Open Innovation in Secondary Software Firms: An Exploration of Managers' Perceptions of Open Source Software

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Abstract

Open source software (OSS) is probably the best known exemplar of open innovation, with many practitioner-oriented publications having debated the merits and drawbacks of OSS in recent years. Nevertheless, much of the academic research on OSS has focused on individual rather than organizational issues. Hence while there is some understanding of why individual developers and users opt for particular OSS applications, relatively little is known about the adoption of OSS as a software acquisition policy. This paper presents a study of 13 managers in the secondary software sector in Europe, and examines how their perceptions of the benefits and drawbacks of OSS affected their decision to adopt an open source policy for software in their companies. The study reveals how their perceptions of the business and technical benefits and drawbacks of OSS influenced the technological, organizational, environmental and individual factors considered within the adoption process. The findings reveal that many of these factors are similar to those reported by previous work on the adoption of innovation, leading us to conclude that organizational processes for the adoption of open innovation are reliant on the practices for closed innovation despite frequently cited loss of organizational control associated with open innovation.

ACM Categories: K.6.1. project and people management; K.6.3 software management;

Keywords: Open Source Software, Open Innovation, Adoption of Innovation, Field Study, Secondary Software Sector.

Introduction

The concept of open innovation, of which open source software (OSS) is a well cited example, challenges existing theories of innovation adoption due to changes in organisational control (cf. Chesbrough, 2003) and risk (cf. Chesbrough and Crowther, 2006). In addition, a fundamental change in inter-organisational activities is evident with the adoption of an open innovation strategy. It is accepted that an increase in the use of inter-organisational mechanisms in relation to any activity necessitates a re-examination of existing paradigms and perspectives, and the construction of new theory due to increased complexity and reduced routinization associated with supra-organisational goals (cf. Alter and Hague, 1993). This study begins to address the need to examine our theory of innovation adoption by investigating the effects of how managers perceive OSS impacts on adoption decisions by companies in the European secondary

software sector. We thus studied managers in firms where software is used as a component in other products, such as embedded software in the automotive sector, consumer electronics, mobile systems, telecommunications and utilities (e.g. electricity, gas, oil). As the focus is on an open source approach to software rather than the adoption of particular OSS applications, we use the term OSS to refer to the range of open source applications.

Open Innovation and Open Source Software

Despite the importance of inter-organisational co-operation in relation to servicing consumer needs for products and services (Okamura and Vonortas, 2006), organizations have been slow to harness the same type of external cooperation in relation to innovation (Lane and Probert, 2007). For most of the 20th century, innovation happened inside the business and companies rarely looked outside for new ideas or inventions (Tapscott and Williams, 2005). Innovation is the result of combining different knowledge sets (Nonaka et al. 2003; Tidd et al, 2005), and such knowledge is frequently to be found outside the organization (Chesbrough, 2003; De Wit et al. 2007). However, with the exception of notable examples of collective invention (cf. Allen, 1983; von Hippel, 1987), organisations have been slow to engage in open innovation (cf. Chesbrough, 2003).

According to Chesbrough (2004), a paradigm shift is taking place in how companies commercialise knowledge; characterised as a move from 'Closed Innovation' to 'Open Innovation.' Closed innovation is a view that successful innovation needs control, and that firms need to be strongly self-reliant because of uncertainty with quality, availability and capability of others' ideas. Chesbrough (2004) proposes that with the open innovation paradigm, (i) firms can, and should, use external as well as internal ideas and (ii) that internal ideas can be taken to market through external channels, outside a firm's current business, to generate value. According to Chesbrough (2006), ideal businesses resist the 'not invented here' and 'not sold here' syndromes in favour of open innovation. They search outside their own companies for the best ideas, seeking input from other companies, which include competitors, as well as from customers, suppliers and vendors. A popular example of open innovation in various sectors is open source software (Chesbrough et al, 2008; West and Gallagher, 2006). The open source software phenomenon has been around for some time. The Free Software Movement began its campaign in 1984 for free software, meaning software that respects users' freedom and community, and explained that 'free' as in 'free software' means 'free as in free speech', and not 'free as in free beer.' The central organising principle is that the software remains free of most constraints on copying and use common to proprietary software (Hissam et al., 2001). In other words, "no one owns the software in the 'traditional sense' of being able to command how it is used or developed, or to control its disposition" (Benkler, 2002). However, there was a widespread perception, especially in business, that free software was zero cost software. The term 'open source' was coined in 1998 to avoid this perception and to place the phenomenon on a more business-friendly footing than that associated with the somewhat confusing 'free software' term (Fitzgerald, 2006). A formal definition of OSS published by the Open Source Initiative, establishes that software can be called 'open source' if it and its source code can be freely modified and redistributed (Coar, 2006). Some of the key conditions of the definition are that (i) the source code must be available to the user, (ii) the software must be redistributable, and (iii) the software must allow modifications and derived works. The open source moment has pragmatically shifted the centre of gravity towards a more business-friendly and hybrid concept, and OSS is now rapidly changing into a viable alternative to proprietary software in commercial settings (Agerfalk et al., 2005).

Despite this transformation, however, issues surrounding the adoption of an OSS strategy have received little attention. While open source has transitioned into the realm of mainstream business, understanding the underlying dynamics and values of the model and how this translates into business value is less known (CANfloss Report, 2003). Instead, research on OSS has concentrated mainly on the motivations of open source programmers (Hars and Ou, 2001; Hann et al., 2002; Lerner and Tirole, 2002; Ye and Kishida, 2003; and Von Hippel and Von Krogh, 2003) and the organisation of specific products and projects (Fielding, 1999; Mockus et al., 2002; and Koch and Schneider, 2002). Comparatively, little effort has been dedicated to studying the reasons behind business managers' decision to adopt, or conversely refrain from adopting, an OSS approach to software. Although some research has been conducted in the area of OSS adoption (e.g. Ven and Verelst, 2006; Goode, 2005; Dedrick and West, 2003; Varian and Shapiro, 2003; and Chau and Tam, 1997), these studies have either focussed on the adoption of specific open source products such as Linux and Apache, have been conducted with companies outside of Europe or have concentrated largely on

public administrations and companies operating in the primary software sector. Moreover, there is a paucity of research on OSS adoption in Europe. This is rather surprising as 3/5 of OSS developers are in Europe and the region has a strong secondary software sector (Ghosh et al., 2006).

In the commercial area, adopting an open innovation process "includes various perspectives: (1) globalization of innovation, (2) outsourcing of R&D, (3) early supplier integration, (4) user innovation, and (5) external commercialization and application of technology" (Gassmann, 2006, p. 224). Consequently, in order to move towards open innovation, there is a need for organisations to utilise "both external and internal ideas to create value, while defining internal mechanisms to claim some portion of that value" (Chesbrough, 2003, p. xxiv). To do so, Gassmann and Enkel (2006) identify three core open innovation processes: (1) the outside-in process whereby a company's innovativeness can increase through the integration of suppliers, customers and external knowledge sourcing, (2) the inside-out process where companies can earn profits by bringing ideas to market and transferring ideas to the outside environment, and (3) the coupled process where companies can combine the outside-in and inside-out processes by working in alliance with complimentary partners where give and take is vital for success.

There have been examples of the successful application of open innovation R&D processes in commercial settings such as consumer electronics (Blau, 2007), pharmaceuticals (Lane and Probert, 2007), as well as automobiles and computer hardware (Gwynne, 2007). Nonetheless, Chesbrough and Crowther (2006) found that companies that 'look outside' for technologies tend to minimise risk by investing in technologies that are often proven in other applications as opposed to 'new to the world' technologies. Open innovation practices are not limited to 'high-tech' sectors (Chesbrough and Crowther, 2006). However, Dahlander and Gann (2007) have argued that open innovation is far more complicated than it seems because it is not always that straightforward for organisations to have a high degree of openness and it can also be costly to implement. Thus, it is necessary to identify the benefits and barriers of an open innovation approach in order to provide credible insights for practitioners (Dahlander and Gann, 2007).

