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INNOVATIVE SOFTWARE BUSINESS STRATEGIES: EVIDENCE FROM FINNISH FIRMS

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ABSTRACT: Our study aims at shedding light on the innovative business strategies in the software sector and particularly providing a better understanding of the economics underlying the supply of Open Source Software (OSS). We use survey data collected from 170 Finnish software companies to investigate the determinants of the choice of OSS production. Our study focuses on the role of a firm's absorptive capacity in its adoption of OSS supply as a business strategy. We find that the quality of a firm's human capital indeed matters: those companies that supply OSS solutions also have relatively more highly educated employees. However, our data do not indicate that a firm's accumulated intellectual property affects in any significant way its choice to apply OSS-based strategy.

KEY WORDS: Open Source, Software Market, Innovative Business Strategies

JEL Classification: L11, L86, M21, O32

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TIIVISTELMÄ: Tämä tutkimus pyrkii tarjoamaan uutta tietoa ohjelmistotoimialan yritysten innovatiivisista liiketoimintamalleista ja erityisesti avoimeen lähdekoodin ohjelmistojen (Open Source Software, OSS) tarjonnan taloudellisista mekanismeista. Aineistoanalyysi selvittää avoimen lähdekoodin ohjelmistojen tarjontaa määrittäviä tekijöitä käyttäen 170 suomalaisesta ohjelmistoyrityksestä kerättyä kyselyaineistoa. Tutkimuksen kiinnostuksen kohteena on erityisesti yrityksen kyvyn hyödyntää sen ulkopuolella tuotettua tietoa eli sen ns. absorptiokyvyn rooli avoimen lähdekoodin tarjontaan perustuvan liiketoimintamallin käyttöönotossa. Aineistoanalyysi viittaa siihen, että yrityksen inhimillisen pääoman laadulla on todellakin merkitystä: avoimen lähdekoodin ohjelmistoratkaisuja tarjoavilla yrityksillä on korkeammin koulutetut työntekijät kuin pelkästään kaupallisin lisenssein ohjelmistoja tarjoavilla yrityksillä. Tämän aineiston perusteella näyttäisi kuitenkin siltä, ettei yritykseen kasaantuneen aineettoman omaisuuden määrä liity merkittävästi sen valintoihin avoimen lähdekoodin ohjelmistojen tarjonnan suhteen.

AVAINSANAT: Avoin lähdekoodi, Ohjelmistomarkkinat, Innovatiiviset liiketoimintamallit

1. Introduction

Software producers are provided with appropriation regimes that are stronger than ever and can protect their product as intellectual property by both patents and copyrights (Cowan and Harison, 2001). In theory, we should not thus see much Open Source Software (OSS),[1] a privately produced public good of which source code can be downloaded from the Internet and used at no cost, and large scale OSS development should be unsuccessful, attempting against economic logic. However, in reality the number of OSS projects continuously increases, ranging from small utilities and device drivers to large and complex packages, such as Apache, Open Office and MySQL. OSS has proved to be a viable mode of innovation and software production as several projects capture substantial market shares from commercial competitors and enhance their reputation in terms of novel features, superior performance and reliability. The Linux operating system, initially developed by the Finnish Linus Torvalds, is a paragon of an OSS product that successfully competes with rival proprietary products (such as Microsoft's operating systems) and is continuously improved by a large community of programmers and users.[2]

In the past few years OSS has rapidly shifted from a model driven purely by the developer community and supported by the academic milieu to a more central domain, in which development is furthered largely by the software industry. OSS has mushroomed new SMEs providing products and services by applying freely available products. It has spawned a thriving environment of small focused businesses, typically devoted to the

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[1] OSS is freely distributed online, can be used and developed by all and hence it is non-excludable as other public goods. OSS relies on volunteering for the provision of new code, bug fixes of the existing code, online help with problems running and installing the program. See http://www.opensource.org/docs/definition_plain.html for the definition of the Open Source. Taxonomy of Open Source licenses is brought in http://www.opensource.org/licenses/

[2] For instance, Kuan (2001) suggests that OSS outperforms commercial proprietary software by comparing bug resolution rates in OSS and proprietary applications as a proxy for quality.

development and support of specific products or to maintenance and integration activities. Further, OSS has reshaped the business models and strategies of large firms, including such major industrial players as IBM, Oracle, Philips, Nokia and SAP, which have chosen to integrate OSS applications into their R&D activities, core products and services.[3]

The major literature on Open Source focuses on the technological and business aspects of OS applications[4] (Raymond, 2001; Feller and Fitzgerald, 2002; Fink, 2003) and on cost-saving effects achieved by substituting proprietary programs with equivalent OSS applications (see, for example, Fitzgerald and Kenny, 2003a). Only recently, economists have begun analyzing the economic mechanisms underlying Open Source communities and the incentives of their participants to contribute to OSS development by applying new theoretical concepts and empirical analyses. For example, Lerner and Tirole (2005) explore the properties of OSS licenses using data from 40,000 OSS projects. They conclude that projects that are geared toward end-users tend to have restrictive licenses, while those that are oriented toward developers, geared toward the Internet or designed to run on commercial operating systems use less restrictive terms. Bonaccorsi and Rossi (2003a,b) conducted a large-scale survey on Italian firms that supply and implement Open Source solutions. They analyze how the role played by social, economic and technological classes of motivations determines the involvement of different groups of developers in Open Source activities. However, these studies primarily aim at identifying the internal structure of Open Source communities and motives of individuals to participate in them. Other studies explore and provide initial explanations how open source can benefit firms and examine possible business models mostly from theoretical standpoints.

