnaire, the ones who give the right picture of the research questions investigating in this thesis.
C) Although it is comparatively small, it is the result of an enormous amount of work to contact all possible sources to get more respondents.
D) Previously performed academic enquiries tell us that, generally a larger sample size could be collected by a group of researchers for their projects in a comparatively longer period of time.
E) This thesis is a combination of two separate but relevant empirical studies: Phase 1 of the empirical studies – qualitative research, and Phase 2 of the empirical studies – quantitative research. This means that the whole thesis does not rely only on the sample size of 137 respondents, but it is a combination of various studies.

5.5 Conclusion of Chapter 5

This Chapter describes how the research questions, which were identified in the previous Chapter, will plan to be studied through empirical studies. This thesis uses a combination of qualitative and quantitative research approaches. The qualitative research approach is used as a foundation for the quantitative research approach, where quantitative research is built on what is found in the academic literature and via the qualitative research. The combination of qualitative and quantitative research approaches is used through the facilitation method, where qualitative research supports quantitative research.

Above in this Chapter it was explained that qualitative data was collected through participant observation and three in-depth interviews. The last section of the Chapter explained how the quantitative questionnaire was designed and collected. Quantitative data was collected through an online questionnaire (URL: http://www.dur.ac.uk/zilia.iskoujina/qq.htm). The questionnaire is divided into main sections, identified according to variables in the Model (individual level): motivations, position/roles, educational level/explicit knowledge, tacit experience, trust, identification, satisfaction, incentives, and monetary reward (see the previous Chapter "Theoretical Framework").

After the creation of the questionnaire, it was piloted and followed by a long and challenging period of questionnaire distribution and data collection. As demonstrated, an extensive amount of work, strategies, and ways have been used in contacting OSS communities and their individuals to collect data. Detailed analysis of each method will be given in phases 1and 2 of the empirical studies in the next Chapter.

CHAPTER 6

EMPIRICAL STUDIES ANALYSIS and DISCUSSION

6.0 Introduction to Chapter 6

Chapter 6 brings together the analysis of different datasets and discusses the findings in relation to the propositions outlined in chapters based on the literature review. It does this by providing the analyses of Phase 1 (Qualitative Research) and Phase 2 (Quantitative Research), discussed earlier in Chapter 5. In Phase 1 we get to know OSS communities from a qualitative data perspective, where the outcomes of the participant observation and in-depth interviews will be considered in detail. These then formed the basis of Phase 2, the quantitative data analysis, will give some broad statistics on the respondents such as geographical location, gender, age, outside activities of the respondents, roles inside OSS communities, hierarchy in OSS communities and communication tools, before exploring each proposition in detail. Then quantitative data analysis will take place in order to test propositions. Factor analysis, correlation analysis, and regression analysis conducted in relation to this aspect of the analysis will be explained. After that research questions in the thesis and findings will be discussed, where main findings on personal factors (Research Question 1) and organisational factors (Research Question 2) will be given. As a result integration of findings on personal factors and organisational factors in the Model will be reviewed and provided.

6.1 Phase 1: Getting to Know OSS Communities from Qualitative Perspective

As was already mentioned in Chapter 5, section 5.3, Phase 1 of the empirical studies had an exploratory purpose and conducted while generating the theoretical framework and before collecting quantitative data initially trying to answer the research questions. The qualitative research was used to inform the design of the quantitative research. So that the reader understands this background material, the qualitative research itself will be explored in detail in this section.

6.1.1 Participant Observation

6.1.1.1 Meetings

As mentioned in Chapter 5, participant observation took place within a local network of the OSS community in web development called Qwerty. Qwerty met offline once a month (every second Thursday of the month at 7 pm), where its members discussed particular software for their web development projects. The majority of its membership is drawn from web designers/web masters of local companies specialising in web development. For analysis of Qwerty, observation results of the monthly offline meetings; its official website; the Google group, which was created in January 2007; and the Facebook group, which was created in May 2007, were used. As discussed in Chapter 5, only monthly meetings, which took place in the period between September 2006 and July 2007, are taken into consideration during this analysis.

The author was able to join the "academic" part of the meetings. The members of the group knew the purpose of her attendance during the meetings (it was not a spy operation). The number of the members increased quite quickly (for example some members started to join the Qwerty group by coming from other UK cities). The second meeting (when the author joined the group) was in a pub with a general discussion about web development, where there were around five people. In April 2008, the Google group comprised 51 members. The members were all male.

Generally meetings were organised around three to four presentations (Table 6.1.1) mainly related to OSS and its opportunities, as well as other web development issues. Firstly meetings were held in Business Centres, in a room, which could hold 15 people. When the number of members increased, the meetings were transferred to a bigger room in one of the educational bodies in the city, where Qwerty had been located. Presentations were made using IT equipment. Although the primary occupation of each member was not know, it was possible to summarise that members were people mainly from the local web development industry, academic and support (IT departments) staff or students from local Universities and other educational bodies.

During participant observation, the author did not have particular questions for members of the group. The main idea was to participate in the meetings and observe the group in order to experience an OSS network from the inside and investigate their activities from an external perspective. It was very useful to participate in Qwerty meetings in order to digest academic literature through participant observation during the design of the theoretical framework and quantitative questionnaire. Therefore, instead of approaching participation within the Qwerty group with set questions, the process was reversed, namely to participate passively and observe actively in order to understand current academic literature from an internal and practical perspective. How the outcome of participant observation was used during the design of the theoretical framework and quantitative questionnaire is explained in detail in Chapter 4 and Chapter 5 accordingly.

It was exciting to observe how competitors in real life interacted to share their skills with each other in Qwerty meetings. The meetings took place after working hours and started at around 7.00pm until 9.30 – 10.00pm, so unfortunately the author could not participate in the social part of the meetings in a pub. This normally took place after 10.00pm, the time catch a train to go back to Durham. The result of the participant observation would be much more fruitful with the analysis of the social interaction after the official meeting had ended. Clearly such social interactions gave lots of advantages for the members to get know each other better. Social interactions were a very important part in the knowledge sharing process. It was experienced twice by the author, in September 2006 and July 2007, when the entire meeting took place in the pub (Table 6.1.1), where a relaxed atmosphere helped people to be more open with others and talk about issues other than concrete issues in software, but undoubtedly to create friendly and trustful environment, a basis for further networking.

Table 6.1.1 (QL): Participant observation: agenda from some meetings

Year	Date	Presentations' topics
2006	September	Social meeting in a pub (with 5 people) General chat about web development and opportunities of OSS
	December 14	How to use software in the creating web / web development Which automatically write JavaScript, Specialised software
		News in web development, Infoq.com – good source of IT news Therailsway.com – code contributors' site, Remote job adv Amazon uses OSS, Tiobe software – popularity of languages, The Grosen Bach – test-first development , OOP
		Enabling designed value implications for web design ISO 9126 – quality attributes, Web quality model – giorgio branjik Value and web quality, Collective motivations Belief (explicit) versus values (implicit) Cultural forms, Revealed associations, Personal motivations Alder – existence relatedness growth Maslow – impulsive not-motivated purposeless
2007	January 11	Invisible walls – how OSS works in/with databases
		OSS & E-commerce
	February	Radiant – content management simplified systems – OSS
		Thoughts from a furniture maker, OSS for your toolkit
	March, 8	Restful development with OSS
		Act…rest
		Resource Oriented Architecture, Open-source-network.org
	April, 12	Django, Python, a language for web development
		Behaviour driven development, Test driven development
	July, 12	Social meeting in a pub

However, although the "academic" parts of the meetings included primarily one-to-many presentations and questions-answers section, it was interesting to see how enthusiastic and active members are, and how new members interact with each other, and how the knowledge sharing processes through their presentations occurs, how they share information about new books, new tools, and most importantly useful, and as they call it, 'beautiful codes' and the ways to use /write them, etc. The atmosphere was friendly and although the members are competitors in real life, in Qwerty it was a warm, friendly climate during the meetings, with a helpful attitude, and overall understanding that such interactions such as sharing their skills to write 'beautiful code' can be beneficial for everyone.

6.1.1.2 The Website

The official home page of Qwerty declares its identity with a description of that they "exist to promote all aspects" of software they use within their region. They emphasise that they "particularly welcome newcomers to join their friendly local community to share, teach and create" knowledge about special software. This description underlines the importance of knowledge sharing in online communities in order to create new knowledge and skills. This description shows that yesterday's competitors need to reconsider their views and become co-operators today.

6.1.1.3 Questions that arose during the Qwerty meetings

So, what kind of questions arose during passive participation and active observation? What kind of ideas was created in the mind of the observer during participant observation in Qwerty? As mentioned earlier, Qwerty includes inside web designers and web masters of one of the UK regions, web programmers of the region, who in reality are competitors, because they are specialising in same area in one region. If so, why do these people come together? How and to what extent do they share their knowledge? According to one of the members of Qwerty, people in Qwerty shared their knowledge only to a particular extent, sharing a bit of knowledge and keeping the rest for themselves, because the are real life competitors within the same industry and geographical area. However, they still meet, socialise, and share (!) their knowledge and skills with others Nevertheless, what do they mean by knowledge sharing? Do they really share their know-how? If yes, how do they do that? If no, what is it that they share? Let's participate to observe!

6.1.1.4 Online Presence: Google Group and Facebook – As a Medium for Information and Knowledge Exchange

As was already mentioned, together with their official website, Qwerty opened its group on Facebook in May 2007; however, the Facebook existence of the Qwerty group had not been active. Since its creation until April 2008, there had not been any interaction via Facebook; the group had only 21 members (the same network in Google group had 51 members during the same period of time). In January 2007 Qwerty created its Google group, where all communication with members of the group was transferred. On the 25th of June, 2007, the Google group had 51 members, and browsing the Google group showed that this space had been used for general interaction purposes, for mail merges, for sharing new tools in IT and web development, informing about meetings and their schedule, job advertising and even for social purposes, for example drink invitations to celebrate the marriage of one of the members. The Google group has been used as an online medium for communication between offline meetings. Below there is a table archiving Qwerty interaction in the Google group.

Table 6.1.2 (QL): Archive of Qwerty interaction in Google group

	Month	Archive of messages	Top posters during Jan 2007 – April 2008
2007	Jan	27	86 posts by Member 1 77 posts by Member 2 32 posts by Member 3 29 posts by Member 4 26 posts by Member 5 24 posts by Member 6 24 posts by Member 7 21 posts by Member 8 18 posts by Member 9 11 posts by Member 10
	Feb	33	
	Mar	82	
	Apr	49	
	May	88	
	Jun	34	
	Jul	19	
	Aug	9	
	Sep	19	
	Oct	6	
	Nov	9	
	Dec	5	
2008	Jan	8	
	Feb	10	
	Mar	11	
	Apr	20	

Below there is an example of the many discussion topics in the Google group, as an interaction between members regarding web development issues. The topic below was selected randomly, where the only requirement was that topic should be purely technical. There is a discussion, an interaction between two active members of the group, where they discuss the features of writing some 'beautiful code' and share/advise each other with suggestions regarding some codes.

Member 1 wrote on May 31 2007, 1:08pm

> "Hey all,
>
> Rails core members Marcel Molina and Jamis Buck teamed up to do a Rails code review recently at MountainWest Ruby Conference. There is a video of this presentation here:
>
> http://mtnwestrubyconf2007.confreaks.com/session10.html

It's absolutely worth watching. Apart from the clear plugging of Beck's Smalltalk Patterns book, there's interesting points made about disliking elsif clauses, refactoring of behaviour, thin-controller fat-model implementation, and the difference between Integer("S") and "S".to_i

All good stuff.

Also, if you want to save your eyes from doing a lot of squinting, download the flash movie directly and view it in your preferred flash movie app:

http://mtnwestrubyconf2007.confreaks.com/videos/session10.flv"

Then the same Member continued on 1, May 31 2007, 3:48 pm

"Whilst watching this video, I noticed the following snippets which I don't quite understand. Does anyone else have more understanding, and is able to explain what's going on?

In their proposed helper method for refactoring out the tab creation code Jamis sneaked in something like this:

```
def tab(name, options={}
  lang = _(name)
end
```

It looks like it's something to do with languages, but I've never seen the _ used except within irb where it represents the result from the previous statement.

Also in the editable block helper Marcel wrote the following line:

```
def editable(&block)
  concat(block.call, block.binding) if
state_of_the_world_is_some_condition
end
```

Can anyone break this down and explain what's going on?

Also, for those interested, the rest of the Mountain West Ruby Conference talks are available here:

http://mtnwestrubyconf2007.confreaks.com/

Thanks,"

As can be seen, there is an interaction regarding writing the codes and also information exchange, for instance about the conference. The questions of Member 1 were approached by Member 2. Member 2 replied to the Member 1 on May 31 2007, 5:33 pm

> Whilst watching this video, I noticed the following snippets which I
> don't quite understand. Does anyone else have more understanding, and
> is able to explain what's going on?
> In their proposed helper method for refactoring out the tab creation
> code Jamis sneaked in something like this:
> def tab(name, options={}
>   lang = _(name)
> end

"Not sure what's going on there unless they've got some kind of localization plugin which defines _ as its string loopup function."

> Also in the editable block helper Marcel wrote the following line:
> def editable(&block)
>   concat(block.call, block.binding) if
> state_of_the_world_is_some_condition
> end
> Can anyone break this down and explain what's going on?

The docs for concat are probably your friend here. You'd use it like:
<% editable do %>
  optional stuff goes here
<% end %>

"Essentially, it renders 'optional stuff goes here' if state_of_the_world_is_some_condition. The 'block.binding' bit is because concat needs to get the _erbout variable from the guts of Erb to work its magic, and erb is in scope when the block is declared, but it isn't in scope in the helper."

Then the discussion between Member 1 and Member 2 started, while Member 1 sent his message to Member 2 on May 31 2007, 6:05 pm

>> def tab(name, options={}
>>   lang = _(name)
>> end
> Not sure what's going on there unless they've got some kind of
> localization plugin which defines _ as its string loopup function.

"Yeah, that was my guess too. I just wondered if it was anything standard, that's all."

>> Also in the editable block helper Marcel wrote the following line:
>> def editable(&block)
>> concat(block.call, block.binding) if
>> state_of_the_world_is_some_condition
>> end
>> Can anyone break this down and explain what's going on?
> The docs for concat are probably your friend here. You'd use it like:
> <% editable do %>
>   optional stuff goes here
> <% end %>

"Yep, that's exactly how Marcel introduced the whole thing. It's exactly like the new form_for helper."

> Essentially, it renders 'optional stuff goes here' if
> state_of_the_world_is_some_condition.
> The 'block.binding' bit is because concat needs to get the _erbout
> variable from the guts of Erb to work its magic, and erb is in scope
> when the block is declared, but it isn't in scope in the helper.

"Sure. After messing around with erb and bindings a fair bit myself, I (think I) understand the basics of what's going on at a high level. What I'm missing really is what's going on underneath the hood. : what is the _erbout variable, and what is concat (which I guess is a Rails specific thing). I know that there are docs, it's just nicer to get an explanation - and using the mailing list allows other people to see what's going on too, and hopefully promotes discussion :-)

I'm also guessing that concat grabs all the outputs from the block defined within <%= %> tags. However, I've no idea how any of this works. It's all magic to me :-)"

To the above comments, Member 2 replied on May 31 2007, 8:51 pm

"To be honest, your best bet is just to treat it as magic. Any time you want to write a helper that you use in a similar way to <% form_tag do %> ... <% end %> rather than <%= some_helper %>, you need to use the concat(block.call, block.binding) pattern. You can also add arbitrary extra stuff using concat, but you need to grab the block.binding so that concat knows where to put the text:

```
concat "<div class='arbitrary_wrapper'>", block.binding
concat block.call, block.binding
concat "</div>"
```

If you really need to know _how_ it works, then you're going to have to look at concat's source and also at eruby's. At the handwavy level, the thing that should help is to imagine that

```
pre
<% editable do %>
something
<% end %>
post
```

is compiled by erb into something (very approximately) like:

```
_erbout << "pre"
editable do
  _erbout << "something"
end
_erbout << "post"
```

Then all you have to do is understand what eval(string, binding) does. Which I leave as an exercise for the interested reader."

Member 1 replied to Member 2 on May 31 2007, 9:37 pm

> Then all you have to do is understand what eval(string, binding) does.

"Which is content of a previous post (subject: Ruby Bindings). I think I understood the semantics of what was going on, but not how it was doing its thing."

> Which I leave as an exercise for the interested reader.

"Hopefully any interested readers will share what they know/find out with the list :-)"

Additionally to that Member 1 sent the following message on Jun 5 2007, 4:47 pm

> Can anyone break this down and explain what's going on?

"Just found this screencast:

http://media.railscasts.com/videos/040_blocks_in_view.mov it deals exactly with the issue in question, and even expands further than the Rails Code Review. Worth watching if you want to clean up your views."

Also Member 1 added on Jun 5 2007, 5:28 pm

>> Can anyone break this down and explain what's going on?

> Just found this screencast:

> http://media.railscasts.com/videos/040_blocks_in_view.mov

"Just an interesting point. The screencast shows that you don't need to pass the result of the block into a concat command. Here's a (slightly more complicated) example from my current project:

```
def planner(&block)
   concat '<div id="planner">', block.binding
   concat '<ul>', block.binding
   Factor::FACTORS.each do |factor|
     category =  (/([a-z]*)\d*/.match factor)[1]
     block.call(factor, category)
     #or yield works too:
     #yield(factor, category)
     concat '<li class="arrow"> </li>', block.binding
   end
   concat '</ul>', block.binding
   concat '</div>', block.binding
end
```

The interesting bit is the stuff within the FACTORS iterator. Either a block.call, or yield will work without the need for the concat.

Another thing I was wondering was whether it's possible to stick the:

```
concat '<div id="planner">', block.binding
  #lots of gumpf
concat '</div>', block.binding
```

in one of those nice content_tag helpers. I'm not sure how to do that and still pass it the binding. Does anyone have any smart ideas?"

So from this example of the interaction between two members, it can be seen how information exchange happens in the Qwerty network. It is seen how members welcome anyone to share their knowledge and are happy to exchange the knowledge they have themselves. Bearing in mind, that the Google group is open and accessible to everyone interested in OSS particularly, it is easy to imagine how such discussion can develop further. At the same time, the Google group was used for social interaction, for example one of the members sent an invitation to a football match.

Member 3 sent on 19 July 2007, 11:36 a message

> "Hi All
> Short notice call for anyone who fancies a game of football tonight.
> I'm playing 5-a-side with a few people from the amazing group and amazing media and we need a few more people. Playing about 6 just on westgate road.
> If anyone fancies a game drop me a line. You dont have to play regularly or have a proper kit or anything. And if you need directions I can sort em out.
> Thanks "

6.1.1.5 The Level of Activeness, Leadership

According to the public website, the group committee consisted of four of the most active members. The table 6.2.2 shows the archive of messages and the list of top posters in the Google group. According to this table and comparing it with the public website, it is possible to demonstrate support for the academic literature that the leadership in the OSS communities are "decided" upon the level of the knowledge sharing in the community, which can be relevant to knowledge in the knowledge-based economy. Those members of Qwerty, who are in the committee, are also ones who are the top posters and most active members in Qwerty (Table 6.1.2).

An interesting point is that in autumn 2007, when the unofficial leader left the UK, the group became less active. Because the author stopped attending the meeting after July 2007, it is difficult to write exactly about the further activities of the group. However, from the messages they sent to Google group members, where all interactions take place, it is easy to see the extent of activities they undertook after Autumn 2007. The number of new members, the number of the presentations, the number of the messages, and the content of the messages show a decrease in their activities after the leader's departure. However, after a certain period of time, other individuals took over the organisational responsibility and have brought activities back to life. This fact once again shows the importance of leadership in an organisation, even though in such a community as this the leadership was unofficial and that such leadership builds on the level of knowledge sharing, because of the level of knowledge.

6.1.1.6 Short Summary

The participant observation was very useful to understand the OSS community from the inside, to digest the academic literature on such communities, to prepare the content of the quantitative questionnaire accordingly (Chapter 5, Sections 5.4.2 and 5.4.3). The quantitative questionnaire was piloted on this group's members (Chapter 5, Section 5.4.5), with one of the members interviewed in-depth. It was very fruitful to be inside the group, and to be able to get used the atmosphere of the OSS community from within. There was an important reflection of the participant observation during the design of the quantitative questionnaire. How participant observation and in-depth interviews influenced the design of the theoretical framework (see Chapter 4).and the design of the quantitative questionnaire (mentioned in Chapter 5: Phase 2 - Operationalisation of the Model through Quantitative Research).

6.1.2 In-Depth Interviews

6.1.2.1 The Questions That Were Asked

The discussions were based on open-ended questions (see Appendix 2). The questions were created after the literature review, during participant observation as a result of the digestion of the collected explicit knowledge in order to be able to understand better the tacit side of the interviewees' opinion. Table 6.1.3 below gives detailed descriptions on how the questions for the in-depth interviews fit the research questions in this thesis (Table 6.1.3 has been redesigned from Table 4.1, Chapter 4). The first question (Appendix 2) was directly related to the main aim of the thesis. Interviewees were asked for their opinions of how does/should KM operate in their own OSS community. Also they were asked their opinion on why knowledge sharing is important.

The next section of the questions (Appendix 2) was related to management issues in their OSS communities, because all three interviewees were in a leading position in their OSS communities. The questions regarding management of the OSS communities were asked with the aim of building a picture of how OSS communities work from the leading people's point of view, so that it will be possible to understand KM processes inside of the OSS communities, which will be derived from the answers of the interviews.

After discussing the general information (Appendix 2): the size of the OSS communities and the groups of developers, the structure of OSS communities, roles and responsibilities of the developers; the following questions were asked in order to better understand the work processes within the OSS communities, virtual space of VO, directly addressing the gaps found during the current academic literature review. Who submits codes for official releases? How is the OSS community managed? What is the division of management in coordination of activities? Who are the coordinators of particular tasks? What is the procedure for selecting members? What is the procedure in identifying work to be done? How is work distributed within the development community? Are functions carried out by distinct groups of people, that is, do people primarily assume a single role? Where do the code contributors work in the code? How does the "chaotic" OSS style of development work: how to manage people, who can make uncoordinated changes, particularly to the same file or module, which interferes with one another? How does the development community avoid this? Are high priority problems resolved faster than low priority problems? The last section of the questions (Appendix 2) was asked randomly, for example regarding innovation: what do they understand by innovation and how do they measure innovation? Regarding general and final comments, in their opinion, why do OSS communities work?

Table 6.1.3 (QL): Propositions and the Research Questions to Be Investigated Through In-Depth Interview Questions

N	Research questions of the thesis	Propositions, which will answer research questions	Questions from in-depth interviews (Appendix 2)
1	What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?	Propositions 1-5 on personal factors	See Question 1 in Appendix 2 regarding KM and knowledge sharing
2	What are the characteristics of the communities that affect knowledge sharing in OSS communities?	Propositions 6 – 10 on organisational factors	See Question 2 in Appendix 2 regarding management of the OSS Community

6.1.2.2 Answers Given To the Questions Asked[34]

[34] See Appendix 2.

According to these responses, it is possible to highlight the following main results of the in-depth interviews with the leaders of some OSS communities. People, who contribute to the OSS, generally are “users of software and the developers of the OSS”. Online interaction takes place through various online tools, for example wiki, public forums, mailing lists, teleconferences, Skype, and instant messaging. Offline conferences play an important role, for example in discussion of the next releases. Interviewees showed that OSS developers contribute to the OSS communities because of the following reasons: hobby, extra activity (In addition to the main work on behalf of their employers), career opportunities, and peer recognition.

Interviewees noted that knowledge sharing has lots of motivations. According to interviewees, some of the motivations are payment and learning experience. In general knowledge sharing is “a personal thing”. In some of the OSS communities, people are competitors, therefore “they can share knowledge at a particular level”. But generally “a person knows something, a person keeps nothing back”, while “in OSS, doing things where anybody can contribute – a part of OSS”. Interviewees point out that “knowledge sharing is the way OSS works, in a distributive way”. And most importantly it is noted that “generally OSS work is not face to face work, therefore sharing knowledge is very important. Because in classical companies knowledge sharing is implicit. But in OSS, worldwide location, people share knowledge explicitly.”

Because of the differences in the size of the OSS communities where the three interviewees have been involved, there are some differences in the answers in terms of the management /coordination in the OSS communities. However, the following are the main points mentioned in the interviews and are related to management and leadership in the OSS communities. In small OSS communities, there is not a single coordinator, “from that sense it is managed by everybody who is involved in this project”. In large OSS communities, management is as hierarchical as in a normal “traditional” company. The head is a Chief Technical Officer, followed by a Technical Development Manager. Then there is a Project Leader, then developers and coordinators. As it is mentioned in the academic literature as well, in every OSS community, including those who were interviewed, “knowledge is the most important tool for being a leader.” Even in those OSS communities, where there is any form of hierarchy, knowledge remains the main tool for being a leader.

As seen, the size of the OSS development community plays an important role in leadership issues inside the OSS communities. Such communities, where almost everyone worldwide can join the community, can seem chaotic. According to interviewees, it is both chaotic and non-chaotic at the same time depending on the nature of the OSS community. If the OSS community is small and in its initial stage, then the size is small. In the case of C, it is "difficult to say" about its size even for its leader, because there are official employees and volunteers. As for volunteers, it is "difficult to give accurate number, est. probably 250-300 people". The number of developers who are officially employed is about 150 people. The main criteria for volunteers to share their knowledge is the opportunity to be officially employed in a well known and well developed OSS community.

6.1.2.3 Short Summary of Phase 1: Qualitative Research

It was very fruitful to conduct interviews with the leaders of the OSS communities before starting Phase 2 on quantitative research. There was an important reflection of the participant observation during the design of the quantitative questionnaire.

As mentioned in Chapter 5, Section 5.3, Phase 1 of the empirical studies had an exploratory purpose and was done during generating the theoretical framework and before collecting quantitative data initially trying to answer the research questions. Qualitative research was the basis for quantitative research; and it played a fundamental role for the quantitative research. Although qualitative research as such did not test propositions (Chapter 4), it explored the background for the quantitative research. Qualitative research took place to explore the OSS communities in more detail from inside. The in-depth interviews were very valuable, as all three above mentioned individuals are the very top managerial people in their OSS communities. It was helpful to shed light on issues in the quantitative questionnaire with such active OSS developers, to take their advice and comments and to examine the research questions.

How participant observation and in-depth interviews influenced the design of the quantitative questionnaire was discussed in Chapter 5: Phase 2 - Operationalisation of the Model through Quantitative Research. Also Chapter 7 will use the answers from the in-depth interviews during an overall discussion of the empirical studies and literature review. However, before combining the literature review and findings of the data analysis into overall conclusions, quantitative data and test propositions will be analysed in order to find out the answers to the research questions. The quantitative data analysis will be given in Section 6.2 below.

6.2 Phase 2: Quantitative Data Analysis

As was mentioned earlier, the data for the Model will take place in Phase 2, where some statistics before data analysis such as geographical location of the respondents, gender, age, outside activities of, roles inside OSS communities of the respondents, hierarchy in OSS communities and communication tools will be discussed. Then quantitative data analysis will take place in order to test propositions. Factor analysis, correlation analysis, and regression analysis will also be given. After that, research questions in the thesis and findings will be discussed, where main findings on personal factors (Research Question 1) and findings on organisational factors (Research Question 2) will be given. As a result integration of findings on personal factors and organisational factors in the Model will be reviewed and provided.

6.2.1 Descriptive Data of Sample

Before starting quantitative data analysis, this section gives initial information regarding the respondents and their responses. Together with introductory information about the respondents, the result of this description will also be useful later when various control and dummy variables will be created for the data analysis and propositions testing.

6.2.1.1 Geographical Location of the Respondents

As was discussed before in the literature review, e-business provides equal opportunities for everyone worldwide. If you open any book about e-business/e-commerce, it shows that IT and the Internet in particular provide equal benefits / opportunities to everyone worldwide. Companies and individuals have equal chances of entering global markets and similar opportunities to implement their activities online. Before the collection of primary data it was supposed that respondents of the questionnaire could be located all over the world.

However, the primary data shows that the reality is different from the theory. The majority of the contributors to the OSS communities are from countries which have high level of e-business readiness, according to the Economist research (2008), in terms of connectivity and technology infrastructure, business environment, social and cultural environment, legal environment, government policy and vision, consumer and business adoption (the first 20 countries accordingly are: USA, Hong Kong, Sweden, Australia, Denmark, Singapore, Netherlands, UK, Switzerland, Austria, Norway, Canada, Finland, Germany, South Korea, New Zealand, Bermuda, Japan, Taiwan, Belgium). The respondents of the quantitative questionnaire are mainly from USA (35.77%) and UK (24.82), and others are mostly from other European countries (France (3%), Switzerland (2%), and Germany (2%)), or from Australia (4%), New Zealand (2%) or Canada (3%).

6.2.1.2 Gender of the Respondents

According to the results of the quantitative data, the dominant gender in OSS communities is male. This proves a hunch during the in-depth interviews and participant observation. During the whole time spent conducting the empirical studies, and despite the huge number of individuals met during the research, there were no female-contributors to the OSS communities. Almost 98% of the respondents of the quantitative questionnaire are males.

6.2.1.3 Age of the Respondents

More than half of respondents (51.82%) are in the age 20-29. 22.63% are of the age 30-39; 8.76% are of the age 40-49; 2.19% are of the age 50-59; less than 1% are of the age 60-69; 6.57% are of the age under 19. That means that almost three-quarters of the respondents are younger than 40. Combining geographical location and age of the respondents, it is interesting to find out that countries other than the UK and USA, have much younger contributors: the rest of the world has 21.9% of those who are of the age 20-29, and 10.95% of those who are of the age 30-39. Whereas, in USA, those who are of the age 20-29 took 20.44% and those who are of the age 30-39 took 5.84%; and in UK, those contributors who are of the age 20-29 took 9.49% and those who are of age 30-39 took 5.84%. The USA has more age varieties than the UK and other countries, including those who are of the age of 60-69, who are contributing to the development of the OSS communities. Nevertheless, to summarise a general picture of a random OSS contributor, he is a young North American / British (European) male.

6.2.1.4 Outside Activities of the Respondents

Outside of the OSS communities, the majority of the contributors to the OSS communities are either an IT employee (35.48%) or IT, self employed (32.26%). 18.06% are students, presumably in studies related to computer science. Only 6.45% of the contributors are in employment other than IT. This is because of the specific characteristics of the OSS communities; the producers of software need people with knowledge about the creation of software, writing its code, etc.

6.2.1.5 Roles inside OSS Communities of the Respondents

Inside the OSS communities the respondents take the following roles: project leader, core member, active developer, peripheral developer, bug fixer, bug reporter, reader, passive user, and other. According to the data, roles can be divided into 3 main parts: "top" position – project leader, core member, and active developer; "middle" position – peripheral developer, bug fixer, and bug reporter; and "not very active" position – reader, passive user, and other. In each part of the positions: top, middle and not very active; there is a tendency for the number of respondents to increase. For example in "top" position it starts with Project Leader role – 6.55%; continues with Core Member position – 8.31%, and finished with Active Developer – 12.34%. Again in "middle" position it starts with not high number of responses of Peripheral Developer – 9.57%, continues with Bug Fixer – 11.84%, and finishes with Bug Reporter – 19.9%. Then in "not very active" position there is a variety of common/passive users (13.60%) and readers (13.85%) of the software code.

Such tendencies can mean that roles in OSS communities do not have exact divisions and flow fluidly between contributors, as a project leader can be an active developer and can be a bug fixer as well; whereas for example a bug reporter cannot necessarily be a core member and not necessarily is a project leader, because leadership in OSS communities is a fruit of reputation accepted by other members and based on the previous level of the knowledge sharing: tacit skills and experience. One of the respondents completed the questionnaire with the following comment: "You've mostly focussed on the coding aspects of contributing to OSS projects, but there are far more people who contribute by doing documentation, helping out on forums and contributing feedback and bug reports on software. Coding is generally done by the core developers + patches by the peripheral developers.” The answer options for the question regarding roles and responsibilities in the OSS communities were taken from the current academic literature (Chapter 2). However, the comment made by the respondent shows that the OSS communities still need more in depth analysis

6.2.1.6 Hierarchy in OSS Communities

The most contact is with peers in the OSS communities (47.3% of the respondents). 36.94% of the respondents contact forum/project moderators. Only 15.77% of the respondents contact top management team. This data proves the existing hierarchy inside OSS communities, where only small parts of them contact top management, perhaps project moderators, where project moderators are contacted by relevant contributors. And almost the half of the respondents is in touch with their peers in the process of the OSS development.

6.2.1.7 Communication Tools

Contributors mainly use emails (27.42% of the respondents), internal web resources (28.29%), other relevant web resources (24.89%), or online books and journals (16.61%) to obtain/share explicit knowledge. Due to the intangibility of the OSS products / services, the main platform is online. Offline books and journals are used pretty rarely (only 2.79%). And from online resources internal ones are more preferable to external ones. Even though offline forums and conferences (14.42% of the respondents) have a high level of popularity, due to the geographical spread of the contributors, online forums and conferences have almost twice higher range of popularity (28.83%). Even though online sources of communication take the main position, face-to-face meetings keep their importance in software development (11.35% of the respondents). But again, due to the geographical spread, face-to-face meetings cannot be as popular as online meetings. Also online chat rooms are the most popular (almost 70%), instant messaging (12.2%), blogs (4.88%), Wiki (4.88%), newsgroups (4.88%) are very popular among communication tools among OSS developers.