In exploiting OSS as part of an open innovation approach, companies such as HP and Sun have used an outside-in process by donating R&D to the Mozilla open source project while exploiting the pooled R&D and knowledge of all contributors (e.g. academics, user organizations, individual hobbyists) to facilitate the sale of related products. The result was that these firms maximised the returns from their innovation by concentrating on their own needs and then incorporating the shared browser technology into their own integrated systems. Other companies like IBM have often used an inside-out approach as part of its OSS initiative that represented spinouts in the 1990s and more recently, donated software patents to the OSS community. In addition, the aforementioned companies have also integrated elements of the coupled process by successfully co-operating with universities and research institutes in terms of both exploiting and sharing information and knowledge (West and Gallagher, 2006).

It is clear that OSS plays a critical role in the business models for firms in high technology and other industries (Rosenberg, 2008; Overby et al., 2006). However, the use of OSS in commercial settings has led to managerial debate about the business value of OSS in comparison to proprietary software, particularly business and revenue models as well as strategic implications (Agerfalk et al. 2005). Whilst studies of adoption by Rogers (2003) and Geroski (2000) highlight the importance of how perceptions could influence the adoption of an innovation, there is little in the OSS literature that indicates whether managerial perceptions of OSS have any impact on adoption. The common assumption that the perceived benefits and drawbacks of OSS are a contributing factor to OSS adoption relies heavily on anecdotal evidence found mainly in white papers, web articles, and practitioner papers. Our review of such sources has identified the benefits and drawbacks shown in Table 1.

Research Design and Method

The objective of this study is to examine how the adoption of an open source approach in secondary software firms is affected by how managers perceive the benefits and drawbacks of OSS. In the context of this objective, two research questions were formulated:

RQ1: What are the perceived benefits and drawbacks of OSS?

RQ2: How do these perceptions impact on the adoption of OSS?

Table 1: Review of the Benefits and Drawbacks of OSS

OSS BENEFITS	
Quality	Kenwood, 2001; Krishnamurphy, 2003; Varian and Shapiro, 2003; Forge, 2006
Security	Coppola and Neeley, 2004; Forge, 2006
Flexibility of Use	Varian and Shapiro, 2003; Krishnamurthy, 2003
Large Developer and Tester Base	Kenwood, 2001; Krishnamurthy, 2003
Low Cost	OGC Report, 2002; Fanini, 2005;
Flexibility Allowed by Licenses	Broersma, 2005
User Support from a Community	Krishnamurthy, 2003; Williams et al., 2005
Escape from Vendor Lock-in	Johnson, 2003; Hendrick, 2004
Increased Collaboration	Agerfalk et al., 2005
Encouraging Innovation	Howe et al., 2000; Wheeler, 2005
OSS DRAWBACKS	
Compatibility Issues	Webb, 2001; Guth, 2006
Security Risks	Herbsleb, 2002; Giera and Brown, 2004
Installation Problems	Webb, 2001
Lack of Expertise	Krishnamurthy, 2003
Version Proliferation	Krishnamurthy, 2003
Less User-Friendly	Kenwood, 2001
Lack of User Support	Webb, 2001
Lack of Ownership	Kenwood, 2001; Guth, 2006
Insufficient Marketing	Krishnamurthy, 2003
Giving Away the Source Code for Product	Hecker, 2000
Higher Training Investments	Giera and Brown, 2004

The use of classical diffusion theory (cf. Rogers, 2003) to study organisations has been criticised for focusing primarily on simpler innovations being adopted autonomously by individuals and being less applicable to complex technologies and to technologies adopted by organisations (cf. Fichman, 1999). In addition, there are weaknesses in innovation adoption research in its failure to take adequate consideration of the business context and its integration with the overall environment (Swanson, 1994). It is therefore evident that the theoretical foundation for our study needs to take into consideration specific factors such as the technological, organisational, and environmental circumstances of the organisation in addition to individual factors.

We thus begin by drawing on the work of Tornatzky and Fleischer (1990). This model consists of three elements that influence the process by which innovations are adopted – the technology, organisation and environment. This framework has been elaborated on in relation to the OSS adoption process in studies carried out by Glynn et al., (2005), Dedrick and West (2003), and Chau and Tam (1997). The technological context relates to the technologies available to an organisation. Its focus is on how technology factors influence the adoption process (Tornatzky and Fleisher, 1990). According to Rogers (2003), five technology factors influence the likelihood of adoption - relative advantage, compatibility, complexity, trialability and observability. Tornatzky and Klein (1982) have also carried out some related work spanning these five characteristics and several of these factors were mentioned by Dedrick and West (2003) as influencing OSS adoption. The organisational context looks at the structure and processes of an organisation that constrain or facilitate the adoption and implementation of innovations (Tornatzky and Fleischer, 1990). Organisational factors such as total cost of ownership (Varian & Shapiro, 2003), boundary spanners (Ven & Verelst, 2006), relevance to the organisation (Goode, 2005) and top management support (Glynn et al. 2005) could fall into this category.

Tornatzky and Fleischer (1990) propose that the external environmental context, i.e., the industry, competitors, regulations, and relationships with governments, in which an organisation conducts its business presents constraints and opportunities for technological innovations. Research carried out by Chau and Tam (1997) and Dedrick and West (2003) found that environmental factors such as market conditions and available skills and services influence OSS adoption. Other factors such as lack of real world experience (OGC Report, 2002) and the need for a well-performing business model (Barnes, 2003) also appear to impact OSS adoption. Having considered the technological, organisational and environmental factors, we now examine individual factors. Classical innovation adoption theory also emphasises the importance of individual factors such as the presence of an OSS champion for innovation adoption (Glynn et al, 2005). Other factors identified in the literature that could be labelled as individual include uncertainty (OGC Report, 2002) and skills

obstacles (Barnes, 2003). Table 2 draws from studies of innovation as well as from studies of OSS to present our conceptualisation of the factors that may affect OSS adoption.

Data Gathering

The study was categorised as exploratory due to the scarcity of empirical work in the area of OSS adoption. Thus, Marshall and Rossman (1989) propose that either a case study or field study research methodology can be used. The researchers decided that a field study would be appropriate as it would facilitate the collection of data from a larger number of informants. A stratified sample was used (cf. Patton, 1990), in that we sought out managers in companies that had complete adoption, partial adoption and non-adoption of OSS. Data collection was carried out using semi-structured interviewing based on a common protocol in 13 companies (see Table 3).

Interviews were used in this study for a number of reasons. First, detailed information is acquired. Second, emotions, sensitive or privileged information can be investigated that respondents might not be willing to write about on paper for a researcher that they have not met (cf. Oates, 2006). Third, the interviewer can ask new questions that follow up interviewees' replies and can vary the order of questions and even the wording of questions (cf. Bryman and Bell, 2003).

Table 2: Factors that may affect OSS adoption

Technological Factors	
Relative Advantage	The level to which an advantage is perceived as better than the idea it supersedes (Rogers, 2003).
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters (Rogers, 2003).
Complexity	The level to which an innovation is perceived as difficult to understand and use (Rogers, 2003).
Trialability	The degree to which the innovation can be tried and assimilated in small chunks over time (Rogers, 2003).
Observability	The level to which the results of an innovation are visible to the technology adopter (Rogers, 2003).
Organisational Factors	
Total Cost of Ownership	The cost of acquiring and using an innovation (Wouters et al., 2005).
Boundary Spanners	Individuals within an organisation who connect their organisation with external information and can bring the organisation in contact with new innovations (DePietro et al., 1990).
Relevance to the Organisation	Perception that the benefits of the innovation are relevant to the organisation (Goode, 2005).
Top Management Support	Senior management support the adoption of the innovation (Morisio, 2000; Glynn et al., 2005).
Environmental Factors	
Market Conditions	Competitive forces and levels of uncertainty in the market (Chau and Tam, 1997).
Available Technology Skills and Services	The availability of external skills and services that are required to utilise OSS (Dedrick and West, 2003).
Real World Experience	The level of understanding on how to migrate to OSS (OGC Report, 2002).
Well-performing business model	An explicit model for profitability (Barnes, 2003).
Individual Factors	
Uncertainty	Individual fear, uncertainty and doubt regarding the relative strengths and weaknesses of OSS (OGC Report, 2002).
Skills	Ability of the individual to use the innovation (Barnes, 2003).
OSS Champion	Someone with drive and charisma supporting the adoption (Glynn et al., 2005).