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[3] In January 2005, IBM released 500 of its software patents for the use of OSS developers. Moreover, in November 2005, IBM, Novell, Philips, Red Hat and Sony jointly announced a creation of a Open Invention Network (OIN) that offers a collection of patents royalty-free to promote innovation around Linux.

[4] Garzarelli and Galoppini (2003) analyze the development and production process and project organization of the Debian GNU/Linux operating system. Kuan (2001) tests the quality of software using bug resolution rates as a proxy for quality, and finds support for the hypothesis that OSS outperforms commercial proprietary software.

Our study aims at providing a better understanding of the economics underlying OSS production by analysing the differences in software companies that supply OSS products and/or services and those that provide only proprietary software solutions and differences between firms providing *only* OSS and those firms that employ *hybrid* strategies providing both OSS and proprietary solutions. We call those companies that provide OSS (either purely or as part of the hybrid strategy) *OSS firms*, and those that provide only proprietary software *non-OSS firms*. By identifying the attributes and the practices of firms that have chosen to develop proprietary and OSS applications, we provide an enhanced outlook on firms' strategic choices concerning the production and use of OSS. Closest to our work is the recent empirical study of Koski (2005) exploring the product and license type choices of the Finnish open source software companies. Her major findings are that the service-oriented firms tend to supply more often their products under OSS licenses, whereas firms owned by family or by individuals tend to rely on "traditional" proprietary software in their product selection. Moreover, the market trends and participation in OSS development projects affect the licensing of individual software products such that a company tends to choose mostly the dominant OSS license type for the products that it develops. Firms participating in OSS development projects more often favour restrictive copyleft licenses than other companies.[5] Koski's study differs from our work in two major respects. First, it uses product-level data of 18 different product categories, whereas we focus on firm-level analyses. Second, it analyzes differences in the strategies of the firms that provide OSS (i.e. data comprise only of OSS companies), whereas our study explore the differences between OSS and non-OSS firms by including both OSS and non-OSS companies in our dataset.

[5] This finding is consistent with the findings of Lerner and Tirole (2005) that more than 70% of the OSS development projects employ the GPL copyleft license.

Several case studies explore why some software companies choose to supply OSS products and services whereas others apply hybrid strategies (in which a part of the products are developed and offered as OSS and part of the features is kept proprietary), or merely proprietary supply strategies (McKelvey, 2001). West (2003) studies the shift in IBM, Apple and Sun's strategies from proprietary platforms from development of proprietary operating systems to hybrid, Linux and Solaris-based platforms in response to increasing R&D costs and competitive pressure from software and hardware producers. Harison and Cowan (2004) explain how different firm strategies, represented by the share of features distributed as OSS, affect their profitability and the performance of their products. The results of their model suggest that rent-seeking firms would adopt hybrid strategies, and even increase the share of OSS features in their products, when their revenues from complementary services and features increase as well.

Unlike previous studies, we use systematic (econometric) data analysis to shed light on the adoption of different software supply strategies. We use survey data collected from 170 Finnish software companies to investigate the determinants of open source business strategies in the software sector. Our study focuses on the role of absorptive capacity (Cohen and Levinthal, 1990) – i.e. the ability of a firm to absorb, apply and draw commercial benefits from external information or innovation produced outside the firm boundaries – in adoption of business strategies based on OSS supply. Therefore, accessibility to publicly available know-how and the necessary learning and assimilation skills among employees play a particularly important role as in producing knowledge by building upon former know-how.[6] This know-how is typically shared within and among

[6] Scotchmer (1991) describes technological progress as an ongoing innovative process, in which new discoveries are made by "standing on the shoulders of giants".

organizations, as well as between companies and Open Source communities, via joint activities and experiences (Nonaka *et. al.*, 2000).

A firm's intellectual capital – its human capital and intellectual property - determines, by and large, its absorptive capacity. Our major finding is that the quality of human capital is important for the adoption of such innovative business strategy as OSS supply is; those software companies that had relatively more highly educated employees were more likely to be the suppliers of OSS than other companies. The share of developers of a firm's employees – i.e. the share of work force that has specific skills to develop and create new software products based on open source code – was not statistically significant in explaining the differences between the OSS and non-OSS firms. Neither did our measure of a firm's intellectual property.

The paper is organized as follows. Section 2 discusses the business strategies of software companies in the light of the economic literature. Section 3 introduces our data and discusses estimation results. Section 4 concludes with the summary of our main findings.

2. Software Business Strategies

A vast number of potential firm level factors may affect a firm's business strategy in regard to its OSS provision. The contemporary empirical evidence on the topic relies by and large on particular projects and case studies (e.g. Dahlander and Magnusson, 2005), with few exceptions (see Bonacorssi and Rossi, 2003c; Henkel and Tins, 2004). Our research differs from previous studies in that it tests the statistical significance of variables representing various characteristics of the firm and its activities that can explain the choice of their software business supply strategies. As we lack a rigorous theoretical framework

on OSS business strategies, the factors chosen for the analysis are based on the economic literature on the dynamics of innovation and firm strategic behaviour and on adoption of new (software) technologies (see e.g. Antonelli, 1995; Freeman and Soete, 1997 - Ch. 7, 15; Von Westarp, 2003). The research also builds on and contributes to the recent discussion on entrepreneurial activities that are based on the provision of OSS products and services (see e.g. Young, 1999; West, 2003, Välimäki and Oksanen, 2005).