6.2.1.8 A Short Summary

If we draw a rough picture of a developer to OSS communities, we can see that he is a young North American / British (European) English speaking male with extensive knowledge in IT (see for example, Ghosh, Glott, Krieger & Robles, 2002; Jensen & Scacchi, 2007 (Chapter 3, Section 2)). After having a general look at OSS communities and having become familiar with statistics gained from the collected data, the quantitative data analysis for propositions testing will be done through factor analysis, correlation analysis and hierarchical multiple regression analysis.

6.2.2 Data analysis

In this section the quantitative data analysis is provided: factor analysis, correlation analysis, hierarchical multiple regression analysis with dummy variables, which will be implemented. For the data analysis, SPSS (Statistical Package for the Social Sciences) software package will be used. Pallant's manuals (2005, 2007) and Hair, Black, Babin, Anderson & Tatham (2007) were used as a guide in using SPSS. The mentioned analyses will allow testing of the propositions identified earlier.

In order to test propositions, variables are identified by using factor analysis (Section 6.2.2.1). In factor analysis a set of questions under the same section, which can be related to each other, is analysed together. According to the results of those analyses, appropriate variables will be built. After identifying variables by the factor analysis, the next step is to use correlation analysis (Section 6.2.2.2). Correlation analysis will give an answer in terms of the relationships between variables in the propositions, how strong or weak these relationships are. And after that, hierarchical multiple regression analysis (Section 6.2.2.3) will be used to test propositions identified in Chapter 4, Section 4.2.

6.2.2.1 Factor analysis

In order to identify variables to test propositions, and also for checking data for reliability, factor analysis was implemented. The questions in the questionnaire were divided according to their similarities in meanings and those, which were suitable for propositions' analysis (how the questions were divided are shown below in the process of the factor analysis). Variables were identified by setting appropriate questions together from the quantitative questionnaire in order to test propositions by these variables.

The following variables were identified:
1. Hobby
2. Altruism
3. Accomplishment
4. Philosophical factors “PhilosophicalFactors”
5. Network opportunities “NetworkOpportunities”
6. Personal needs “PersonalNeeds”
7. Main work needs “MainWorkNeeds”
8. Incentives/benefits for the future “Incentives/BenefitsForTheFuture”
9. Satisfaction with management “SatisfactionWithManagement”
10. Identification
11. Trust

Additionally to the above mentioned variables, the following variables in tacit knowledge were identified:
1. Gaining Tacit Knowledge “GainTacKn”
2. Colleagues Give their Tacit Knowledge “ColleaguesGivingTacKn”
3. Sharing Tacit Knowledge with Others “SharingTacKn”

It means that a total of 14 main variables[35] will be used for testing the propositions later. However, before testing the propositions, the factor analysis will be described below.

6.2.2.1a Variables 1-7: Motivations

Q20 - What are your personal motivations to contribute to the OSS Community?
The answer options for this in the questionnaire were divided into 3 main sections: hobby, psychological factors and philosophical factors. Factor analysis showed that the cumulative percentage is equal to 69%. Answers from a) to e) were given for hobby option, from f) to j) –

[35] In this section under the variables by the letter “Q” will be meant the question and its number in the quantitative questionnaire (Appendix 3).

psychological factors' option, and from k) to o) - philosophical factors' option. After factor analysis , it was found out that options a) – e) can be gained under one subgroup, because in item loadings they show themselves as one group (Table 6.2.1 (FA)). Whereas psychological factors can be divided into two main subgroups: altruism and accomplishment. And finally the psychological factors' option show as one component in item loadings (Table 6.2.1 (FA)). This means that these formulated new components can be considered as variables: hobby, altruism, accomplishment, and psychological factors.

Table 6.2.1 (FA): Rotated Component Matrix, Q20 – What are your personal motivations to contribute to the OSS Community?

	Component			
	1	2	3	4
Q20a	**.745**	-.082	.088	.126
Q20b	**.772**	-.010	.312	.055
Q20c	**.823**	-.010	-.013	.074
Q20d	**.880**	.050	-.045	-.031
Q20e	**.801**	.162	.085	-.120
Q20h	.150	-.001	**.832**	.294
Q20i	.031	.164	**.893**	.110
Q20j	.102	.132	**.875**	.048
Q20k	-.077	**.723**	-.079	.105
Q20l	-.016	**.777**	.182	.050
Q20m	.061	**.805**	.158	-.136
Q20n	.018	**.736**	-.022	.213
Q20o	.243	**.521**	.256	.237
Q20f	.106	.013	.232	**.862**
Q20g	-.058	.357	.143	**.787**

Considering each particular variable separately, the following results can be observed.

Q 20a – Q 20e. For these five items Cronbach's Alpha is equal to .865 (Table 6.2.9 (FA)). The variable is named "Hobby".

a) I enjoy writing programs.

b) Programming gives me a chance to do what I can do the best.

c) I spend my free time with programming.

d) Programming is my favourite activity.

e) I cannot imagine my life without programming.

Q20f – Q20g. For these two items Cronbach's Alpha is equal to .721 (Table 6.2.9 (FA)). The variable is named "Altruism".

f) I enjoy helping other people.

g) I have an altruistic approach towards communicating with other people.

Q20h – Q20j. For these three items Cronbach's Alpha is equal to .878 (Table 6.2.9 (FA)). The variable is named "Accomplishment".

h) It gives me the feeling of success.

i) It gives me the feeling of competence.

j) It gives me the feeling of effectiveness.

Q20k – Q20o. For these five items Cronbach's Alpha is equal to .782 (Table 6.2.9 (FA)). The variable is named "PhilosophicalFactors".

k) I believe software should be free.

l) OSS is more secure than commercialised software.

m) OSS is more updated than commercialised software.

n) I contribute to the OSS Community because of reciprocal approach.

o) I want to be someone who creates free software available for use by everybody.

Statistics show that in Q20, 15 items (answer options) can be combined in 4 variables (personal motivations) (Table 6.2.9 (FA))

- Hobby
- Altruism
- Accomplishment
- Philosophical Factors

In rotated component matrix Q20a-Q20e can be combined in one variable because those items are >0.5 (Table 6.2.1 (FA)). Q20f-Q20g can be combined in one variable because those items are >0.5. Q20h-Q20j can be combined in one variable because those items are >0.5. Q20k-Q20o can be combined in one variable because those items are >0.5. All the data is reliable, because all Cronbach Alpha's reliability statistics are high >0.8 in most of them (Table 6.2.9 (FA)).

Q21 – What are your professional motivations to contribute to the OSS Community?

The answer options for the question in the questionnaire were divided into 3 main sections: main work needs, personal needs and network opportunities. Factor analysis showed that cumulative percentage is equal to 66%. Answers from a) till d) were given for main work related needs' option, from e) till i) – personal needs' option, and from k) till o) – network opportunities' option. After factor analysis of the Q21, it was found out that options a) and b); c) and d); e), f), and i); and finally j), l), m), g), h), and k) can be gained under different subgroups, because in item loadings they show themselves as one group (Table 6.2.2 (FA)). This means that these formulated new components can be considered as variables: network opportunities, personal needs, main work related needs, and social prestige.

Table 6.2.2 (FA): Rotated Component Matrix, Q21 – What are your professional motivations to contribute to the OSS Community?

	Component			
	1	2	3	4
Q21j	**.744**	.322	.218	-.065
Q21l	**.741**	-.022	-.073	.310
Q21m	**.712**	-.055	.158	.195
Q21g	**.674**	.207	.004	.098
Q21h	**.665**	.397	.092	-.124
Q21k	**.631**	.406	.232	-.086
Q21e	.123	**.830**	-.017	.071
Q21f	.129	**.789**	.165	.261
Q21i	.475	**.575**	.022	.062
Q21b	.050	.127	**.889**	.096
Q21a	.180	.004	**.866**	.074
Q21c	-.045	.071	.180	**.796**
Q21d	.333	.230	-.028	**.674**

If to consider each particular variable separately, then the following results can be observed:

Q 21j - Q 21l - Q 21m - Q 21g - Q 21h - Q 21k. For these six items Cronbach's Alpha is equal to .823 (Table 6.2.9 (FA)). The variable is named "NetworkOpportunities".

j) To exchange advice and solutions with knowledgeable people.

l) To be one of the team who produce the innovative software.

m) To meet new and different people.

g) Improves the level of my programming skills.

h) Gives me extra opportunities for learning.

k) To keep abreast of new ideas and innovations.

Q 21e - Q 21f - Q 21i. For these three items Cronbach’s Alpha is equal to .735 (Table 6.2.9 (FA)). The variable is named “PersonalNeeds”.

e) I use OSS myself excluding programming or testing activities.

f) The software provides functionality that matches my unique and specific needs.

i) I like sharing my knowledge and skills.

Q 21a - Q 21b. For these two items Cronbach’s Alpha is equal to .781 (Table 6.2.9 (FA)). The variable is named “MainWorkNeeds”.

a) The software itself is my main job.

b) The software is critical for my main job.

Q 21c - Q 21d. For these two items Cronbach’s Alpha was equal to .417. The variable is named “SocialPrestige&IndividualisticApproach”.

c) I prefer individualistic approach in my work.

d) Increases my social prestige social competence and skills.

In rotated component matrix Q 21j, Q21l, Q 21m, Q 21g, Q 21h, Q 21k can be combined in one variable because those 6 items are >0.5. Q 21e, Q 21f, Q 21i can be combined in one variable because those 3 items are >0.5. Q21a-Q21b can be combined in one variable because those 2 items are >0.5. Q21c and Q21d will be deleted as their Cronbach's Alpha is less then 0.5 (.417) which is not reliable. After their deleting and analysing again all data variables in Q21 (without Q21c and Q21d), the data statistics keep their high and reliable level. In the end, in Q21, there have been created 3 variables (professional related): “NetworkOpportunities”, “PersonalNeeds”, and “MainWorkNeeds” (Table 6.2.9 (FA)).

It means now there are 4 variables (personal related motivations) and 3 variables (professional related motivations). There are 7 variables so far.

6.2.2.1b Variable 8: Incentives for the Future Such as Long Term Benefits

Q22 – What are the long-term benefits of contributing to the OSS Community for you?
This question had four answer options. Factor analysis showed that the cumulative percentage is equal to 64%. Factor analysis collected all four answer options into one component, which can be considered as a variable "Incentives for the future such as long term benefits," (Table 6.2.3 (FA)).

Table 6.2.3 (FA): Component Matrix, Q22 – What are the long-term benefits of contributing to the OSS Community for you?

	Component
	1
Q22c	**.841**
Q22b	**.823**
Q22a	**.769**
Q22d	**.752**

Q22a – Q22d. For these four items Cronbach's Alpha is equal to .802 (Table 6.2.9 (FA)). The variable is named "Incentives for the future such as long term benefits".
a) After participating in the OSS Community, I can improve career progression prospects.
b) After participating in the OSS Community, I can increase my income in my main work place.
c) After participating in the OSS Community, I can increase my income from additional activities by using OSS.
d) I will establish my own business by selling consulting, training, implementation or customisation services related to the project.

Statistics show that in q22 4 items can be combined in one variable "Incentives for the future such as long term benefits". In component matrix Q 22a – Q22d can be combined in one variable because those 4 items are >0.5. All data is reliable, because Cronbach Alpha's reliability statistic is higher >0.8.

6.2.2.1c Variable 9: Satisfaction with Management in the OSS Community

Q26 – 31

26) Are you satisfied with the management of your OSS Community?

27) I receive on time the information needed to do my job in the OSS Community.

28) The Project Administrator offers guidance for solving job-related problems.

29) I am satisfied with the supervision in the OSS Community.

30) I am satisfied with organisational commitment in the OSS Community.

31) I am satisfied with my co-workers in the OSS Community.

These questions in the questionnaire are connected with one meaning - satisfaction with the management in the OSS Community. Factor analysis showed that the cumulative percentage is equal to 62%. Factor analysis collected all six questions into one component, which can be considered as a variable – satisfaction with the management in the OSS Community (Table 6.2.4 (FA)). For these six items Cronbach's Alpha is equal to .862 (Table 6.2.9 (FA)).

Table 6.2.4 (FA): Component Matrix, Q26 – 31, Satisfaction with management in the OSS Community

	Component
	1
Q29	**.884**
Q30	**.859**
Q27	**.848**
Q31	**.783**
Q28	**.752**
Q26	**.539**

Statistics show that in q26-31 6 items can be combined in one variable – "SatisfactionWithManagement". In component matrix Q 26-31 can be combined in one variable because those 6 items are >0.5. All data is reliable, because Cronbach Alpha's reliability statistic is equal to .862 (Table 6.2.9 (FA)), is higher >0.8.

6.2.2.1d Variable 10: Identification in the OSS Community

Q36 – Q38

36) I strongly identify myself with this OSS Community.

37) I gain a feeling of belonging the OSS Community.

38) There is a "team spirit" in the OSS Community.

These questions are connected with one aspect - identification in the OSS Community. Factor analysis showed that cumulative percentage is equal to 75%, and collected all these questions into one component, which can be considered as a variable – identification in the OSS Community (Table 6.2.5 (FA)). For these three items Cronbach's Alpha is equal to .838 (Table 6.2.9 (FA)).

Table 6.2.5 (FA): Component Matrix, Q36 – Q38, Identification in the OSS Community

	Component
	1
Q37	**.927**
Q36	**.860**
Q38	**.814**

Statistics show that in q36-38 3 items can be combined in one variable – "Identification". In component matrix Q 36-38 can be combined in one variable because those 3 items are >0.5. All data is reliable, because Cronbach Alpha's reliability statistic is higher >0.8 (Table 6.2.9 (FA)).

6.2.2.1e Variable 11: Trust

Q39 – Q44

39) I trust the peers in the OSS Community.

40) I trust the quality of the information and knowledge provided by group members.

41) If I share my technical problems with the group, I know group members will respond constructively.

42) I think peers in the OSS Community trust me.

43) We have confidence in one another in the OSS Community.

44) Members in the OSS Community show a great deal of integrity.

These questions in the questionnaire are connected with one meaning – trust. Factor analysis showed that the cumulative percentage is equal to 65%. Factor analysis collected all six questions into one component, which can be considered as a variable – trust (Table 6.2.6 (FA)). For these six items Cronbach's Alpha is equal to .890 (Table 6.2.9 (FA)).

Table 6.2.6 (FA): Component Matrix, Q39-44, Trust

	Component
	1
Q43	**.850**
Q40	**.841**
Q44	**.828**
Q39	**.826**
Q41	**.761**
Q42	**.710**

Statistics show that in q39-44 6 items can be combined in 1 variable – trust. In component matrix Q 39-44 can be combined in one variable because those 6 items are >0.5. All data is reliable, because Cronbach Alpha's reliability statistic is higher >0.8 (Table 6.2.9 (FA)).

6.2.2.1f Variables 12 and 13: Gaining Tacit Knowledge "GainTacKn" and Colleagues Give their Tacit Knowledge "ColleaguesGivingTacKn"

Q11, 12, 17, 18

11) How often have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

12) To what extent have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

17) Colleagues within the OSS Community tell me what they know, when I ask them about it.

18) Colleagues within the OSS Community tell me what their skills are, when I ask them about it.

These questions in the questionnaire are connected with one meaning – the opinion of the individual contributors to the OSS communities regarding their gaining of tacit knowledge from others in the communities. Factor analysis showed that cumulative percentage is equal to 85%. Factor analysis collected all these questions into two components, which can be considered as two variables – gaining tacit knowledge “GainTacKn” and colleagues give their tacit knowledge “ColleaguesGivingTacKn” (Table 6.2.7 (FA)).

Table 6.2.7 (FA): Rotated Component Matrix, Q 11, 12, 17, 18, Variables Gaining Tacit Knowledge “GainTacKn”, Colleagues Give their Tacit Knowledge “ColleaguesGivingTacKn”

	Component	
	1	2
Q17	**.923**	.037
Q18	**.923**	.034
Q12	.027	**.918**
Q11	.043	**.918**

Q17 – Q18

17) Colleagues within the OSS Community tell me what they know, when I ask them about it.

18) Colleagues within the OSS Community tell me what their skills are, when I ask them about it.

For these two items Cronbach’s Alpha is equal to .823. Statistics show that in q17-18, 2 items can be combined in 1 variable - Colleagues Giving their Tacit Knowledge. In component matrix Q 17-18 can be combined in one variable because those 2 items are >0.5. All data is reliable, because Cronbach Alpha’s reliability statistic is higher >0.8 (Table 6.2.9 (FA)).

Q11 – Q12

11) How often have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

12) To what extent have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

For these two items Cronbach’s Alpha is equal to .815. Statistics show that in q11-12, 2 items can be combined in 1 variable - Gaining Tacit Knowledge (from others)

In component matrix Q 11-12 can be combined in one variable because those 2 items are >0.5. All data is reliable, because Cronbach Alpha’s reliability statistic is higher >0.8 (Table 6.2.9 (FA)).

6.2.2.1g Variable 14: Sharing Tacit Knowledge with Others "SharingTacKn"

Q13-16

13) How often have you shared your knowledge to other members that enabled them to perform new tasks?

14) To what extent have you shared your knowledge to other members that enabled them to perform new tasks?

15) I share the information I have with colleagues in the OSS Community.

16) I share my skills with colleagues in the OSS Community.

These questions in the questionnaire are connected with one meaning – the opinion of the individual contributors to the OSS communities regarding how they share their tacit knowledge with others in the communities. Factor analysis showed that the cumulative percentage is equal to 65%. Factor analysis collected all these questions into one component, which can be considered as two variables – sharing tacit knowledge (Table 6.2.8 (FA)).

Table 6.2.8 (FA): Component Matrix, Q13-16, Variable: Sharing Tacit Knowledge with Others "SharingTacKn"

	Component
	1
Q15	**.828**
Q13	**.809**
Q16	**.804**
Q14	**.789**

For these items Cronbach's Alpha is equal to .818. Statistics show that in q13-16, four items can be combined in 1 variable - Sharing tacit knowledge with others. In component matrix Q 13-16 can be combined in one variable because those 4 items are >0.5. All data is reliable, because Cronbach Alpha's reliability statistic is higher >0.8 (Table 6.2.9 (FA)).

Q11 – Q18 were analysed together as one group for tacit knowledge. The result was the same – 3 variables: gaining tacit knowledge "GainTacKn", colleagues give their tacit knowledge "ColleaguesGivingTacKn", sharing tacit knowledge with others "SharingTacKn", with high Cronbach's Alpha - 0.765. Therefore, 3 different variables will be used.

6.2.2.1h Summary

The factor analysis can be summarised in Table 6.2.9 (FA), which shows the successful factor analysis with reliable results: cumulative percentage is high in all 14 variables and all data is reliable because Cronbach's Alpha Reliability Statistics are high. This is robust and exceeds the requirements.

Table 6.2.9 (FA): The final table of variables with cumulative % and Cronbach's Alpha Reliability Statistics

<table>
<tr><th>N</th><th colspan="3">Variables</th><th>Total variance explained Cumulative %</th><th>Cronbach's Alpha Reliability Statistics</th></tr>
<tr><td>1</td><td rowspan="7">Motivations</td><td rowspan="4">Personal motivations</td><td>Hobby</td><td rowspan="4">69%</td><td>.865</td></tr>
<tr><td>2</td><td>Altruism</td><td>.721</td></tr>
<tr><td>3</td><td>Accomplishment</td><td>.878</td></tr>
<tr><td>4</td><td>PhilosophicalFactors</td><td>.782</td></tr>
<tr><td>5</td><td rowspan="3">Professional motivations</td><td>NetworkOpportunities</td><td rowspan="3">66%</td><td>.823</td></tr>
<tr><td>6</td><td>PersonalNeeds</td><td>.735</td></tr>
<tr><td>7</td><td>MainWorkNeeds</td><td>.781</td></tr>
<tr><td>8</td><td colspan="2" rowspan="4"></td><td>Incentives/BenefitsForTheFuture</td><td>64%</td><td>.802</td></tr>
<tr><td>9</td><td>SatisfactionWithManagement</td><td>62%</td><td>.862</td></tr>
<tr><td>10</td><td>Identification</td><td>75%</td><td>.838</td></tr>
<tr><td>11</td><td>Trust</td><td>65%</td><td>.890</td></tr>
<tr><td>12</td><td colspan="2" rowspan="3">Tacit knowledge</td><td>Gaining Tacit Knowledge "GainTacKn"</td><td rowspan="2">85%</td><td>.823</td></tr>
<tr><td>13</td><td>Colleagues Give their Tacit Knowledge "ColleaguesGivingTacKn"</td><td>.815</td></tr>
<tr><td>14</td><td>Sharing Tacit Knowledge with Others "SharingTacKn"</td><td>65%</td><td>.818</td></tr>
</table>

After factor analysis, where variables were identified for propositions testing, the next step is to test the propositions.

6.2.2.2 Correlation analysis

Before the actual testing of the propositions by regression analysis, after identifying variables by the factor analysis, the correlation analysis has been done in order to find out what kind of relationship the variables in the propositions have, and how strong or weak these relationships are. To find out what kind of relationships variables in propositions has, the following questions from the questionnaire and the following variables will be used. The questions and variables (identified earlier in the factor analysis) were chosen because they are the ones, which will be used in testing the propositions (Table 6.3.1 (CA)).

Table 6.3.1 (CA): Descriptive Statistics for Correlations Analysis

Variables	Mean	Std. Deviation	N
Q3 - What is your role in the OSS development project in the OSS Community?			
Q3a - Project Leader	.19	.394	137
Q3b - Core Member	.24	.429	137
Q3c - Active Developer	.36	.481	137
Q3d - Peripheral Developer	.28	.449	137
Q3e - Bug Fixer	.34	.476	137
Q3f - Bug Reporter	.58	.496	137
Q3g - Reader	.40	.492	137
Q3h - Passive User	.39	.490	137
Q6 - How long have you participated in the OSS Community?	54.63	44.071	130
Q7 - How often do you communicate with other members in the OSS Community?	3.70	1.292	130
Q8 - On average how many hours per week do you contribute to the OSS Community?	12.21	14.992	123
Q9 - What percentage of your participation is related to project development in the OSS Community?	35.27	36.380	120
Q32 - Do you gain any monetary rewards for your contribution to the OSS Community?	.18	.385	123
QP4 - Highest education attainment	3.17	.935	127
Variables:			
Motivations:			
Hobby	3.7967	.96962	122

Philosophical Factors	3.9568	.81105	125
Accomplishment	3.9843	.89862	127
Altruism	3.9840	.80806	125
Network Opportunities	4.0393	.72557	123
Personal Needs	4.4107	.69835	125
Main Work Needs	3.4094	1.31297	127
Incentives for the future such as long term benefits	3.3448	1.08087	124
Satisfaction with Management	3.8739	.69275	111
Identification	3.8836	.96454	126
Trust	4.1148	.67290	119
Gaining Tacit Knowledge	3.9920	.69845	125
Colleagues Giving Tacit Knowledge	4.3000	.78545	125
Sharing Tacit Knowledge	3.9464	.68674	126

The following are the findings, which were observed as a result of the correlation analysis (Table 6.3.2 (CA)). The point numbers on the text regarding correlation analysis' results below fit the numbers of the rows in the Table 6.3.2 (CA). The correlations for main findings are shown in the grey boxes in the Table 6.3.2 (CA).

6.2.2.2a Correlation analysis: Propositions on Personal Factors

Proposition 1 – The higher the education level is, the more knowledge contributors share.

Main findings:

- Quite interesting is to find out that according to the correlation analysis, a higher level of education does not have a significant influence on the level of the knowledge sharing (-.049, -.038, -.014). It could be because tacit experience seems more important in the OSS development rather than explicit knowledge (The row N5 in the Table 6.3.2 (CA)).

Proposition 2 – The longer members participate, the more tacit knowledge they have.

Main findings:

- The length of participation in OSS communities does not have a significant influence on extend of tacit knowledge (-.047, .078, .037) (The rows N17, 18, 19 in the Table 6.3.2 (CA)).

Extra findings:

- Spending time knowledge sharing in the OSS communities and the frequency of communication has a strong relationship (.281**), meaning that the main aim of the communication in the OSS communities is knowledge sharing in the OSS communities, where passive users do not get involved, as they “just” use the software (The row N2 in the Table 6.3.2 (CA)).
- On average how many hours per week do they contribute to the OSS Community? Top level of contributors such as project leaders (.238**), core members (.408**) and active developers (.236**) spend more hours a week knowledge sharing in the OSS. Among those members, core members are more active and spend more time contributing to the OSS rather than project developers and active developers. Passive users (-.299**) are not the active ones in spending their time for the knowledge sharing in the OSS, which can mean that passive users are members of the OSS communities “just” for using the software rather than knowledge sharing in OSS development (The row N2 in the Table 6.3.2 (CA)).

Proposition 3 – The higher the level of the role in OSS communities, the more motivations contributors have.

Main findings:

- Hobby as a motivation plays a significant role only for active developers (.226*). The rest of the contributors have other motivations in the knowledge sharing within OSS development (The row N6 in the Table 6.3.2 (CA)).
- Accomplishment and network opportunities as motivations influence only the core members (.187* and .180* accordingly) (The rows N8, 10 in the Table 6.3.2 (CA)).

Extra findings:

- Philosophical factors do not influence the level of responsibilities of the members or the level of knowledge sharing for OSS development (The row N7 in the Table 6.3.2 (CA).

- Motivation has positive relations with other motivations. The motivation “accomplishment” has significant relations with “hobby” (.218*) and positive relationship with “philosophical factors” (.295**) (The row N8 in the Table 6.3.2 (CA)).
- Altruism has no relationships either with the level of responsibilities of the members or with the level of knowledge sharing. This motivation has positive relations with other motivations such as “philosophical factors” (.380**) and “accomplishment” (.758**) (The row N9 in the Table 6.3.2 (CA)).
- Network opportunities as a motivation have relationships with core members. Again this motivation has positive relations with other motivations such as “hobby” (.247**), “philosophical factors” (.342**), “accomplishment” (.351**), and “altruism” (.269**) (The row N10 in the Table 6.3.2 (CA)).
- Personal needs have positive relationships with other motivations such as “philosophical factors” (.623**), “accomplishment” (.504**), “altruism” (.555**), and “network opportunities” (.532**) (The row N11 in the Table 6.3.2 (CA)).
- “Main work needs” and “network opportunities” have strong relationships with each other (.253**). Also “main work needs” has a relationship with “philosophical factors” (.219*) and “personal needs” (.219*) (The row N12 in the Table 6.3.2 (CA)).

Proposition 4 – Personal motivations have positive impacts to the knowledge sharing in the OSS community.

Main findings:

- Personal needs” have an important influence in gaining tacit knowledge (.265**) (The row N17 in the Table 6.3.2 (CA)).
- “Personal needs” have an important influence in colleagues in sharing tacit knowledge (.412**) (The row N18 in the Table 6.3.2 (CA)).
- “Personal needs” have an important influence in sharing tacit knowledge (.304**) (The row N19 in the Table 6.3.2 (CA)).

Proposition 5 – Work related motivations have positive impacts to the knowledge sharing in the OSS community.

Main findings:

- Work related motivations do not show influence in gaining/sharing tacit knowledge (.071, .073, .110) (The rows N17, 18, 19 in the Table 6.3.2 (CA)).

Extra findings:

- Collecting tacit knowledge from others is related to motivations in the OSS communities. Motivations such as "philosophical factors" (.283**), "accomplishment" (.270**), "altruism" (.230*), "network opportunities" (.245**), and also "incentives for the future such as long term benefits" (.234*) have an important influence in gaining tacit knowledge (The row N17 in the Table 6.3.2 (CA)).

6.2.2.2a Correlation analysis: Propositions on Organisational Factors

Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.

Main findings:

- "Satisfaction with management" and motivations such as "philosophical factors" (.305**), "accomplishment" (.262**), "altruism" (.367**), "network opportunities" (.310**), "personal needs" (.393**) (The row N14 in the Table 6.3.2 (CA)).

Extra findings:

- "Satisfaction with management" and "incentives for the future such as long term benefits" have positive relations (.239*) (The row N14 in the Table 6.3.2 (CA)). "Satisfaction with management" plays an important role for the level of knowledge sharing in the OSS development in communities as a whole.

Proposition 7 – The more trust there is inside of the OSS community, the more motivations to share knowledge contributors have.

Main findings:

- Trust has positive relations with such motivations as "philosophical factors" (.310**), "accomplishment" (.347**), "altruism" (.530**), "network opportunities" (.257**), and "personal needs" (.392**), also it has positive relations with "satisfaction with management" and "identification" (The row N16 in the Table 6.3.2 (CA)).

Extra findings:

- Trust is important for the top level of contributors such as project leaders (.181*) and core members (.201*). Trust is an important issue in the development of the OSS. Trust has positive relations with "satisfaction with management" (.582**) and "identification" (.482**) (The row N16 in the Table 6.3.2 (CA)).

Proposition 8 – The more strongly contributors identify with OSS community, the more motivations to share knowledge they have.

Main findings:

- Identification and the level of knowledge sharing have a positive relationship (.238**), and identification is related to motivations, such as "philosophical factors" (.320**), "accomplishment" (.227*), "altruism" (.352**), "network opportunities" (.304**), "personal needs" (.378**) (The row N15 in the Table 6.3.2 (CA)).

Extra findings:

- Satisfaction with management (.213*), identification (.406**), and trust (.337**) have an important relationship with knowledge sharing (The row N19 in the Table 6.3.2 (CA)).
- Only core members find identification as significant (.223*). Also identification is related with "satisfaction with management" (.233**) (The row N15 in the Table 6.3.2 (CA)).
- Identification and gaining tacit knowledge have powerful relations between each other (.267**) (The row N17 in the Table 6.3.2 (CA)).

Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.

Main findings:

- "Incentives"/Benefits for the future" have positive relations with motivations such as "philosophical factors" (.414**), "accomplishment" (.308**), "altruism" (.231*), "network opportunities" (.461**), "personal needs" (.305**), and "main work needs" (.372**). Benefits for the future and the level of the knowledge sharing in the OSS have negative relations (.-.208*), which can mean that contributors are involved in the development purely for the development itself without such motivations as incentives and gaining benefits form it in the future (The row N13 in the Table 6.3.2 (CA)).

Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

Main findings:

- Monetary reward positively influences the time of the knowledge sharing in the OSS (.351**), which can be interpreted as positive relations between monetary reward and core members. Among the top level of the contributors, core members have the highest level of relationship with monetary reward for knowledge sharing in the OSS community (218*). If core members of some OSS communities are officially employed, then the relation between monetary reward and time for the knowledge sharing is understandable. It can be explained by the fact that either in some commercialised OSS or large and well developed OSS, contributors who show their high performance lately can be hired as formal employees and therefore the top level of the contributors can show a level of interest in monetary reward. Among passive members, monetary reward and passive users (-.236**), and readers (-.213*) are not positively related, which can be interpreted that the OSS is free software and the knowledge sharing is financially free of charge at least at the starting point of knowledge sharing (The row N4 in the Table 6.3.2 (CA)).
- Monetary reward plays an important role in knowledge sharing (.185*). Knowledge sharing is completely related to the motivations (The row N19 in the Table 6.3.2 (CA)).