Table 3: Companies Studied

Name	Business	Extent of OSS Adoption	Interviewees
Nokia Research Centre, Finland	Mobile Communications	Moderate use in telecommunications infrastructure and embedded applications. Uses Linux, Gnome and D-Bus, Debian, Python, Symbian, G-Streamer, OBEX and other OS components	Head of Software Technology
Phillips Medical Systems, The Netherlands	Supplier of medical equipment & devices	Limited. Involved in some OS projects. Hope to increase level of adoption	International Project Leader
Siemens AG, Germany	Large Engineering Multinational	Working on global software initiative – using open source model internally in business unit called corporate source	Program Manager
Sony Computer Entertainment Europe, UK	Manufacturers & Distributors of entertainment systems	Moderate use in servers and consumer products. Increasing levels of adoption. Presently use PostgreSQL, Apache & PHP, Linux, Sendmail, postfix	Linux for Playstation 2 Specialist
Vodafone, Spain	Mobile Communications	None. Collaborating with others to create Linux platform for mobiles	R&D Engineer Head of R&D
BSS Group PLC, UK	Specialist Distributor of heating and plumbing .	Decreasing adoption. Abandoned previous use of OS email system. Now limited to Linux on servers	IT Contracts Manager
Combitech Systems, Sweden	Consultancy	Have used it in some projects, e.g. ECOS. Evaluating use in embedded systems	Lead Engineer
Conecta, Italy	Consultancy	Predominant – service built on OSS	Head of R&D
Eircom Group PLC, Ireland	Telecommunications	Some use of OS products in Technical support, e.g. JBoss app. server, MySQL	Technical Architecture Mgr
Eurocontrol Experimental Centre, France	Air Traffic Mgt	Limited to infrastructure. Evaluating further use in air traffic mgt.	Senior Researcher
Consult Comp. (pseudo), Switzerland	Consultancy	Specializes only in open source consultancy/training	Consultant
St. Galler Tagblatt AG, Switzerland	Media	Extensive – migrated entire SAP software environment to OSS. Now use Linux, MaxDB, MySQL, and Apache Tomcat	CIO
Supertramp, UK	Manufacturing	Extensive (100% open source shop). Use OpenOffice.org, Mozilla Web, Linux, and GIMP, Sendmail and Smoothwall	Tech. Director

Finally, the interviewer is provided with rich, detailed answers. The interview guide approach (cf. Patton, 1990) was used to conduct the interviews, as it is more comprehensive and systematic for data collection than the purely conversational interview, and more flexible than the standardised, open-ended interview or the closed, fixed response interview.

Data gathering took place between September and November 2006. The timing of the data gathering is significant in the context of changing attitudes towards OSS in business environments (cf. Fitzgerald, 2006). Interviewees were senior decision makers with experience of assessing OSS adoption. Interviews were carried out in person or by telephone, were tape-recorded and each interview lasted between forty-five minutes and two hours.

Each interview was structured around 4 issues, with the interviewer asking probing questions based on responses. These 4 issues were: (a) the company's history of engagement with OSS, (b) the level of adoption, (c) perceptions of benefits and drawbacks of OSS and (d) how such perceptions affected the adoption of OSS.

Interview data was transcribed, generating 115 pages of field notes. Content analysis was undertaken using coding techniques proposed by Strauss and Corbin (1990).

Table 4: Open Innovation Processes in Companies Studied

Name	Open Innovation Process	Description
Nokia Research Centre, Finland	Outside-in using elements of a coupled process	Integrates external knowledge & competencies. Have joint ventures/ exercises with partners and collaborates with communities e.g. Eclipse
Phillips Medical Systems, Netherlands	Outside-in thinking	Collects and integrates external knowledge from research projects and universities. Also involved in research forums investigating OSS
Siemens AG, Germany	Outside-in thinking	In terms of corporate source initiative, integrates software development know-how from several of the operating companies that Siemens has
Sony Computer Entertainment Europe, UK	Outside-in using elements of a coupled process	Integrates external knowledge from customers for products and services. Successfully collaborated with another company in terms of producing Linux for PS3
Vodafone, Spain	Outside-in thinking	Successfully collaborated with Spanish government (received funding) and other companies to develop Linux mobile platform
BSS Group PLC, UK	Outside-in thinking using elements of coupled process	Strong cooperation with suppliers/customers. Contributes knowledge to external environment, e.g. research projects
Combitech Systems, Sweden	Outside-in	Collaborates with different software vendors. Involved in COSI, a Eureka project that aims to raise awareness of OSS and distributed development
Conecta, Italy	Coupled process	Integrates and externalises knowledge/competencies. Cooperation and collaboration with universities and research institutes
Eircom Group PLC, Ireland	Outside-in thinking	Often get involved in collaborative innovation projects, e.g. Eurescom where knowledge has been integrated into some of their mainstream products
Eurocontrol Experimental Centre, France	Outside-in thinking	Involved in task force investigating potential of OSS. Collaborates with universities and research institutes
Consult Comp. (pseudo), Switzerland	Coupled process	Integrates and externalises knowledge. Cooperation and collaboration with universities and research institutes
St. Galler Tagblatt AG, Switzerland	Outside-in	Integrates external sources of knowledge and competencies
Supertramp, UK	Inside-out using elements of a coupled process	Creation of spin-out company following successful adoption of OSS. Collaborates with other companies to deliver state of the art technology systems

This approach encourages researchers to be flexible and creative (Sarker et al., 2000) while imposing systematic coding procedures (Strauss and Corbin, 1990). This form of analysis facilitates the development of substantive theory without prior hypotheses, and can be utilised in the absence of, or in conjunction with, existing theory (Strauss and Corbin, 1990; Urquhart, 1997). In the initial phase, 'open coding' was used to determine the main ideas in each transcript. These ideas were then grouped by significant headings (informed by the items in Tables 1 and 2) to reveal categories and sub-categories. The next step involved 'axial coding' which is the process of relating categories to their sub-categories. As a list of codes began to emerge, the analysis moved to a higher level of abstraction, looking for a relationship between the codes. Once a relationship had been determined, the focus returned to the data to question the validity of these relationships. The final step, 'selective coding', is the process of determining a core category; that category that is connected to most of the other categories.

The issues of trustworthiness (validity) and replicability (reliability) (cf. Denzin and Lincoln, 2000) were addressed as follows. First, the data analysis approach utilised rigorous *coding* and *memoing* processes providing an audit trail of the process by which conclusions are reached. Second, *venting* (cf. Goetz and LeCompte, 1984) was used as results and interpretations were formally discussed with respondents.

Findings and Analysis

As can be seen in Table 4 one or more aspects of the primary innovation processes as outlined by Gassmann and Enkel (2006) are evident in the study sites.