The *absorptive capacity* of the firm, i.e. its ability to absorb, apply and draw commercial benefits from external information or innovation produced outside its boundaries (Cohen and Levinthal, 1990), is likely to be one the key factors affecting the adoption of OSS supply as a business strategy. Even though absorptive capacity is essentially a qualitative concept rather than a quantitative term, it can be attributed to many aspects of the organization and its activities. For example, absorptive capacity can be perceived as a threshold under which workers can assimilate and exploit new knowledge that they acquire (e.g. through development of new products). When the technical complexity of the knowledge is too high, i.e. when workers lack the necessary degree of absorptive capacity, they are likely to ignore it, even though it could have been useful to the firm. Following this argument, when the degree of absorptive capacity increases, so do the benefits from external innovation that can be implemented by the firm. Consequently, as the firm's level of absorptive capacity increases, we expect higher degrees of adoption of external technologies and business practices, in this case OSS.[7]

A major determinant that affects the ability of the firm to absorb, use and possibly further develop inventions external knowledge and innovations is the firm's *intellectual*

[7] Ghosh *et. al.* (2005) indicate that a significant number of software firms allow their workers to participate in OSS projects **during their workday**, as those companies perceive contribution to OSS projects and knowledge exchange with other developers an essential source of learning and acquisition of professional skills.

capital, which includes its human capital and intellectual property.[8] The strategic use of OSS requires not only technical (computing) skills but also knowledge of complex legal issues and business practices that involve high degrees of uncertainty due to the novelty of incorporating OSS in business models. *The education level of personnel* roughly quantifies the quality and the skills of employees and is often used to measure firm's human capital. Empirical evidence also indicates that the development of major OSS projects was initiated within academic and public research institutes.[9] In turn, it seems possible that strategies of the firms in which advance degree holders are employed would be affected towards wider implementation of OSS. We use the variable measuring (log) share of employees having at least university degree (variable EDUC) to capture the education level of the firm's employees.

Specific skills are often necessary for the adoption of inventions. Software developers form an important part of software firm's specialized human capital that acts as "change agents" fostering the Open Source movement. It seems likely that companies that have more developers – i.e. more skilled staff to utilize and further develop Open Source code - are also more likely to adopt OSS-based strategies. This prediction is based upon the main motives programmers and engineers, i.e. development of new technologies and functional features and solutions to technologically-challenging problems (Brooks, 1995), prompted by accessibility to the programs' source code. Technology-driven motives (often

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[8] Granstrand (2000) defines intellectual capital as follows: "Intellectual capital comprises all non-material or intangible resources that could be considered as capitalizable assets of an economic agent… decomposed from the point of view of a firm into IPRs in patents, databases, trade secrets, trademarks, relational capital related to qualities in internal and external relations incorporating organizational capital, goodwill and reputation and human capital related to competencies of various kinds". Empirical studies identify positive correlation between firm value and its intellectual capital (see, e.g., Hall, 1999).

[9] Economic literature suggests that strong links exist between Open Source and academic communities. Various scholars highlight the similarities between Open Source and "open science", as both modes are driven by community efforts and by reputation and their final results are freely distributed to the public. Feller and Fitzgerald (2002) discuss the relations between Open Source and *open science* and draw analogies between the dynamics of OS and scientific communities. Dalle and Julien (2003) describe the success of Open Source communities to create a framework for software development in similar terms to those used in the academic world. David and Spence (2003) analyze the development of the Open Source *Globus* grid-computing platform and draw parallels between the Open Source movement and scientific research.

referred to as "self satisfaction" that employees derive from accomplishing technically-advanced or complex tasks) are usually stronger than profit-generating motives (Lerner and Tirole, 2002; Ghosh *et. al.*, 2005).[10] Therefore, programmers are likely to encourage the firm to favour OSS-based strategies in which they can further the performance of programs and continuously be challenged by other practitioners, over proprietary policies.

Programmers' ambition to apply Open Source in their workplace is also driven by learning. The operation of OSS projects as "communities of practice" and the disclosure of source code enable programmers to acquire valuable knowledge, new methods and tools and to develop skills and capabilities upon work that others have done.[11] Third, ideologically, programmers are more motivated to participate in OSS projects through which they can contribute to communities of software developers and users. Fourth, developers of OSS receive credits for their developments and can gain reputation within firms and the professional community, thus enhancing their future career prospects.[12] In our analysis the variable DEVELOPER captures the share of software developers among firm's employees.

The intellectual property of firms includes inventions that have commercial value for them such as copyrighted works, trademarks and patented inventions. Companies that manage larger portfolios of intellectual property also manage their knowledge assets more efficiently and, hence, are assumed to have higher degree of intellectual capacity that enables them to create greater benefits from inventions made outside of the company. Therefore, we expect that firms with larger intellectual property portfolios would be early

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[10] Ghosh *et. al.* (2005) found that programmers that develop OSS do it mainly in their free time as a hobby or leisure activity. Interaction with other professionals and innovativeness were main motives to participate in those projects.

[11] A common view among developers is that "good programmers know what to write. Great ones know what to rewrite (and reuse)" (Raymond, 2001).