Table 6.3.2 (CA): Correlations' Interpretation

N		Q3a	Q3b	Q3c	Q3d	Q3e	Q3f	Q3g	Q3h	Q6	Q7	Q8	Q9	Q32	QP4	M-Hob	M-PhilFac	M-Acc	M-Altr	M-NetOpp	M-PersNeed	M-WorkNeed	IncBen	SatisMgmt	ID	Trust	GainTacKn	CollGivTacKn	SharingTacKn
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	za	zb
	a	1																											
	b	.467**	1																										
	c	.493**	.470**	1																									
	d	-.050	-.006	-.020	1																								
	e	.238**	.276**	.263**	.205*	1																							
	f	.038	.206*	-.008	.234**	.432**	1																						
	g	-.206*	-.183*	-.238**	-.075	-.059	.250**	1																					
	h	-.276**	-.315**	-.353**	-.033	-.237**	.117	.497**	1																				
	i	-.103	-.105	.074	.199*	-.057	-.040	-.050	.101	1																			
1	j	-.012	.105	.119	.134	-.082	-.075	-.139	-.200*	.088	1																		
2	k	.238**	.408**	.236**	.022	.056	.128	-.127	-.299**	-.057	.281**	1																	
3	l	.341**	.269**	.320**	.054	.347**	.062	-.134	-.326**	.070	.092	.221*	1																
4	m	.133	.218*	.130	.073	-.054	-.054	-.213*	-.236**	.159	.153	.351**	.174	1															
5	n	-.003	.071	.004	-.063	-.062	.072	.155	.089	.120	-.049	-.038	-.014	.098	1														

6	**o**	.019	.160	.226*	-.020	.137	.059	.068	.013	-.132	-.035	.158	.064	.031	-.099	1													
7	**p**	-.102	.021	-.133	-.091	.131	.156	.066	-.021	.007	-.112	-.038	-.022	-.057	-.101	.111	1												
8	**q**	-.021	.187*	-011	.031	.086	.098	.051	-.016	-.091	-.038	.066	-.063	-.052	-.036	.218*	.295**	1											
9	**r**	.035	.161	-.037	-.031	.087	.064	.067	-.045	-.056	-.097	.016	.059	-.140	.007	.159	.380**	.758**	1										
10	**s**	.080	.180*	.128	.013	-.026	-.060	-.107	-.116	-.070	.012	.101	-.076	-.069	.033	.247**	.342**	.351**	.269**	1									
11	**t**	-.075	.105	-.139	.087	.066	.147	.137	.066	-.001	-.167	.004	-.076	-.167	.013	.124	.623**	.504**	.555**	.532**	1								
12	**u**	.019	-.017	.065	-.009	-.010	.088	-.045	-.061	.107	-.023	.083	-.018	.165	.097	.024	.219*	.067	.108	.253**	.219*	1							
13	**v**	.035	-.015	.099	.016	.043	.036	-.043	-.028	.030	-.053	-.041	-.208*	.075	-.109	.172	.414**	.308**	.231*	.461**	.305**	.372**	1						
14	**w**	.104	.153	.024	-.063	.101	-.174	-.064	-.230*	-.086	.007	.195*	.221*	.090	.080	.119	.305**	.262**	.367**	.310**	.393**	.175	.239*	1					
15	**x**	.102	.223*	.063	.096	.029	.027	-.109	-.112	-.046	.036	.238**	.040	.041	.002	.013	.320**	.227*	.352**	.304**	.378**	-.040	.121	.233*	1				
16	**y**	.181*	.201*	-.078	-.008	.016	-.105	-.110	-.175	-.124	-.122	.122	.187*	-.079	-.061	.115	.310**	.347**	.530**	.257**	.392**	-.032	.092	.582**	.482**	1			
17	**z**	-.097	.101	.033	-.081	-.039	.038	.161	.127	-.047	.064	.063	-.171	.105	-.108	.086	.283**	.270**	.230*	.245**	.265**	.071	.234*	.104	.267**	-.029	1		
18	**za**	-.013	.033	-.038	.027	.011	-.035	.109	.069	.078	-.099	.097	.142	-.102	-.098	.037	.262**	.223*	.353**	.238**	.412**	.073	.030	.420**	.248**	.481**	.080	1	
19	**zb**	.257**	.348**	.240**	.172	.216*	.102	-.124	-.245**	.037	.262**	.378**	.185*	.185*	-.095	.083	.198*	.217*	.254**	.196*	.304**	.110	.095	.213*	.406**	.337**	.223*	.275**	1

After identifying variables by the factor analysis, the correlation analysis was done to find out what kind of relationship variables the propositions have. To have a complete analysis of the variables and their relationships, it is necessary to test propositions. The propositions will be tested through regression analysis, which will be done below. After regression analysis, the correlation analysis and regression analyses will be collected together to form the basis of a discussion of the propositions.

6.2.2.3 Regression analysis

This thesis will use hierarchical multiple regression analysis, which be termed regression analysis here. In hierarchical regression analysis, the independent control variables are entered into the quotation in blocks, where the independent variable, which is being assessed, is entered after the previous variables have been controlled for. Therefore, before the regression analysis itself, control variables should be identified.

6.2.2.3a Identifying Control Variables

1) Ruby-on-Rails (RoR)

Because the majority of the respondents were from RoR community, all respondents were divided into main groups: contributors for RoR (yes/1) and others (/no /0).

2) Dummy Variables for Q3

The other dummy variables were identified for Q3: “What is your role in the OSS development project in the OSS Community?” As was already seen from the above analysis, knowledge creation and sharing can be influenced by roles and responsibilities inside the OSS communities. Because OSS communities are organisations where knowledge and skills are the most powerful value in “career growth”, it will be useful to analyse relationships between roles and responsibilities and propositions regarding knowledge sharing.

All roles were divided into 3 main sections: active level roles, middle level roles, and low level roles. Active level roles consist of project leaders, core members, and active developers. Middle level roles consist of peripheral developers, bug fixers, and bug reporters. Low level roles consist of readers and passive users. Hence, there are three dummy variables for Q3:

dummy A 1/0 (active level of roles), dummy B 1/0 (middle level of roles), and the rest (Tables 6.3.3 (a) and (b)). Correlation between Dummy A and Dummy B does not exceed 0.7; therefore there will not be a multicollinearity problem with the eventual regression analysis (Pallant, 2007, p.155).

Table 6.3.3a (RA): Dummy variables for Q3

N	Roles in the OSS development project in the OSS Community	Division	Dummy Variables
1	Project Leader	Top level of roles	Dummy A 1/0
2	Core Member		
3	Active Developer		
4	Peripheral Developer	Middle level of roles	Dummy B 1/0
5	Bug Fixer		
6	Bug Reporter		
7	Reader	Low level of roles	
8	Passive User		

Table 6.3.3b (RA): Correlations and Descriptive Statistics, Dummy variables for Q3

	Mean	Std. Deviation	N	Correlations	Q3 DummyA	Q3 DummyB
Q3 DummyA	.44	.498	137	Pearson Correlation	1	-.055
				Sig. 2-tailed		.527
Q3 DummyB	.68	.469	137	Pearson Correlation	-.055	1
				Sig. 2-tailed	.527	

3) Dummy Variable for QP2: Age of the contributors

More than 50% of respondents are people who are younger than 30. The majority of current research is based on criteria such as age and gender. Since the majority of respondents (more than 98%) are male, it would be interesting to analyse data according to their age, where more than half of population are of a younger generation. 1 dummy variable: Dummy A: 29 and younger than 29 is = 1 / and the rest part 30 and older is = 0, was identified.

4) Dummy Variable for QP6: Primary Occupation

OSS communities are organisations that create technical products, and in this research it is software for web development applications. Therefore as a control variable it will be interesting to analyse data according to respondents' primary occupation, such as IT industry, non-IT industry and students or other. Because the activities in the OSS communities generally are not the main activity for the members, primary occupation where were identified 3 dummy variables: A, B, and C, were chosen as control variables. Dummy variable A 1/0 consists from IT Employee, IT Self-Employed: who work in IT industry. Dummy variable B1/0 comprise those who are in employment other than IT: work in non-IT industry. Dummy variable C 1/0 consists from students: all levels, including below university or undergraduate level students, postgraduate students or PhD students. And the rest are none of the above: retired or not working respondents (Tables 6.3.3 (c) and (d)). Correlation between Dummy A, Dummy B, and Dummy C is not exceeding 0.7; therefore there will not be a multicollinearity problem with the eventual regression analysis (Pallant, 2007, p.155).

Table 6.3.3c (RA): Dummy variables for QP6

N	Primary Occupation	Division	Dummy Variables
1	IT Employee	Work in IT industry	Dummy A 1/0
2	IT, Self-Employed		
3	In employment other than IT	Work in non-IT industry	Dummy B 1/0
4	Below university or undergraduate level student	Student	Dummy C 1/0
5	Postgraduate student		
6	PhD student		
7	Retired/Not working	None of the above	0
8	Other		

Table 6.3.3d (RA): Correlations and Descriptive Statistics, Dummy Variables for QP6

	Mean	Std. Deviation	N	Correlations	QP6 Work InIT	QP6 WorkIn NonIT	QP6 Student
QP6 WorkInIT	.69	.463	137	Pearson Correlation	1	-.300**	-.370**
				Sig. 2-tailed		.000	.000
QP6 WorkInNonIT	.07	.261	137	Pearson Correlation	-.300**	1	.136
				Sig. 2-tailed	.000		.113
QP6 Student	.20	.405	137	Pearson Correlation	-.370**	.136	1
				Sig. 2-tailed	.000	.113	

** Correlation is significant at the 0.01 level 2-tailed.

The following Table 6.3.1e summarises the variables, which were identified for hierarchical multiple regression analysis:

Table 6.3.3e (RA): Final List of Variables for Hierarchical Multiple Regression Analysis

N		Source	Variables	Description
1	Variables consist from propositions and created by the result of factor analysis	Motivations	M-Hob	Hobby
2			M-Altr	Altruism
3			M-Acc	Accomplishment
4			M-PhilFac	Philosophical Factors
5			M-NetOpp	Network Opportunities
6			M-PersNeed	Personal Needs
7			M-WorkNeed	Main Work Needs
8		Incentives / Benefits	IncBen	Incentives / Benefits For the Future
9		Satisfaction with Management	SatisMngt	Satisfaction with Management
10		Identification	ID	Identification
11		Trust	Trust	Trust
12		Tacit knowledge	GainTacKn	Gaining Tacit Knowledge
13			CollGivTacKn	Colleagues Give their Tacit Knowledge
14			SharingTacKn	Sharing Tacit Knowledge with Others

Control Variables				
Dummy Variables				
1	For making complicated data analysis such as multiple regression analysis, control variables were created. The following questions were chosen as control variables.	Q2 - To which OSS Community do you mostly contribute?		
		RoR	Q2Dummy A	yes/no: 1/0
2		Q3 - What is your role in the OSS development project in the OSS Community?		
		Q3a - Project Leader	Q3DummyA	Top level of roles Dummy A: 1/0
		Q3b - Core Member		
		Q3c - Active Developer		
		Q3d - Peripheral Developer	Q3DummyB	Middle level of roles Dummy B: 1/0
		Q3e - Bug Fixer		
		Q3f - Bug Reporter		
		Q3g - Reader		Low level of roles
		Q3h - Passive User		
3		QP2 - Age	QP2DummyA	Dummy A → 29 and younger than 29 is = 1 / and the rest part 30 and older is = 0
4		QP6 – Primary occupation		
		QP6a – IT Employee	QP6DummyA	Work in IT industry Dummy A: 1/0
		QP6b – IT, Self-Employed		
		QP6c – In employment other than IT	QP6DummyB	Work in non-IT industry Dummy B: 1/0
		QP6d – Below university or undergraduate level student	QP6DummyC	Student Dummy C: 1/0
		QP6e – Postgraduate student		
		QP6f – PhD student		
		QP6g – Retired/Not working		None of the above: 0
Questions Necessary for Using in Propositions Testing				
5	Q6	Q6 - How long have you participated in the OSS Community?		
6	Q7	Q7 - How often do you communicate with other members in the OSS Community?		
7	Q8	Q8 - On average how many hours per week do you contribute to the OSS Community?		
8	Q9	Q9 - What percentage of your participation is related to project development in the OSS Community?		
9	Q32	Q32 - Do you gain any monetary rewards for your contribution to the OSS Community?		
10	QP4	QP4– Highest education attainment		

So now the thesis will look at the regression analysis[36] for the propositions testing. After factor analysis and creating variables for propositions testing; after correlation analysis and finding relationships between variables in propositions has, how strong or weak these relationships are; the final step in data analysis will be regression analysis. The interpretation of the regression analyses and their relationships to the propositions will be given below. All analyses will show that the data is reliable. Generally the R2 indicator varied between 5% and 38%. The indicator of the significant F showed very low levels (apart from 2 indicators in the Proposition 2), which means that all data analysis is reliable and valid (Pallant, 2007).

6.2.2.3b Test of Propositions

The coding of all variables used for regression analysis below is given on Table 6.3.3e (RA) with description of each variable.

Proposition 1 – The higher the education level is, the more knowledge contributors share.

Proposition 1 was tested using hierarchical multiple regression analysis. Control variables and QP4 (Highest education attainment) as independent variables tested three dependent variables: Q6, Q7, Q8, and Q9.
Q6 - How long have you participated in the OSS community?
Q7 - How often do you communicate with other members in the OSS community?
Q8 - On average how many hours per week do you contribute to the OSS community?
Q9 - What percentage of your participation is related to project development in the OSS community?

Main findings
A higher level of education does not play a role in the level of the knowledge sharing in the OSS communities ((b=.059, t=.633, ns), (b=-.006, t=-.062, ns), (b=-.040, t=-.447, ns), (b=-.051, t=-.546, ns)).

Extra findings

[36] $p < .05$*, $p < .01$**, $p < .001$***

- The frequency of the communication with other members in the OSS Communities does not have a significant relationship with any control or independent variables.
- Only contributors at the top level have marginally significant relationships with the frequency of the communication with other members in the OSS Communities (b=.167, t=1.774, p<1).
- Contributors in top (b=.243, t=2.727, p<.01**) and middle level roles (b=.199, t=2.303, p<.05*), students (b=-.245, t=-2.334, p<.05*) and those, who contribute to the RoR community (b=-.290, t=-3.207, p<.01**), have significance in the length of hours per week spent in knowledge sharing in the OSS Communities.
- Only contributors at the top level have a significant relationship in the percentage of their participation, which is related to project development in the OSS Communities (b=.392, t=4.225, p<.001***).

Table 6.4.1 (1) (RA): Proposition 1: Q6 – “How long have you participated in the OSS community?”

$F(8,117) = 1.532$, $p < .05$, adj $R = .033$

Dependent Variable: Q6	Standardised Beta	t	Sig.
Q2RubyYesNo	-.046	-.492	.624
Q3DummyA	-.002	-.018	.986
Q3DummyB	-.064	-.713	.477
QP2DummyA	-.251	-2.451	.016*
QP6WorkInIT	.050	.471	.639
QP6WorkInNonIT	-.031	-.332	.741
QP6Student	-.034	-.308	.759
QP4	.059	.633	.528

Table 6.4.1 (2) (RA): Proposition 1: Q7 – "How often do you communicate with other members in the OSS Community?"

F (8,116) = 1.26, $p < .05$, adj R = .017

Dependent Variable: Q7	Standardised Beta	t	Sig.
Q2RubyYesNo	-.049	-.513	.609
Q3DummyA	.167	1.774	.079
Q3DummyB	-.017	-.181	.856
QP2DummyA	.149	1.436	.154
QP6WorkInIT	-.169	-1.580	.117
QP6WorkInNonIT	-.111	-1.161	.248
QP6Student	-.104	-.942	.348
QP4	-.006	-.062	.951

Table 6.4.1 (3) (RA): Proposition 1- Q8 – "On average how many hours per week do you contribute to the OSS Community?"

F (8,108) = 4.05, $p < .05$, adj R = .174

Dependent Variable: Q8	Standardised Beta	t	Sig.
Q2RubyYesNo	-.290	-3.207	.002**
Q3DummyA	.243	2.727	.007**
Q3DummyB	.199	2.303	.023*
QP2DummyA	.132	1.346	.181
QP6WorkInIT	-.092	-.908	.366
QP6WorkInNonIT	-.045	-.497	.620
QP6Student	-.245	-2.334	.021*
QP4	-.040	-.447	.656

Table 6.4.1 (4) (RA): Proposition 1- Q9 – "What percentage of your participation is related with project development in the OSS Community?"

F (8,105) = 3.07, $p < .05$, adj R = .128

Dependent Variable: Q9	Standardised Beta	t	Sig.
Q2RubyYesNo	-.043	-.462	.645
Q3DummyA	.392	4.225	.000***
Q3DummyB	.056	.626	.532
QP2DummyA	-.104	-1.018	.311
QP6WorkInIT	-.006	-.060	.952
QP6WorkInNonIT	-.142	-1.502	.136
QP6Student	.027	.250	.803
QP4	-.051	-.546	.586

Proposition 2 – The longer members participate, the more tacit knowledge they have.

Control variables and Q6 as independent variables tested three dependent variables: sharing tacit knowledge, colleagues give their tacit knowledge and gaining tacit knowledge.

Main findings

- The length of the participation in OSS development does not play a role in extending the amount of tacit knowledge members have ((b=.047, t=.515, ns), (b=.103, t=1.167, ns), (b=.005, t=.055, ns)).

Extra findings

- Contributors with top level of roles are more likely to share their knowledge (b=.268, t=2.945, p<.01**).
- Also middle level contributors have marginally significant relationships with sharing tacit knowledge (b=.160, t=1.800, p<.10).
- Young contributors (people younger 30 year old) found that they can gain tacit experience of others in the OSS communities (the relationship between young contributors and gaining tacit knowledge is marginally significant (b=.210, t=1.955, p<.10). As the majority of young contributors are most probably students, who have less tacit experience, such significance is reasonable.

Table 6.4.2 (1) (RA): Proposition 2 – Sharing Tacit Knowledge

F (8,114) = 2.48, p < .05, adj R = .088

Dependent Variable: SharingTacKn	Standardised Beta	t	Sig.
Q2RubyYesNo	-.128	-1.381	.170
Q3DummyA	.268	2.945	.004**
Q3DummyB	.160	1.800	.074
QP2DummyA	.111	1.091	.278
QP6WorkInIT	.001	.005	.996
QP6WorkInNonIT	-.090	-.966	.336
QP6Student	-.108	-1.003	.318
Q6	.047	.515	.608

Table 6.4.2 (2) (RA): Proposition 2- Colleagues Giving Tacit Knowledge

F (8,113) = .713, p < .05, adj R = – .019

Dependent Variable: ColleagGivingTacKn	Standardised Beta	t	Sig.
Q2RubyYesNo	-.051	-.516	.607
Q3DummyA	-.048	-.499	.619
Q3DummyB	-.087	-.924	.357
QP2DummyA	.173	1.595	.113
QP6WorkInIT	.086	.810	.420
QP6WorkInNonIT	-.064	-.649	.518
QP6Student	-.034	-.296	.768
Q6	.103	1.067	.288

Table 6.4.2 (3) (RA): Proposition 2- Gaining Tacit Knowledge

F (8,113) = .985, p < .05, adj R = – .001

Dependent Variable: GainTacKn	Standardised Beta	t	Sig.
Q2RubyYesNo	-.030	-.308	.759
Q3DummyA	-.048	-.499	.619
Q3DummyB	-.031	-.332	.741
QP2DummyA	.210	1.955	.053
QP6WorkInIT	.141	1.348	.180
QP6WorkInNonIT	.039	.403	.687
QP6Student	.031	.274	.784
Q6	.005	.055	.956

Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.

Control variables as independent variables tested seven motivation related variables as dependent variables. Because the level of the roles of the contributors to the OSS communities is among control variables, those dummy variables, which are directly related to this Proposition were used as the second block in the hierarchical multiple regression analysis.

Main findings

- The level of the roles inside OSS communities does not really show statistical significance for the motivations to contribute to the OSS communities. Only, the top level contributors have a marginal significance with such motivations as philosophical factors (b=-.175, t=-1.895, p<.10), and personal needs (b=-.166, t=-1.836, p<.10). That can mean that those contributors, who contribute to OSS because of their philosophical attitude, for example toward commercialised software or that they need OSS because they can improve it for their personal needs, they are the ones who are knowledge workers and they are the ones who have a high level of tacit knowledge, so that they can take high level roles and responsibilities in OSS communities.

Extra findings

- Young contributors have a statistically significant relationship with such motivations as hobby (b=.269, t=2.688, p<.01**), philosophical factors (b=.220, t=2.196, p<.05*), and network opportunities (b=.205, t=2.095, p<.05*).
- Those, whose primary occupation is in non-IT industry found that hobby (b=-.259, t=-2.766, p<.01**) and networking opportunities (b=-.226, t=-2.473, p<.05*) are important to them to increase their contribution to the OSS communities.
- Among those motivations, work related factors showed the most significance in statistics for the members, whose primary occupation is in IT industry. Those, who work in IT-industry, found that work related motivations (b=.436, t=4.778, p<.001***), personal needs (b=.269, t=2.688, p<.01**), network opportunities (b=.208, t=2.121 p<.05*), accomplishment (b=.300, t=3.046, p<.01**) are the important factors which contribute to the OSS development; whereas altruism (b=.194, t=1.877, p<.10), philosophical factors (b=.192, t=1.904, p<.10) have a marginally significant relationship.

Table 6.4.3 (1) (RA): Proposition 3 – Hobby

$F(7,114) = 2.51$, $p < .05$, adj $R = .080$

Dependent Variable: Hobby	Standardised Beta	t	Sig.
Q2RubyYesNo	-.140	-1.498	.137
QP2DummyA	.269	2.688	.008**
QP6WorkInIT	-.112	-1.116	.267
QP6WorkInNonIT	-.259	-2.766	.007**
QP6Student	-.086	-.792	.430
Q3DummyA	.103	1.123	.264
Q3DummyB	.017	.190	.849

Table 6.4.3 (2) (RA): Proposition 3 – Philosophical Factors

F (7,117) = 1.97, p < .05, adj R = .052

Dependent Variable: PhilosophicalFactors	Standardised Beta	t	Sig.
Q2RubyYesNo	-.090	-.961	.339
QP2DummyA	.220	2.196	.030*
QP6WorkInIT	.192	1.904	.059
QP6WorkInNonIT	.070	.744	.459
QP6Student	-.142	-1.304	.195
Q3DummyA	-.175	-1.895	.061
Q3DummyB	.003	.028	.977

Table 6.4.3 (3) (RA): Proposition 3 – Accomplishment

F (7,119) = 1.69, p < .05, adj R = .037

Dependent Variable: Accomplishment	Standardised Beta	t	Sig.
Q2RubyYesNo	.012	.130	.897
QP2DummyA	.165	1.643	.103
QP6WorkInIT	.208	2.070	.041*
QP6WorkInNonIT	-.073	-.779	.438
QP6Student	.123	1.134	.259
Q3DummyA	.038	.416	.678
Q3DummyB	.015	.169	.866

Table 6.4.3 (4) (RA): Proposition 3 – Altruism

F (7,117) = .940, p < .05, adj R = – .003

Dependent Variable: Altruism	Standardised Beta	t	Sig.
Q2RubyYesNo	-.020	-.207	.836
QP2DummyA	.129	1.255	.212
QP6WorkInIT	.194	1.877	.063
QP6WorkInNonIT	-.024	-.249	.804
QP6Student	.008	.073	.942
Q3DummyA	-.013	-.138	.891
Q3DummyB	-.062	-.671	.503

Table 6.4.3 (5) (RA): Proposition 3 – Network Opportunities

F (7,115) = 3.18, p < .05, adj R = .111

Dependent Variable: NetworkOpportun	Standardised Beta	t	Sig.
Q2RubyYesNo	-.059	-.650	.517
QP2DummyA	.205	2.095	.038*
QP6WorkInIT	.208	2.121	.036*
QP6WorkInNonIT	-.226	-2.473	.015*
QP6Student	-.101	-.950	.344
Q3DummyA	.061	.675	.501
Q3DummyB	-.045	-.516	.606

Table 6.4.3 (6) (RA): Proposition 3 – Personal Needs

F (7,117) = 2.77, p < .05, adj R = .091

Dependent Variable: PersonalNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	-.126	-1.370	.173
QP2DummyA	.145	1.477	.142
QP6WorkInIT	.300	3.046	.003**
QP6WorkInNonIT	-.063	-.684	.495
QP6Student	-.035	-.325	.746
Q3DummyA	-.166	-1.836	.069
Q3DummyB	.041	.472	.638

Table 6.4.3 (7) (RA): Proposition 3 – Main Work Needs

F (7,119) = 5.69, p < .05, adj R = .207

Dependent Variable: MainWorkNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	.132	1.559	.122
QP2DummyA	-.099	-1.084	.281
QP6WorkInIT	.436	4.778	.000***
QP6WorkInNonIT	-.112	-1.316	.191
QP6Student	.067	.679	.498
Q3DummyA	.032	.382	.703
Q3DummyB	-.059	-.723	.471

Proposition 4 - Personal motivations have positive impacts on the knowledge sharing in the OSS community.

Control variables and the motivation of personal needs as independent variables tested one dependent variables: Q6, Q7, Q8, and Q9.

Q6 - How long have you participated in the OSS community?

Q7 - How often do you communicate with other members in the OSS community?

Q8 - On average how many hours per week do you contribute to the OSS community?

Q9 - What percentage of your participation is related to project development in the OSS community?

Main findings

- Personal motivations do not have a significant contribution in the relationship to knowledge sharing in the OSS community (b=.001, t=.011, ns), (b=-.145, t=-1.499, ns), (b=.011, t=.117, ns), (b=-.042, t=-.448, ns).

Extra findings

- RoR contributors have a relationship with the level of knowledge sharing from a personal motivations point of view (b=-.287, t=-3.180, p<.01**).
- Top (b=.242, t=2.706, p<.01**), (b=.382, t=4.100, p<.001***) and middle level roles (b=.202, t=2.352, p<.05*) in the OSS community and those who are students (b=-.248, t=-2.380, p<.05*) have relationships with the level of knowledge sharing in the OSS community.

Table 6.4.4 (1) (RA): Proposition 4 – Q6 – "How long have you participated in the OSS community?"

$F(8, 113) = 1.426$, $p < .05$, adj $R = .027$

Dependent Variable: Q6	Standardised Beta	t	Sig.
Q2RubyYesNo	-.048	-.498	.619
Q3DummyA	.003	.028	.978
Q3DummyB	-.068	-.745	.458
QP2DummyA	-.263	-2.538	.013*
QP6WorkInIT	.069	.641	.523
QP6WorkInNonIT	-.026	-.266	.791
QP6Student	-.030	-.265	.791
PersonalNeeds	.001	.011	.991

Table 6.4.4 (2) (RA): Proposition 4 – Q7 – "How often do you communicate with other members in the OSS community?"

$F (8, 112) = 1.522, p < .05$, adj $R = .034$

Dependent Variable: Q7	Standardised Beta	t	Sig.
Q2RubyYesNo	-.067	-.691	.491
Q3DummyA	.142	1.484	.140
Q3DummyB	-.010	-.111	.912
QP2DummyA	.171	1.650	.102
QP6WorkInIT	-.127	-1.188	.237
QP6WorkInNonIT	-.121	-1.256	.212
QP6Student	-.110	-.985	.327
PersonalNeeds	-.145	-1.499	.137

Table 6.4.4 (3) (RA): Proposition 4 - Q8 – "On average how many hours per week do you contribute to the OSS Community?"

$F (8, 110) = 4.090, p < .05$, adj $R = .173$

Dependent Variable: Q8	Standardised Beta	t	Sig.
Q2RubyYesNo	-.287	-3.180	.002**
Q3DummyA	.242	2.706	.008**
Q3DummyB	.202	2.352	.020*
QP2DummyA	.139	1.433	.155
QP6WorkInIT	-.108	-1.083	.281
QP6WorkInNonIT	-.048	-.538	.591
QP6Student	-.248	-2.380	.019*
PersonalNeeds	.011	.117	.907

Table 6.4.4 (4) (RA): Proposition 4 – Q9 – "What percentage of your participation is related to project development in the OSS community?"

$F (8, 107) = 3.113, p < .05$, adj $R = .128$

Dependent Variable: Q9	Standardised Beta	t	Sig.
Q2RubyYesNo	-.047	-.500	.618
Q3DummyA	.382	4.100	.000***
Q3DummyB	.062	.691	.491
QP2DummyA	-.088	-.874	.384
QP6WorkInIT	-.010	-.099	.921
QP6WorkInNonIT	-.150	-1.600	.113
QP6Student	.022	.206	.837
PersonalNeeds	-.042	-.448	.655

Proposition 5 - Work related motivations have positive impacts on the knowledge sharing in the OSS community.

Control variables and work related motivations as independent variables tested one dependent variables: Q6, Q7, Q8, and Q9.
Q6 - How long have you participated in the OSS community?
Q7 - How often do you communicate with other members in the OSS community?
Q8 - On average how many hours per week do you contribute to the OSS community?
Q9 - What percentage of your participation is related to project development in the OSS community?

Main findings

- Work related motivations have marginal significance to the knowledge sharing in the OSS community (b=.180, t=1.908, p<.10) (b=.180, t=1.908, p<.10).

Extra findings

- RoR contributors have a significant relationship with the level of the knowledge sharing from work related motivations point of view (b=-.312, t=-3.538, p<.01**).
- Top (b=.235, t=2.725, p<.01**), (b=.391, t=4.296, p<.001***) and middle levels of roles (b=.213, t=2.540, p<.05*) in the OSS community and those who are students (b=-.260, t=-2.558, p<.05*) have relationships with the level of the knowledge sharing in the OSS community.
- Also work related motivations and those who are young contributors (b=-.260, t=-2.558, p<.05*) have marginal significance.

Table 6.4.5 (1) (RA): Proposition 5 – Q6 – "How long have you participated in the OSS community?"

F (8, 115) = 1.504, p < .05, adj R = .032

Dependent Variable: Q6	Standardised Beta	t	Sig.
Q2RubyYesNo	-.057	-.591	.556
Q3DummyA	.000	.005	.996
Q3DummyB	-.065	-.710	.479
QP2DummyA	-.257	-2.513	.013*
QP6WorkInIT	.041	.372	.711
QP6WorkInNonIT	-.019	-.194	.846
QP6Student	-.034	-.306	.760
MainWorkNeeds	.063	.617	.538

Table 6.4.5 (2) (RA): Proposition 5 – Q7 – "How often do you communicate with other members in the OSS community?"

F (8, 114) = 1.262, p < .05, adj R = .017

Dependent Variable: Q7	Standardised Beta	t	Sig.
Q2RubyYesNo	-.054	-.560	.576
Q3DummyA	.165	1.744	.084
Q3DummyB	-.014	-.148	.882
QP2DummyA	.154	1.494	.138
QP6WorkInIT	-.190	-1.683	.095
QP6WorkInNonIT	-.107	-1.105	.272
QP6Student	-.108	-.964	.337
MainWorkNeeds	.043	.416	.679

Table 6.4.5 (3) (RA): Proposition 5 - Q8 – "On average how many hours per week do you contribute to the OSS community?"

F (8, 112) = 4.752, p < .05, adj R = .200

Dependent Variable: Q8	Standardised Beta	t	Sig.
Q2RubyYesNo	-.312	-3.538	.001**
Q3DummyA	.235	2.725	.007**
Q3DummyB	.213	2.540	.012*
QP2DummyA	.158	1.681	.096
QP6WorkInIT	-.184	-1.791	.076
QP6WorkInNonIT	-.029	-.328	.743
QP6Student	-.260	-2.558	.012*
MainWorkNeeds	.180	1.908	.059

Table 6.4.5 (4) (RA): Proposition 5 – Q9 – “What percentage of your participation is related to project development in the OSS community?”

F (8, 109) = 3.197, p < .05, adj R = .131

Dependent Variable: Q9	Standardised Beta	t	Sig.
Q2RubyYesNo	-.034	-.362	.718
Q3DummyA	.391	4.296	.000***
Q3DummyB	.056	.637	.525
QP2DummyA	-.100	-1.008	.316
QP6WorkInIT	.003	.032	.974
QP6WorkInNonIT	-.154	-1.652	.101
QP6Student	.028	.259	.796
MainWorkNeeds	-.061	-.609	.544

Interestingly, Propositions 4 and 5 showed almost the same results, when control variables were tested. However, according to the personal and work related motivations point of view, work related motivations have a much more significant contribution in the relationship to the knowledge sharing in the OSS community.

Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.

Control variables and satisfaction with the OSS project administration within OSS community as independent variables tested seven motivation related variables as dependent variables.

Main findings

- Satisfaction with management plays a crucial rule in increasing motivations for contributors. Only hobby does not show a significant relationship (b=.093, t=.963, ns) with the satisfaction with management. All other motivations are dependent on the satisfaction with management:
  - Altruism (b=.369, t=3.962, p<.001***)
  - Personal Needs (b=.399, t=4.625, p<.001***)
  - Philosophical Factors (b=.322, t=3.492, p<.01**)
  - Accomplishment (b=.271, t=2.888, p<.01**)
  - Network Opportunities (b=.280, t=3.064, p<.01**)
  - Hobby (b=.093, t=.963, p<.10)
  - Main Work Needs (b=.153, t=1.753, p<.10)

It is interesting to find out that personal motivations and altruism have a higher significance with satisfaction with management. It is probably because contributors with work related motivations will contribute to the projects even though they are less likely to be satisfied with management, while satisfaction with management demonstrates a goo relationship with the personal motivations of the contributors.

Extra findings

- Top level contributors show a marginal significance in satisfaction with management in their personal motivations (b=-.167, t=-1.900, p<.10) and philosophical factors (b=-.176, t=-1.866, p<.10). Bearing in mind that some of the top level contributors are management, which is tested in this Proposition, it is interesting to find out how significant it is for their personal motivations such as philosophical factors and personal needs.
- Young contributors have significant relationships in satisfaction with management in their motivations such as hobby (b=.270, t=2.514, p<.01**), philosophical factors (b=.224, t=2.185, p<.05*), and network opportunities (b=.208, t=2.055, p<.05*).
- Contributors in the RoR community found that satisfaction with management has a marginally significant relationship to work related motivations (b=.153, t=1.677, p<.10).
- Also satisfaction with management plays an important role for people from the IT industry: work related needs (b=.425, t=4.369, p<.001***), personal needs (b=.272, t=2.827, p<.01**), accomplishment (b=.189, t=1.805, p<.10), network opportunities (b=.188, t=1.850, p<.10) are influenced by satisfaction with management; whereas, for non-IT contributors satisfaction with management plays important role in such motivations as hobby (b=.-248, t=-2.459, p<.05*) and network opportunities (b=-.195, t=-2.048, p<.05*).