Table 5: Perceived Benefits of OSS

Benefit	Description of Benefit	Respondents
Quality (T)	High availability and dependability of applications, higher performance in terms of capacity and speed. Enhanced quality from peer reviews and the quality of developers / testers	13
Large Developer/Tester Base(T)	Very beneficial as it ensures that OSS is quality software and is up-to-date	13
Flexibility of Use (T)	Beneficial because it facilitates changes, customization, experimentations and allows freedom of choice	12
Encourages innovation (B)	Access to the source code produces ideas and encourages technical innovation while also creating more opportunities for innovation.	12
Increases collaboration (B)	Greater collaboration from OSS facilitates product development, cooperation and exchange of knowledge, provides new ways of collaboration and permits sharing of expenses with other companies	12
Security (T)	High security due to the availability of source code, the reduced threat of viruses and extra awareness of security in design phase of products	11
Escapes vendor lock-in (B)	Highly beneficial as it facilitates freedom of choice, gives sense of control and provides independence from private vendors	11
Low Cost (B)	In terms of reduced licensing fees, upgrades, virus protection and the cost of the whole package, i.e. service and software	7
Compatibility (T)	Great interest in conserving formats for better interoperability	6
Flexibility by licenses (B)	Has a significant impact on reducing capital expenditure in company	6
Extra business functionality (B)	Beneficial because it results in ability to keep teams small which in turn improves productivity and communication	2
De facto standards (B)	Establishes de facto standards results as many organizations work together to create applications rather than relying on a software market leader.	2
Harmonization (T)	Improved harmonization in interoperability and practices/operations	1

For example, many of the companies have opened up their internal innovation process by successfully gathering and integrating external sources of knowledge and competencies through successful collaboration and joint exercises with customers, suppliers, partners, and research institutes.

The benefits and drawbacks of adopting an open innovation strategy such as OSS as perceived by those managers studied are outlined in Tables 5 and 6. These benefits and drawbacks are categorised as being primarily business or technical, and are ranked in order of the number of managers citing them as being relevant to their adoption decision. The ability to access the source code and modify it has resulted in many of the perceived technical benefits, e.g. security, quality and flexibility of use. The business benefits found were seen as very significant for the managers, particularly escaping vendor lock-in, increased collaboration, and innovation.

Although many of the benefits are similar to those found in the literature, some new findings also surfaced. These included improved harmonisation, extra functionality and establishment of de facto standards. The drawbacks include: poor documentation, less functionality, proliferation of interfaces and problems with finding the right staff and competencies.

While it is recognised that the perceived benefits found in the study can be significant for adoption, there are also many drawbacks of OSS that have the potential to impede it. As can be seen from Table 6, only two of the technical drawbacks outlined in the existing literature (compatibility issues and lack of expertise) were perceived as drawbacks by those studied. Interestingly, perceptions of drawbacks regarding the software being less user-friendly, version proliferation and problems with troubleshooting/upgrading were not found. Indeed, OSS was seen to be positive in this regard. New issues in the form of poor documentation, less functionality and lack of roadmaps were perceived to be the primary drawbacks. Essentially, the business drawbacks were found to pose a bigger challenge than the technical drawbacks, with lack of support, lack of ownership and insufficient marketing ranking the biggest drawbacks to adoption.

Table 6: Perceived Drawbacks of OSS

Drawback	Description of Drawback	Respondents
Insufficient marketing (B)	No one organization owns it all. OSS has no marketing budget which results in it being driven primarily by word of mouth	13
Lack of support (B)	No safety net as there is no support and no company to back it up	11
Lack of ownership (B)	Inability to hold someone responsible or accountable for problems	11
Lack of Expertise (T)	Employees lack OSS expertise – may be more about lack of awareness	6
Poor documentation (T)	Documentation outdated or may have died in development	5
Finding staff/ Competencies (B)	Can be difficult to find staff and develop competencies to work with OSS	5
Compatibility Issues (T)	Some compatibility problems with current technology, skills and tasks	4
Access to the source code (B)	Some are uncomfortable with releasing source code for products. Lack of knowledge in relation to this issue	3
Proliferation of Interfaces (T)	Results in confusion in deciding which one to choose	2
Lack of Roadmaps with OSS Products (T)	Makes it difficult for companies to see any strategic direction	2
Less Functionality (T)	Level of integration not as good as Microsoft	1

In order to fully understand how managerial perceptions of the benefits and drawbacks impact OSS adoption, the findings were interpreted in the context of the technology, the organisation, the environment and the individual.
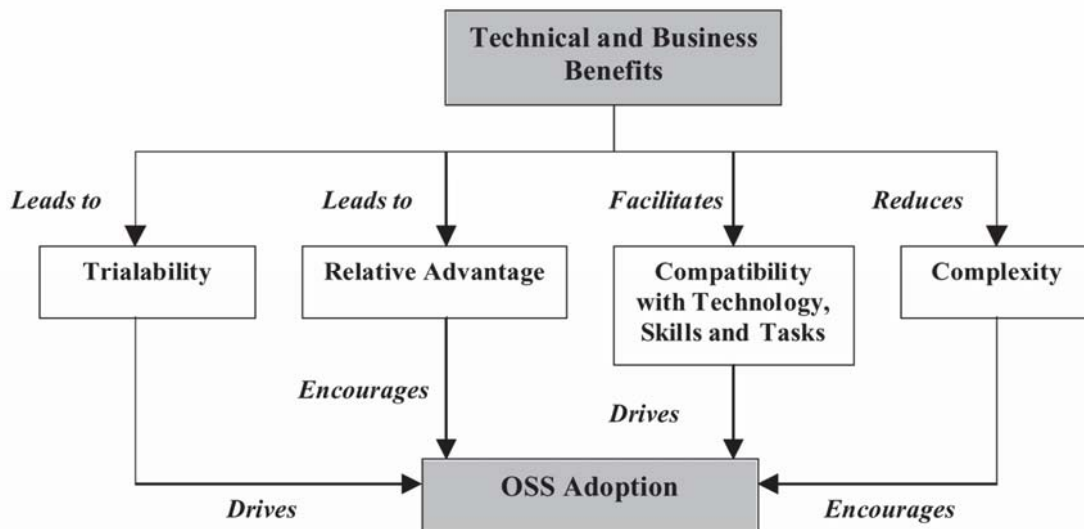
Technological Context

Four technological characteristics were evident in this study as influencing the adoption decision: trialability, relative advantage, compatibility, and complexity. Observability was not seen as relevant. The manner in which the technical and business benefits and drawbacks impact these four areas are outlined in Figures 1 and 2.

The analysis reveals that *Trialability* was a driving force in the adoption decision as the technical and business benefits associated with OSS have led to trials and experimentations by managers in nine of the companies studied. On the technical side, the reliability of OSS appeared to be a real positive influence while on the business side, the low cost and opportunities that OSS provides for innovation were also significant.

Figure 1: Impact of Benefits on OSS

Figure 2: Impact of Drawbacks on OSS Adoption in the Technological Context
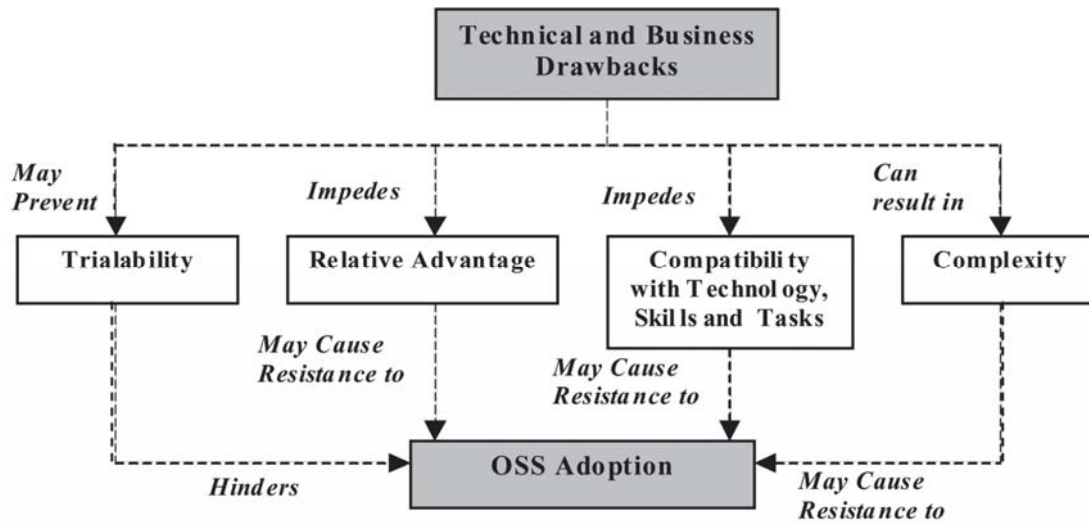
In some cases, adoption of OSS has led to further trialability of more open source projects. For instance, the IT Manager at Sony Computer Entertainment explained that they had experiences of staff using some software out of interest that turned out to be directly relevant to the company. Several of the companies pointed out that they considered OSS less difficult to try out than proprietary software because the software can be downloaded from the Internet, without any cost. As the Technical Architecture Manager in Eircom pointed out "having the software available for free that one can play around with is seen as useful." The Technical Manager at Supertramp explained that prior to fully migrating to OSS, he had invested three months carrying out some feasibility testing on OSS.