[12] For a detailed discussion of developers' motives to participate OSS projects see, e.g., Lerner and Tirole (2002).

adopters of innovations, such as the Open Source methodology and programs. In the case of software, it is particularly difficult to measure the volume of intellectual property that a firm owns, as the majority of software products are by nature protected by copyrights.[13] There are no statistical data available on the size and range of copyrighted software of the companies. However, our dataset includes records of trademarks and patent applications of firms in Finland and in the United States, used to form an indicator for the intellectual capacity of companies. We form a variable (IPR) that gives a rough idea of a firm's intellectual property. The variable gets values from 0 to 3 as a sum of three dummy variables that measure whether firm has applied some of the following appropriation methods: i) patents in Finland, ii) patents in the United States and iii) trademarks in Finland. This is by no means a perfect measure of firms' intellectual property, but it roughly distinguishes between companies that have chosen to patent their innovations and/or to protect their trademarks from those that have none.[14]

Since a part of our sampled companies provide only services and do not develop any products, technical innovation usually lies outside the scope of their business and the order of magnitude of patenting activities does not describe well their innovativeness. Therefore, we control for the pure service companies by a dummy variable, PURE_SERVICE that gets value 1 when the firm provides only services and 0 otherwise.

We predict that companies with a larger volume of intellectual capital (i.e. human capital and intellectual property) are more likely to adopt OSS, and test the following hypotheses:

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[13] Different from patent protection, creators of artistic and literary works, **including** software, do not have to register them in order to protect their output. In this sense, copyright protection can be viewed as an "automatic right", unless it is deliberately abolished by the authors, as most OSS licenses do.

[14] Only about 9 % of sampled firms have applied for one or more patents and about 15 % of them applied for one or more trademarks.

Hypothesys 1a: The adoption of OSS-based strategies increases with the share of advanced degree holders employed by the firm.

Hypothesys 1b: The adoption of OSS-based strategies increases with the share of developers employed in the firm.

Hypothesys 1c: The adoption of OSS-bases strategies is positively correlated with the volume of firm's intellectual property.

New companies are often the best exploiters of new business opportunities, including (potentially) radical innovations that make the old business models and technologies obsolete. The economic theory of industrial organization suggests that incumbents may resist technical change not only because they lack of capabilities to apply new methods and techniques, but mainly because they do not want to cannibalize their previous sunk investments in products, facilities and capabilities (Arthur, 1989; various examples in different technological areas can be found in: David, 1985; Cowan, 1990; Cowan, 1991). Further, insights from evolutionary economics suggest that older firms tend to rely on prior experience and to "lock-in" to their regular market strategies, proven procedures and existing know-how. Younger firms are typically more flexible in adapting their strategies and internal practices to the changing environment (Nelson and Winter, 1982). Therefore, older firms would be more reluctant to offer their products and services under OSS licensing terms and to apply OSS-based strategies than recently established companies.

The organizational theory, however, provides also a contradictory view suggesting that older firms may have features enabling them better utilize innovations than younger ones. This may happen as the older firms have over time built up superior resources and capabilities (e.g., more experienced work force, access to extensive distribution channels) that improve their organizational competence and capability to adopt new technologies and

innovate (Sørensen and Stuart, 2000). Hence, whether the older firms are more or less likely adopt OSS supply strategies than younger companies is not clarified in the literature and requires further empirical inquiry.

Strategies of software firms can also be explained by drawing some useful insights on firms' behaviour in different stages of their organizational life and survival over time from *organizational ecology* (Hannan and Freeman, 1989). Organizational ecologists have explored the relations between firm's age and their long-term survival and identified main attributes that explain why some of the infant firms vanish from the market in early stages of development and others reach maturity (see, for example, Hannan and Freeman, 1977; Baum, 1996). They differentiate between three possible relations between firm's lifetime and its probability to succeed in the long term. First, the *liability of newness* suggests that older firms are able to sustain their activities more successfully than young firms, due to formerly established organizational routines that have been proving their efficiencies over time. Further, vast numbers of new firms collapse shortly after commencing their activities due to lack of established routines and experience in a competitive environment (Hannan and Freeman, 1984; Bruderl and Schussler, 1990). Second, the *liability of adolescence* suggests that older firms can rely on their capital and knowledge assets and, hence, enjoy better chances to survive in the long run (Bruderl and Schussler, 1990). Third, the *liability of obsolescence* explains how the performance of firms is negatively affected by age. Older companies often follow firm and established routines despite changes in their business environment. Consequently, those firms that fail to adapt their organizational processes and to renew their technological capabilities remain with obsolete know-how and do not catch up with rivals and with advanced technologies (Henderson, 1999).

In order to avoid stagnation of strategies and obsolescence of their knowledge, firms constantly search for new technologies and ideas (Henderson, 1999). Some firms rely

on internal resources and prefer developing new technical know-how “in-house”. Other firms acquire it from external sources, e.g. by participating in online communities and retrieving their innovative output. Yet, the liability of adolescence suggests that older firms would generally rely on their internal resources (including their augmented body of know-how) and would face lower levels of risk in accomplishing their R&D, avoiding disclosure of source code to external programmers (as participation in OSS development requires). We measure the age of the firm by the (log) year of its establishment (ESTABL_YEAR) and form the following hypothesis:

Hypothesis 2: Application of OSS supply strategies may either decrease or increase as firm’s age increases.

The Open Source model provides a tangible potential for developing innovation and fostering the growth of small and medium enterprises (SMEs) and service firms in the ICT industry. Literally, firms have zero entry and production costs acquiring freely available source code for development of new products and for their own needs. Instead, large established firms are expected to more widely implement proprietary strategies. This rationale draws from three phenomena reported in innovation studies. First, the scale of “critical missions” is typically wider in large firms than in SMEs. Therefore, large firms are more likely to avoid risks and would prefer to develop proprietary software and to implement products from known producers, which include vendor’s liability and technical support.