Table 6.4.6 (1) (RA): Proposition 6 – Hobby

F (8,98) = 2.02, $p < .05$, adj R = .072

Dependent Variable: Hobby	Standardised Beta	t	Sig.
Q2RubyYesNo	-.127	-1.261	.210
Q3DummyA	.103	1.044	.299
Q3DummyB	.035	.356	.722
QP2DummyA	.270	2.514	.014**
QP6WorkInIT	-.119	-1.099	.274
QP6WorkInNonIT	-.248	-2.459	.016*
QP6Student	-.086	-.741	.461
SatisfactWithMgmt	.093	.963	.338

Table 6.4.6 (2) (RA): Proposition 6 – Philosophical Factors

F (8,100) = 3.18, $p < .05$, adj R = .139

Dependent Variable: PhilosophicalFactors	Standardised Beta	t	Sig.
Q2RubyYesNo	-.047	-.487	.627
Q3DummyA	-.176	-1.866	.065
Q3DummyB	.064	.687	.493
QP2DummyA	.224	2.185	.031*
QP6WorkInIT	.169	1.638	.104
QP6WorkInNonIT	.106	1.097	.275
QP6Student	-.143	-1.290	.200
SatisfactWithMgmt	.322	3.492	.001**

Table 6.4.6 (3) (RA): Proposition 6 – Accomplishment

F (8,102) = 2.42, $p < .05$, adj R = .093

Dependent Variable: Accomplishment	Standardised Beta	t	Sig.
Q2RubyYesNo	.048	.493	.623
Q3DummyA	.037	.392	.696
Q3DummyB	.067	.706	.482
QP2DummyA	.168	1.611	.110
QP6WorkInIT	.189	1.805	.074
QP6WorkInNonIT	-.043	-.437	.663
QP6Student	.122	1.082	.282
SatisfactWithMgmt	.271	2.888	.005**

Table 6.4.6 (4) (RA): Proposition 6 – Altruism

F (8,101) = 2.78, p < .05, adj R = .166

Dependent Variable: Altruism	Standardised Beta	t	Sig.
Q2RubyYesNo	.029	.301	.764
Q3DummyA	-.014	-.149	.882
Q3DummyB	.008	.090	.928
QP2DummyA	.133	1.293	.199
QP6WorkInIT	.168	1.619	.109
QP6WorkInNonIT	.017	.176	.861
QP6Student	.007	.059	.953
SatisfactWithMgmt	.369	3.962	.000***

Table 6.4.6 (5) (RA): Proposition 6 – Network Opportunities

F (8,98) = 3.77, p < .05, adj R = .173

Dependent Variable: NetworkOpportunit	Standardised Beta	t	Sig.
Q2RubyYesNo	-.022	-.231	.818
Q3DummyA	.060	.643	.522
Q3DummyB	.008	.089	.929
QP2DummyA	.208	2.055	.043*
QP6WorkInIT	.188	1.850	.067
QP6WorkInNonIT	-.195	-2.048	.043*
QP6Student	-.102	-.928	.355
SatisfactWithMgmt	.280	3.064	.003**

Table 6.4.6 (6) (RA): Proposition 6 – Personal Needs

F (8,102) = 5.23, p < .05, adj R = .235

Dependent Variable: PersonalNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	-.072	-.805	.423
Q3DummyA	-.167	-1.900	.060
Q3DummyB	.117	1.350	.180
QP2DummyA	.149	1.563	.121
QP6WorkInIT	.272	2.827	.006**
QP6WorkInNonIT	-.018	-.204	.838
QP6Student	-.036	-.349	.727
SatisfactWithMgmt	.399	4.625	.000***

Table 6.4.6 (7) (RA): Proposition 6 – Main Work Needs

F (8,102) = 4.78, p < .05, adj R = .216

Dependent Variable: MainWorkNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	.153	1.677	.097
Q3DummyA	.032	.354	.724
Q3DummyB	-.030	-.336	.738
QP2DummyA	-.097	-1.001	.319
QP6WorkInIT	.425	4.369	.000***
QP6WorkInNonIT	-.095	-1.042	.300
QP6Student	.066	.632	.529
SatisfactWithMgmt	.153	1.753	.083

Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.

Control variables and trust within the OSS community as independent variables tested seven motivation related variables as dependent variables.

Main findings

- Trust is another important issue in increasing motivations for knowledge sharing in the OSS communities. Almost all motivations apart from hobby (b=.063, t=669, ns) and work related needs (b=-.016, t=-.181, ns), show high significant relationship with trust:
  - Personal Needs (b=.398, t=4.713, p<.001***)
  - Altruism (b=.552, t=6.803, p<.001***)
  - Accomplishment (b=.372, t=4.248, p<.001***)
  - Network Opportunities (b=.228, t=2.538, p<.01**)
  - Philosophical Factors (b=.309, t=3.444, p<.01**)

Extra findings

- Those contributors, whose primary occupation is in IT industry, found trust an important factor for the motivations to contribute to the OSS communities:
  - Main Work Needs (b=.436, t=4.567, p<.001***)
  - Personal Needs (b=.312, t=3.325, p<.01**)
  - Network Opportunities (b=.215, t=2.154, p<.05*)
  - Altruism (b=.211, t=2.336, p<.05*)
  - Accomplishment (b=.219, t=2.250, p<.05*)

- Philosophical Factors (b=.201, t=2.010, p<.05*)

- Those contributors, whose primary occupation is in non-IT industry, found trust an important factor for the following motivations to contribute to the OSS communities:
  - Hobby (b=-.253, t=-2.576, p<.01**)
  - Network opportunities (b=-.205, t=-2.194, p<.05*)
- Young contributors found trust an important factor for the following motivations to contribute to the OSS communities:
  - Hobby (b=.261, t=2.488, p<.01**)
  - Philosophical Factors (b=.183, t=1.834, p<.10)
  - Network opportunities (b=.178, t=1.780, p<.10)

Table 6.4.7 (1) (RA): Proposition 7 – Hobby

F (8,104) = 2.07, p < .05, adj R = .071

Dependent Variable: Hobby	Standardised Beta	t	Sig.
Q2RubyYesNo	-.126	-1.261	.210
Q3DummyA	.105	1.097	.275
Q3DummyB	.023	.246	.806
QP2DummyA	.261	2.488	.014**
QP6WorkInIT	-.110	-1.050	.296
QP6WorkInNonIT	-.253	-2.576	.011**
QP6Student	-.076	-.666	.507
Trust	.063	.669	.505

Table 6.4.7 (2) (RA): Proposition 7 – Philosophical Factors

F (8,107) = 3.26, p < .05, adj R = .135

Dependent Variable: Philosophical Factors	Standardised Beta	t	Sig.
Q2RubyYesNo	-.021	-.223	.824
Q3DummyA	-.164	-1.791	.076
Q3DummyB	.032	.362	.718
QP2DummyA	.183	1.834	.069
QP6WorkInIT	.201	2.010	.047*
QP6WorkInNonIT	.099	1.058	.292
QP6Student	-.094	-.862	.391
Trust	.309	3.444	.001**

Table 6.4.7 (3) (RA): Proposition 7 – Accomplishment

F (8,109) = 3.84, p < .05, adj R = .162

Dependent Variable: Accomplishment	Standardised Beta	t	Sig.
Q2RubyYesNo	.095	1.024	.308
Q3DummyA	.051	.574	.567
Q3DummyB	.051	.586	.559
QP2DummyA	.121	1.236	.219
QP6WorkInIT	.219	2.250	.026*
QP6WorkInNonIT	-.038	-.417	.678
QP6Student	.181	1.708	.091
Trust	.372	4.248	.000***

Table 6.4.7 (4) (RA): Proposition 7 – Altruism

F (8,108) = 6.87, p < .05, adj R = .288

Dependent Variable: Altruism	Standardised Beta	t	Sig.
Q2RubyYesNo	.103	1.198	.234
Q3DummyA	.006	.073	.942
Q3DummyB	-.009	-.108	.914
QP2DummyA	.064	.709	.480
QP6WorkInIT	.211	2.336	.021*
QP6WorkInNonIT	.028	.332	.741
QP6Student	.094	.956	.341
Trust	.552	6.803	.000***

Table 6.4.7 (5) (RA): Proposition 7 – Network Opportunities

F (8,105) = 3.50, p < .05, adj R = .150

Dependent Variable: NetworkOpportunit	Standardised Beta	t	Sig.
Q2RubyYesNo	-.009	-.092	.927
Q3DummyA	.069	.750	.455
Q3DummyB	-.023	-.260	.795
QP2DummyA	.178	1.780	.078
QP6WorkInIT	.215	2.154	.033*
QP6WorkInNonIT	-.205	-2.194	.030*
QP6Student	-.065	-.601	.549
Trust	.228	2.538	.013**

Table 6.4.7 (6) (RA): Proposition 7 – Personal Needs

F (8,107) = 5.45, p < .05, adj R = .236

Dependent Variable: PersonalNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	-.037	-.417	.678
Q3DummyA	-.152	-1.768	.080
Q3DummyB	.080	.951	.344
QP2DummyA	.098	1.042	.300
QP6WorkInIT	.312	3.325	.001**
QP6WorkInNonIT	-.025	-.289	.773
QP6Student	.027	.267	.790
Trust	.398	4.713	.000***

Table 6.4.7 (7) (RA): Proposition 7 – Main Work Needs

F (8,109) = 4.57, p < .05, adj R = .196

Dependent Variable: MainWorkNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	.129	1.421	.158
Q3DummyA	.031	.360	.720
Q3DummyB	-.060	-.707	.481
QP2DummyA	-.097	-1.012	.314
QP6WorkInIT	.436	4.567	.000***
QP6WorkInNonIT	-.113	-1.271	.207
QP6Student	.065	.622	.536
Trust	-.016	-.181	.856

Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.

Control variables and identification within OSS community as independent variables tested seven motivation related variables as dependent variables.

Main findings

- Identification is another important factor for increasing motivations to contribute to the OSS communities. Five motivations out of seven and identification have strong statistically significant contributions:

- Personal Needs (b=.399, t =4.885, p<.001***)
- Network Opportunities (b=.308, t =3.655, p<.001***)
- Altruism (b=.372, t =4.266, p<.001***)

- Philosophical Factors (b=.326, t =3.757, p<.001***)
- Accomplishment (b=.244, t =2.743, p<.01**)

Only motivations such as hobby (b=-.017, t =-.189, ns) and work related motivations (b=-.015, t =-.175, ns) do not have a significant relationship with identification.

Extra findings

Control variables show a significant contribution in identification: identification within the OSS communities is important:

- To top level (in Personal Needs (b=-.208, t =-2.493, p<.05*), in Philosophical Factors (b=-.210, t =-2.357, p<.05*)),
- To young contributors (in Network Opportunities (b=.185, t =1.978, p<.05*), in Philosophical Factors (b=.199, t =2.066, p<.05*), in Hobby (b=.270, t =2.660, p<.01**)),
- to those who work in IT (in Main Work Needs (b=.437, t =4.721, p<.001***), in Personal Needs (b=.291, t =3.210, p<.01**), in Network Opportunities (b=.202, t =2.151, p<.05*), in Altruism (b=.186, t =1.919, p<.10), in Accomplishment (b=.203, t =2.054, p<.05*), in Philosophical Factors (b=.184, t =1.911, p<.10))
- And non-IT industries (in Network Opportunities (b=-.255, t =-2.903, p<.01**), in Hobby (b=-.257, t =-2.703, p<.01**)).

Table 6.4.8 (1) (RA): Proposition 8 – Hobby

$F\ (8,111) = 2.14$, $p < .05$, adj $R = .071$

Dependent Variable: Hobby	Standardised Beta	t	Sig.
Q2RubyYesNo	-.143	-1.490	.139
Q3DummyA	.105	1.122	.264
Q3DummyB	.018	.201	.841
QP2DummyA	.270	2.660	.009**
QP6WorkInIT	-.112	-1.098	.275
QP6WorkInNonIT	-.257	-2.703	.008**
QP6Student	-.088	-.797	.427
Identification	-.017	-.189	.851

Table 6.4.8 (2) (RA): Proposition 8 – Philosophical Factors

F (8,113) = 3.64, $p < .05$, adj R = .149

Dependent Variable: PhilosophicalFactors	Standardised Beta	t	Sig.
Q2RubyYesNo	-.035	-.390	.697
Q3DummyA	-.210	-2.357	.020*
Q3DummyB	-.021	-.240	.811
QP2DummyA	.199	2.066	.041*
QP6WorkInIT	.184	1.911	.059
QP6WorkInNonIT	.040	.441	.660
QP6Student	-.101	-.965	.337
Identification	.326	3.757	.000***

Table 6.4.8 (3) (RA): Proposition 8 – Accomplishment

F (8,116) = 2.48, $p < .05$, adj R = .087

Dependent Variable: Accomplishment	Standardised Beta	t	Sig.
Q2RubyYesNo	.053	.568	.571
Q3DummyA	.012	.134	.893
Q3DummyB	-.002	-.025	.980
QP2DummyA	.149	1.511	.134
QP6WorkInIT	.203	2.054	.042*
QP6WorkInNonIT	-.095	-1.032	.304
QP6Student	.154	1.433	.155
Identification	.244	2.743	.007**

Table 6.4.8 (4) (RA): Proposition 8 – Altruism

F (8,115) = 3.21, $p < .05$, adj R = .126

Dependent Variable: Altruism	Standardised Beta	t	Sig.
Q2RubyYesNo	.042	.462	.645
Q3DummyA	-.053	-.592	.555
Q3DummyB	-.088	-1.021	.310
QP2DummyA	.105	1.088	.279
QP6WorkInIT	.186	1.919	.057
QP6WorkInNonIT	-.058	-.640	.523
QP6Student	.054	.517	.606
Identification	.372	4.266	.000***

Table 6.4.8 (5) (RA): Proposition 8 – Network Opportunities

$F(8,113) = 4.72$, $p < .05$, adj $R = .197$

Dependent Variable: NetworkOpportunit	Standardised Beta	t	Sig.
Q2RubyYesNo	-.008	-.090	.929
Q3DummyA	.028	.321	.749
Q3DummyB	-.067	-.802	.424
QP2DummyA	.185	1.978	.050*
QP6WorkInIT	.202	2.151	.034*
QP6WorkInNonIT	-.255	-2.903	.004**
QP6Student	-.062	-.613	.541
Identification	.308	3.655	.000***

Table 6.4.8 (6) (RA): Proposition 8 – Personal Needs

$F(8,114) = 5.84$, $p < .05$, adj $R = .241$

Dependent Variable: PersonalNeeds	Standardised Beta	T	Sig.
Q2RubyYesNo	-.059	-.690	.492
Q3DummyA	-.208	-2.493	.014*
Q3DummyB	.013	.160	.873
QP2DummyA	.119	1.315	.191
QP6WorkInIT	.291	3.210	.002**
QP6WorkInNonIT	-.099	-1.170	.244
QP6Student	.015	.154	.878
Identification	.399	4.885	.000***

Table 6.4.8 (7) (RA): Proposition 8 – Main Work Needs

$F(8,116) = 4.86$, $p < .05$, adj $R = .199$

Dependent Variable: MainWorkNeeds	Standardised Beta	t	Sig.
Q2RubyYesNo	.130	1.492	.138
Q3DummyA	.034	.394	.695
Q3DummyB	-.058	-.700	.486
QP2DummyA	-.098	-1.058	.292
QP6WorkInIT	.437	4.721	.000***
QP6WorkInNonIT	-.111	-1.279	.204
QP6Student	.065	.649	.518
Identification	-.015	-.175	.862

Proposition 9 - Having incentives for the future such as long term benefits influences the level of knowledge sharing.

Control variables and incentives/benefits for the future as independent variables tested four dependent variables: Qs 6, 7, 8, and 9.

Q6 - How long have you participated in the OSS community?

Q7 - How often do you communicate with other members in the OSS community?

Q8 - On average how many hours per week do you contribute to the OSS community?

Q9 - What percentage of your participation is related to project development in the OSS community?

Main findings

Hierarchical multiple regression analysis showed that incentives/benefits for the future from knowledge sharing in the OSS communities does not relate to the knowledge sharing in the OSS communities as much as the previously mentioned factors:

- For example, Q9 - What percentage of your participation is related to project development in the OSS community? is related to the incentives/benefits for the future from the knowledge sharing in the OSS communities (b=-.237, t=-2.637, p<.01*)
- Q6 - How long have you participated in the OSS community? is marginally related to the incentives/benefits for the future from the knowledge sharing in the OSS communities (b=.002, t=.021, p<.10)
- Q7 - How often do you communicate with other members in the OSS community? is not related to the incentives/benefits for the future from the knowledge sharing in the OSS communities (b=-.025, t=-.258, ns)
- Q8 - On average how many hours per week do you contribute to the OSS community? is not related to the incentives/benefits for the future from the knowledge sharing in OSS communities (b=-.012, t=-.136, ns)

Extra findings

- Nevertheless, incentives can have a positive relationship specifically to the level of project development.
- Young contributors have demonstrated a relationship between the length of the knowledge sharing and the incentives for the future (b=-.263, t=-2.548, p<.05*).
- Contributors in RoR community (b=-.287, t=-3.165, p<.01**) and students (b=-.249, t=-2.377, p<.05*) in general have found that incentives have some significance for their knowledge sharing level.

- Also top level contributors found that incentives have a role in influencing the level of knowledge sharing (b=.240, t=2.712, p<.01**) as well as the percentage of participation related to OSS development (b=.389, t=4.348, p<.001***); whereas middle level contributors do not rank it as important as top level contributors (b=.202, t=2.347, p<.05*).

Table 6.4.9 (1) (RA): Proposition 9 - Q6 – How long have you participated in the OSS community?

$F (8,112) = 1.41, p < .05$, adj $R = .027$

Dependent Variable: Q6	Standardised Beta	T	Sig.
Q2RubyYesNo	-.049	-.500	.618
Q3DummyA	.002	.026	.979
Q3DummyB	-.068	-.741	.460
QP2DummyA	-.263	-2.548	.012*
QP6WorkInIT	.069	.648	.518
QP6WorkInNonIT	-.026	-.265	.791
QP6Student	-.029	-.263	.793
Incentive/Benefits	.002	.021	.984

Table 6.4.9 (2) (RA): Proposition 9 - Q7 – How often do you communicate with other members in the OSS community?

$F (8,111) = 1.22, p < .05$, adj $R = .014$

Dependent Variable: Q7	Standardised Beta	T	Sig.
Q2RubyYesNo	-.046	-.464	.643
Q3DummyA	.167	1.736	.085
Q3DummyB	-.016	-.176	.861
QP2DummyA	.150	1.441	.153
QP6WorkInIT	-.165	-1.546	.125
QP6WorkInNonIT	-.113	-1.158	.249
QP6Student	-.107	-.942	.348
Incentive/Benefits	-.025	-.258	.797

Table 6.4.9 (3) (RA): Proposition 9 - Q8 – On average how many hours per week do you contribute to the OSS community?

F (8,109) = 4.053, p < .05, adj R = .173

Dependent Variable: Q8	Standardised Beta	T	Sig.
Q2RubyYesNo	-.287	-3.165	.002**
Q3DummyA	.240	2.712	.008**
Q3DummyB	.202	2.347	.021*
QP2DummyA	.140	1.457	.148
QP6WorkInIT	-.102	-1.036	.302
QP6WorkInNonIT	-.050	-.550	.583
QP6Student	-.249	-2.377	.019*
Incentive/Benefits	-.012	-.136	.892

Table 6.4.9 (4) (RA): Proposition 9 - Q9 – What percentage of your participation is related to project development in the OSS community?

F (8,106) = 4.12, p < .05, adj R = .180

Dependent Variable: Q9	Standardised Beta	t	Sig.
Q2RubyYesNo	-.012	-.131	.896
Q3DummyA	.389	4.348	.000***
Q3DummyB	.058	.668	.506
QP2DummyA	-.093	-.960	.339
QP6WorkInIT	.031	.307	.759
QP6WorkInNonIT	-.158	-1.737	.085
QP6Student	.007	.063	.950
Incentive/Benefits	-.237	-2.637	.010*

Proposition 10 - Having monetary rewards influences the level of knowledge sharing.

Control variables and Q32 regarding having monetary reward for knowledge sharing in OSS communities as independent variables tested four dependent variables: Qs 6, 7, 8, and 9.

Q6 - How long have you participated in the OSS community?

Q7 - How often do you communicate with other members in the OSS community?

Q8 - On average how many hours per week do you contribute to the OSS community?

Q9 - What percentage of your participation is related to project development in the OSS community?

Main findings

Hierarchical multiple regression analysis showed that monetary reward is not the most important factor for knowledge sharing in the OSS communities. However, some statistical significance showed in the relationship between monetary reward and knowledge sharing: ($b=.146$, $t=1.559$, $p<.05$*), ($b=.106$, $t=1.118$, $p<.05$*), ($b=.287$, $t=3.409$, $p<.01$**), ($b=.121$, $t=1.324$, $p<.05$*), which can be interpreted as the monetary reward can have a statistical significant contribution in those members of the OSS communities, who in fact may be officially employed in those communities, and those monetary reward can be simply their salaries.

- Top level contributors ($b=.205$, $t=2.419$, $p<.05$*)
- Middle level contributors ($b=.222$, $t=2.704$, $p<.01$**)
- OSS developers in RoR ($b=-.262$, $t=-3.048$, $p<.01$**)

This is proved by one of the interviews undertaken in this thesis, where an interviewee explained how their OSS community officially hire staff for the various projects.

Extra findings

- A certain level of statistical significance toward monetary reward showed with young contributors, most probably students; where the reason is also understandable (in average hours in the knowledge sharing in OSS development ($b=.-172$, $t=-1.687$, $p<.10$), in the length of the participation ($b=-.269$, $t=-2.630$, $p<.01$*)).
- And again the top level members have shown a certain level of statistical significance toward monetary reward, because some of them can be officially employed or have commercial interest in the OSS movement. In terms of the other contributors, there is no obvious statistical significance toward monetary reward ($b=.374$, $t=4.054$, $p<.001$***).

Table 6.4.10 (1) (RA): Proposition 10 - Q6 – How long have you participated in the OSS community?

F (8,112) = 1.75, p < .05, adj R = .048

Dependent Variable: Q6	Standardised Beta	t	Sig.
Q2RubyYesNo	-.035	-.363	.717
Q3DummyA	-.015	-.163	.871
Q3DummyB	-.058	-.638	.525
QP2DummyA	-.269	-2.630	.010*
QP6WorkInIT	.088	.851	.397
QP6WorkInNonIT	-.025	-.259	.796
QP6Student	.009	.082	.935
Q32	.146	1.559	.122

Table 6.4.10 (2) (RA): Proposition 10 - Q7 – How often do you communicate with other members in the OSS community?

F (8,111) = 1.38, p < .05, adj R = .025

Dependent Variable: Q7	Standardised Beta	t	Sig.
Q2RubyYesNo	-.039	-.399	.691
Q3DummyA	.153	1.597	.113
Q3DummyB	-.009	-.095	.924
QP2DummyA	.146	1.406	.162
QP6WorkInIT	-.157	-1.500	.136
QP6WorkInNonIT	-.111	-1.146	.254
QP6Student	-.077	-.664	.508
Q32	.106	1.118	.266

Table 6.4.10 (3) (RA): Proposition 10 - Q8 – On average how many hours per week do you contribute to the OSS community?

F (8,109) = 5.93, p < .05, adj R = .252

Dependent Variable: Q8	Standardised Beta	t	Sig.
Q2RubyYesNo	-.262	-3.048	.003**
Q3DummyA	.205	2.419	.017*
Q3DummyB	.222	2.704	.008**
QP2DummyA	.129	1.409	.162
QP6WorkInIT	-.068	-.739	.461
QP6WorkInNonIT	-.047	-.550	.584
QP6Student	-.172	-1.687	.095
Q32	.287	3.409	.001**

Table 6.4.10 (4) (RA): Proposition 10 - Q9 – What percentage of your participation is related with project development in the OSS community?

F (8,106) = 3.232, $p < .05$, adj R = .140

Dependent Variable: Q9	Standardised Beta	t	Sig.
Q2RubyYesNo	-.030	-.327	.745
Q3DummyA	.374	4.054	.000***
Q3DummyB	.068	.766	.446
QP2DummyA	-.099	-.992	.323
QP6WorkInIT	-.007	-.074	.941
QP6WorkInNonIT	-.146	-1.570	.119
QP6Student	.056	.506	.614
Q32	.121	1.324	.188

6.2.3 Answers to Q19 – "Why do you share your knowledge with other members of the OSS Community?"

The questionnaire contained one open-ended question: Q19 – "Why do you share your knowledge with other members of the OSS Community?" (Appendix 7). This question was the only open ended question in the questionnaire. It was interesting to find out an inductive answer regarding the main topic of the thesis – knowledge sharing. Monitoring the answers shows that these can be grouped into two main parts, philosophical reasons and knowledge learning/teaching.

In terms of philosophical reasons, the respondents pointed out that they share their knowledge with other members in the OSS communities because of reciprocity reasons. They found that knowledge sharing is the right thing to do and it gives a sense of community. Altruism, 'ego feed', peer recognition and networking opportunities are some examples of the philosophical approach in knowledge sharing. Other examples within this approach that were noted include to make OSS more powerful and better and because OSS should be different from the closed software.

However, there is another side to knowledge sharing. OSS contributors share their knowledge with others because they believe that it is the best way to learn knowledge. Teaching through learning and learning through sharing is the best way in knowledge gaining. The respondents found out that by knowledge sharing they can get back what they received themselves from others. There are some quotes (for detailed quotes see Appendix 7), which clearly show the reasons of knowledge sharing.

- “Open source is all about sharing ideas and knowledge within a group based atmosphere. Sharing is part of being a member of the community. I personally enjoy it because it increases the growth of my own skills while enabling me to build many of my own ideas. Often groups will give me new ideas to work with as well.” (Anonymous 11)
- “Because that's what the OSS community is all about - sharing knowledge and working together to improve things for everyone.” (Anonymous 26)
- “Knowledge exists to be shared.” (Anonymous 39)
- “There is no reason not to.” (Anonymous 38)
- “OSS communities are largely defined by what they share: code, knowledge, time, history. Without sharing of knowledge, the community cannot function properly, nor grow.” (Anonymous 42)
- “Knowledge should be good for the whole community / world. That's the way to make technology prosper. Keeping your knowledge hidden from others might appear to give you a short-term competitive edge, but in the long term does not lead to overall prosperity. It's like keeping a lamp hidden under a hat - it will never light up the room.” (Anonymous 106)
- “The value and effectiveness of knowledge multiplies with sharing. This isn't anything new, and isn't specific to the OSS communities.” (Anonymous 124)

These answers from the respondents support the academic literature, concentrating on the motivations contributing to the OSS development. At the same time they support the propositions, which were tested in this thesis especially those (Propositions 4 and 5), which were related to the motivation to contribute to OSS communities. A more detailed connection of these answers with the current academic literature will be given later, when the analysed data will be discussed.

6.2.4 Discussion: Research Questions in the Thesis and Findings

Pulling together all this analysis in this section, the data collected and analysed from the empirical studies will be put together with the previously identified theoretical framework and the Model (Chapter 4), to ascertain whether the research questions have been answered. The Model will be revised according to the tested propositions, and necessary changes/improvements in the Model will be done. The research questions will be considered under the prism of the tested propositions and the Model.

Before revision of the Model however, we should recall the research, which were identified after the literature review.

- What are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?
- What are the characteristics of the communities that affect knowledge sharing in OSS communities?

Chapter 4 finished with Table 4.1, indicating which propositions would answer which research questions. After testing the propositions in this Chapter, we can explore how testing the propositions answered the research questions above.

6.2.4.1 Main Findings on Personal Factors (Research Question 1)

Research Question 1: what are the characteristics of the individual contributors that affect knowledge sharing in OSS communities?

The first five propositions, which were analysed, tested and discussed in the previous Chapter and which examined personal factors in the Model, have been used to answer Research Question 1. The first five propositions explain the personal factors necessary for knowledge sharing inside OSS communities. Explicit and tacit knowledge together with motivations to contribute to OSS development were identified as necessary personal factors in the Model (Chapter 4). As was mentioned in Chapter 4, these factors can be considered as being dependent on the individual contributors to OSS development. The motivations behind these contributors are totally up to the individuals concerned. Whether they wish to share their knowledge with others or not is dependent on the contributors themselves. Because the knowledge-based economy is based on knowledge, where roles and responsibilities are dependent on the level of knowledge contributors have, the factor of roles and responsibilities can also be considered as an individual aspect. The educational level of contributors to OSS communities is dependent on the individual contributors to the OSS communities. Therefore, motivations to contribute to OSS communities, roles and responsibilities inside OSS communities, and the educational level of contributors to can be considered as factors on a personal level which influence knowledge sharing inside OSS communities. The first five propositions were tested and the results shed light on the personal elements necessary for improving knowledge sharing, for effective knowledge using, and for encouraging knowledge owners to share their individual knowledge.

Proposition 1 – The higher the education level is, the more knowledge contributors share.

The testing of Proposition 1 discovered that a higher level of education does not have a significant influence on the level of knowledge shared (correlation analysis: -.049, -.038, -.014; regression analysis: ((b=.059, t=.633, ns), (b=-.006, t=-.062, ns), (b=-.040, t=-.447, ns), (b=-.051, t=-.546, ns)). Only contributors at the top level have a significant relationship in the percentage of their participation, which is related to project development in OSS communities (b=.392, t=4.225, p<.001***). As was seen in Chapter 3, there has been very limited academic work done in terms of the educational level of OSS developers.

It has been found that according to research conducted by Ghosh, Glott, Krieger & Robles (2002, p.10) on 2784 Open Source/Free Software developers, OSS developers have a high educational level: 70% of their respondents have an undergraduate degree, 17% of OSS developers have high school degrees, and 8% have A-level as their highest educational qualification. Such high educational level though can only mean that participation to OSS development already acts as a filter and those who have a certain level of, or particular IT knowledge can give value in OSS development. Further inside OSS communities the educational level as such does not play the most crucial role in the knowledge sharing processes.

Nevertheless the high educational level is important for contributors at the top level, who have a significant relationship with the percentage of their participation, which is related to project development in OSS communities, which can further be related to leadership issues that had been studied under Proposition 3 (below). Regarding Proposition 1 it is possible to summarise that because there has been very limited work done in this particular area, the findings for Proposition 1 are an important start for future research related to the educational level of OSS developers in VO. In summary, testing of this Proposition shows that educational level can play a significant role in leadership, but not in knowledge sharing.

Proposition 2 – The longer members participate, the more tacit knowledge they have.

Testing Proposition 2 revealed that the length of participation in OSS communities does not have a significant influence on the extent of tacit knowledge (correlation analysis: -.047, .078, .037; regression analysis: (b=.047, t=.515, ns), (b=.103, t=1.167, ns), (b=.005, t=.055, ns)). However, contributors with top level roles (b=.268, t=2.945, p<.01**) and middle level roles (b=.160, t=1.800, p<.10) are more likely to share their knowledge, where top level roles have a higher significance than middle level roles. Once again the top level and middle level contributors show a difference in the tested Proposition. That means there is a need to test Proposition 3, which is related to the roles and responsibilities in OSS communities.

Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.

The testing of Proposition 3 discovered that the hierarchy of roles as such are not important to the level of knowledge sharing in the OSS communities. The level of the roles inside OSS communities does not really show statistical significance for the motivations to share knowledge in the OSS communities. However, once again, the top level OSS developers show different result in the tested Proposition. Top level contributors have marginal significance with such motivations as philosophical factors (b=-.175, t=-1.895, p<.10), and personal needs (b=-.166, t=-1.836, p<.10).

The first thee Propositions prove the previous literature (Chapter 3) that here unlike traditional organisations where roles and rewards are formally fixed, online communities are open and the role behaviour is rather flexible (Madanmohan & Navelkar, 2002). Additionally the fact that top level have a significant relationship to the percentage of participation, which is related to project development and this also proves the result of participant observation in this thesis (Chapter 6), where the importance of the leadership in OSS communities was highlighted, where leadership can be gained as a result of knowledge sharing and level of knowledge. This again proves the previous literature (Chapter 3). Hertel, Niedner & Herrmann (2003), with the example of Linux, identified the structural conditions for successful OSS development. Compared with traditional organisations, VOs and especially OSS communities have a culture, where authority comes from competence, and the knowledge-driven economy appreciates knowledge workers.

On the other hand, leadership principles combine with clear responsibilities in OSS development. Knowledge, shown through contributions, increases the contributor's supposed merit, which in turn leads to power. If contributors can show their ability (or if they can gain respect from the community), they might be invited into the developer group, where they may have more rights over the code (for instance to incorporate their own modifications into the code base) (Gacek, Arief & Arief, 2004). The findings in Proposition 1, 2, and 3 prove the previous academic literature and show that authority comes from competence, and that is why the top level contributors showed significant results in the testing of knowledge sharing.

Propositions 4 and 5

Pr 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community.

Pr 5 – Work related motivations have positive impacts on knowledge sharing in the OSS community.