Although this manager had broad experience in Unix systems, he pointed out that "although most of my lifetime experience has been working in IT, I did find the learning curve quite steep and hard work." The CIO at St. Galler Tagblatt explained that they had not carried out any trials on the software as they had consultants that were very helpful in providing pre-implementation advice. As this manager indicated "we worked with very skilled partners. And these partners knew Linux especially well for SAP." It can therefore be said that the availability of support and services was a significant factor in reducing the requirement for trialability in this company. However, four of the companies viewed technical drawbacks such as poor documentation and business drawbacks such as insufficient marketing as potential hindrances to trialability of OSS projects occurring whatsoever in the organisation.

The *Relative Advantage* was seen in terms of hardware and software costs as well as the technical benefits outlined in Table 5. The CIO at St. Galler Tagblatt explained that adopting open source resulted in 40% cost savings on infrastructure along with lower costs for software licenses and freedom of choice in their new server hardware.

In terms of software costs, adopting OSS enabled Supertramp to wipe £15,000 off their licensing budget and re-invest in the development of their systems. Surprisingly, for the Project Leader at Philips Medical Systems, the R&D Engineer and Head of R&D at Vodafone and the Senior Researcher at Eurocontrol, the low cost of software was not a significant factor in deciding whether to adopt OSS. They indicated that quality in terms of high reliability and performance, and flexibility of use were all main advantages of OSS and would be seen as contributing factors to OSS adoption. At the same time, the experiences of several managers revealed that technical drawbacks such as lack of expertise, and business drawbacks such as training investments for staff and user support would have a negative impact on relative advantage.

Adoption in the Technological Context

For the majority of the managers the decision to adopt OSS was greatly influenced by the C*ompatibility* of the software with their current technology, skills and tasks, supporting the findings of Dedrick and West (2003). Many of the technical benefits and drawbacks (mainly compatibility) are a huge influence in this area, while some business drawbacks (particularly lack of support and skills obstacles) appear to be a barrier to ensuring

compatibility with the current technology, skills and tasks.

According to the Technical Director in Supertramp, "the amount of compatibility for running applications wasn't available when the company adopted OSS and still isn't." However, this manager was already very experienced with Unix, which resulted in the migration to OSS being less complicated. The IT Contracts Manager of the BSS Group stated that if the company were to introduce more open source products, they would have to ensure 100% compatibility. For example, he suggested that even if they were told something was 95% compatible, he would not be able to recommend it internally because in relation to the remaining 5%, there was a very good chance of staff coming back and saying it didn't work. While many of the companies had, or could foresee, no problems in terms of compatibility with the current technology, important issues in terms of compatibility with current skills and tasks arise. According to the IT Manager at Sony Computer Entertainment "not all developers in the European market are as comfortable or happy with using OS based operating systems packages. A lot of them are only familiar with proprietary operating systems, and they were not happy that they had to invest extra time and resources in getting people who were familiar with the open source solutions."

In the organisations that had adopted OSS, technical drawbacks such as lack of expertise resulted in *Complexity* issues while some of the business drawbacks in relation to finding the right staff and developing the right competencies, training

and lack of support also had a compounding affect, thus making OSS adoption difficult. For example, the CIO at St. Galler Tagblatt explained that the software is more difficult to understand and use and although their system programmers were familiar with Unix, there was quite a significant investment in training them on Linux. Several of the other managers believed that there may be some complexity issues in adopting OSS due to lack of understanding of OSS. However, some technical and business benefits of OSS have the potential to reduce complexity problems. For example, the low cost of acquisition of OSS often makes it possible for the company to invest in training for staff. This coupled with staff motivation to learn something new and become more innovative also assist in reducing complexity problems.

Organisational Context

In support of findings from Goode (2005), Varian and Shapiro (2003), Ven and Verelst (2006) and Glynn et al. (2005), organisational factors were frequently cited by managers as impacting the adoption decision. Figures 3 and 4 outline how the technical and business benefits and drawbacks influence these areas.

The analysis revealed that the adoption of OSS is primarily a bottom-up initiative in most of the companies, and that the presence of *Boundary Spanners* is very important. In many cases, a number of employees in the company possess knowledge and understanding of OSS, and aid its introduction.

Figure 3: Impact of Benefits on OSS Adoption in the Organizational Context
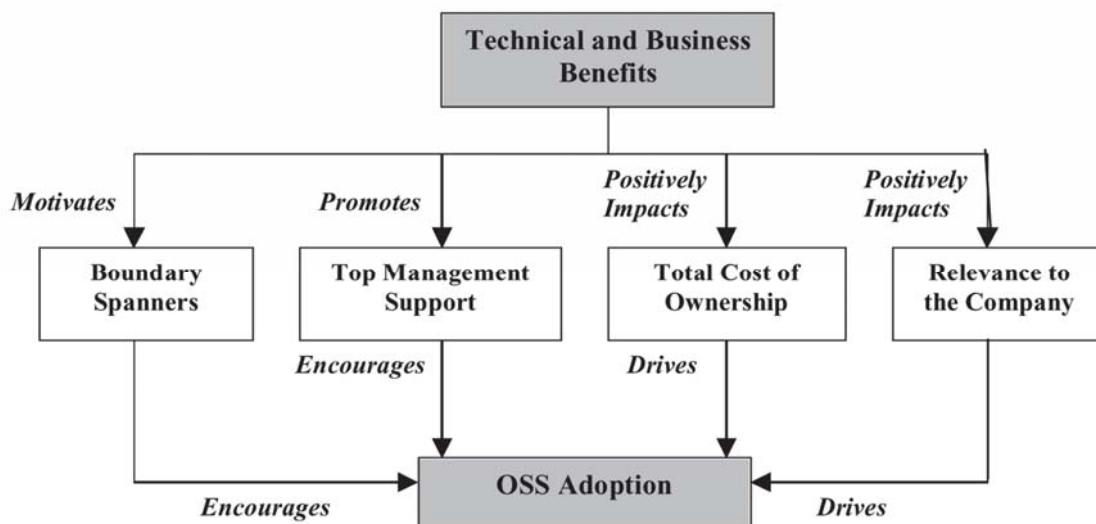
Figure 4: Impact of Drawbacks on OSS Adoption in the Organizational Context
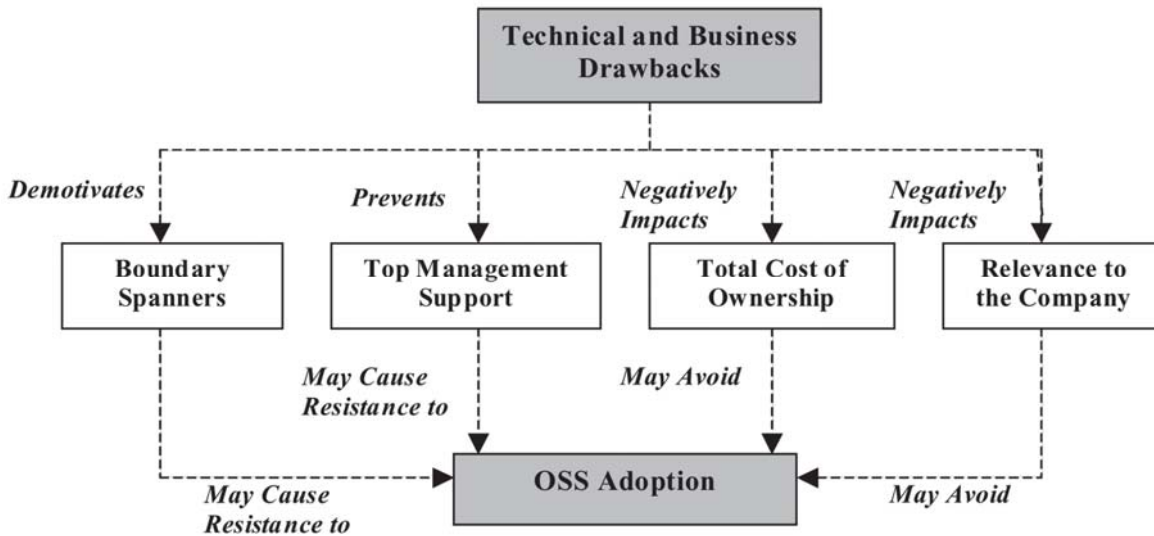
It also became apparent that the perceptions of technical and business benefits of OSS have been influential in motivating and convincing these boundary spanners to 'spread the word' in the company. For example, the IT Manager at Sony Computer Entertainment explained that she was not a lone voice "gunning for open source" as there were other others in the company supportive of it. Therefore, she added that she did not have to be evangelical internally in the company. As is typical of open innovation, many of the boundary spanners in the companies are investigating open source with other EU companies and universities. The business benefit associated with increased collaboration allowed by OSS appears to be very influential in this regard. However, two of the companies explained that the lack of ownership and support associated with OSS may often de-motivate boundary spanners in encouraging the adoption of an OSS strategy.