Second, cost-saving opportunities through implementation of OSS largely affect the strategic choices of SMEs. However, the ability of organizations to reduce their investments in information technologies by applying OSS is highly controversial. Numerous studies (e.g. IDC, 2002 and Gartner, 2003) have reached opposite conclusions on the total costs of ownership (TCO) of desktop and server installations of Linux vs.

Microsoft's proprietary systems. Anecdotal evidence suggests that TCO of information technologies implemented in public organizations can be lowered by applying OSS (see for example, Fitzgerald and Kenny, 2003a, b).

Independence from large software vendors is another important factor that may affect the preferences of SMEs to implement OSS or proprietary products. The Microsoft Anti-trust case illustrates how firms' choices are significantly affected by the business practices of the monopolist. Whinston (2001) reviews the economics underlying this case and argues that Microsoft relied on two prominent strategies: First, it established exclusive agreements with hardware vendors to provide its operating system as the sole platform for their products. A second and complementary strategy was the bundling of applications (e.g. Microsoft Internet Explorer and Media Player) with its operating system, offering distributors reduced licensing fees, co-marketing funds and other incentives to promote them. OSS has then provided users with alternative products, which guarantee technical flexibility and can be obtained for less than Microsoft's monopoly price. However, the use of those alternative products has remained relatively limited as SMEs often lack the magnitude and the variety of IT skills necessary to implement non-standard, non-complementary applications. Against that Lakhani and Von Hippel (2003) suggest that Open Source communities have succeeded in providing solutions to the limited resources of SMEs by creating efficient online "helpdesks" for OSS users. Those online services successfully substitute formal technical support offered by proprietary software producers.

Third, successful adoption of OSS strategies requires knowledge flows between workers by forming organizational interaction structures that "resemble a great babbling bazaar of differing agendas and approaches out of which a coherent and stable system could seemingly emerge only by a succession of miracles" (Raymond, 2001). Therefore, Open Source model may be foreign to the ways many large organizations operate. In a

study on barriers to innovation in large firms, Dougherty (1992) concludes that large firms usually combine a broad variety of organizational units that operate like distinct “thought worlds”, focusing on different elements of knowledge, technologies and markets. Further, distinct organizational routines and byrocracy form high barriers for informally coordinated collective innovation and joint learning that results in **separate**, rather than coordinated, different *thought worlds*. As the degree of informal knowledge exchange is typically lower in large firms and complex informal structures of communication are less observant in them, we expect that their abilities to integrate their software development and implementation activities with those of Open Source communities would be more limited than SMEs. The variable SIZE, the order of magnitude of firm’s turnover, captures the firm size (see Table 1 for a more detailed description).

We form the following hypothesis:

Hypothesis 3: The propensity to apply OSS-based supply strategies decreases with the firm’s size.

The ownership structure of firms may also affect the OSS strategies that they adopt. *Agency theory* suggests that decision-making in family-owned firms may differ from those in the other companies (Schulze *et. al.,* 2001). Family-owned companies typically have less managerial incentive problems than diffusely held companies, as the owner is often either the manager or, due to his major shareholder position, has incentive to closely monitor what the manager does. This reduces the chance that the manager would make investments that are not the best interest of the firm and, rather, would provide himself some private benefits, such as improved career opportunities. The managers of diffusely held software companies do not fully bear the costs of their strategic decisions and they may further gain some private benefits from adoption of OSS supply strategy (such as knowledge and experience that enhances the market value of their own human capital and

thus their future career opportunities). Hence, more likely they would apply OSS strategy than the manager-owners.

In addition, OSS supply strategy may be adopted for *signalling* to the investors that the firm has innovative capabilities and knowledge that increase its (future) value. This is particularly important for the diffusely-held companies that have a plenty of small individuals shareholders. Moreover, family- or individual-owned firms tend to be more risk-averse than diffusely held companies as often the private wealth of manager-owners is tied to the company. Therefore, as OSS business is a new business model and a relatively risky investment with highly uncertain returns, family-owned companies may be more reluctant to adopt OSS supply strategies.

Koski (2005) indicates that family-owned software firms *that have adopted the OSS business model* tend to supply proprietary software products or have a hybrid OSS strategy that is biased towards supply of proprietary solutions more often than diffusely-held OSS companies. Therefore, we expect that family- and individually-owned firms would apply purely proprietary strategies more often than OSS and hybrid strategies. In our analysis, the dummy variable FAMILY_OWN distinguishes between family-owned and diffusely-held companies. Hence, we can form the following hypotheses:

Hypothesis 4: Family-owned firms are more likely to apply proprietary software supply strategies than other companies.

In network markets, such as information technologies, complementary products and services have an important role. As Open Source business strategies rely on the distribution of free products, complementary services play a major role in generating revenues. We use two types of variables to capture the influence of service provision on the decision to adopt OSS supply strategy. First, in the case of model 1, we measure the order of magnitude of a firm's service variety by a variable SERVICE_VARIETY that receives values on a 0 to 11

scale: If a firm does not offer any services it gets value 0, while a firm that provides services in all of the sampled categories it gets the value 11.

Hypothesis 5: Larger variety of services is positively correlated with firm's propensity to adopt an Open Source business strategy.