As was discussed in Chapter 3, motivations to share knowledge and the ability to share knowledge are not the same thing. Motivations to share knowledge in order to contribute to OSS development was analysed in this thesis. The tested Propositions 4 and 5 discovered that collected data supports previous academic studies regarding the importance of motivations for knowledge sharing (Chapter 3). The tested Propositions showed that "personal needs" have an important influence in gaining tacit knowledge (.265**), when colleagues share their tacit knowledge (.412**), and in sharing tacit knowledge (.304**). Work related motivations have only marginal significance to the knowledge sharing in the OSS community ($b=.180$, $t=1.908$, $p<.10$).

However, although work related motivations do not demonstrate an influence in gaining/sharing tacit knowledge (.071, .073, .110); work related motivations have more impact than personal motivations. In addition to the importance of the motivations to the sharing of knowledge however, there are various factors, which OSS communities should provide in order for OSS developers to feel happy and ready to share their knowledge with others. For the next step, it will be useful to discuss the findings on factors influencing the level of motivation as well as the ability to share knowledge and how they are related to each other.

6.2.4.2 Findings on Organisational Factors (Research Question 2 in this thesis)

Research Question 2: What are the characteristics of the communities that affect knowledge sharing in OSS communities?

The Research Question 2 is answered by testing Propositions 6 – 10 on organisational factors in the Model (Chapter 4). The second and last set of propositions were constructed to analyse factors that influence knowledge sharing from an organisational perspective, what kind of environment do the communities provide for their members, when motivated and knowledgeable people are joining the communities ready and willing to share their experience . How can the level of knowledge sharing be influenced by environment? The individuals who share knowledge for OSS development show their vision on the question and explain how the OSS community could keep the uniqueness of knowledge owners and manage knowledge on time frame effectively. Satisfaction of the individuals with the management of the OSS communities, identification with these communities, trust inside of these communities, and incentives as organisational factors shed light on the Research Question 2 through testing the identified last five propositions discussed in Chapter 6.

Proposition 6: The more satisfied the contributors are with OSS project administration, the more motivation to contribute they have.

The testing of Proposition 6 discovered that satisfaction with management plays a crucial role for increasing the motivation of contributors in knowledge sharing in OSS communities. Also satisfaction with management plays an important role for the level of the knowledge sharing in the development of OSS in the communities as a whole. Only hobby does not show significant relationships (b=.093, t=.963, ns) with satisfaction with management. All other motivations are dependent on satisfaction with management: altruism (b=.369, t=3.962, p<.001***); personal needs (b=.399, t=4.625, p<.001***); philosophical factors (b=.322, t=3.492, p<.01**); accomplishment (b=.271, t=2.888, p<.01**); network opportunities (b=.280, t=3.064, p<.01**); hobby (b=.093, t=.963, p<.10); main work needs (b=.153, t=1.753, p<.10).

These findings on the importance of the satisfaction with management in knowledge sharing back up the previous literature (Chapter 3). For instance, according to Metiu & Kogut (2001), coordination in software communities is an important principle. According to Asklund & Bendix (2001), in the OSS communities, a moderator should not play the role of a bottleneck, because such bottlenecks delay awareness and usability of the application which is being developed. That means that management and coordination of the geographically dispersed online communities play a crucial role in creating a healthy atmosphere for contributors so that they can create and share their knowledge and as a result contribute to the success of the OSS communities. This tested Proposition proved the current academic literature and showed once again the importance of well organised and proper management for successful knowledge sharing between OSS developers in OSS communities.

Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.

The testing of Proposition 7 discovered that trust is an important issue in increasing motivations for knowledge sharing in the OSS communities, and in the development of the OSS. Trust has positive relations with such motivations as "philosophical factors" (.310**), "accomplishment" (.347**), "altruism" (.530**), "network opportunities" (.257**), and "personal needs" (.392**), also it has positive relations with "satisfaction with management" and "identification". Almost all motivations apart from hobby (b=.063, t=669, ns) and work related needs (b=-.016, t=-.181, ns), show highly significant relationships with trust: personal needs (b=.398, t=4.713, p<.001***); altruism (b=.552, t=6.803, p<.001***); accomplishment (b=.372, t=4.248, p<.001***); network opportunities (b=.228, t=2.538, p<.01**); philosophical factors (b=.309, t=3.444, p<.01**).

These findings on the importance of trust in knowledge sharing back up studies in the previous literature (Chapter 3). Trust in VO has been widely studied in the current academic literature in the work of the following authors for example, Ishaya & Macaulay, 1999; Jarvenpaa & Leidner, 1999; Faraj & Wasko, 2001; Bauer & Koeszegi, 2003; Jarvenpaa, Shaw & Staples, 2004; Roberts, 2003, 2006; Collins & Smith, 2006.

Bauer & Koeszegi (2003) find that trust between members has a fundamental impact on the success of VOs. Roberts (2006) finds that without trust, members of a community may be hesitant to share knowledge. Faraj & Wasko (2001) find that trust and identification are attributes for knowledge sharing. Ishaya & Macaulay (1999) focus on trust as a key factor for successful VOs, where social control is based on self-direction and self-control. According to the findings in this thesis, trust is critical in OSS communities. Trust inside the OSS communities between contributors and also within the management and coordination of the communities is an important factor for successful knowledge sharing in these communities.

Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.

The tested Proposition 8 discovered that identification within the community is an important factor for increasing motivations for knowledge sharing in OSS communities. Identification and gaining tacit knowledge have powerful relations. Identification and the level of knowledge sharing have positive relationship (.238**). And identification is related with motivations, such as "philosophical factors" (.320**), "accomplishment" (.227*), "altruism" (.352**), "network opportunities" (.304**), "personal needs" (.378**). Five motivations out of seven and identification have a strong statistically significant contribution: personal needs ($b=.399$, $t=4.885$, $p<.001$***); network opportunities ($b=.308$, $t=3.655$, $p<.001$***); altruism ($b=.372$, $t=4.266$, $p<.001$***); philosophical factors ($b=.326$, $t=3.757$, $p<.001$***); accomplishment ($b=.244$, $t=2.743$, $p<.01$**).

These findings on the importance of identification within the community in knowledge sharing agree with the previous literature (Chapter 3, for example, Edwards, 2001; Faraj & Wasko, 2001). If trust has been a popular field for research in VO, identification within online communities was not found to be as widely researched. Wiesenfeld, Raghuram & Garud (2001) find that organisational identification is an important factor in a virtual setting because it may replace/compensate for the loss of aspects from traditional organisations that facilitate co-operation and coordination. The ability to manage virtual employees may depend on identifying the factors that anticipate their organisational identification. According to Wiesenfeld, Raghuram & Garud (2001), employees in VOs requirement for a connection and work-based social support are both vital in organizational identification. Because identification within online communities has not been widely researched yet, it was important to find out through empirical studies how identification and the intensity of the motivations are related to each other inside OSS communities for successful knowledge sharing.

Propositions 9 and 10

Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.

Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

The testing of Proposition 9 discovered that incentives for the future showed some significance in some points, however, it does not play a crucial role in influencing the level of knowledge sharing in OSS development. Hierarchical multiple regression analysis showed that incentives/benefits for the future from contribution to the OSS communities does not relate to knowledge sharing in the OSS communities as much as for previously mentioned factors: for example

- the percentage of participation, which is related with project development in the OSS community, is related to the incentives/benefits for the future (b=-.237, t=-2.637, p<.01*);
- the length of participation within the OSS community is marginally related to the incentives/benefits for the future gained from knowledge sharing in the OSS communities (b=.002, t=.021, p<.10);
- the extent of communication with other members in the OSS community is not related to the incentives/benefits for the future from knowledge sharing in the OSS communities (b=-.025, t=-.258, ns);
- Finally the level of activeness in knowledge sharing in the OSS community is not related to the incentives/benefits for the future from knowledge sharing in the OSS communities (b=-.012, t=-.136, ns).

Top level contributors found that incentives have a role in influencing the level of the knowledge sharing (b=.240, t=2.712, p<.01**) as well as the percentage of participation related to OSS development (b=.389, t=4.348, p<.001***); whereas middle level contributors do not rank it as important as top level contributors (b=.202, t=2.347, p<.05*).

The testing Proposition 10 discovered that monetary reward is related to some extent with the top level of contributors, whereas it does not have any relationship with the lower level contributors. Although, monetary reward plays a role in knowledge sharing (.185*), hierarchical multiple regression analysis showed that monetary reward is not the most important factor for knowledge sharing in the OSS communities. The statistical significance showed the relationship between monetary reward and the amount of hours per week spent on knowledge sharing in the OSS communities (Q8) ($b=.287$, $t=3.409$, $p<.01$**), which can be interpreted as stating that the monetary reward can have statistical significance on knowledge sharing in those members of the OSS communities, who in fact may be officially employed in those communities, and the monetary reward can be simply relate to their salaries: top level contributors ($b=.205$, $t=2.419$, $p<.05$*), middle level contributors ($b=.222$, $t=2.704$, $p<.01$**). Monetary reward positively influences the time spent knowledge sharing in the OSS (.351**), which can be interpreted as a positive relationship between monetary reward and core members.

These findings support the current academic literature. For example, Lerner & Tirole (2000) find that the delayed reward for the activities in OSS communities covers two distinct/hard-to-distinguish incentives: career related incentive (such as future job offers, shares in commercial open source-based companies, future access to the venture capital market) and ego satisfaction incentives (such as a desire for peer recognition). From an economic perspective, the incentives are similar in most respects. The empirical findings in this thesis in terms of incentives/benefits are useful additional sources and a basis for future studies. The findings show how incentives (benefits for the future) and monetary rewards can influence knowledge sharing in OSS communities at a certain level; however is not the most crucial element in knowledge sharing.

As a result it was found that satisfaction with management plays a crucial rule in increasing motivations for contributors, as well for the level of knowledge sharing in OSS development in the communities as a whole. Trust is another important issue in increasing motivation for knowledge sharing in the OSS communities, and in the development of the OSS. Identification within the community is also an important factor for increasing motivations to share knowledge within the OSS communities. Identification and the level of knowledge sharing play important role, and identification and gaining tacit knowledge have powerful relations. Incentives for the future showed some significance in some points, however, it does not play a crucial role in influencing the level of knowledge sharing in the development of OSS. Monetary reward is related to some extent to the top level contributors, whereas it does not have any relationship with lower level contributors.

The findings on an organisational level in the Model (Chapter 4) support current academic literature regarding the importance of such factors as trust inside OSS communities, satisfaction with management in OSS communities and identification within OSS communities.

6.2.4.3 Integration of Findings on Personal Factors and Organisational Factors in the Model

The Model was identified in the Chapter 4 “Theoretical framework” (Figure 4.3) to investigate the OSS communities from an individual viewpoint. Correlation and regression analyses, done earlier, make it possible to conclude the investigation by revising the Model. On the revised version of the Model (Figure 6.1), the results of the propositions testing the factors which influenced the sharing of personal knowledge within OSS community is shown under the prism of the Model (Chapter 4, Figure 4.3). As was already discussed in Chapter 2 regarding work processes in VO and limited research on that particular topic, the Model investigated in this thesis at the same time shed light on the wider picture of the knowledge sharing processes inside OSS communities.

In the Model (Figure 6.1), the pink boxes show personal perspective in knowledge sharing inside OSS communities. The higher the level of education the contributors have does not directly influence the level of knowledge sharing, however, it does influence the level of the roles in OSS communities: top level contributors have a significant relationship in the percentage of their participation, which is related to project development in the OSS Communities ($b=.392$, $t=4.225$, $p<.001$***); contributors at the top ($b=.243$, $t=2.727$, $p<.01$**) show significance on the length of hours per week in knowledge sharing in the OSS Communities. The level of roles and the level of activeness in OSS communities together with monetary reward influencing the level of tacit knowledge sharing: the statistical significance showed the relationship between monetary reward and the amount of hours per week spent on knowledge sharing in the OSS communities (b=.287, t =3.409, p<.01**). The level of tacit knowledge sharing under the motivational factors has a significant relationship with the level of personal knowledge sharing on product innovation inside OSS communities. Motivations (both personal and work related) are the atmosphere, which is created inside the OSS communities, and which is necessary inside the OSS communities to influence knowledge sharing.

Similarly incentives/benefits for the future from the participation in OSS communities do not directly influence the level of knowledge sharing. However, it influences the percentage and the length of participation: the percentage of participation, which is related with project development in the OSS community, is related to the incentives/benefits for the future (b=-.237, t=-2.637, p<.01*); and to the length of the participation to the OSS community is marginally related to the incentives/benefits for the future from the knowledge sharing in the OSS communities (b=.002, t=.021, p<.10);

The green boxes box in the Model (Figure 6.1) shows that in order to attract effective knowledge owners inside OSS communities and in order to provide healthy environment for sharing tacit knowledge, there is a need for well organised, good leadership, because management in OSS communities plays a significant role. Therefore it is important to conduct further research and investigate the organisational level of the factors influencing knowledge sharing in OSS communities. However, for now, in this study, as it was analysed in the Model, the empirical studies discovered that trust, satisfaction with management, and identification within an OSS community are essential features for successful knowledge sharing (green boxes). The literature review showed that integrating people with different knowledge is one of the necessary conditions for knowledge creation (Davenport & Prusak, 2000; Cohen, 2006; Nonaka & Takeuchi, 1995). It was supported by the fact that motivations to share knowledge are evoked in an atmosphere where players interact for the purpose of knowledge sharing.

In Figure 6.1, the level of importance of the factors influencing knowledge sharing in OSS communities and the strength of the relationships between these factors are shown with the number of the stars (★), where ★-star has a minimum level of the importance and ★★★-stars has maximum level of importance. The Model can be reviewed and renewed as is shown in Figure 6.1. This finding shows the necessity of further research on the organisational level, because such issues as identification, trust and satisfaction with management can be created and managed inside the organisations on the organisational level.

The last point in the Model is to calculate the level of personal knowledge sharing in product innovation, the level of the personal tacit knowledge sharing. A one sample chi-square test was used in order to find out the "suitability of fit" (Pallant, 2005, p.287), where the time of the participation of the particular OSS community (Question 6 in the online questionnaire, Appendix 3) was compared with the percentage of the participation, which is related to project development in the OSS Community (Question 9, Appendix 3).

According to the test, there is 100% of violated the assumption. Table 6.5 shows that there is a significant chi-square test, because Asymp.Sig is less than .05, which means that the time-activity relationship is significant and this shows that time spent in the OSS communities is significantly spent for the OSS development. Time-activity relationship calculates the level of personal knowledge sharing in the OSS development (the Model): sharing knowledge with others in the OSS community. This can be summarised by saying that a significant level of personal knowledge sharing is related to all those factors identified in Model. Personal knowledge sharing is effective and dependent on those factors and it is significant, when these tested factors work properly.

Table 6.5: Question 9 & Question 6: Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	601.232(a)	483	**.000**
Likelihood Ratio	255.337	483	1.000
Linear-by-Linear Association	.579	1	.447
N of Valid Cases	118		

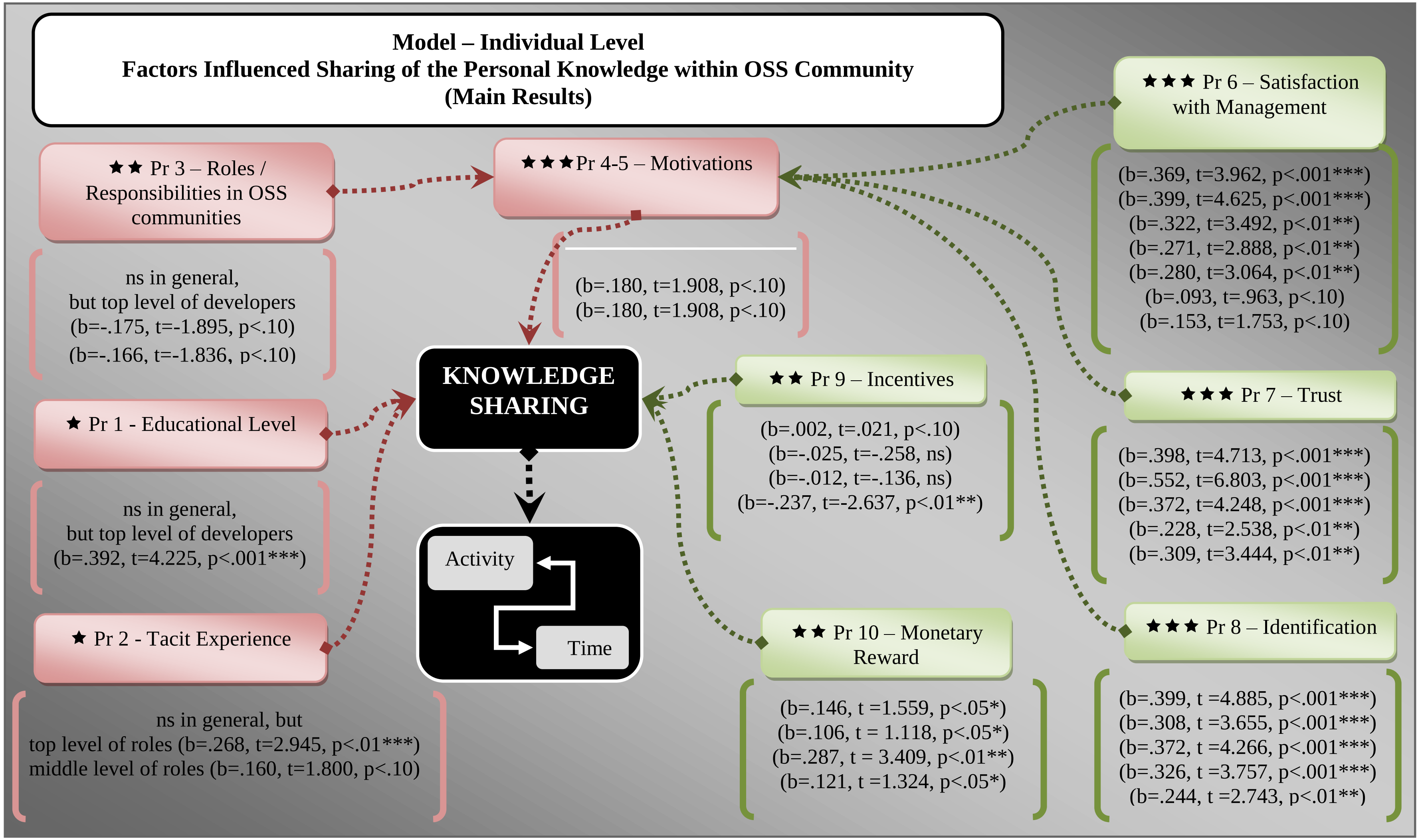


Figure 6.1: The Revised Version of the Model – Individual Level / Factors Influenced Sharing of the Personal Knowledge within OSS Community

6.2.5 Summary of Phase 2: Quantitative Research

Variables were identified by putting together appropriate questions from the quantitative questionnaire in order to test propositions by these variables. The factor analysis showed that the cumulative percentage is high for all the variables and therefore all the data is reliable because Cronbach’s Alpha Reliability Statistics are high. After factor analysis, where variables were identified for proposition testing, the next step involving correlation analysis was undertaken. What kind of relationships do the variables in the propositions have, how strong or weak are these relationships, are all answers that were found through correlation analysis. The descriptive statistics for the correlation analysis were interpreted and discussed above.

Then regression analysis was implemented, however before multiple regression analysis, a number of control variables were identified. The interpretation of the multiple regression analyses and their relationships to the propositions were given. All analyses showed that the data is reliable. Generally the R2 indicator varied between 5% and 38%, and the indicator of the significant F showed a very low level (apart from 2 indicators in the Proposition 2), which means that all data analysis is reliable and valid (Pallant, 2007).

In this Chapter data collected and analysed from the empirical studies was put together with the previously identified theoretical framework and the Model, to ascertain whether the research questions were answered. The Model was revised according to the tested propositions. Necessary changes and improvements in the Model were done, and the research questions were considered under the prism of the tested propositions and the Model.

After collection and analysis of the quantitative data and after receiving comments from the respondents (Appendix 8), the comments/suggestions about data collection and regarding the questionnaire itself are as per the following.

6.2.5.1 Data Collection

In the future, in approaching OSS contributors, it would better to join some big conferences where it is possible to develop good networking opportunities and to distribute the online questionnaire among attendants and/or to colleagues of those attendants. It was not done in the collection data for this thesis because of various outside reasons, however, if it would be done, then the response rate perhaps would be much higher.

6.2.5.2 The Questionnaire Itself

Generally the questionnaire was found to be of good quality and the respondents were interested in hearing the results of the data analysis. However, there were a few stages which could have been done better. Following the current academic literature, after face-to-face meetings with software programmers, and after pilot studies on the questionnaire, it was distributed worldwide. It was found that the questionnaire was "mostly focussed on the coding aspects of contributing to OSS projects, but there are far more people who contribute by doing documentation, helping out on forums and contributing feedback and bug reports on software. Coding is generally done by the core developers + patches by the peripheral developers." (Appendix 8). One respondent found that some of the questions were hard to quantify, for example "how many times do I do X" is difficult when a large amount of my time is spent on OSS related work. Some of these activities I do dozens of time a week. It might be easier to order them in which activities I do most versus least." The questionnaire was found to be quite long, and also a few of the respondents found some grammatical mistakes in the questionnaire. One respondent found that especially section D regarding tacit knowledge is "a bit uncertain".

CHAPTER 7

DISCUSSION and CONCLUSION

7.0 Introduction to Chapter 7

This Chapter will formally conclude the thesis, considering and discussing the contributions to knowledge and the methodological contributions. The limitations of the study will be analysed before the thesis is formally finalised, with ideas for further investigation of knowledge sharing in OSS communities at the organisational level.

7.1 Contributions to Knowledge

7.1.1 Theoretical Contribution

7.1.1.1 Contribution to the Current Academic Literature

In this thesis VO was reviewed from a wide angle. Knowledge sharing in VO was investigated and OSS communities were considered under the prism of knowledge sharing. More than four hundred academic sources on different topics related to e-business, e-commerce, knowledge management, virtual organisations, open source software, online communities, innovation, entrepreneurship and so forth were reviewed. This is a large amount of academic sources, and from those sources, the research questions were identified in order to fill the gaps found in the current academic literature. There are comparatively few other works which are specialised in this particular field. The new form of organisations, a VO, due to its "newness" and due to its many forms of virtuality, required further investigation. This thesis gives both theoretical and practical benefits to help fill this gap.

This thesis contributes to the current academic literature on VO in general and on OSS communities in particular. This study explores factors influencing knowledge sharing in a VO rather than concentrating solely on its structure. Leaders of OSS communities as well as managers of organisations in general, who implement or are going to implement their business activities in an online medium and thus become a VO, can benefit from the results of the thesis through increasing the knowledge sharing processes in their organisations through analysis of the results of the Model (Figure 6.1), whilst also improving their organisational factors in order to encourage knowledge sharing amongst their members. The thesis concentrated on knowledge sharing as a process in the concrete example of a particular form of organisation - OSS communities - so as to explore factors that influence successful knowledge sharing in a concrete and specific example in the real business world, in order to mirror that practice into theory in the academic literature.

At the same time, this thesis contributes to the current academic literature on managing knowledge in general and on knowledge sharing in particular. During the literature review (Chapter 2) it was identified that knowledge sharing is one of the most delicate issues because people by nature do not share their knowledge with others. Yet in OSS communities they need to share tacit knowledge into explicit knowledge and inarticulable knowledge into articulable knowledge in order to gain a competitive advantage. This thesis demonstrated the factors involved in allowing successful knowledge sharing processes to begin within OSS communities. This thesis investigated the knowledge sharing process in detail and what factors influence successful knowledge sharing. The revised version of the Model, which builds on the empirical studies, is an answer to what factors influence successful knowledge sharing in the specific example of OSS communities; it is a reflection of the practice into theory. Therefore, the findings in the Model form a contribution to the current academic literature in terms of managing knowledge and knowledge sharing in VO in general and in OSS communities in particular. However, before discussing the contribution to the current academic literature of the Model itself, we turn to how each proposition tested in Chapter 6 contributes to extant academic knowledge.

Proposition 1 – The higher the education level is, the more knowledge contributors share.

Proposition 2 – The longer members participate, the more tacit knowledge they have.

Since the thesis was investigating knowledge issues, it was useful to analyse the educational level of the developers and how this educational level might influence the factors affecting individuals' contribution to the OSS communities. However, there is not a lot of research done previously on this question. Therefore, the importance of the empirical evidence from Proposition 1 and Proposition 2 becomes even more meaningful in terms of their contribution the current literature, which was limited in this particular topic.

The previous studies, for instance Blundell, Dearden, Meghir & Sianesi (1999) found that better-educated workers can be more skilled at responding to technological change, and as a consequence they may be more productive in high-tech firms. As Chapter 3 mentioned, browsing online sources such as scholar.google.com, web of knowledge, or EBSCO (January 2008) found only one instance of research, where the educational level of OSS developers were investigated. According to research conducted by Ghosh, Glott, Krieger & Robles (2002, p.10) on 2784 Open Source/Free Software developers, OSS developers have a high educational level: 70% of their respondents have an undergraduate degree, 17% of OSS developers - high school degree, and 8% have A-level as their highest educational qualification. Additionally, positive economic returns to education at the individual level have been always found (Blundell, Dearden, Meghir & Sianesi, 1999; Ghosh, Glott, Krieger & Robles, 2002).

This lack in the current academic literature on research focusing on the link between educational level and knowledge led the author to investigate this further. The following questions arose in the course of this research. If tacit knowledge is know-how, implicit and not always possible to be documented from one hand; explicit knowledge can be documented from another hand; can it be that certified knowledge is explicit knowledge? If so, then can professionally certified knowledge be considered as explicit knowledge? Can educational level be considered as explicit knowledge, especially in knowledge intensive organisations such as OSS communities? If so, can the length/intensity of the contribution to the OSS development be considered as tacit knowledge accordingly? There was no evidence found from any other academic literature; however, the logic allowed the acceptance of this idea to consider explicit knowledge, which can be obtained through educational bodies such as universities, whereas the length/intensity of the contribution can influence the level of tacit experience. In other words, the higher the educational level is, the more explicit knowledge is gained, and the longer/the more intensive the contribution is, the more tacit knowledge the contributors to the OSS development can have. Explicit knowledge has its root in the tacit knowledge of the individuals (Polanyi, 1969). If so, then can explicit knowledge come from the educational level of the individuals? (Chapter 3, Section 2). Can it come from the educational level especially in knowledge-based economy, where knowledge is the main driver?

It was useful to analyse the relationship between the level of education and its impact on the intensity of the contribution to the OSS development, the relationship between individual explicit and individual tacit knowledge. It was also useful to analyse the impact of the length of the participation in the OSS communities and the level of the knowledge they have gained during the participation, how the tacit knowledge increases during the process of the contribution/participation to the OSS communities, and how individual tacit knowledge can be influenced by other individual tacit knowledge and organisational tacit knowledge.

The data analysis showed, 42% of respondents to the quantitative questionnaire (Chapter 6) had an undergraduate level of education, 17% had progressed to obtain a Masters degree, 11% held PhD levels of education and 23% had a high school level of education. That means that 70% of all respondents had education at a university level, which is surprisingly similar to the data results of Ghosh, Glott, Krieger & Robles (2002, p.10). Nevertheless, the education level does not directly affect knowledge sharing. The correlation analysis conducted for Proposition 1 in this thesis showed that there was no significant relationship between the level of education and the level of knowledge sharing (Chapter 6, Section 6.2.2.2 Correlation Analysis). The regression analysis conducted for Proposition 1 (Chapter 6, Section 6.2.2.3 Regression Analysis) gave similar results and showed that a higher level of education does not play a role in the level of knowledge sharing in the OSS communities. The regression analysis conducted for Proposition 2 showed that the length of participation in OSS communities does not have a significant influence on the extent of tacit knowledge gained either (Chapter 6, Section 6.2.2.3 Regression Analysis). In other words, the regression analysis conducted showed that the length of participation to OSS development does not play a role in extending the amount of tacit knowledge members have.

As seen, although the educational level of individuals is an important aspect in a knowledge-based economy, as the majority of the contributors have a university level of education; the analysis of the empirical studies in this thesis (Chapter 6) shows that none of the control variables have significant relationships between education levels and the frequency of communication with other members in the OSS communities. Although an individual’s educational level and the collective grouping of worker’s educations together have a relationship with the productivity and innovativeness of individuals in general (Blundell, Dearden, Meghir & Sianesi, 1999; Ghosh, Glott, Krieger & Robles 2002), in OSS communities, higher levels of education do not play a significant role in terms of its influence on the level of the knowledge sharing. These results support Polanyi (1967, p.20), who discussed that “an explicit integration cannot replace its tacit counterpart”. Data analysis (Chapter 6, Section 6.2.2.3 Regression Analysis) showed that only contributors with top level responsibilities have a significant relationship in the percentage of their participation, which is related to project development in OSS communities; and only these top level contributors have a marginally significant relationship with the frequency of communication with other members in the OSS Communities. This means that those contributors with high tacit skills, who are able to reach high positions in the OSS communities, are the ones who mostly participate in the OSS project development. This finding supports the previous literature, where it was found that knowledge, shown through contributions, increases the contributor’s supposed merit, which in turn leads to power (Hertel, Niedner & Herrmann, 2003; Gacek, Arief & Arief, 2004). The findings in this Proposition show the importance of leadership in an organisation, even though in such a community as this, the leadership was unofficial, and that such leadership builds on the level of knowledge sharing, because of the level of knowledge. This Proposition leads us to discuss further other propositions related with management and leadership in OSS communities.

Furthermore, this can be attributed to the fact that generally by being a member, and especially an active contributor inside OSS communities, can mean that such people need to already possess a particular level of knowledge. They are required to have explicit knowledge in order to be able to contribute to OSS communities which can consequently mean that membership to OSS communities can play a filtering role from an educational perspective. Once inside OSS communities, a higher level of education as such does not play such a major or significant role. As a result, it suggests that in the later stage of activities inside OSS communities, developers need to use their tacit skills more rather than their educational level in order to succeed. The success of using these tacit skills can help aid an individual to gain a higher position in the OSS community and can serve as a “provider” for enhancing further career growth inside OSS communities. In turn, this can infer that practice-based knowledge becomes more important in a knowledge-based economy.

In terms of Proposition 2, according to the study undertaken by Ghosh, Glott, Krieger and Robles (2002), those developers who are very active in OSS and spend more than 40 hours per week doing so, are also very active in developing proprietary software. In fact, these individuals regardless of the time they spend developing OSS, actually spend more time developing proprietary software. The findings in this thesis confirm the findings by Ghosh, Glott, Krieger and Robles (2002) as the following. The individuals at the top level of contribution to the work, such as project leaders, core members and active developers, spend many hours per week devoted to knowledge sharing in the OSS (Chapter 6, Section 6.2.2.2 Correlation Analysis). Among those members, core members are more active and spend more time contributing to the OSS rather than project developers and active developers. Passive users on the other hand are not those active in terms of spending their time to enhance knowledge sharing in the OSS. This suggests that passive users are members of the OSS communities who participate “just” for using the software rather than for knowledge sharing in the OSS development. The amount of time spent in knowledge sharing in the OSS communities and the frequency of communication between individuals has a strong and significant relationship suggesting that the main aim of the communication in the OSS communities is knowledge sharing, where passive users do not become involved but rather “just” use the software.

Further in the Regression Analysis section (Chapter 6, Section 6.2.2.3), the results of Proposition 2 showed that the length of participation in OSS communities and the level of tacit knowledge of an individual do not have a significant relationship. This can be explained by the fact that in OSS communities, contributors are those who already have a high level of IT and computer programming skills. To be able to reach a high level in the OSS communities, contributors need high levels of programming skills in general, rather than a specialisation in particular software. Additionally as the regression analysis (Chapter 6, Section 6.2.2.3) showed in this Proposition, other control variables showed more significance as opposed to the main one examined. For instance, contributors with top level roles and middle level roles are more likely to share their knowledge, with top level o roles having a higher significance than middle level roles. Young contributors (people younger than thirty years of age) found that they can gain the tacit experience of others in the OSS communities and can thus learn from others. The interpretation of this can be because the majority of young contributors are students, who have less tacit experience.

Finally, as the length of participation in a particular OSS community does not influence the level of the tacit knowledge held, this can mean that in a knowledge-based economy, or in an online community which produces such high quality products as software, participants are already expected to have high levels of tacit knowledge. And because the major activity of the participants in the OSS communities is devoted purely to producing software, the length of participation itself does not influence the level of tacit knowledge.

As a result, additional to the findings that a) the education level does not directly affect knowledge sharing; and b) the length of participation in a particular OSS community does not influence the level of the tacit knowledge held; because there was not a lot of research done previously on the similar questions; the findings in Proposition 1 and Proposition 2 are important because of their contribution to the current literature, which was limited in these specific questions.

Proposition 3 – The higher their role in OSS communities, the more motivation for knowledge sharing contributors have.