The study revealed that the *Total Cost of Ownership* (TCO) was relative to technical benefits such as reliability and performance, and business benefits such as low cost and escape from vendor lock-in. However, technical drawbacks such as lack of expertise, and business drawbacks in relation to training investments and finding the right staff have the potential to negatively influence TCO calculations. Some managers in companies that had adopted OSS revealed that it was not possible to make a formal TCO calculation.

However, the CIO at St. Galler Tagblatt calculated a saving of €340,000 with cost savings of 40% on infrastructure. According to the Technical Director at Supertramp, the lower costs associated with OSS

adoption was "tremendous." For the migration to OSS, the company worked within a budget of £30,000 and felt they had got the assessment pretty right. This Technical Director pointed out that if the company had not migrated to OSS, the budget on hardware and software would have meant that their investment in staff and staff capabilities would have been quite significantly less. By adopting OSS, he added that the company could invest more money back into the business process and make that more efficient. While the Technical Architecture Manager at Eircom revealed that the cost of acquisition of OSS is low, he pointed out that the TCO may be just as high as proprietary software because of the investment needed in support. However for four of the managers, lower cost was not the main driver in adopting OSS. Rather low cost combined with some of technical benefits, i.e. reliability and quality, were seen as more important. For example, the IT Manager at Sony Computer Entertainment revealed that the company had the budget and cost was not a consideration in the adoption decision. She added that the company was more interested in what would get them the most functionality and the most time on the most stable platform.

All of the managers believed that senior managers must see the *relevance* of OSS to their business if they are to endorse its adoption. On the other hand, if drawbacks dominate, senior managers will reject OSS. According to the Project Manager at Siemens, relevance to top management means that they must see the strategic business benefits for the company to go that way. The low cost of OSS and the flexibility allowed by licences were contributing business benefits for many of the companies. For the

companies with a big budget, the technical benefits of OSS adoption were seen as more relevant by management.

The study revealed the necessity of *top management support* for OSS adoption. It was evident that the benefits and drawbacks of OSS have a critical influence on whether top management support its adoption. According to the Program Manager in Siemens "unless companies have the support of top management, OSS would not work because inherently companies like Siemens have a tendency to cling on to what they have." The Head of Software Technology at Nokia also explained that they have the support of top management because they want to learn more about OSS in terms of where it can be used and how it benefits the company. At present some of the drawbacks that impede top management

support for OSS adoption are the difficultly involved with finding the right staff and developing the competencies necessary to work with open source. Other drawbacks include the lack of ownership and lack of support issue. The managers in companies where OSS had been adopted revealed that top management were supportive of its adoption because of the lower cost associated with it.

Environmental Factors

The environmental factors found in the study that impact OSS adoption are also in line with those of Chau and Tam (1997), Dedrick and West (2003), Barnes (2003), and the OGC Report (2002). The manner in which the benefits and drawbacks influence these factors are illustrated in Figures 5 and 6.

Figure 5: Impact of Benefits on OSS Adoption in the Environmental Context
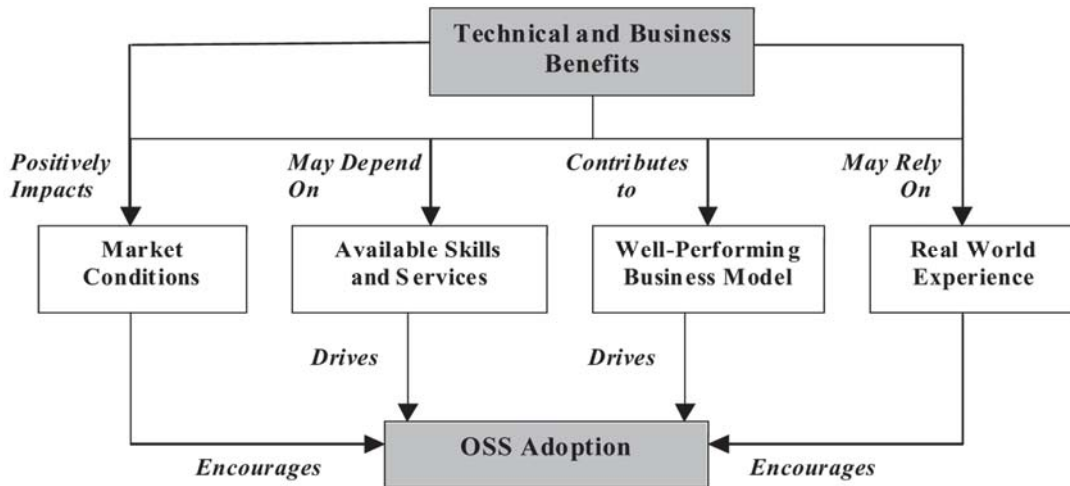
Figure 6: Impact of Drawbacks on OSS Adoption in the Environmental Context
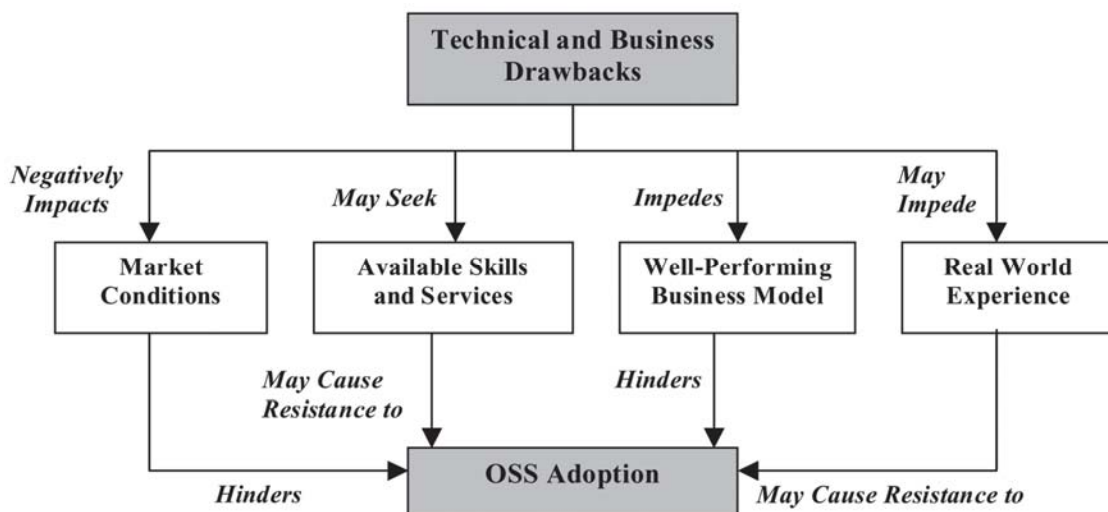
Most of the managers believed that when adopting open source software, *market conditions* have to be considered. Again the technical and business benefits and drawbacks have a significant influence on market conditions because they can impact, positively or negatively, the way the business is conducted. According to the IT Manager at Sony Computer Entertainment, the reason behind adopting Linux for Playstation arose out of consumer demand for the product. In her words "they wanted this product, they wanted to be able to have Linux running on their machine and to be able to run OSS." For the customers, the quality and flexibility of use of OSS was beneficial here. The Lead Engineer at Combitech reflected that if there is widespread adoption of open source, then this would become of high strategic importance to the company. Interestingly, the IT Contracts Manager at BSS Group suggested that "it's a bit of a 'me too' environment." In other words, if one company has a very successful product, other companies will want to avail of it.