We empirically test which particular service types affect the adoption of Open Source software business strategy. For this purpose, we use in Model 2 dummy variables for 11 service categories of our sampled data (see Table 1 for a detailed description of the service types).

3. Empirical analysis

Our data were collected by a web survey[15] during the period of November 2004 – February 2005. We approached 591 Finnish software companies by e-mail messages asking them to respond to our web questionnaire.[16] The data comprises responses from 170 firms (circa 30 % response rate) and covers about 8 % of all software firms in Finland. In our sample, 73 firms supply OSS products and/or services and 97 offer merely proprietary software or services. Seven of the proprietary software producers had previously supplied OSS products/services but discontinued OSS activities.

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[15] The questionnaire used for our web survey was developed in collaboration with the Italian, Spanish, Portuguese and German partners – who undertake a similar survey, with the exception of few country-specific questions, in their countries – of the ELISS (European Libre Software Survey) project. Further information regarding the questionnaire is available from the author.

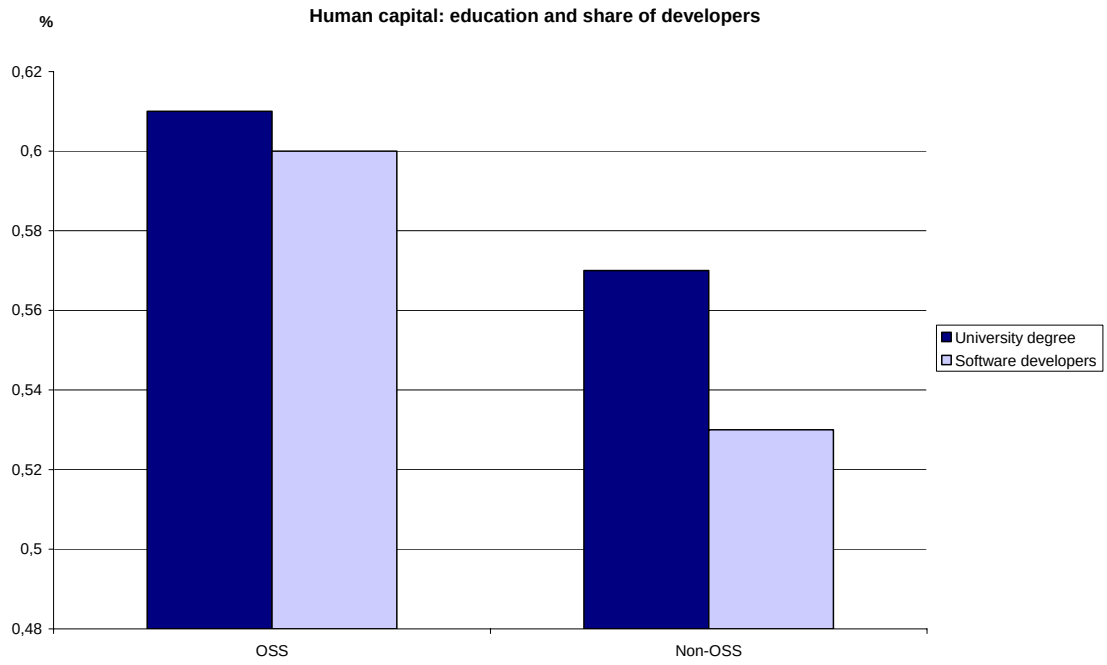
[16] The first e-mail message was followed by several follow-up e-mails, and in January 2005 our research assistant contacted potential respondents by telephone to remind them of the survey.

Table 1. Explanatory variables

Variable	Definition	Mean (Std dev)	Min value	Max value
EDUC	Log share of employees having at least university degree	-0.581 (0.653)	-2.944	0
DEVELOPER	Log share of software developers of firm's employees.	-1.107 (2.001)	-9.210	0
IPR	Variable that is the sum of three dummy variables that get value 1 if firm has applied i) patent(s) in Finland, (ii) patent(s) in the US, iii) trademarks in Finland (and 0 otherwise).	0,252 (0,511)	0	2
SIZE	Variable gets Log(Value) if firm's turnover in 2003 is (1000 Euros) 2 0 3 1 - 199 4 200 – 399 5 400 – 999 6 1000 – 1999 7 2000 – 9999 8 10000 – 19999 9 20000 -	1.525 (0.339)	1.099	2.197
ESTABL_YEAR	Log the year firm was established.	7.599 (0,004)	7.583	7.603
FAMILY_OWN	Dummy variable that gets value 1 if firm is owned by a family or an individual person and 0 otherwise.	0.645 (0.480)	0	1
PURE_SERVICE	Dummy variable that gets value 1 if firm provides only services and 0 otherwise	0.101 (0.302)	0	1
SERVICES	Service variety = number of service categories (S1…S11 below) provided by firm, variable gets values between 0 and 11.	7.276 (3.044)	0	11
S1_Consultancy	Dummy variable that gets value 1 if firm provides consultancy services, 0 otherwise	0,904 (0.206)	0	1
S2_Integration	Dummy variable that gets value 1 if firm provides integration services, 0 otherwise	0.716 (0.452)	0	1
S3_Installation	Dummy variable that gets value 1 if firm provides installation services, 0 otherwise	0.627 (0.485)	0	1
S4_Assistance	Dummy variable that gets value 1 if firm provides assistance services, 0 otherwise	0.754 (0.432)	0	1
S5_Maintenance	Dummy variable that gets value 1 if firm provides maintenance services, 0 otherwise	0.784 (0.413)	0	1
S6_SystemManagement	Dummy variable that gets value 1 if firm provides system management services, 0 otherwise	0.425 (0.496)	0	1
S7_Training	Dummy variable that gets value 1 if firm provides training services, 0 otherwise	0.731 (0.445)	0	1
S8_Application Management	Dummy variable that gets value 1 if firm provides application management, 0 otherwise	0.440 (0.498)	0	1
S9_Adapting codes written by third parties to suit customers' needs	Dummy variable that gets value 1 if firm adapts codes written by third parties to suit customers' needs, 0 otherwise	0.701 (0.459)	0	1
S10_On order software development from the scratch	Dummy variable that gets value 1 if firm does On order software development from the scratch, 0 otherwise.	0.694 (0.463)	0	1
S11_Generating documentation	Dummy variable that gets value 1 if firm generates documentation, 0 otherwise	0.500 (0.501)	0	1