As mentioned in Chapter 4, due to the specificity of the contribution to software development, the higher IT education level people have, the more contributions they may make. On the other hand, their tacit experience may play an even more important role in contributing to the project, because knowledge becomes more valuable and is strongly related to tacit experience. In other words, OSS development needs rich theoretical knowledge, wide programming experience and practice. Previously in the existing academic literature (for example, Schmidt & Porter, 2001), it was found that OSS has scalable divisions of labour. Unlike traditional organisations, where roles and rewards are formally fixed, online communities are open and the role and its set-behaviour is rather flexible (Madanmohan & Navelkar, 2002). OSS communities have a culture whereby authority emanates from the competence of individuals (Hertel, Niedner & Herrmann, 2003). Based on the literature review, if the knowledge-based economy is based on knowledge, then one might conclude that knowledge workers should be the most valuable ones in a knowledge-based economy. Based on such logic, another proposition could lead that the idea that roles and responsibilities in OSS communities can be based on the level of tacit knowledge (Chapter 3, Section 2).

However, as the data analysis showed, the level of the role held inside OSS communities does not really show any statistical significance in explaining the motivation to contribute to the OSS communities (Chapter 6, Section 6.2.2.3 Regression Analysis). It is only at the top level of contribution there was marginal significance, with such motivations as philosophical factors, and personal needs playing a role. This infers that those contributors, who add to OSS communities because of various reasons such as their philosophical attitude toward commercialised software or perhaps these individuals need OSS because they can improve it for their own personal needs, are truly knowledge workers who have a high level tacit knowledge enabling them to take on higher level roles and responsibilities. These findings are also supported via correlation analysis (Chapter 6, Section 6.2.2.2), where it was found that hobby as a motivation plays a significant role only for active developers; accomplishment and network opportunities of contributors as motivational influences for knowledge sharing only play a significant role for the core members of OSS communities.

In testing this Proposition (Chapter 6, Section 6.2.2.3 Regression Analysis), among seven different motivations examined and three dummy variables for the type of roles held, only marginal significance was found, inferring that the level of roles and responsibilities doesn’t really have any meaningful relationship with the level of motivation. This can mean that those contributors who add to the OSS communities because of their philosophical attitude, for example toward commercialised software, or because they need OSS so that they can improve it for their own personal needs, are the participants who are knowledge workers and hold high levels of tacit knowledge, so that they can take on high level roles and responsibilities in the OSS communities. The knowledge-based economy provides an opportunity for knowledge owners to take higher roles and responsibilities.

However, the roles themselves do not influence the level of motivations needed to contribute to the OSS development, which suggests that contributors add to the development of OSS regardless of what responsibilities they have and what roles they take on inside OSS communities. The level of the role is therefore found to be unrelated to the motivations for knowledge sharing. The findings in Proposition 3 as well as previous propositions are important because of their contribution to the current literature, which was limited in this specific question, which found that the hierarchy of roles was not an important explanatory factor to help explain the level of knowledge sharing within the OSS communities.

Propositions 4 and 5:

Proposition 4 – Personal motivations have positive impacts on knowledge sharing in the OSS community.

Proposition 5 – Work related motivations have positive impacts on knowledge sharing in the OSS community.

In Chapter 3, a wide range of studies concerning the motivations for knowledge sharing in the OSS development were considered (for example Bergquist & Ljungberg, 2001; Faraj & Wasko, 2001; Hars & Ou, 2002; Lakhani & von Hippel, 2002; Hertel, Niedner & Herrmann, 2003; Bonaccorsi & Rossi, 2003; Ulhoi, 2004; Rullani, 2006; Mikkonen, Vaden & Vainio, 2007; Schroer & Hertel, 2007). Table 3.1 (Chapter 3) brought together the literature and their findings in terms of motivations to contribute to OSS development, where all motivations from the literature review were divided into the following categories: hobbies, physiological factors, philosophical factors, personal needs, main work needs, network opportunities, and long term benefits. Later, this research divided the motivations into two main parts: personal and work related in order to easily use such categorisation in further investigations using empirical studies in this thesis.

It was useful to analyse work-related and personal-related motivations and to discover the connection between the two. It was remarkable to analyse these two different areas of motivations: personal related and work related, because the overall factors influencing knowledge sharing inside OSS communities were divided into two main parts: personal and organisational. Although there is plenty of academic literature dealing with motivations in terms of their contribution to OSS communities, we still needed to address the subject of motivation in this thesis because motivations to contribute to OSS communities are important drivers in causing knowledge workers to share their knowledge with others for the success of OSS communities, to create innovative products, which leading to a competitive advantage in the knowledge-based economy. Also it was necessary to investigate and analyse the motivations that lead to knowledge sharing issues, because further propositions 6-8 examined what kind of factors influence motivations, which in turn influence the level of the contribution, the level of creation of innovative products, and the overall success of the OSS communities.

In the correlation analysis for both Propositions 4 and 5, the motivations examined have a positive relationship with one other. In the regression analysis (Chapter 6, Section 6.2.2.3) conducted, work-related motivations display stronger significance than personal-needs, especially for those contributors who have their primary occupation in the IT industry. The collected data supports the previous academic research regarding the importance of the type of motivations held to allow for contribution. However, in addition to previous findings in the academic literature, this thesis investigated that most importantly work-related motivations have more impact than personal motivations (Chapter 6, Section 6.2.2.3 Regression Analysis).

Personal motivations were found to not play a significant role in the relationship of knowledge sharing in the OSS community. Nevertheless personal needs had an important influence in the acquisition of tacit knowledge, when colleagues proceed to share this tacit knowledge and in the overall level of tacit knowledge sharing (Chapter 6, Section 6.2.2.2 Correlation Analysis). Work-related motivations only have a marginal significance on the level of knowledge sharing in the OSS community (Chapter 6, Section 6.2.2.3 Regression Analysis). However, work-related motivations do not display any significant influence in the acquisition or sharing of tacit knowledge (Chapter 6, Section 6.2.2.2 Correlation Analysis).

As discussed in Chapter 3, motivations to share knowledge and the ability to share knowledge are not the same thing. Motivations to contribute to OSS development was analysed above. It is now useful to find out what kind of factors influence the level of the motivations, as well as the ability to share knowledge, and how they are related to each other. It will also be useful to find out the level of influence of work related motivations and personal motivations in the contribution to the OSS development. As mentioned, personal motivations play an important role in the knowledge sharing in OSS development for people whose primary occupation is in the IT industry. Additionally, contributors with top-level roles and responsibilities display stronger relationships between personal motivations and the level of knowledge sharing. Collected data supports previous academic research regarding the importance of the motivations behind knowledge sharing and leads us to the analysis of the further propositions 6-8.

The first five propositions were constructed on the individual level, where knowledge sharing was analysed from a personal perspective. As discussed above, in addition to the individual level of the factors that influence the success inside OSS communities, there were factors at the organisational level. In Chapter 3, Section 2, satisfaction with management, trust inside such communities, identification within the communities, and incentives (benefits in the future) including monetary rewards were identified as factors necessary to successful knowledge sharing from the organisational perspective. The second set of propositions was constructed to analyse factors that influence knowledge sharing from the organisational perspective, what kind of environment do the communities provide for their members, when motivated and knowledgeable people are joining the communities ready and willing to share their experience. Organisational factors of knowledge sharing are very important, especially to investigate knowledge from a process perspective that looks at knowledge as “an objective reality”, a “social construct, developed, transmitted and maintained in social situations” (Empson, 2001, p.813) (Chapter 2).

Proposition 6 – The more satisfied the contributors are with the OSS project administration, the more motivation to share knowledge they have.

Chapter 3, Section 2 discussed that in addition to the factors influencing motivations, there are factors which should be implemented, in order to make OSS successful (Asklund & Bendix, 2001; Metiu & Kogut, 2001; Amaratunga & Baldry, 2002; Macbryde & Mendibil, 2003). Asklund & Bendix (2001) divide such factors into three groups: tools, process, and people. Metiu & Kogut (2001) name these factors as communication, coordination, and social context. Although on one side technology provides an excellent environment for communication, on the other side, transmitting some kind of knowledge such as tacit experience can be problematic. Therefore, as mentioned in Chapter 3, Section 2, coordination can play a crucial role in knowledge sharing in OSS communities. For instance, Metiu & Kogut (2001) discuss that coordination in software is an important principle.

According to Asklund & Bendix (2001), in OSS communities, a moderator should not play the role of a bottleneck, because such bottlenecks delay the awareness and usability of the application that is developed. Members of OSS communities need motivations that encourage them to contribute to OSS development. The management and coordination of geographically spread online communities play a vital role in creating a healthy atmosphere for the contributors to OSS communities so that they can create and share their knowledge and as a result contribute to the success of the OSS communities. After such a review of the literature review on the management in OSS communities, as Chapter 3, Section 2 clarified, the question for further analysis in relation to the management and coordination in OSS communities, and satisfaction within the management of the OSS communities, was identified in order to find out how satisfaction and the intensity of the motivation is related to each other inside the OSS communities.

The results of this research confirm the importance of satisfaction with the management in OSS communities for increasing motivations for contributors to share knowledge. As was found in Chapter 6, only the variable hobby does not show a significant relationship with management satisfaction. All other motivations – altruism, personal needs, philosophical factors, accomplishment, network opportunities, main work needs – are dependent on the level of satisfaction with the management (Chapter 6, Section 6.2.2.3 Regression Analysis). Satisfaction with management and motivations, such as philosophical factors, accomplishment, altruism, network opportunities and personal needs, all have significant relationships to the level of motivation for knowledge sharing (Chapter 6, Section 6.2.2.2 Correlation Analysis).

It is interesting to see that the personal motivations of contributors have higher significance with the level of satisfaction with the management (Chapter 6). It is probably because contributors with work related motivations will contribute to the projects even if they are less likely to be satisfied with management, while satisfaction with management also has significance with the personal motivations of the contributors. Top level contributors show marginal significance in the level of satisfaction with the management in their personal needs and philosophical factors (Chapter 6, Section 6.2.2.3 Regression Analysis). Bearing in mind that some of the top level contributors are management, which is tested in this Proposition, it is interesting to find how significant managerial satisfaction is for their personal motivations, such as philosophical factors and personal needs (Chapter 6, Section 6.2.2.3 Regression Analysis).

The results of the data analysis for this Proposition find that satisfaction with the management team plays an essential role in knowledge sharing in OSS communities and therefore supports the current academic literature and provides more detailed information about its importance in relation to other factors, such as different motivations, different levels of responsibilities in OSS communities, etc. (Chapter 6).

Proposition 7 – The more trust there is inside the OSS community, the more motivation to share knowledge contributors have.

As mentioned in Chapter 3, Section 2; the current academic literature (Ishaya & Macaulay, 1999; Jarvenpaa & Leidner, 1999; Faraj & Wasko, 2001; Bauer & Koeszegi, 2003; Jarvenpaa, Shaw & Staples, 2004; Roberts, 2003, 2006; Collins & Smith, 2006) shows that without trust, members of a community of practice may be hesitant to share knowledge. Trust, familiarity and mutual understanding in social and cultural contexts are fundamental for the successful sharing of tacit knowledge (Roberts, 2000 (a), 2006). Ishaya & Macaulay (1999) focus on trust as a key factor for successful VOs. As Chapter 3, Section 2 progressed; it was found that in terms of OSS communities, as the most developed form of virtuality, trust between contributors is an important factor for success in OSS communities. Therefore to find out how trust influences the intensity of the motivations, this aspect was included in the propositions' design in Chapter 3 and 4. The data analysis for this research confirmed that trust is a very important issue in increasing motivations behind knowledge sharing in OSS communities. Almost all of the motivations apart from hobby and work related needs, show highly significant relationships with trust (Chapter 6, Section 6.2.2.3 Regression Analysis).

The results of data analysis in Chapter 6, Section 6.2.2.2 and 6.2.2.3 on correlation and regression analyses confirm that trust is an important issue in increasing the motivation for the knowledge sharing in the OSS communities as well as in the development of the OSS. The findings regarding trust inside OSS communities fully support the current academic literature. For instance, as discussed in Chapter 3, Steil, Barcia & Pacheco (1999) state that promoting intensive socialisation activities to build vital trust in knowledge sharing in VO including OSS communities is important. For example, according to Amin & Roberts (2008 (b), online communities work well when there is a high level of interpersonal trust and where collaboration is built around strong professional attachments. Thus, although there is plenty of current academic literature on trust in online communities, the data analysis in this research demonstrates the relationships between trust and other variables, such as different motivations, and proves once again the necessity of providing a trustful environment for successful knowledge sharing in OSS communities.

Proposition 8 – The more strongly contributors identify with their OSS community, the more motivation to share knowledge they have.

As Chapter 3, Section 2 mentioned, Wiesenfeld, Raghuram & Garud (2001) find that organisational identification is an important factor in a virtual setting because it may replace/compensate for the loss of aspects of traditional organisations that facilitate co-operation and coordination. According to Wiesenfeld, Raghuram & Garud (2001), employees in VOs need for connection and the work-based social support are both vital in organisational identification. According to the current academic literature (Edwards, 2001; Faraj & Wasko, 2001; Wiesenfeld, Raghuram & Garud, 2001), an organisational identification is an important factor in a virtual setting because it may replace/compensate for the loss of aspects of traditional organisations that make co-operation and coordination possible. As Chapter 3, Section 2 mentioned, because identification within online communities has not been widely discovered yet, it was important to find out through empirical studies how identification and the intensity of motivations are related to each other inside the OSS communities. Therefore Proposition 8 on how identification and the intensity of motivations are related to each other inside OSS communities was created.

Chapter 6, Section 6.2.2.2 on correlation analysis found out that identification and the level of knowledge sharing have a positive relationship with one another. Five motivations out of seven alongside identification have strong statistically significant contributions: personal needs, network opportunities, altruism, philosophical factors, accomplishment (Chapter 6, Section 6.2.2.3 Regression Analysis). According to the findings in the data analysis in this research, identification within the community is an important factor for increasing the motivation to knowledge share in the OSS communities. Identification and the level of knowledge sharing play important roles with one another. In particular, identification and the acquisitions of tacit knowledge have powerful relations (Chapter 6, Section 6.2.2.2 and 6.2.2.3 on correlation and regression analyses). These findings are important because of limited previous research on the relationship of identification and motivations to contribute to OSS communities.

Furthermore, these findings confirm the importance of the organisational identification in increasing the motivations to contribute to OSS communities, and therefore, play an important role in the contribution to current knowledge.

Proposition 9 – Having incentives for the future such as long term benefits influences the level of knowledge sharing.

How do incentives influence the contribution to OSS communities? The literature review in Chapter 3 followed by the question, which was studied further in incentives, including monetary rewards, was: how can incentives, including monetary rewards, influence the level of the contribution? The data analysis in this research demonstrated that incentives for the future showed some significance in some cases. However, they do not play a crucial role in influencing the level of knowledge sharing in OSS development. The current academic literature (Lerner & Tirole, 2000) found that the delayed reward for activities in OSS communities covers two distinct/hard-to-distinguish incentives – “career concern incentives” (i.e. future job offers, shares in commercial open source-based companies and future access to the venture capital market) and “ego gratification incentives” (i.e. a desire for peer recognition). This research found that, in general, incentives, such as long term benefits for the future, do not influence the level of knowledge sharing as such. OSS programmers contribute for reasons other than for incentives to be received (see the Propositions above). However, top level contributors found that incentives do influence the level of knowledge sharing as well as the percentage of the participation related to OSS development. However, middle-level contributors do not rank incentives as significantly as top-level contributors do (Chapter 6, Section 6.2.2.2 and 6.2.2.3 on correlation and regression analyses).

Thus, hierarchical multiple regression analysis (Chapter 6, Section 6.2.2.3) showed that incentives/benefits for the future as a result of knowledge sharing in OSS communities do not relate to the level of knowledge sharing in the OSS communities as much as the previously mentioned factors. For example, the percentage of participation, which is related with project development in the OSS community, is also connected to the incentives/benefits for the future. The length of participation in the OSS community is marginally related to the incentives/benefits for the future from knowledge sharing in the OSS communities. The extent of the communication with other members in the OSS community is found to be unrelated to the incentives/benefits for the future from knowledge sharing in the OSS communities. Finally, the level of activeness in knowledge sharing in the OSS community is not related to the incentives/benefits for the future (Chapter 6, Section 6.2.2.2 and 6.2.2.3 on correlation and regression analyses).

In particular, incentives can also have a positive influence on the level of project development. Those developers who reach the top-level in OSS communities may have stronger natural interests in incentives since they are the most active in OSS development. Taking into account that some of the OSS communities may employ (financially hire) active developers, long-term benefits for the future clearly may be of interest to the top-level of OSS developers. Thus, the results of data analysis for this Proposition enriched the current academic literature and gave a more in-depth overview of the importance of the incentives to the contribution to OSS communities and showed the different level of relationships between the incentives, motivations and other variables in data analysis. We will now consider the influence of monetary rewards' on the level of knowledge sharing in OSS communities (Proposition 10).

Proposition 10 – Having monetary rewards influences the level of knowledge sharing.

As was already noted in Proposition 4, knowledge sharing is also related to monetary rewards. The existing literature has found contrasting evidence regarding monetary reward. For example, some existing literature indicates that non-monetary rewards are more influential than monetary rewards in the level of knowledge sharing in OSS development. Ulhoi (2004) writes that "since there does not seem to be any traditional monetary reward to the individual contributor of information and knowhow to an OSS project, motivations must be found elsewhere" (Ulhoi, 2004, p.1100). Conversely, Bonaccorsi and Rossi explain that "monetary reward is likely to be the main incentive of the firms. In fact, they enter this new field in order to profit from the Open Source" (Bonaccorsi & Rossi, 2003, p.3). The data analysis for this Proposition finds that monetary reward is related to some extent with the top-level of contributors whereas it doesn't have any relationship with lower-levels of contributors.

Although, monetary reward plays some role in the level of knowledge sharing, hierarchical multiple regression analysis showed that monetary reward is not the most influential factor in dictating the level of knowledge sharing in the OSS communities

(Chapter 6, Section 6.2.2.2 and 6.2.2.3 on correlation and regression analyses). The statistical significance showed some relationship between monetary reward and the amount of hours per week spent on knowledge sharing in the OSS, which can be interpreted as the monetary reward, can have meaningful contribution to those members of the OSS communities, who in fact may officially be employed in those communities. Those monetary rewards therefore can simply be interpreted as their salaries (Chapter 6, data from in-depth interviews).

Monetary rewards positively influence the time spent knowledge sharing in the OSS (Chapter 6, Section 6.2.2.2 Correlation Analysis), which can be interpreted by through a positive relation between monetary reward and core members. Among the top-level of contributors, core members have the highest level of relationship with monetary rewards for knowledge sharing in the OSS community (Chapter 6, Section 6.2.2.2 Correlation Analysis). If core members of some OSS communities are officially employed, then the relationship between monetary reward and the time spent knowledge sharing is understandable. This is supported by one of the interviews for the in-depth analysis conducted in this thesis, where an interviewee explained how their OSS community officially hires staff for the various projects. The time spent knowledge sharing in the OSS community and the level of monetary reward have statistical significance between each other, which can infer that there are positive relations between monetary reward and the core members.

While, monetary reward is related to some extent to the top-level of contributors; whereas it doesn't have any relationship with low-level contributors. Among the top level of contributors, core members have the highest level of relationship with monetary reward for knowledge sharing in the OSS community (Chapter 6, Section 6.2.2.3 Regression Analysis). It can be explained by the fact that either in some commercialised OSS or large and well developed OSS, contributors who show high performance can be hired as formal employees and therefore the top-level of contributors can show some level of interest in monetary rewards, even though this interest is not statistically significant. Among passive members (passive users and readers), monetary reward is not related at all, which can be interpreted by the fact that OSS is free software. In this way, knowledge sharing is financially "free of charge" at least in the starting period of knowledge sharing.

Thus, the results of data analysis for this Proposition enrich the current academic literature and give more in-depth overview to the importance of the monetary rewards for the contribution to OSS communities and showed the different level of relationships between the monetary rewards, the level of responsibilities and roles, and other variables in data analysis.

Conclusions of the Contributions to the Current Academic Literature

As identified during the literature review (Chapter 3), at the individual level the thesis emphasised the most important three factors: individual explicit knowledge, individual tacit knowledge, and motivations encouraging sharing of tacit experience with others in order to reach a business aim inside the OSS communities. The current literature has considered a wide range of various motivations (Chapter 3, Table 3.1). Although there is plenty of academic literature dealing with motivations in terms of contribution to OSS communities, the subject of motivation in this thesis was one of the most central issues, because motivations to contribute to OSS communities are important drivers that encourage knowledge workers to share their knowledge with others for the success of OSS communities. A wide and in-depth literature review on knowledge sharing demonstrated (Chapter 2 and 3) that we need to study factors together, which influence individuals to share their valuable know-how with others inside OSS communities, to test them and contribute to the current academic knowledge.

As the discussion proceeded (Chapter 3), in addition to the individual level of the factors that influence success inside of OSS communities, the factors necessary for successful knowledge sharing from the organisational perspective were identified: satisfaction with management, trust inside such communities, identification within the communities, and incentives (benefits in the future) including monetary rewards. The analysis of all these factors together gives a value to the thesis, because it contained many factors and analysed their relationships to each other. Furthermore, because there was a lack of research done previously, on combinations of various factors influencing knowledge sharing in OSS communities both from personal and organisational perspective; the thesis contributes to the current academic literature. The evaluation of the Model below will give a deeper understanding on how the findings from the tested propositions which led to the Model design contributed to the theoretical knowledge.

7.1.1.2 Evaluation of the Model

The Model (Figure 6.1) of the factors influencing the sharing of personal knowledge within an OSS community on the individual level was created. The Model is the outcome of the thesis and outlines all the findings discovered after the testing of the propositions was completed. These propositions and subsequently the Model itself were created as a result of the findings of existing academic literature as well as qualitative research conducted via participant observation and in-depth interviews. The qualitative findings were later tested through quantitative research. The Model includes the various factors that have been studied in this thesis but have not been studied in combinations together before this point. At this point, it serves as a theoretical contribution as the Model has covered a range of factors in combination with each other.

From the literature review it was found that OSS communities are the most developed form of virtuality. As was previously mentioned in Chapter 3, although the work processes can show differences in different forms of virtuality in different VOs, the author of the thesis believes that the implications of the findings in this research on OSS communities can be applied to other VOs on certain levels too.

Chapter 6, Section 6.2.4.3 discussed in detail the outcomes of the findings in the Model. According to those findings, a higher level of education of the contributors does not directly influence the level of knowledge sharing. However, it does influence the level of the roles held in OSS communities. The level of roles and the level of activeness in OSS communities together with monetary reward influences the level of tacit knowledge sharing. The statistical significance showed that the relationship between monetary reward and the amount of hours per week spent on knowledge sharing in the OSS communities is meaningful. The level of tacit knowledge sharing under the motivational factors examined has been found to have a significant relationship with the level of personal knowledge sharing on product innovation inside OSS communities. Motivations (both personal and work-related) are the environments created inside the OSS communities necessary to allow for knowledge sharing. Similarly incentives/benefits to be extracted in the future as a result of the participation in OSS communities do not directly influence the level of knowledge sharing. However they do influence the percentage and the length of participation. The percentage of participation, which is related with project development in the OSS community, is also related to the incentives/benefits to be experienced in the future.

However, most importantly, the level of personal knowledge sharing in product innovation is as a result of the satisfaction of the individuals concerning the management of the OSS communities, identification with these communities and the trust inside of these communities. The Model shows that organisational factors are more important than individual factors for successful knowledge sharing inside OSS communities from an individual perspective. These findings demonstrate wide areas for further research on the organisational level, because such issues as identification, trust and satisfaction with management can be created and managed inside the organisations on the organisational level. The findings in this thesis support the literature, for instance Ruuska & Vartiainen (2005), who discussed that knowledge sharing in organisations can be based on two strategies: the codification strategy and the personalisation strategy (Chapter 2). The codification strategy is carefully codifying the knowledge and storing it in archives/databases, where it can be assessed and/or reused. Whereas, the personalisation strategy, which is very important, where knowledge is closely tied to the people who developed it and is shared by personal face-to-face interaction. The findings in this thesis showed that social processes in the personalisation strategy such as identification, trust and satisfaction with management inside OSS communities are important.

As discussed in Chapter 2, recalling the four modes of knowledge conversion, knowledge spiral and contents of knowledge offered by Nonaka & Takeuchi (1995), their modes can be analogised by the codification strategy and the personalisation strategy offered by Ruuska & Vartiainen (2005), where socialisation (from tacit to tacit) and internalisation (from explicit to tacit) can be considered as a personalisation strategy, whereas externalisation (from tacit to explicit) and combination (from explicit to explicit) can be considered as the codification strategy. The same differentiation is made by Hislop (2009), where knowledge sharing has two diverse structures: objectivist perspective and practice based perspective. The objectivist perspective focuses on the codification, collection and storing knowledge in order to make knowledge that can be searched and accessed. The practice based perspective focuses on interpersonal knowledge sharing through interaction and communication. The Model created in this thesis showed that the practice based perspective of knowledge sharing (Hisplop, 2009) or socialisation and internalisation (Nonaka &Takeuchi, 1995) in knowledge sharing can be implemented when such factors as identification, trust and satisfaction with management inside OSS communities are maintained at a high level.

As discussed in Chapter 2, the personalisation strategy (Ruuska & Vartiainen, 2005) or practice based perspective (Hislop, 2009), or as Cabrera & Cabrera (2005) proposed a set of people management practices to promote knowledge sharing among organisational employees, there are socio-psychological determinants of knowledge sharing include facilitation for knowledge sharing, such as social ties and shared language, and encouraging knowledge sharing, such as trust, group identification, perceived cost, perceived rewards, self-efficacy, and expectations of reciprocity. According to Cabrera & Cabrera (2005), socio-psychological determinants of knowledge sharing through those people management practices increase the intention to share knowledge in organisations. The findings in this thesis support Cabrera & Cabrera (2005) in terms of organisational factors for successful knowledge such as identification, trust and satisfaction with management inside OSS communities.

The tested propositions and the finding regarding the importance of the organisational factors in OSS communities for successful knowledge sharing is supported also by the participant observation studies (Chapter 6, Section 6.1.1.5). In the Qwerty group, where participant observation took place, when the unofficial leader left the UK, the group became less active. The level of activeness of the group can be easily compared in their Google pages, how often and how well they interacted before he departure and after. The number of new members, the number of presentations, the number of the messages, and the content of the messages showed a decrease in their activities after the leader's departure. Although after a certain period of time, other individuals took over the organisational responsibility and have brought the activities back to life, it is an important issue to have a strong leader in OSS communities.

From another perspective, Table 6.2.2 shows the archive of messages and the list of top posters in the Google group. According to this Table and comparing it with the public website, it is possible to demonstrate support for the academic literature that the leadership in OSS communities is "decided" upon the level of the knowledge sharing in the community, which can be relevant to knowledge in the knowledge-based economy.

Those members of Qwerty, who are in the committee, are also ones who are the top posters and most active members in Qwerty (Table 6.1.2).

This finding supports the literature regarding leadership in OSS communities. Hertel, Niedner & Herrmann (2003), with the example of Linux, identified the structural conditions for successful OSS development and found that compared with traditional organisations, OSS communities have a culture where authority comes from competence. The knowledge-based economy appreciates knowledge workers. Knowledge, shown through contributions, increases the contributor's supposed merit, which in turn leads to power (Hertel, Niedner & Herrmann, 2003; Gacek, Arief & Arief, 2004). The findings in this thesis once again show the importance of leadership in an organisation, even though in such a community as this, the leadership was unofficial and that such leadership builds on the level of knowledge sharing, because of the level of knowledge.

The Model shows the necessity of further research on the organisational level, which will be investigated after completion of the thesis because issues such as identification, trust and satisfaction with the management can be created and managed inside the firms at the organisational level. Personal factors in OSS communities such as VO are important for knowledge sharing. However, organisational factors are those variables that keep OSS communities alive and productive, looking forward to further innovations. It is an important factor which should be taken into consideration by leaders in OSS communities in particular and by managers in VOs, to encourage sharing knowledge and increasing the personal reasons of individuals contributing to do so to VOs through providing a suitable environment by supporting organisational factors, because for instance Renzl (2008) points out that the ability of an organisation's members to exchange knowledge verifies the speed at which new products and services are introduced.

7.1.2 Methodological contribution

7.1.2.1 Research Methodology

This study combined an innovative approach in terms of the research methods. Previous studies generally used one of the research methods. For instance, Ghosh, Glott, Krieger & Robles (2002) used online survey from 2487 OSS developers; Mulgan, Salem & Steinberg (2005) and von Krogh, Spaeth & Lakhani (2003) used case studies; Bonaccorsi & Rossi (2003), Hars and Ou (2002), Hertel, Niedner & Herrmann (2003) used quantitative research and Sowe, Stamelos & Angelis (2008) used content analysis. Three different methods were used for data collection in this thesis: participant observation, in-depth interviews, and a quantitative questionnaire. Participant observation in a local OSS community Qwerty was conducted for around one year. At the same time three top managers from three different OSS communities were interviewed before the quantitative data collection. Pilot studies for the quantitative questionnaire were conducted on the Qwerty group, and finally the main data was collected via quantitative questionnaire.

The idea of synergy mentioned by Eisenhardt (1989) was included in this thesis (see Chapter 5, Section 5.1 for more details), because qualitative research was a bridge toward the quantitative research. Qualitative and quantitative approaches were a synergy of each other. Perry and Jensen (2001) suggested that the usual way of combining induction and deduction in one project was to include two separate studies: the qualitative and the second quantitative. This allowed the development of statistical generalisation of the propositions developed in the first study. A combination of two research approaches under the facilitation method was applied in this thesis to shed light on the research questions (Figure 5.2, Chapter 5) due to a number of reasons. The topic of the thesis required a study of current theoretical knowledge and observing phenomena in e-business through exploratory ethnographical studies. Then, building upon the collected theoretical knowledge and participant observation, the theoretical framework was formulated.

During the designing of the theoretical framework, the thesis used an inductive approach to observe and interpret the research questions though qualitative studies. The results of the inductive research, together with the current literature review assisted in designing the theoretical framework. During the development of the theoretical framework, ten propositions were identified. These propositions were tested through a quantitative research approach. Empirical Studies, Phase 2 was developed as a result of the literature review and Phase 1. Such combination of three different empirical studies gave the thesis richness of data, a wide horizon of knowledge and innovative uniqueness of the research.

7.1.2.2 Communication with OSS Communities during Quantitative Data Collection

Even though the sample of collected quantitative data is comparatively low, a wide range of communities were approached including online forums, individuals – contributors to the OSS communities - and academicians (Chapter 5, Section 5.4.8). It gave experience and an even better understanding of the OSS communities through approaching a large number of various OSS communities. Although there are some other studies which collected data from OSS members (Ghosh, Glott, Krieger & Robles (2002), Bonaccorsi & Rossi (2003), Hars and Ou (2002), Hertel, Niedner & Herrmann (2003) Sowe, Stamelos & Angelis (2008) are a few of them), the quantitative research in this study is a unique examination, because it is the product of a very wide academic literature review, the result of inductive research and the fruit of an enormous amount of contacts with various sources related with OSS communities (Chapter 5, Section 5.4.8).

7.2 Limitations of the Study

7.2.1 Limitations of Qualitative Research

7.2.1.1 Participant Observation

During participant observation in a local OSS community Qwerty, the author did not have particular questions for members of the group (Chapter 6, Section 6.1.1). The main idea was to participate in the meetings and observe the group in order to experience an OSS network from the inside and investigate their activities from an external perspective. It was very useful to participate in Qwerty meetings in order to digest academic literature through participant observation during the design of the theoretical framework and quantitative questionnaire.

However, it would be much more productive if the author of the thesis could have been more proactive during its official meetings, not only listening to the presentations from Qwerty members, but also interacting and asking questions with those members. It would be much better to be active in personal communications and be able to attend their social events, such as the post-meeting socialisation after the “official” part of the meetings (Chapter 6, Section 6.1.1). Such kind of active participation rather than passive observation would bring much deeper understanding of the OSS culture, knowledge and environment.

7.2.1.2 In-Depth Interviews

As well as participant observations in Qwerty, in-depth interviews with the top leaders in three different OSS communities were valuable for the thesis before and during the design of the quantitative data (Chapter 6, Section 6.1.2). Nevertheless, it would be much more productive if more people could be interviewed. If the author of this thesis could attend the specialised OSS conferences and meet more people not only from the local population, but also worldwide known leaders, to build a wider network with OSS leaders then more information could be gathered. Such social contact would help to have more in-depth interviews and definitely would be useful during quantitative data collection (Chapter 5, Section 5.4.8) to collect completed questionnaire from a wider sample (see below Section 7.3.2.3).

7.2.2 Limitations of Quantitative Research

7.2.2.1 Common Method Biases

As mentioned in Chapter 5, according to Podsakoff, MacKenzie, Lee & Podsakoff (2003), methodology biases can cause problems because they are one of the main sources of measurement error. According to Podsakoff et al. (2003), there are potential sources of common method biases including common rate effects, item characteristic effects, item context effects and measurement context effects. Although the research methods in this thesis were carefully designed in order to avoid such biases as much as possible, there were still some limitations which could not be avoided.