He believed that because there is not a lot of companies doing a 'me too' in relation to OSS products, this hinders its adoption. This Manager also mentioned that there is a completely different mindset involved when buying open source products that are available in the market. In his words "there is a good chance of being sacked for 'buying' open source…is the way the mindset runs." Similarly the Head of R&D at Conecta revealed that most companies tend to stay with the 'tried and true', resisting anything new.

The *availability of external support and services* in adopting OSS was mentioned by most of the managers as being extremely important, as certain business drawbacks such as the lack of user support and lack of ownership were of particular concern to them. This in turn encouraged some of the companies to seek out available skills and services. For example, both the CIO at St. Galler Tagblatt and the IT Contracts Manager at BSS Group considered vendor support contracts to be very important, especially at the start of the adoption phase. The availability of support services appeared to be more important to managers in the larger organisations such as St. Galler Tagblatt, Eircom and the BSS Group that have the budget to buy support. However, according to the Head of R&D at Conecta, for many companies it is difficult to find expertise - companies providing support in the way they do for commercial software. He pointed out that "it's very easy, if you need to buy support for Microsoft Exchange, you simply go through the website and search. For OSS there is no easy way to find other companies providing support. There are too few, usually very small." The IT Contracts Manager of the BSS Group pointed out that the marketplace is not bombarded with companies

who specialise in installing open source software only because "it's not commercially sensible. Most people want to promote the Microsoft world because it benefits their pocket …you need lots of add-ons …to keep it all in good order. So anybody that has got commercial add-ons wouldn't go anywhere near the open source market because there is no money in it, because there is a low cost of acquisition and it doesn't cost a lot to run so you can't make any money in it." Taking these views into consideration, it can therefore be said that while some the technical and business benefits of OSS, e.g. quality and low cost are attractive to many managers, these could be considered potential drawbacks for consultants if they were to deal only in OSS.

The issue of having a *well-performing business model* was also evident amongst those studied. According to the Technical Architecture Manager in Eircom, "the key thing is why should I be interested in doing it? What makes it better for me? And it's nothing to do with open source per se. I mean proprietary can offer just the same thing but they're just better at getting their message out, not necessarily having a better quality product."

Again, the fact that OSS is insufficiently marketed can be viewed as an impediment. For instance, the Technical Director at Supertramp believed that proprietary vendors do not want to see open source come to market because they feel it encroaches on their business model, so they ramp up their marketing efforts to try and stop this occurring. However, he believed that companies who are building businesses based around OS products utilising the service model will start to push things forward in the market more. The IT Manager at Sony also revealed that she did not think a company could have a successful business model, product based, with open source unless they were providing a good service using open source. It is evident that the availability of support and services are extremely important in order for a successful business model to transpire.

Most of the managers believed that senior management would like to see more *evidence of real world experiences* in terms of the benefits and drawbacks of OSS and case studies on successful and unsuccessful migration from proprietary software to OSS. It is apparent that real world experience from other companies that have adopted OSS can be perceived by senior management as a safety-net comfort factor. For example, the Lead Engineer at Combitech remarked that they would like to see more examples of companies that have successfully migrated from proprietary to OSS because the success of others is always 'good marketing.'

Figure 7: Impact of Benefits on OSS Adoption in the Individual Context
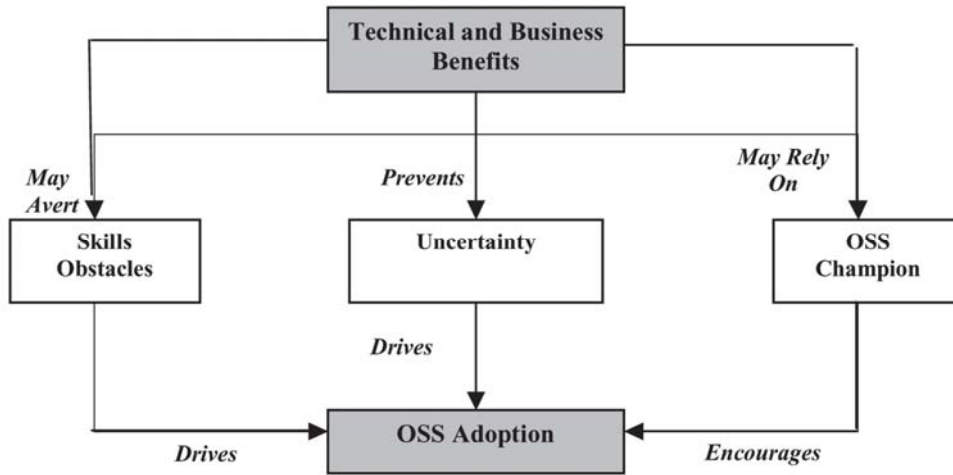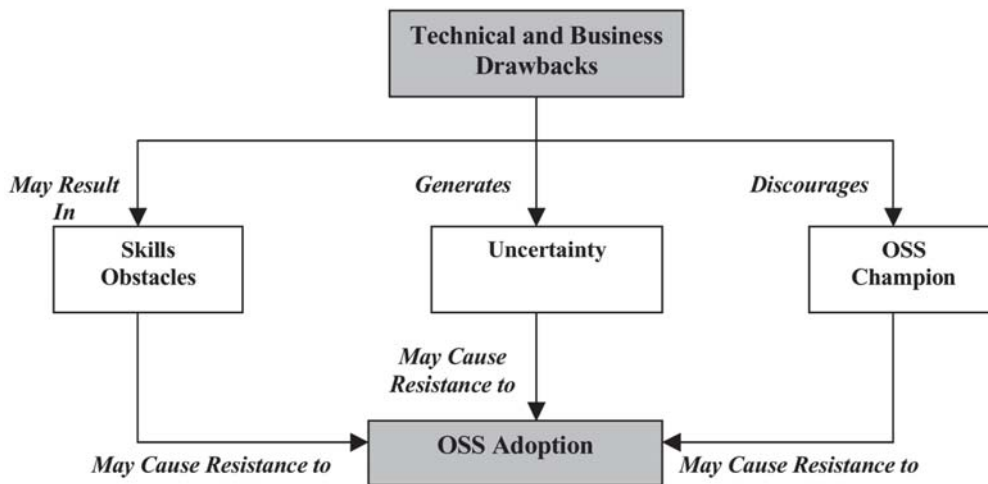

Figure 8: Impact of Drawbacks on OSS Adoption in the Individual Context

Likewise the Technical Director at Supertramp reported that, at the time of the company's migration to OSS, they would have liked to have seen more case studies of other companies that had 'put their toe in the water first.' At the time of this company's migration to OSS, there were no real reference files or case studies available so the Technical Director had to speak with some open source advocates. The fact that OSS is insufficiently marketed could be one drawback in terms of the availability of real world experience. However, the Head of Software Technology at Nokia believed that often companies are normally hesitant to talk about the failures they experience with OSS adoption.