Figure 1 compares the human capital, i.e. the share of developers and employees with a university degree, of OSS firms with those of non-OSS firms. On average, OSS firms employ relatively more developers and that their employees have higher education than in companies that provide only proprietary solutions. About 61% (57%) of employees of OSS (non-OSS) companies have obtained some sort of a university degree, usually a Bachelor's or a Master's degree and less than 2% of the employees have a PhD. About 60% (53%) of the degree holders are developers. The statistical significance of these descriptive observations is tested in the estimations of the empirical models.

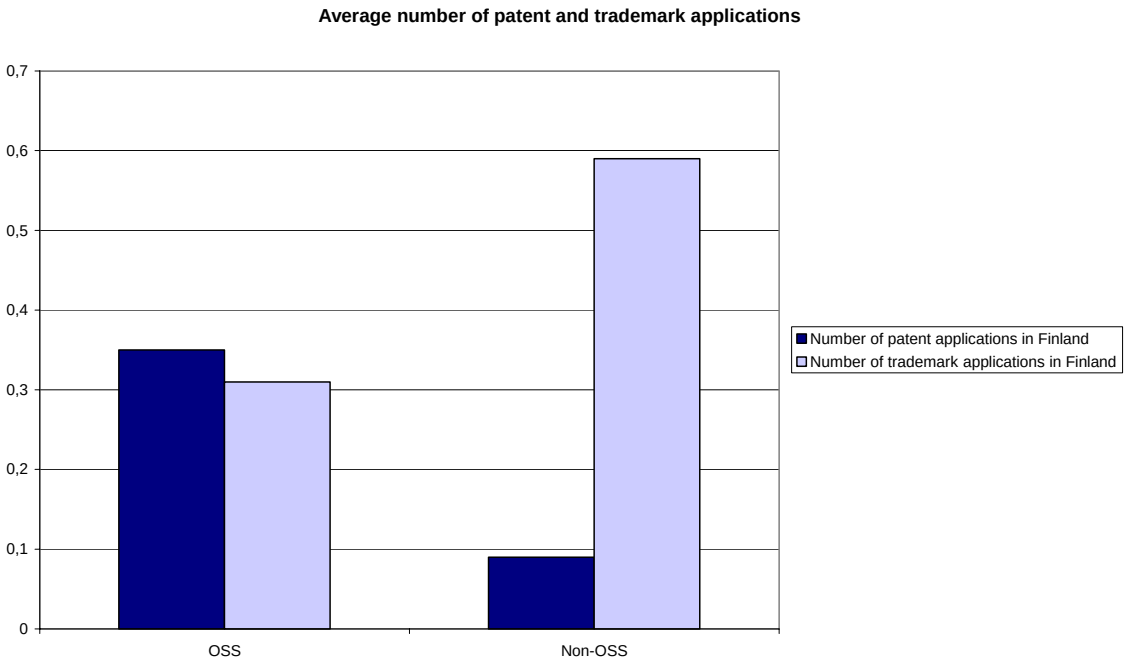
Figure 1. Human capital: share of developers and employees with university degree



A relatively small share of the companies in our sample applied for patents in Finland or in the United States, 10% and 11% respectively among the non-OSS and OSS firms. The Open Source movement is strongly associated with the opposition to software patents and patenting in general, yet companies that provide OSS solutions are not less active in this respect than firms that develop and supply proprietary software. On average, an OSS firm filed 0,35 patent applications in Finland, whereas non-OSS companies filed

only 0,09 patent applications. Proprietary solution providers had more trademark applications than OSS firms: about 19% of the non-OSS firms applied for trademarks with 0,59 trademarks per firm, in comparison to 10% of the OSS firms that applied for trademarks with 0,31 trademarks per firm.

Figure 2. Patent and trademarks applications per firm: OSS vs. non-OSS firms



4. Discussion of the Estimation Results

We first estimate the probit model that compares software companies supplying OSS products and/or services (dependent variable gets value 1) with those companies that provide only proprietary products and services (dependent variable gets value 0). Table 2 presents the estimation results. As various individual service dummy variables and the service variety variable SERVICES were quite highly correlated we used these variables in two separate models. Model 1 includes SERVICES variable and Model 2 individual service dummy variables.