Although the online questionnaire (Appendix 4) was designed with a careful consideration of problematic factors such as obtaining measures of the predictor and criterion variables from different sources, protecting respondent anonymity to reduce evaluation apprehension, counterbalancing the question order and improving scale items, there still can be a bias of 'measurement context effects' present in the nature of the work which corresponds to any artifactual covariation formed from the context, where the measures are obtained (Podsakoff, MacKenzie, Lee & Podsakoff, 2003).

Another bias potentially present could be 'item characteristic effects', which refer to any artifactual covariance in the questionnaire, i.e. when a respondent might choose an item/answer only because of specific characteristics the item possesses. Also the use of the same scale format[37] , as well as the repeated use of the same anchor points (for example: always, never, Appendix 4), on the questionnaire can be sources of bias. Moreover, 'item context effects', which refer to any influence/interpretation on the individual so that a respondent might choose an item only because of its relation to the other items making up an instrument, can be considered as potential bias too. 'Common rater effects' can be a serious source for common method biases and this is outside of the researcher's control. The detailed information about common method biases can be found in Chapter 5, Section 5.4 of this thesis.

7.2.2.2 Cross-Sectional Study

Chapter 5, Section 5.4 also considered the cross-sectional study as one of the potential biases. As was mentioned earlier, according to Bozionelos (2002), causal path modelling is a useful technique for the well-designed description of the relationships between variables. Such modelling was used in this thesis during regression analysis and also in the creation of the Model. Chapter 5, Section 5.4 analysed in detail the notion that such types of design do not allow "causality assertions", because "causality in cross-sectional research can be only speculated and tentatively accepted; and needs to be further substantiated with utilization of the other research designs…" (Bozionelos, 2002, p.7). According to Bozionelos (2002, p.7), when cross-sectional designs are "utilized certainty on causality is seriously compromised, regardless of the way authors

[37] In this thesis Nominal scale, Ratio scale, Interval scale were used and are available in Appendix 4.

choose to present their findings". However, the research was conducted through cross-sectional studies, with measures obtained at the same point in time.

7.2.2.3 Sample Size

Although the sample size in the quantitative data collection can be accepted as reliable, it would be much better if there were more observations. It could be improved in future research by attending major OSS conferences and distributing the questionnaire for completion by the conference attendants.

7.2.2.4 Questionnaire design

Some of the comments[38] received from the respondents showed that the quantitative questionnaire was long. However, it was designed to produce optimal results in as short a time as possible. The final length was required for the later hypotheses testing. One respondent found some questions confusing whilst another said that some of the questions were difficult to quantify. Moreover, some respondents pointed out some grammatical mistakes on the questionnaire. An important comment from some respondents was regarding roles and responsibilities. They felt the questionnaire focused too much on the coding aspects and they believed that there were more people who contribute to OSS communities by working on documentation, bug reports and so forth. Bearing in mind that the questionnaire was built as a result of the literature review and partly empirical studies, these comments can prove useful for further studies.

7.3 Ideas for Further Investigation – Next Step after This Research

The propositions constructed were tested and analysed in this thesis. However, this thesis serves as the start of a series of research projects, which will be embarked upon after finishing this thesis. E-business is a comparatively new-born field which is constantly developing and changing together with IT and business/economical development. Further research will help to shed more light on this relatively new field.

[38] See Appendix 9.

7.3.1 Next Step in the Further Research on the Individual Level

As seen from the outcome of the thesis, in its conclusion and findings, the second research question can be investigated further on a wider scale. An unanswered question could be how the uniqueness of organisations / individuals – knowledge owners – can be guaranteed in order for these individuals to be in great demand in the future? This kind of uniqueness and demand is increasing in importance, especially in the e-medium, where there are no geographical boundaries, with everything being very transparent. How can KM balance the time spent knowledge sharing and the time spent using this knowledge to produce new products? Which of these time constraints is the most important and cost effective? Although propositions 6-10 tried to answer these questions, they can be investigated further and answered in a more detailed way in future work.

7.3.2 Further Research in Organisational Level

After the thesis, further research will be concentrated around the management of OSS communities, where the role of virtual brokers in the OSS communities will be studied in depth. The second set of propositions (propositions 6 – 10) in this thesis forms a bridge between individual factors for knowledge sharing for innovative production inside OSS communities and the top “management” - virtual brokers. At the same time the structure of the complicated web organisations (as can be sometimes perceived on first examination), in terms of their forms and size, can be important factors in the overall successful activities of these communities. There are different types of OSS communities, well-known larger ones such as PHP, MySQL, Apache, as well as smaller ones created recently so that their projects are online and in the process of growth. Therefore it will be useful to analyse and compare the OSS communities from a size point of view. The following research questions, which were created according to the gaps found in the current academic literature, are some of the examples which can be investigated wider in further research.

Management/leadership: Does the size of the OSS community influence its productivity? Do the hierarchical structures of the OSS communities influence the management of the OSS communities? Are smaller OSS communities more organised? Do larger OSS communities produce more products than smaller OSS communities?

Virtual brokers: How does virtual brokerage in OSS communities influence management and coordination in OSS communities? How can OSS be managed by a virtual broker? Is knowledge management regulated in the OSS community by a virtual broker? What is the interaction between the members of the OSS community and a virtual broker? On what conditions does the OSS community work with a particular virtual broker? Does the OSS community work with a number of virtual brokers at the same time? What can affect the relationship between the OSS community and a virtual broker? What kind of regulations is used in OSS companies by a virtual broker?

Further research will help complete the whole picture of the study on the OSS communities with a focus on the organisational level (Figure 7.1). The next Model will consider the organisational level, where the individual level (the Model analysed in this thesis) together with factors such as the management and structure of the OSS communities, can be shown to be as a result of the product innovation in the OSS communities, i.e. the 'knowledge as an asset' perspective (Empson, 2001; Chapter 2) that will seek to discover valuable knowledge within organisations and to develop mechanisms for managing it effectively. Organisational knowledge is an important source of competitive advantage. Innovation can be considered both radical and incremental (Rogers, 1995; Gallouj & Weinstein, 1997; Stringer, 2000; Cardinal, 2001; Malhotra, 2000; Moore, 2004). In the case of OSS, a new type of software can be considered as a radical innovative product, akin to Linux when it was released into the market. Equally incremental innovation in OSS industry is present such as new releases, which are renewed periodically. Because innovation is an indicator of the success of the OSS communities, it is possible to summarise that in OSS, there can be two forms of innovation - radical and incremental. Radical innovation can be measured through new product introduction. Incremental innovation can be identified via new releases and market-share. Therefore, it is possible to say that in general, innovative OSS will be measured through new product introduction, new releases and market-share.

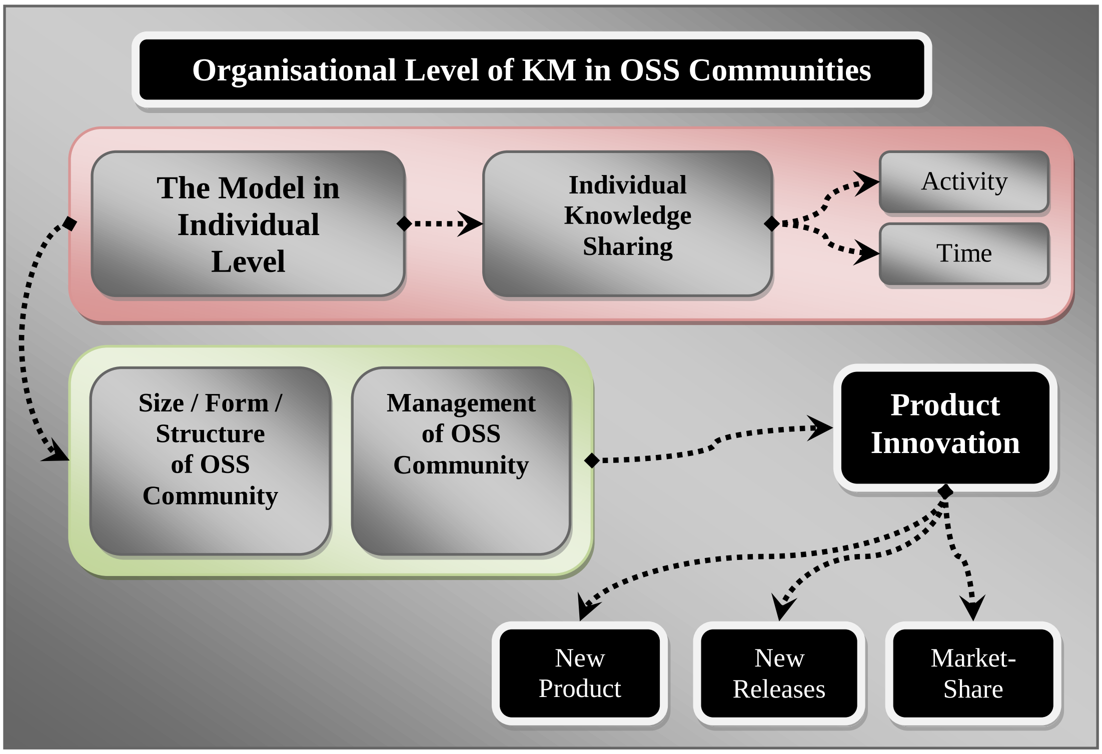


Figure 7.1: Model – Organisational Level of KM in OSS Communities

Appendix 1: Glossary

Electronic Business (E-Business)

"All electronically mediated information exchanges, both within the organization and with external stakeholders supporting the range of business processes" (Chaffey, 2007, p.14).

Managing Knowledge / Knowledge Management (KM)

The management of data and information by people using their tacit knowledge in order to gain competitive advantage.

Virtual Organisation (VO)

A networking of independent companies/individuals who work together temporarily but geographically/organisationally dispersed for one business aim linked by Internet-based technologies.

Open Source Software (OSS)

"Developed collaboratively, independent of a vendor, by a community of software developers and users." (Chaffey, 2007, p.117).

Knowledge Sharing

Sharing of what one knows, i.e. explicit and tacit knowledge with others.

Knowledge sharing in OSS communities does not only happen through sharing the written/documented software code, i.e. explicit knowledge. OSS developers share their tacit knowledge through networking, communication and interaction between each other online and offline.

Appendix 2: The Results of the In-Depth Interviews with the Leaders of Some OSS Communities

	OSS Communities		
Questions	**A**	**C**	**B**
General Introduction	It is a project funded by EU, software for chemists, which is provided to people who need this software free of charge. The community consists of academics: professors, post-doctoral students, and PhD students. It is an old project and needs more people to get involved. There is an active group of 5 -10 people. The total number of participants is more than 40 people.	"Our community consists of individuals and companies from all over the world who participate as users, testers, developers, writers and speakers for the projects. The unifying goal and vision is to develop the best possible Java Enterprise Middleware in open source, available for anyone to use with no license fees. Anybody is welcome to join in at any time and the rewards can be great, both personally and professionally. As part of the community you will have plenty of opportunities to learn from other experienced developers and users who share your desire for success."[39]	The idea to create OSS community came from 1998 where the leader was working in a company (Nestle) where he could not find software, which he needed. Then in 2002, coding and models started to be implemented. It is a self funded project therefore it has progressed slowly until 2006 where stable foundation was found. Published an article in 2005. Second paper accepted in 2007. Third paper will be published in 2009.
Q1: KM & Knowledge Sharing	Q.[40] - Knowledge sharing A.[41] - "I never thought about that".	Q. - KM operation: A. - ▪ Wiki ▪ Public forums ▪ Mailing lists ▪ Tele conferences ▪ Skype	Q. - Why is knowledge shared? A. - ▪ Motivations: Payment, learning experience ▪ In general to share knowledge is "a personal thing" ▪ In some of the OSS communities,

[39] taken from the website of the OSS community (July 2007).
[40] Q. = Question.
[41] A. = Answer.

		▪ Instant messaging – people can see communicate as easily as possible ▪ Workshops ▪ Conferences - What can be in next release Q. - Why is knowledge shared? A. - ▪ "In OSS, doing things where anybody can contribute – a part of OSS" ▪ "Knowledge sharing is the way how OSS works, in distributive way." ▪ "Generally OSS work is not face to face work, therefore sharing knowledge is very important. Because in classical companies knowledge sharing is implicit. But in OSS, worldwide location, people share knowledge explicitly."	people are each other's competitors. "They can share knowledge in particular level." ▪ "They are users of software and the developers of the OSS." ▪ "A person know something, a person keep nothing back." Q. - What are the incentives from management in OSS communities to developers? A. - "you cannot write a code for nothing, you need money, to reinvest money in projects."
Q2: Management of the OSS Community	Q. - Management A. - ▪ No active management and interaction ▪ Publish in journal ▪ "We have discussion lists more about policies. It is not managed, it is not a single director who is dictating who tell us. It is our direction … from that sense it is managed by everybody who	Q. - How is your OSS community managed? A. - ▪ Management is as hierarchical as in normal company. The head is Chief Technical Officer. Then there is Technical Development Manager. Then there is a Project Leader, developers and coordinators. ▪ "It is led by a project leader; he is manager of the project."	Q. - How is your OSS community managed? A. - ▪ HR, funding people ▪ "You have cash and then you have people. It is not about a project, it is about the money." Q. - How long will OSS go to the market? A. -

	involves in this project.” Q. - How to protect from chaotic movement? A. - ▪ Email exchanges to go to conclusions ▪ It is an unstructured community ▪ To make sure that everybody is involved. ▪ “When you have this code, you have many contributors, you have to make sure people are treated not stolen, behaviour should be in the same manner.” ▪ Trust should be built before starting the involvement to the project. Q. - What is the hierarchical structure of an OSS Community? A. - “There is a hierarchical structure which is not written down. It is based on the involvement, contributions and time of contributions. They became leaders of the project, based on the knowledge they have. Some people have more power from their knowledge. There is no one how is control. We do not have a leader. We	▪ “There is one maybe 2 (if it is possible) main leader, who coordinate other people.” ▪ “Selection of the main leaders is related purely on past performance.” ▪ “It is hired people from the community, who did most work”, which means project leaders are people who contributed to projects in past so much, that they hire them as project leaders. ▪ “Knowledge is the most important tool for being a leader.” ▪ “Some leaders are good managers, say good leaders and good managers. Knowledge-owned people should have excellent knowledge about the project, but not necessarily that they have good managerial skills, in this case our community has other people who will manage with them.” Q. - What is the size of the OSS development community? A. - ▪ “Difficult to say” ▪ Volunteers - “difficult to give accurate number, est. in our community probably 250-300 people. ▪ Developers’ number who is officially	“Organically after 3-4 years”. “If to use venture capital and other investments, after 6 months OSS can go to the market”. “Sometimes it is better to be slower.” Q. - Who does pay for the OSS project? A. - ▪ “1. Venture capitalists, there is one OSS in UK with venture capital. ▪ 2 Customers pay for it. ▪ 3 Funding internally through our revenue.” ▪ “There are gaps in funding OSS.”

	have people with more authority. There are not so many decisions to make. People will make contributions. Everybody is free on how much to work. Everybody has access on code. No control, you should trust people." Q. - Who is making the last decision? A. - "All people together will agree on the last version of the release. End product will be on work of all those people."	employed is about 150 people." Q. - What is a criteria to choose employees? A. - ▪ Traditional job application ▪ "Volunteers are highly motivated to share their tacit knowledge in order to be employed in our community." Q. - How does code submission and writing releases work? A. - Project leader work with product manager and they decide on road map and deadline. Then they work on that project. Later they make tests and then new release is coming. Q. - What are motivations and incentives in contribution to the OSS development? A. - for employees: Salary for volunteers: ▪ "They just happy to do their work". ▪ "Different types of volunteers ▪ Some of them are happy to do it, to contribute. Other types of volunteers – everywhere who work on behalf of companies, so that is in their interest how this product is working." For volunteers, it is an opportunity to write	

		their activities in the OSS communities on "bio on web pages" ▪ There is also an opportunity to be hired, to have training, to attend to conferences, etc. ▪ Peer recognition	
Q3: Innovation		Q. - What is innovation? A. - ▪ "Innovation is something new, innovative" ▪ "It is between companies. It can be innovative for a particular company, which is not necessarily innovative to another company. Particular product/service not necessarily mean innovative for a second company." ▪ "There is different level of innovation." ▪ "Product release cannot make innovation." ▪ "New in one company cannot necessarily mean innovation for other company." ▪ "There is local and global innovation." Q. - What is measurement of innovation? A. - ▪ "Innovation cannot be measured quantitatively. It is possible to measure qualitatively. If somebody	Q. - What is innovation? A. - ▪ "If it is new to somebody." ▪ "It does not need to be new to the world." ▪ "If organisations implement something new, it is innovation." ▪ "It is new in terms of the context." Q. - What is the measurement of innovation? A. - ▪ "If models are innovative, if nobody else did it, it is innovation." ▪ "If framework, platform, structure is new, then it is innovation."

		says this is innovation, then you can check whether it is innovative or no." ▪ "It is difficult to measure innovation. Only people involve in IP and patent can speak about measurement about innovation. Because they have to be sure it is new and innovative." ▪ "OSS communities also use a patent for measurement innovation."	
<u>Q4: Finally</u> - Why do OSS Communities work?		▪ "We are successful because they produce codes which are much cheaper." ▪ "After .com crisis, even big companies need to save money, therefore they choose us." ▪ "Codes are visible, fixed a lot quicker." ▪ "Linux is so successful, bugs get fixed quickly, new features offered quickly."	▪ "Because there is no cost to the production and distribution, it is why OSS and OSS hardware work." ▪ "Microsoft is more negative feedback model. OSS is a positive feedback model, the more you done, the more feedback you have."

Appendix 3: Quantitative Questionnaire

(http://www.dur.ac.uk/zilia.iskoujina/qq.htm)

Durham Business School

Research Questionnaire

"Knowledge Management and Innovation in Virtual Organisations"

Durham University

Dear Member of an Open Source Software Community,

I am a PhD student in e-Business in Durham University, Durham Business School (UK). My research topic is "Knowledge management and innovation in virtual organisations". The aim of my thesis is to assess how and to what extent knowledge is created, shared, and circulated in open source software (OSS) communities. In my empirical studies I am going to collect primary data from members/developers of OSS communities. This research is beneficial for OSS communities, because it will shed light on how and why knowledge-workers in OSS communities share their unique tacit know-how knowledge to create more innovative products/services. At the same time it is very important for my PhD study to find sufficient empirical data. Because you are the one who can give me a correct picture of how you experience your contribution to OSS activities, it is important that you respond to the questions frankly and honestly. The information you provide will help me to reach the aim of my thesis. Your response will be kept strictly confidential. I am sure you are very busy, but if you could spend no more than 15 minutes to answer to my questionnaire, which is below, I would be grateful for your contribution. There will be some prizes - after finishing the data collection, I will randomly select some respondents and send them gift vouchers for £20 from Amazon. A summary of the results will be e-mailed to you after the data has been analysed. Also I will place the summary of the results to my website. Thank you very much for your time and cooperation. I greatly appreciate your help in contributing to this research endeavour.

Zilia Iskoujina

E-mail: zilia.iskoujina@durham.ac.uk

In this questionnaire under the term of "explicit knowledge", please understand codified & documented knowledge; under the term of "tacit knowledge", please understand your own personal software programing experience, your own know-how, which you use in contribution to OSS development.

A) Your roles and activities in the Open Source Software (OSS) Community

1) Which OSS Community did you receive this questionnaire from?

- Apache
- MySQL
- PHP
- Ruby-on-Rails
- Python
- Second Life
- MagicAjax.NET - AJAX Framework
- Castle Project
- SimpleTest
- MaNGOS
- Other, please specify

2) To which OSS Community do you mostly contribute?

- Apache
- MySQL
- PHP
- Ruby-on-Rails
- Python
- Second Life
- MagicAjax.NET - AJAX Framework
- Castle Project
- SimpleTest
- MaNGOS
- Other, please specify

Please focus your answers to the Open Source Software (OSS) Community where you mostly contribute to.

3) What is your role in the OSS development project in the OSS Community? (please indicate all that apply)

- ☐ Project Leader
- ☐ Core Member
- ☐ Active Developer
- ☐ Peripheral Developer
- ☐ Bug Fixer
- ☐ Bug Reporter
- ☐ Reader
- ☐ Passive User
- ☐ Other, please specify

4) What are your activities in the OSS development project and approximately how many times in total have you contributed to these activities? (please indicate all that apply)

- ☐ Coordinate the projects
- ☐ Authorising distribution of new codes
- ☐ Implementing new features
- ☐ Fixing bugs
- ☐ Reviewing code
- ☐ Suggesting new features
- ☐ Reporting bugs
- ☐ Other, please specify

B) Your participation / contribution to the OSS Community

5) How do you participate in the OSS Community? (please indicate all that apply)

- ☐ By e-mail
- ☐ Online forums
- ☐ Offline forums / conferences
- ☐ Face-to-face meetings
- ☐ Other, please specify

6) How long have you participated in the OSS Community?

☐ month/s OR ☐ year/s

7) How often do you communicate with other members in the OSS Community?

- ○ Every day
- ○ Nearly every day
- ○ Once / twice in a week
- ○ Once / twice in a month
- ○ Other, please specify ☐

8) On average how many hours per week do you contribute to the OSS Community?

☐

9) What percentage of your participation is related with project development in the OSS Community?

☐ %

C) Explicit (codified) knowledge obtaining process in the OSS Community

10) On average how many times in a week have you used the following resources to get new / to improve current skills that enabled you to perform new tasks?

a) Community emails ☐

b) Community web resources ☐

c) Other relevant web resources ☐

d) Online books / journals ☐

e) Printed books / journals ☐

D) Tacit knowledge (your own know-how) obtaining / sharing process in the OSS Community

11) How often have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

○ Always ○ Often ○ Sometimes ○ Rarely ○ Never

12) To what extent have you got new / improved current skills from the OSS Community members' knowledge that enabled you to perform new tasks?

○ A lot ○ Many ○ Few ○ A little bit ○ Not at all

13) How often have you transferred your knowledge to other members that enabled them to perform new tasks?

○ Always ○ Often ○ Sometimes ○ Rarely ○ Never

14) To what extent have you transferred your knowledge to other members that enabled them to perform new tasks?

○ A lot ○ Many ○ Few ○ A little bit ○ Not at all

Please rate as appropriate from 5 - "strongly agree" to 1 - "strongly disagree".

15) I share the information I have with colleagues in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

16) I share my skills with colleagues in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

17) Colleagues within the OSS Community tell me what they know, when I ask them about it.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

18) Colleagues within the OSS Community tell me what their skills are, when I ask them about it.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

19) Why do you share your knowledge with other members of the OSS Community? (Please write in the box below.)

E) Motivations & benefits of contributing to the OSS Community

20) What are your personal motivations to contribute to the OSS Community?

Hobby

a) I enjoy writing programs. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

b) Programming gives me a chance to do what I can do the best.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

c) I spend my free time with programming. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

d) Programming is my favourite activity. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

e) I cannot imagine my life without programming. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

Psychological factors

f) I enjoy helping other people. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

g) I have altruistic approach in communication with other people.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

h) It gives me the feeling of success. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

i) It gives me the feeling of competence. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

j) It gives me the feeling of effectiveness. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

Philosophical factors

k) I believe software should be free. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

l) OSS is more secure than commercialised software. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

m) OSS is more updated than commercialised software.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

n) I contribute to the OSS Community because of reciprocal approach.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

o) I want to be one who creates free software available for using by everybody.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

21) What are your professional motivations to contribute to the OSS Community?

Main work needs

a) The software itself is my main job. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

b) The software is critical for my main job. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

c) I prefer individualistic approach in my work. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

d) Increases my social prestige (social competence and skills).

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

Personal needs

e) I use OSS myself (excluding programming or testing activities).

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

f) The software provides functionality that matches my unique and specific needs.
○ 5 ○ 4 ○ 3 ○ 2 ○ 1

g) Improves the level of my programming skills. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

h) Gives me extra opportunities for learning. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

i) I like sharing my knowledge and skills. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

Network opportunities

j) To exchange advice and solutions with knowledgeable people.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

k) To keep abreast of new ideas and innovations. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

l) To be one of the team who produce the innovative software.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

m) To be meet new and different people. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

22) What are the long-term benefits of contributing to the OSS Community for you?

a) After participating the OSS Community, I can improve career progression prospects.
○ 5 ○ 4 ○ 3 ○ 2 ○ 1

b) After participating the OSS Community, I can increase my income in my main work place. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

c) After participating the OSS Community, I can increase my income from additional activities by using OSS. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

d) I will establish my own business by selling consulting, training, implementation or customisation services related to the project. ○ 5 ○ 4 ○ 3 ○ 2 ○ 1

F) Management in the OSS Community

23) When you add new code, who accepts it?

○ Peer review
○ Project Administrator
○ Other, please specify [ ]

24) Is there a clearly identifiable person who coordinates your OSS Community?

○ No ○ Yes, please specify [ ] ○ N/A

25) With whom from the following hierarchical staff have you had contacts in your OSS project/s? (please indicate all that apply)

- ☐ Forum/Project moderators
- ☐ Your peers
- ☐ Company/Product/Service top management team
- ☐ Other, please specify ______

26) Are you satisfied with the management of your OSS Community?

- ○ Very Satisfied
- ○ Satisfied
- ○ Neither Satisfied nor Dissatisfied
- ○ Dissatisfied
- ○ Very Dissatisfied

27) I receive on time the information needed to do my job in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

28) The Project Administrator offers guidance for solving job-related problems.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

29) I satisfy with the supervision in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

30) I satisfy with organisational commitment in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

31) I satisfy with my co-workers in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

32) Do you gain any monetary rewards for your contribution to the OSS Community? ○ Yes ○ No

33) Who appointed you to your position in the OSS Community?

- ○ Peer review
- ○ Project Administrator
- ○ Other, please specify ______

34) Are you a formal employee or a volunteer contributor in the OSS Community?

- A formal employee
- A volunteer
- Other, please specify

G) Identification in the OSS Community

35) Would you feel a loss if you were no longer able to participate in the OSS Community? No Yes

36) I strongly identify myself with this OSS Community.

5 4 3 2 1

37) I gain a feeling of belonging the OSS Community.

5 4 3 2 1

38) There is a "team spirit" in the OSS Community.

5 4 3 2 1

H) Trust in the OSS Community

39) I trust the peers in the OSS Community. 5 4 3 2 1

40) I trust the quality of the information and knowledge provided by group members.

5 4 3 2 1

41) If I share my technical problems with the group, I know group members will respond constructively.

5 4 3 2 1

42) I think peers in the OSS Community trust me.

5 4 3 2 1

43) We have confidence in one another in the OSS Community.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

44) Members in the OSS Community show a great deal of integrity.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

I) Personal details

1. Your gender is: ○ M ○ F ○ Prefer not to say

2. Your age is: [▾]

3. You are from: [United Kingdom ▾]

4. Your highest education attainment is:

○ PhD
○ Master level (MSc, MA, MBA)
○ Undergraduate level
○ High school graduation
○ Other, please specify [ ]

5. Do you have any professional qualifications?

○ No ○ Yes, please specify [ ]

6. Your primary occupation is: (please indicate all that apply)

☐ IT Employee
☐ IT, Self-Employed
☐ In employment other than IT
☐ Below university or undergraduate level student
☐ Postgraduate student
☐ PhD student
☐ Retired/Not working
☐ Other, please specify [ ]

7. Which languages do you use frequently? (please indicate all that apply)

- ☐ Java
- ☐ C++
- ☐ C#
- ☐ Ajax
- ☐ Perl
- ☐ Other, please specify

8. If you wish to receive a summary of the results and/or participate in the prize selection, please enter your e-mail address:

9. If you would like to make any final comments, please fill the box below.

SUBMIT **RESET**

Appendix 4: OSS Project Topics in Source Forge

Project Topics	The amount of the projects
Topic	193159
Communications	19322
▪ BBS	1051
▪ Chat	4920
AOL Instant Messenger	266
ICQ	284
Internet Relay Chat	1495
MSN Messenger	326
Unix Talk	54
▪ Conferencing	728
▪ Email	3925
Email Clients MUA	564
Filters	539
Mailing List Servers	237
Mail Transport Agents	310
Post-Office	492
IMAP	137
POP3	260
▪ Fax	108
▪ FIDO	68
▪ File Sharing	2497
BitTorrent	250
Gnutella	121
Napster	66
▪ Ham Radio	212
▪ Internet Phone	434
▪ Streaming	483
▪ Telephony	989
▪ Usenet News	326
Database	7227
▪ Database Engines/Servers	960
▪ Front-Ends	2879
Desktop Environment	3904
▪ Gnome	869
▪ K Desktop Environment KDE	649
Themes	29
▪ Screen 2Savers	100
▪ Window Managers	352
Enlightenment	36
Themes	7
Education	5200
▪ Computer Aided Instruction CAI	852
▪ Library	551
MARC and Book/Library Metadata	45
OPAC	25
▪ Testing	594

Formats and Protocols	3102
▪ Data Formats	2553
DocBook	23
HTML/XHTML	413
SGML	13
TeX/LaTeX	102
XML	1014
▪ Protocols	549
NNTP	19
RSS	226
SOAP	181
XML-RPC	123
Games/Entertainment	17995
▪ Board Games	1471
▪ Card Games	396
▪ Console-based Games	233
▪ First Person Shooters	1025
▪ Multi-User Dungeons MUD	1372
▪ Puzzle Games	981
▪ Real Time Strategy	933
▪ Role-Playing	3035
▪ Side-Scrolling/Arcade Games	1155
▪ Simulation	1635
▪ Turn Based Strategy	1259
Internet	29496

▪ File Transfer Protocol FTP	696
▪ Finger	27
▪ Log Analysis	590
▪ Name Service DNS	325
▪ WAP	184
▪ WWW/HTTP	23616
Browsers	990
Dynamic Content	11227
CGI Tools/Libraries	1484
Message Boards	1000
Page Counters	108
▪ HTTP Servers	1135
▪ Indexing/Search	1420
▪ Site Management	5553
Link Checking	166
Multimedia	16140
▪ Graphics	7134
3D Modelling	648
3D Rendering	1334
Capture	479
Digital Camera	201
Scanners	71
Screen Capture	89
Editors	722
Raster-Based	148

Vector-Based	238
Graphics Conversion	506
Presentation	804
Viewers	1016
▪ Sound/Audio	5798
Analysis	329
Capture/Recording	254
CD Audio	327
CD Playing	74
CD Ripping	145
Conversion	333
Editors	335
MIDI	335
Mixers	138
Players	1538
MP3	734
Sound Synthesis	353
Speech	273
▪ Video	2297
Codec	46
Conversion	388
Display	393
Non-Linear Editor	94
Realtime Processing	89
Special Effects	44

Still Capture	29
Video Capture	327
Office/Business	10182
Enterprise	2172
CRM	413
Data Warehousing	180
ERP	386
OLAP	70
Financial	2305
Accounting	722
Investment	290
Point-Of-Sale	472
Spreadsheet	110
Office Suites	443
Project Management	707
Scheduling	1438
Calendar	356
Resource Booking	132
Time Tracking	385
To-Do Lists	434
Other/Non-listed Topic	2670
Printing	530
Religion and Philosophy	345
▪ New Age	29
Scientific/Engineering	15700

Artificial Intelligence	2168
Intelligent Agents	303
Astronomy	305
Bio-Informatics	1189
Chemistry	318
Earth Sciences	231
Ecosystem Sciences	103
Electronic Design Automation EDA	399
GIS	604
Human Machine Interfaces	651
Information Analysis	1166
Interface Engine/Protocol Translator	251
Mathematics	1920
Medical Science Apps.	552
Molecular Science	174
Physics	696
Robotics	422
Simulations	1093
Visualization	1732
Security	3395
▪ Cryptography	1040
Sociology	444
▪ Genealogy	119
▪ History	57
Software Development	**29578**

Algorithms	900
Genetic Algorithms	126
Build Tools	2213
CASE	222
Code Generators	2452
Compilers	1432
Cross Compilers	142
Debuggers	727
Design	557
Documentation	481
Frameworks	3975
I18N Internationalization	203
Interpreters	1459
L10N Localization	167
Modelling	496
Object Brokering	455
CORBA	102
Object Oriented	**1130**
Profiling	202
Quality Assurance	600
Testing	1020
Usability	254
User Interfaces	1541
Version Control	757
CVS	220

RCS	25
SCCS	8
Virtual Machines	302
System	23899
Benchmark	261
Boot	335
Init	75
Clustering	527
Distributed Computing	1091
Emulators	668
Filesystems	898
Hardware	1907
Hardware Drivers	759
Mainframes	5
Symmetric Multi-processing	300
Installation/Setup	912
Logging	934
Log Rotation	15
Networking	5320
Firewalls	651
Monitoring	1957
Hardware Watchdog	63
Wireless	291
Operating System Kernels	1697
BSD	57

GNU Hurd	7
Linux	838
Power UPS	54
Search	265
Software Distribution	912
Storage	2688
Archiving	1812
Backup	690
Compression	265
Packaging	249
File Management	758
Systems Administration	3847
Authentication/Directory	490
LDAP	242
NIS	8
System Shells	483
Terminals	710
Serial	123
Telnet	156
Terminal Emulators/X Terminals	189
Text Editors	3320

Appendix 5: Browsing 174 Object Oriented Project Results and Searching "Web Development"

Project Name	Rank	Activity	Registered	Latest File	Downloads
MagicAjax.NET - AJAX Framework	5,215	97.22%	19/10/2005	09/02/2006	92,724
▪ A framework that provides AJAX technologies for web pages created with ASP.NET. ▪ Members 7 ▪ Topic: Object Oriented, Dynamic Content, Frameworks ▪ Programming Language: ASP.NET, C#, JavaScript			▪ Operating System: OS Independent Written in an interpreted language, 32-bit MS Windows NT/2000/XP ▪ License: GNU Library or Lesser General Public License LGPL ▪ Intended Audience: Developers ▪ Development Status: 4 – Beta		
Castle Project	9,119	95.13%	17/11/2004	01/11/2006	89,420
▪ Castle aims to simplify the development of enterprise and web applications. ▪ Members: 7 ▪ Topic: Object Oriented**,** Frameworks			▪ User Interface: .NET/Mono, Web-based ▪ Programming Language: C# ▪ License: Apache License V2.0 ▪ Intended Audience: Developers, Science/Research		
SimpleTest	1,334	99.29%	16/03/2003	09/12/2006	49,784
▪ Unit testing for PHP built around test cases. ▪ Members: 10 ▪ Topic: Object Oriented, Testing, Quality Assurance ▪ User Interface: Web-based, Command-line, Eclipse			▪ Programming Language: PHP ▪ Operating System: OS Independent Written in an interpreted language ▪ License: Open Group Test Suite License, GNU Library or Lesser General Public License LGPL ▪ Intended Audience: Developers ▪ Development Status: 5 - Production/Stable, 4 – Beta		
MaNGOS	2,526	98.65%	21/09/2006	29/01/2007	43,873
▪ MaNGOS is an object-oriented Massively Multiplayer Online Role-Playing Game Server MMORPGS. It's an educational project, to help developers get familiar with large scale C++ and C# development projects. ▪ Members: 21			▪ Operating System: All POSIX Linux/BSD/UNIX-like OSes, All BSD Platforms FreeBSD/NetBSD/OpenBSD/Apple Mac OS X, All 32-bit MS Windows 95/98/NT/2000/XP ▪ License: GNU General Public License GPL ▪ Intended Audience: Developers, Advanced End Users		

- Topic: Object Oriented, Simulation, Role-Playing
- User Interface: Non-interactive Daemon, Command-line, Web-based
- Programming Language: C#, C++
- Development Status: 3 - Alpha
- Database Environment: MySQL, SQLite

Appendix 6: Distribution of the Questionnaire

N	The source where potential respondents were searched	Names of OSS communities or people related with OSS communities	More details	Result
1	SourgeForge.net Small OSS in web development	MaNGOS, The request was sent to all 20 members https://sourceforge.net/project/memberlist.php?group_id=177921		2 respondents completed the questionnaire
		SimpleTest, The request was sent to 10 members https://sourceforge.net/project/memberlist.php?group_id=177921		2 respondents completed the questionnaire
		Castle Project, The request was sent to 7 members https://sourceforge.net/project/memberlist.php?group_id=124416		none
		MagicAjax.NET, The request was sent to 7 members https://sourceforge.net/project/memberlist.php?group_id=151083		1 respondent completed the questionnaire
2	Source Forge and its partners	Management of Source Forge A request to distribute the questionnaire was sent to 20 people.		The answer was that it was impossible to help, due to privacy of email addresses.
		ThinkGeek http://www.thinkgeek.com/bug-us/		The request was sent to their general email addresses. No reply was received.
		FreshMeat http://freshmeat.net/contact/		The request was sent to their general email addresses. No reply was received.
3	Main sites of the targeted OSS communities	Apache, apache@apache.org, human-response@Apache.Org		1 respondent completed the questionnaire.
		Second life. General email for developers of the community: SLDev@lists.secondlife.com. Also the same request was sent to four active contributors		1 respondent completed the questionnaire.
		MySQL. MySQL Contact and Questions Form		10 respondents completed the questionnaire.
		PHP. info@phpdeveloper.org		6 respondents completed the questionnaire.
		Ruby. ruby-talk-admin@ruby-lang.org. ruby-core-admin@ruby-lang.org		No reply from the main site.
		Python. Addresses were taken from http://www.python.org/psf/committees/		9 respondents completed the questionnaire.