Individual Factors

In support of finding from the OGC Report (2002), Barnes (2003) and Glynn et al. (2005), it was found that individual factors such as presence of an OSS champion, skills obstacles and uncertainty impact adoption. Figures 7 and 8 outline how the benefits and drawbacks influence these factors.

The analysis revealed that *skills obstacles* are an important factor to take into consideration when adopting OSS. The Lead Engineer at Combitech believed that there might be some resistance in the company if they were to replace Windows with Linux for instance.

However, he added that this would be a learning curve and the benefits of open source might kick in. Similar beliefs were evident in Philips Medical Systems and Vodafone. However, for the companies that had adopted OSS, e.g. St. Galler Tagblatt and Supertramp, skills obstacles did not present too much of a barrier. As already mentioned, St. Galler Tagblatt had engaged the help of consultants. In addition many of the staff in several of the companies had experience in working with Unix so the switch over to Linux and open source was considered relatively straightforward.

However, according to the IT Contracts Manager at the BSS Group, the end users were not aware that they were using an open source system because it was only used on servers and behind the scenes, so to them, they were working in a Microsoft environment. In the case of St Galler Tagblatt, the CIO explained that employees were happy to move over to OSS because they got new systems, in terms of disc space, storage, hardware and servers. He also added that the employees had worked on several operating systems so the change did not bother them. For Supertramp, the Technical Director revealed that no resistance was encountered from staff because, at that stage, they were fed up with the reliability problems and issues that were happening in the company. According to him "there was this sense of if somebody could just fix this for us, we will embrace it and we don't really care what it looks like."

Issues related to *uncertainty* proved to be inhibiting factors in half of the companies studied. The R&D manager at Vodafone expressed some uncertainty about the whole issue of giving away the source code. Again, it can be suggested that the technical drawback associated with giving away the source code can generate uncertainty and negatively impact managers' perception of the software. Thus companies might resist adopting OSS. In addition, managers in both Philips Medical Systems and Eurocontrol revealed that employees had doubts about OSS adoption. The Senior Researcher in Eurocontrol explained that because OSS is unknown, it is very likely staff will have the wrong idea about it and so there is fear. However, the Technical Director at Supertramp explained that proper leadership and motivation is important in preventing these feelings of uncertainty, otherwise one could have a "mutiny on their hands." Similarly, the Consultant at Consult Comp. explained that there needs to be an awareness of what is actually being introduced and people need to know what the benefits are.

The findings revealed that the charisma and drive of an *OSS champion* was a significant factor influencing open source adoption in two companies, Supertramp

and Conecta. For example, the Technical Director at Supertramp had the knowledge and awareness of OSS benefits that was critical in an initial conversation with top management of the business benefits of open source. In the other companies it was difficult to make a distinction between boundary spanners and project champions. However, it is obvious that OSS champions need to realise the benefits of OSS if they are to invest the time and effort needed for effective adoption. Such effort involves sustaining top management support in order to stimulate adoption.

Conclusions

This study revealed that open innovation practices are already in operation in all of the companies studied, revealing the need to increase innovativeness by opening up internal software innovation processes. Interestingly, there were no significant differences between the perceptions of managers in companies with different levels of OSS adoption of the benefits and drawbacks of OSS. For example, the majority of managers believed that quality, security, flexibility of use and escape from vendor lock-in were significant benefits of OSS, while there was also some conformity in terms of the perceived drawbacks, e.g. lack of ownership, lack of support, OSS being insufficiently marketed. In addition, it was apparent that managers favoured technical benefits such as quality over business benefits like low cost. Overall, the study has contributed to understanding the adoption of open innovation by systematically investigating the impact of managerial perceptions of the benefits and drawbacks of OSS on the adoption of an open source approach to software. The results are also useful in providing a better understanding of how perceptions impact adoption which may in turn lead to more informed managerial decision-making processes.

It is evident that the technical benefits of OSS (e.g. quality, flexibility, security) are perceived to outweigh the technical drawbacks (e.g. concerns with documentation, expertise), and that the business benefits (e.g. encouraging innovation/collaboration and escaping vendor lock-in) make OSS a very attractive option for businesses. However, it is also evident that there are still business drawbacks (insufficient marketing, support and ownership) that hinder adoption. Arguably, such drawbacks stem from the community-based peer-production processes that drive OSS development, and thus such concerns may prevail longer than previous concerns with technical expertise and documentation. However, this issue may be dealt with by (i) OSS proponents addressing such issues and (ii) organisations reconsidering the appropriateness of how they evaluate risk and control in relation to the adoption of open innovation.

Our study demonstrates that the dominant managerial perceptions of business and technical benefits are in keeping with the assessment of OSS as a form of open innovation. For example, greater collaboration and innovation are at the heart of open innovation in general. Thus, particular business benefits allowed by OSS, the most palpable ones being increased collaboration, escape from vendor lock-in and encouraging innovation, permit companies to team up with other companies, customers, universities, research institutes etc. to overcome certain adoption factors like technological complexity and facilitate product development. Even so, the dominant perceived drawbacks concern issues of reduced organisational control, increased risk and increased inter-organisational complexity associated with open innovation. Nevertheless, the study provides empirical support for theories associated with traditional (closed) adoption of innovation (i.e. Rogers, 2003; Tornatzky and Fleischer, 1990) in explaining the adoption of an open innovation strategy such as OSS. This suggests the applicability of such theories to the adoption of open innovation despite the organisational risks and complexity associated with open innovation. While this may be a transitory situation in relation to practice, it is evident that open innovations strategies depend on network-based activities that contribute to the successful acceleration and exploitation of innovations (cf. Chesbrough 2006). It is therefore timely for both researchers and managers to examine the appropriateness of extant approaches to adoption in light of (i) the differences in risk and control associated with open and closed innovation, and (ii) the role of an external network (e.g. partners, peer-production communities, IP intermediaries) in the adoption decision. Furthermore, additional research should investigate the circumstances that motivate firms to even consider an open innovation strategy like OSS. In addition, deciding to embrace an open innovation strategy like OSS will require managers to reconsider the key processes that underlie value creation and value capture in the company. In other words, how will the firm successfully create value for the customer while at the same time capture some value for themselves? Indeed, such an examination would greatly improve our understanding of OSS as a form of open innovation and also open innovation in general.

In calling for further research on OSS and open innovation adoption, we acknowledge that our study did not take into consideration variables such as organisational size, structure and culture in assessing the impact of managerial perceptions on adoption. It will be necessary for future research to consider such issues as they are likely to affect how managers deal with the risk and control issues associated with open innovation as well as the external relationships required for leveraging open innovation strategies. In addition, our research design was exploratory, and further research should go deeper into each factor and level of analysis, as well as focussing on consistent theoretical lenses that can help to explore these levels. In doing so we recommend the use of theoretical lenses that consider technological, environmental, organisational and individual factors, so that a more integrated perspective on the complexities surrounding the adoption of open innovation may be achieved.

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