		- committees, conferences, developers; http://news.gmane.org/gmane.comp.python.devel - developers; http://www.python.org/community/sigs/ - special interest groups. Second time the request was sent to 16 addresses.	
4	Facebook Facebook was searched for finding special interest groups in OSS development.	The request was sent to administrators and main pages of those groups in Facebook ▪ Linux, BSD, Free OS's, Software and the Open Source community – 24 members ▪ MySQL - The world's most popular open source database – 243 members ▪ LAMP Linux Apache MySQL PHP – 270 members ▪ PHP – 485 members – created new topic in the group ▪ The Web Designer Index – 3333 members ▪ Open Source Developers – 21 members ▪ Python Developers – 40 members ▪ Django Web Framework – 57 members ▪ UK Rails Developers – 30 members	Administrators distributed the request to the members of the group. 5 respondents completed the questionnaire after receiving the request from Facebook groups.
5	Other organisations related to OSS development	The Developers Group http://www.ukbug.co.uk/links/index.asp	None
		W3C World Wide Web Consortium	No reply.
		Open Source Initiative http://www.opensource.org/ membership-discuss-subscribe@opensource.org	No reply.
		OASIS Organization for the Advancement of Structured Information Standards is a not-for-profit, international consortium that drives the development, convergence, and adoption of e-business standards http://www.oasis-open.org	The request was sent to its subscribers. The result: none.
		Open Source Software Institute (OSSI) OSSI Board of Directors, http://www.oss-institute.org/index.php?option=com_content&task=blogcategory&id=121&	OSSI Executive Director John M. Weathersby asked for a research abstract and then distributed my request to its

		Itemid=31, the request was sent to 8 people		members.
		OSDC The Open Source Developers' Club President Scott Penrose Vice President Debbie Pickett		
6	Conferences	Conference on 11-12 June About the Holland Open Software Platform http://www.hosc.nl/index.jsp?nr=248		The request was sent to general email. No reply.
		Conference in Lumerick, Ireland 11-14 June http://oss2007.dti.unimi.it/index.php?id=officials.htm		Limerick OSS Conference 11-14 June – distributed leaflets to delegates
		Fosdem, info@fosdem.org		The request was sent to general email. No reply.
7	Academics	Current literature was reviewed and relevant academics were found. The request was sent to 14 different groups of academics.		Brian.Fitzgerald distributed the questionnaire in Ireland in one of OSS conferences
		Attendants to a First International Workshop on Emerging Trends in FLOSS Research and Development 21 May 2007 - Minneapolis - US in conjunction with 29th Int. Conference on Software Engineering	Juan Carlos Fernandez-Ramil Lecturer, Computing Department, The Open University	Very good advice for research, but not for questionnaire
			Cornelia Boldyreff, Professor of Software Engineering in the Department of Computing and Informatics within the Faculty of Technology at the University of Lincoln.	An answer was received.[42]
		British Computer Society's Open Source Specialist Group The chairman Paul Adams		Invitation to conferences in OSS in Birmingham and Cambridge

[42] "Zilia, thank you for your email. I suggest that you contact the British ComputerSociety's Open Source Specialist Group and get your questionnaire circulated through them; their web site is at http://ossg.bcs.org/ and the chairman is Paul Adams chair@ossg.bcs.org. Cornelia"

8	Discussion boards	Developers forum http://forums.devshed.com/, PHP Development, Python Programming, Ruby Programming, MySQL Help, Apache Development	After sending request to discussion boards, access was banned permanently.
		Linux forum, http://www.linuxforum.com/forums/index.php?action=post;board=40.0	Topic: knowledge management in open source software communities (for 19 October Read 110 times)
		Developers network, http://forums.devnetwork.net/index.php	For 19 October 2007, Replies: 2[43], Views: 350
		Newcastle Ruby-on-Rails local network http://groups.google.co.uk/group/ncl-osn/topics?start=&hl=en northofengland.osn@googlegroups.com ncl-rb@googlegroups.com	
		Python forum, http://python-forum.org/py/posting.php?mode=newtopic&f=1 email to administrator chrjim@gmail.com	Replies: 0 Views: 228
		Ubuntu, ubuntu-devel-discuss@lists.ubuntu.com ubuntu-devel@lists.ubuntu.com	The request was sent to Ubuntu developers by subscribing to Ubuntu developers email list.
		Ruby forum, http://www.ruby-forum.com/forum/3	The request was sent to online forums of those communities.
		Developers' papers, http://www.devpapers.com/contact.php	
		Slashdots, http://slashdot.org/authors.pl	
		PHP, https://www.zend.com/forums/index.php?t=msg&goto=11409&S=432c8295b84aa252b6b1329aac8d5155#msg_11409	
		Linux, editors@ostg.com	

[43] Reply 1: "Wow this is cool. Shame the only open-source projects I've ever worked on I either wasn't programming or was the sole member ☹"

Reply 2: "That was an interesting survey. A little vague and hard to follow in some areas, but interesting none the less."

		Mozilla, Firefox, Thunderbird, Webtools dev-apps-webtools@lists.mozilla.org, dev-apps-thunderbird@lists.mozilla.org, dev-apps-firefox@lists.mozilla.org http://www.mozilla.org/community/developer-forums.html	
9	Google groups The request was sent to Google groups. For July 2007	Ruby-on-Rails: Ruby-on-Rails-Talk Members: Talk – 9945 Members, http://groups.google.co.uk/group/rubyonrails-talk?hl=en http://groups.google.com/group/rubyonrails-talk Members: Core - 1641 Members, http://groups.google.com/group/rubyonrails-core Ruby-Language-General, http://groups.google.com/group/comp.lang.ruby/about comp.lang.ruby – 6094 members Ruby-Language-Talk. http://groups.google.com/group/ruby-talk-google ruby-talk-google – 1220 members	
		Python, http://groups.google.co.uk/group/comp.lang.python/topics?lnk=srg&hl=en – 11280 members	
		MySQL, http://groups.google.co.uk/group/comp.databases.mysql/topics?lnk=gschg&hl=en – 1155 members	
		Apache, http://groups.google.co.uk/group/alt.apache.configuration/topics?hl=en - 1132 members	
		PHP, http://groups.google.co.uk/group/comp.lang.php/topics?hl=en – 6106 members	
		Second Life, http://groups.google.co.uk/group/slccdiscussion?lnk=gschg&hl=en – 95 members	
10	Gurus		
	▪ Eric Raymond, A programmer, author and open source software consultant ▪ Richard Stallman, A software freedom activist, hacker, and software developer ▪ McCool, An author of the original NCSA HTTPd web server, later known as the Apache HTTP Server, and to this day httpd.conf files as distributed contain comments signed with his name. ▪ Brian Behlendorf, A technologist, computer programmer, and an important figure in the open-source software movement. He was a primary developer of the Apache Web server, the most popular web server software on the Internet, and a founding member of the Apache Group, which later became the Apache Software Foundation. Behlendorf served as President of the Foundation for three years. ▪ Dr David Mertz, An author and columnist for IBM's developerWorks, Intel Developer Services, O'Reilly's ONLamp, and other online publications; maintains Gnosis Utilities, a public domain of Python package. ▪ Roy T. Fielding, *Chief Scientist*, Day Software, *Co-founder and member*, The Apache Software Foundation, *Ph.D.*, Information and Computer Science, UC Irvine ▪ Mitchel Baker, Mozilla CEO ▪ Jono Bacon, Ubuntu Community Manager, Canonical		

	▪ Daniel Berlin, Google, Google's Open Source Program Office ▪ Aaron Boodman, Google, Inc. ▪ Danese Cooper, Open Source Diva, Intel and Open Source Initiative ▪ Chris DiBona, Open Source Programs Manager, Google, Inc. ▪ Mark-Jason Dominus, Chief Programmer, Plover Systems Co. ▪ Justin Erenkrantz, Senior Software Engineer at Joost, a Director for The Apache Software Foundation ▪ Schuyler Erle, a free software developer and activist ▪ Brad Fitzpatrick, President, CTO, LiveJournal.com, founder and CTO of Danga Interactive, best known for the popular community blogging and social networking site LiveJournal.com. ▪ Brian W. Fitzpatrick, Software Engineer, Google, Inc. ▪ David Goodger, Director & Secretary, Python Software Foundation ▪ Ted Leung, Senior Engineer, OSAF ▪ Timothy Miller, Founder, Open Graphics Project ▪ Eric Pugh, Principal, OpenSource Connections ▪ Sam Ramji, Director, Open Source Software Lab, Microsoft ▪ Mark Shuttleworth, Founder, Ubuntu/Canonical Ltd. ▪ Nathan Torkington, Conference Chair, O'Reilly Media, Inc. Nat Torkington lives and works in New Zealand where he consults on open source and startup strategies, writes for O'Reilly Radar, and co-chairs the Open Source Convention OSCON. ▪ Simon Wardley, COO, Fotango ▪ Andrei Zmievski, Chief Architect, Outspark Inc. ▪ 18 people were contacted from OpenLogic – site which provides software, stacks and services that help enterprises to maximize the value of open source software http://www.openlogic.com ▪ Ruby founder, Yukihiro Matsumoto ▪ David Heinemeier Hansson from Ruby on Rails, The request was published in Ruby-on-Rails blog (http://weblog.rubyonrails.org/2007/7/1/phd-study-on-innovation-with-open-source) by David.[44] This publishing was the main source of

[44] **“**PhD study on innovation with open source Posted by David July 01, 2007 @ 11:58 PM

Zilia Iskoujina is a PhD student from the UK who is doing research on Knowledge management in virtual organisations. As part of that, a questionnaire for people working in open source has been created. If you have 15 minutes, consider filling it out.”

	receiving the responses for the questionnaire.		
	OSS Community	Bryght , http://bryght.com/	The request was sent to discussion board.
		Open Source Think Tank http://thinktank.olliancegroup.com/component/option,com_contact/Itemid,3/, thinktank@olliancegroup.com	The request was sent to discussion board.
		Pligg forum CRM http://forums.pligg.com/forumdisplay.php?f=47	The request was sent to discussion board.
		Drupal - Drupal.org is the official website of Drupal, an open source content management platform. http://drupal.org/forum/2 [45]	
11	Most Active Projects -	WebCalendar	The request was sent to 6 members.

[45] The request was sent to discussion board.

1 comment was received on June 27, 2007

"Zilia, This is very interesting and a topic that seems to be gaining ground in virtual communities and Drupal. Are you only looking at OSS communities? If you are interested in how others are doing this there are some people I should put you in touch with.

I think this could get more promotion in the Drupal community if you would offer your results back to the Drupal community to better understand and assess how knowledge sharing is working on drupal.org, and what changes can be made."

The author of the thesis answered on June 27, 2007

"Hi …, many thanks for your email. When I will finish my data analysis, I will send the results to all respondents who filled my questionnaire and who left their email addresses. Also I will publish it in my website. Regarding OSS and other online communities. My primary interest is OSS, but I am more than happy to consider other possibilities as well. Which online communities have you got in your mind? I would like to speak about other possibilities. You can contact me on zilia.iskoujina [at] durham.ac.uk. Am looking forward to hearing from you. Kind regards, Zilia"

	All Time http://sourceforge.net/top/mostactive.php	http://sourceforge.net/project/memberlist.php?group_id=3870	
		SourceForge.net http://sourceforge.net/project/memberlist.php?group_id=1	The request was sent to 32 members.
		Crystal Space is an Open Source 3D SDK for Unix, Windows, MacOS/X. http://sourceforge.net/project/memberlist.php?group_id=649	The request was sent to 62 members.
		Pidgin, a GTK+ instant messaging application for Windows and Unix. http://sourceforge.net/project/memberlist.php?group_id=235	The request was sent to 26 members.
		The Python programming language http://sourceforge.net/project/memberlist.php?group_id=5470	The request was sent to 75 members.
		PhpWiki, a WikiWikiWeb clone in PHP http://sourceforge.net/project/memberlist.php?group_id=6121	The request was sent to 16 members. An answer was received.[46]
		phpBB, the worlds leading Open Source flat style discussion forum software. http://sourceforge.net/project/memberlist.php?group_id=7885	The request was sent to 8 members.
		phpWebSite http://sourceforge.net/project/memberlist.php?group_id=15539	The request was sent to 13 members.
		The JBoss/Server http://sourceforge.net/project/memberlist.php?group_id=22866	The request was sent to 77 members.

[46] "Sorry, I get so many of these OSS survey requests now I don't do them anymore."

Appendix 7: Question 19[47] – "Why do you share your knowledge with other members of the OSS Community?"

N	The Answer
1	It's the right thing to do and I learn from doing it.
2	Because I want everyone to know what I know and mostly because we want our OSS software to be powerful and bug-less.
3	By sharing all interested parties can mutually improve their skills
4	If I help them, they are more likely to help me.
5	OSS thrives on the sharing of knowledge and community. For it to be better than non-OSS we need to share this knowledge and this sense of community.
6	Why not? I find that sharing knowledge is the best way to learn, so why should anything be restrictive? Especially the OSS community, which is all (mostly) free
7	Software quality in general is far lower than I would like it to be. Everyone benefits from improving the skills of people writing software, myself included.
8	When I get the time to share my learning experiences with the community I think it helps everyone. If it wasn't for others doing the same I wouldn't be where I am now.
9	Open source is all about sharing ideas and knowledge within a group based atmosphere. Sharing is part of being a member of the community. I personally enjoy it because it increases the growth of my own skills while enabling me to build many of my own ideas. Often groups will give me new ideas to work with as well.
10	Teaching is fun and satisfying. It is after all as you say, a community.
11	Altruism, recognition, training of communication
12	Because I want to give a little back, for all the hard work people do. Plus I get great applications at the end of the day, which I know will be supported far beyond a proprietary application would.
13	Because I like to help other people, and if people shared their knowledge more freely, working in the technological domain would be a lot less frustrating for many of them.
14	To help improve the entire Open Source Community. We need to expand and grow larger each and every day. The improvement of developers, programmers, project managers is crucial to the success of Open Source. Knowledge is always the key to success.
15	It helps them, some ego feed, gets others to contribute in return
16	I share my knowledge with others because I feel it helps other developers use my experience to guide them in developing a better product.
17	Because I like to contribute to the community - that's how OSS works
18	Sharing is good!
19	People need to know.
20	Because that's what the OSS community is all about - sharing knowledge and working together to improve things for everyone.
21	Because I think knowledge should be available for everyone
22	Because it is the right thing to do.

[47] This Table includes comments from respondents as quotes, where only typing mistakes were changed.

23	I want to tell something I knew and I want someone to share or send information back to me else.
24	To promote better software
25	I like the idea of a world wide community, its a great way to meet people who have the same interests. It helps me relive stress and avoid work.
26	I learn a lot when I teach something to others. Similarly, I learn a lot when someone else teaches me something. So, sharing helps each other in learning a lot. Knowledge is power.
27	The Microsoft era has got to come to an end. There are so many talented people and so much good software that, when opened up, can be made so much better for an individual situation. Closing the source makes things too cookie cutter and puts too much control into the hands of too few people.
28	Its open source there is no point using something open and keeping the workings closed.
29	Because it makes it easier to do the jobs I have to do. I also enjoy interacting with other people and helping them.
30	There is no reason not to.
31	Knowledge exists to be shared.
32	Most of what I've learned has been from other members of the Community, so sharing the culmination of that knowledge with others seems like a great idea. Plus, I like to collaborate.
33	OSS communities are largely defined by what they share: code, knowledge, time, history. Without sharing of knowledge, the community cannot function properly, nor grow.
34	The sharing of knowledge is, for me, a primary motive for involvement in OSS. I work with very intelligent people on a computational geometry library, and I have certainly learned a lot of things from them, and they may have learned a bit from me. Often times this knowledge isn't even precisely specific to the task at hand - discussions of programming languages, concurrency, electronics, growing plants, etc.
35	To improve the community and the products.
36	I believe that by sharing knowledge openly we can increase the popularity and encourage healthy organic growth of software projects.
37	Just trying to return what I've received.
38	To participate in a shared collective of knowledge - you have to give to receive.
39	Because I receive back in (almost) equal amount and that makes my professional life a lot easier.
40	To learn new things and communicate with other people, enabling the development of a platform/ programming language to accelerate.
41	Open source builds on existing code. It is important to share knowledge to be able to do so.
42	I joined pligg because it was a small team and I would get a chance to gain some programming knowledge and experience. You get a great feeling when you're helping out people on forums or irc and getting to meet new people, solving problems and writing code. and it's a nice little earner doing some project for people using the software.
43	I just like sharing and it is reciprocal effect, they also let me know pf what they know best. And is always fun.
44	To further the development of the software.

45	Because that helps them. It is enough for me.
46	It's a way to be social and help others.
47	Because it helps the progress if more people understand it fully.
48	Simply because I like to help people.
49	My knowledge is useless if I just keep it for myself. I want to share it as much as I can so that everyone can benefit from it. The community can also give me feedback on potential mistakes or ways to improve my techniques.
50	White papers, speaking with the local Linux Users Group, contributing code to the phpWebSite project and the conversations and collaboration with other developers in that project
51	Both out of altruism (the desire to educate and spread knowledge) and to further the cause (to make the OSS project better.)
52	It is the only way to maintain open communications.
53	To better the Project and allow others to use their knowledge to creatively find better or more astute solutions to problems the project is facing.
54	Because that's the whole point of open source development to share the knowledge and skills so better products can be developed and bugs can be corrected much faster.
55	Simple, I wanted to write books, but due to my work, it's not yet finished for a long long time, so instead keeping it, I just opened it. Besides, I got my experienced much more improved.
56	Because that's the way it works, you take knowledge, and then give knowledge.
57	Just returning the favour.
58	1 - Because it's no use keeping it to myself. The economics of keeping my cards close to my chest just don't work out when you compare them to the economics of helping get the word out. 2 - An indescribable karma like" feeling
59	That's the way the OSS community works. We share knowledge and code. The sharing process brings mutual benefit to all involved.
60	Reciprocation
61	Its just natural to contribute, the community can only improve if people share.
62	I owe them for what they've done for me.
63	Common interest, mutual gain in knowledge, improving the community as a whole
64	Others have helped me, I would like to return the favour.
65	When I began using OSS, many people helped me to gain skills early on and I feel that contributing knowledge and time keeps the community healthy and productive.
66	Quid pro quo.
67	Because it is right.
68	To find best practices
69	Spirit of sharing and fairness, mutual benefit
70	To help people.
71	Because I have benefited in the past from freely available knowledge/source code and would like to pass along things that I know or might make someone else's life easier.
72	Share the wealth. It's not going to benefit me when I die.
73	The more information is pooled and taught, the more comes back and improves

	the overall situation.
74	Because I believe in being nice and sharing. As Mr. Rogers taught us when we were kids. :)
75	To give something back
76	Because it's the whole point of open source, we all learn from each other and in turn the product improves. It is better than waiting on Microsoft or any other big corporation to getting around to tech support or bug fixing!
77	Because if I share my knowledge of how I solved a problem, it is much more likely that other individuals will do the same for me.
78	That's the only way of improving ourselves.
79	Teaching someone something gives them value, yet takes none away from me.
80	For the good of the community, to learn new things.
81	Knowledge should be a good for the whole community / world. That's the way to make technology prosper. Keeping your knowledge hidden from other might appear to give you a short-term competitive edge, but in the long term does not lead to overall prosperity. It's like keeping a lamp hidden under a hat - it will never light up the room.
82	I treat it as a gift economy
83	Because I have learned a lot of things from knowledge shared by others so it seems just not only to take but to give as well. Also it's fun and gives you a feeling of accomplishment when helping thy peers.
84	I share knowledge with anyone who wants to learn, and learn from anyone who wants to teach.
85	I get back what I put in and I depend on these tools for my business so I try to put a lot in.
86	Sharing is caring.
87	To pay back all the knowledge I get from the community. To make the community grow. Because I believe in the OSS philosophy.
88	Good feeling of sharing and helping.
89	Encourage the growth of the community. To get involved and improve my own understanding of the software in the process.
90	Enjoyment. Community involvement. Increasing my knowledge. I received help, so I'll help in return.
91	The value and effectiveness of knowledge multiplies with sharing. This isn't anything new, and isn't specific to the OSS communities.
92	As a means of peer review.
93	A big plus in OSS is not re-inventing the wheel. You share what you know and all can progress further rather than being occupied solving already solved issues.
94	Because it was first shared with me by others - simply put, it's what we do, and therefore what should continue to be done.
95	I believe that software freedom is to use a computer, ethically.
96	I think most of the motivation is self-centred. The project in question is usually the overriding concern. I want the project to succeed; therefore I want the project to avoid making mistakes.
97	It's one of the easiest ways to improve the software, plus both learning new things and teaching things are enjoyable in their own right.
98	Because I might be wrong. They are good at pouncing upon that!
99	Though ranking low in the skill sets of the majority of the developers, I give

	other things back (different perspective/insight on usability, for example).
100	Because I know that I will get knowledge in return, and the community is improved through the sharing.
101	I've gotten so much help through the years, I want to help others in the same way. I also feel that if I've spent time solving a problem, I should contribute the solutions so that others can make use of my work.
102	1. To foster the sense of helpfulness and community on the mailing list, so that it will be there when I need help. 2. To get useful feedback and criticism of my own ideas.
103	I don't like to be only on the receiving side. I also like seeing people do their work well, so if I know how to help them, I do.
104	I enjoy sharing information / teaching people. In OSS projects this also makes people contribute more effectively, which is good for the project.
105	The community is all about sharing. I use other people's code, and I contribute by testing and providing support to other users/developers. Not only does it give me a warm fuzzy feeling to be in a position that I can help others, I enjoy solving problems. It is also (rather selfishly) good for my CV to demonstrate that I am an active member of the open source community.
106	It allows development of better code.
107	Because that's what OSS is about.
108	1. "Paying back" 2. "just fun"

Appendix[48] 8: Comments at the End of the Questionnaire

N	Respondents' Comments
1	Surely some kind of sense making technique would be a more effective way to explore this subject? Narrative capture, perhaps? The most useful information I have found on running an OSS group is from the Subversion group video on handling difficult people. There is a real dearth of this type of material.
2	Good luck with this research topic!
3	I am not highly active in any formal OSS projects, although I am an active member of the local Linux User Group, several programming-related IRC channels and I often put interesting (to me, anyway) code snippets and small apps on my personal website.
4	Apologies if my answers are a bit vague, I haven't been very active in the Rails community, though I am a hopeful bystander!
5	Great survey, I would very much appreciate a copy of the results. Thank you.
6	Couple of pointers; You should be wary of referring to Ajax as a language, it isn't. It is a collection of technologies. Some of the questions felt quite general and open source projects vary greatly in how they are managed. For example, some will have 4 people and others 20 people. One of the questions was in relation to open source software security. The belief that open source software is more secure is false. I am on a security mailing list and I receive many emails warning of security measures in a multitude of applications. In many, many cases I would trust proprietary software over open source. You may want to consider that programming languages have bugs, look at how many a language such as PHP(open source) has compared to ASP.NET(closed source - Microsoft). Also, you have no mention of - but they do exist. Open source communities for proprietary software. For example companies such as Adobe and Microsoft are releasing certain products in an open source manner, however there are some restrictions. Finally, what about projects that are highly commercial open source software? Like Sun Microsystems. There is allot of money in open source software, however it has the misconception that its free. Interesting survey. I would be interested in talking to you more about it if you need more input. I do have a few more comments but I need to get back to work just now. You have my e-mail or you can see me in the PHP facebook group, look for Dougal Matthews.
7	The questionnaire is very confusing, especially the difference between the OSS community" and "your community". Many incorrect/confusing sentences ("I satisfy with"). The answers to "To what extent ..." are "many"
8	The Python community is not a monolithic community centred totally on the (most popular version of the) Python language and runtime. I do participate in the part of the community which develops those particular things by sometimes fixing bugs, more frequently discussing enhancements. However, most of my time is spent enhancing what Python has to offer as a wider product" by developing my own software in the Python language which works with the "core" Python software. I am very active in this peripheral work
9	The Open Source Community cannot succeed without participation from knowledgeable professionals and highly interested students. The community itself is very diverse and decentralized; this means less structure, but more input.

[48] This table includes comments from respondents as quotes, where only typing mistakes were changed.

	The outcome of open source projects do not necessarily become more secure, however, they should become more stable and usable. I also believe that Open Source Software does not have to be free. This is because money talks, profits can help turn the wheels of success and speed up the growth and development of future projects. Competition is also key - large corporations such as Microsoft and Adobe are wonderful innovators, but I firmly believe in and whole-heartedly support Open Source because of the numerous benefits over the former.
10	One of the places where the open-source community is failing miserably is in the area of accessibility for handicapped people. I'm disabled (RSI). I am in the middle of a multi-day search to find a speech recognition friendly editor so it can continue programming in Python. When you asked what accessibility issues, you get no response or that sucks". I wish there were more disabled open source developers so that the awareness of the problems would permeate the community."
11	Just to note, AJAX is not a language, it's a use of multiple languages to help web-based applications quickly respond and update the page. I've been doing web-development for over nine years now, and I've been a professional software developer for over two years now, specializing in Java J2EE web based applications centred around an oracle infrastructure.
12	Thank you.
13	A lot of people contribute to oss communities in online forums other then those offered by the projects them selves. Linux should be one of the community options for question 1. I participate in linuxforum.com and wikipedia which are both open source communities to an extent.
14	Good luck!
15	Sorry - your survey makes very little sense to me. It seems to reflect a view of the free software community that I barely recognise.
16	Ajax isn't really a language its JavaScript and maybe XML (or JSON, etc)
17	You've mostly focussed on the coding aspects of contributing to OSS projects, but there are far more people who contribute by doing documentation, helping out on forums and contributing feedback and bug reports on software. Coding is generally done by the core developers + patches by the peripheral developers.
18	Some of the questions you have here are very difficult to quantify. For example, how many times do I do X" is difficult when a large amount of my time is spent on OSS related work. Some of these activities I do dozens of times a week. It might be easier to order them in which activities I do most versus least."
19	OSS technologies like rails are helping to shape the future of the internet. By making web technologies accessible to more people, both social and commercial information can be shared far more efficiently.
20	You should add Ruby and Javascript to the languages selection. Also, the grammar is very bad throughout the survey, which is a disincentive for completing it.
21	Good luck with your thesis
22	Not sure all of this applies to me.
23	Good luck with your thesis!
24	Cheers!
25	Good luck with the PhD ... :-) ... am still going to Uni and know how hard it is ...
26	Too long!
27	Best wishes on your PhD

28	Non-grammatical questions, and those with many typos, discredit the seriousness of this survey.
29	There are grammatical errors in the wording of some of the questions in this survey.
30	No prize needed, just interested in the summary. Was this questionnaire reviewed by anyone in the OSS community ahead of time? Some of the questions are worded rather oddly and the language/major community questions were rather limited. Additionally, it may be important to note that many people contribute just by themselves without a formal project around them (most of my OSS code was developed and released by just me).
31	I hope that I was able to help.
32	Mostly a great survey, some points are a bit uncertain (especially section D).
33	The reason I rated the administration in the Ruby on Rails community low is because it takes the core team a very, very long time to accept patches and enhancements submitted by members of the community.
34	Thank you!
35	Ajax is not a language, but a technology.
36	Ajax isn't a language and many of these questions are duplicates. You should include Python and Javascript in the languages.
37	Good luck in your PHd stuff.. =D
38	I don't contribute much to the community for several reasons: - I don't have extensive knowledge on any OSS project - I don't have yet extensive software architecture knowledge In the next 2 years I plan to choose an OSS project and commit to it, improving it, supporting users and working as a freelance on services related to it.
39	This was one of the better OSS related questionnaires I filled out this year.
40	The survey did not delve that deeply into motivational aspects. There were grammatical errors and in my opinion it was poorly laid out. I think that the survey would have benefited from a peer review process. You wrote directly to the main Ubuntu developer list, but failed to include it in your options. I felt a little disappointment in the whole survey.
41	One main driving reason for me to participate in OSS community is to contribute to the development of software and technology. It's just the need to have better software, and about the philosophical factor, I don't believe all software should be free. But I believe all general purpose (not business differentiating) software should be free (Open Source). I believe in Open Source. I believe it's the future. IM and IRC are usually used among developers and users to communicate. Ideally it should've made to the list of methods for communication. I personally don't think question 10 can be answered in a satisfied manner, not at least for me. This may vary vastly.
42	Substitute 'OSS' for 'Free Software' with all of my answers, please. I do not identify myself with 'Open Source', but rather with the Free Software community.
43	On the question where you asked if "all software should be free", you don't say whether you mean monetary cost or the freedom to modify. My answer would change depending on what you mean. Questions 11 and 14, the answers don't make sense. Question 32 is fuzzy, there are indirect monetary advantages, as you imply. 29, 30, and 31 have grammar errors that make the question ambiguous. Hope this helps you refine your survey!
44	"IT" means configuring networks, not engineering. The nature of my

	participation in Ruby on Rails is researching how to unit-test it, and then publishing my research. This makes me a "project leader" of this specific test code, yet I am not "appointed" to any role.

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