Table 2. Estimation results for the probit model: OSS vs. non-OSS firms

MODEL	**Model 1**	**Model 2**
Variable	Coefficient (t-value)	Coefficient (t-value)
C	-769,32 (-2,00)	-1009,86 (-1,9)
EDUC	**0,824 (2,258)**	**1,129 (2,744)**
DEVELOPER	-0,06 (-0,591)	0,018 (0,099)
IPR	-0,031 (-0,095)	0,716 (1,605)
SIZE	**-1,653 (-2,620)**	**-2,660 (-2,716)**
ESTABL_YEAR	**101,59 (2,013)**	133,789 (1,790)
FAMILY_OWN	**-0,872 (-2,373)**	**-1,471 (-2,284)**
PURE_SERVICE	-0,601 (-0,985)	-0,853 (-0,977)
SERVICES	**0,139 (2,514)**	
S1_Consultancy		**-3,138 (-2,333)**
S2_Integration		0,370 (0,657)
S3_Installation		-0,501 (-0,796)
S4_Assistance		0,135 (0,155)
S5_Maintenance		-0,432 (-0,484)
S6_SystemManagement		**1,272 (2,137)**
S7_Training		0,450 (0,866)
S8_Application Management		0,889 (1.536)
S9_Adapting codes written by third parties to suit customers' needs		0,223 (0,443)
S10_On order software development from the scratch		0,632 (0,126)
S11_ Generating documentation		0,228 (0,430)
Number of observations	87	87
Fraction of correct predictions	72,4 %	82,8 %
Log-likelihood	-44,86	-31,25

Addressing Hypothesis 1, we find that a firm's human capital does, indeed, affect the adoption of Open Source business strategy among the Finnish software companies. Those companies that have larger academically-educated staff are more likely to employ Open Source business strategies. This finding is not surprising, considering the tight links between OSS and universities and as application of OSS within organizations involves complex commercial and legal issues that require expert knowledge in multiple areas.

Unexpectedly though, the proportion of software developers of firm's employees is not statistically significantly related to the adoption of Open Source software business model. The principles of *absorptive capacity* (Cohen and Levinthal, 1990) might provide an explanation for this finding: the firm should obtain a minimal threshold, in terms of human capital and its know-how, to be able to apply new technological and strategic practices. Implementation of an OSS-based strategy is rather complex and requires not only technical and managerial knowledge, but also legal expertise in intellectual property rights and the ability to interpret OSS licensing conditions and to anticipate their impact on the competitive position of the firm.[17] Therefore, when the number of developers (and possibly also managers) who are familiar with OSS is rather limited, despite being a significant share of the firm's employees motivated to produce OSS solutions, the firm would fail to achieve the necessary level of business and technical know-how required to apply OSS based strategy.

The measure of a firm's intellectual property has a positive coefficient, as expected, with adoption of an OSS supply strategy, but it is not statistically significant.

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[17] Lerner and Tirole (2005) analyze the market determinants that affect the choice of OSS licensing terms by software developers. They conclude that restrictive licenses are applied more often for programs that are used by end-users and system administrators than for applications there are used by software developers.

Yet, the firm's human capital seems to play a greater role in the decision to supply OSS than the volume of its intellectual property. The estimation results concerning the firm age (Hypothesis 2) and size (Hypothesis 3) give further support to this interpretation: Younger and smaller firms typically have accumulated less knowledge and intellectual property than older and larger companies. By providing OSS solutions, young firms and SMEs are able to acquire publicly available know-how and to substitute lack of in-house capabilities and R&D. Therefore, those firms supply OSS solutions more often than other companies. Other parts of our survey also made it clear that OSS provision is a desirable strategy particularly for small software companies. According to the respondents, the top two incentives that motivate firms to offer OSS are: "Being independent from the price and license policies of large software producers" and "Exploiting the possibility Open Source software offers to be innovative while staying small".

Testing Hypothesis 4, we find that the software firms that are owned by a family or one to two individuals are also less likely to adopt OSS business strategies. In other words, diffusely held companies of which managers are typically less often the owners of the company (or if so, with only a small ownership share) tend to supply open source solutions more often than the other firms. This result further confirms the empirical findings of Koski (2005).

There are various possible underlying reasons for this finding including the more risk-averse behaviour of the manager-owners and a greater need of the managers of diffusely held companies to signal to the investors the future potential of the company. Also, it is possible that in diffusely held software firms the managers adopt risky and uncertain OSS supply strategy more easily than in the manager-owned companies for the reasons that rather relate to their personal interests (such as future career opportunities) than the best interest of the firm.

The magnitude of service variety of the firm (variable "SERVICES") is positively and significantly correlated with the adoption of OSS business strategy (Hypothesis 5). This finding indicates that provision of a broad variety of complementary services is a key attribute in establishing business strategy for software solutions markets on the basis of OSS. Firms that offer a wider variety of services in the software markets benefit more from the widespread diffusion of free software products. In this respect, complementarities indeed play an important role in shaping the strategic business decisions of the software companies.

In particular, two service types (denoted by dummies variables) get a statistically significant coefficient: "System management services" is positively and "Consultancy" negatively related to the adoption of OSS supply strategy. Firms' choice to base services that they provide on OSS programs is largely driven by their success and widespread implementation.[18] The reliability of OSS applications, their zero price tag and the knowledge involving implementation and use of OSS platforms, such as the Linux operating system and the Apache server application, seems to influence open source firms to provide particularly services supporting system management solutions. Proprietary solution providers, instead, appear to more active in general consultation than OSS firms. It is difficult to assess what is the underlying reason of this finding but it is possible that the firms of which business model is, by and large, based on selling licenses, have a greater incentive to consult their clients concerning their choice of software solutions (i.e. to sell licenses for their own products).

[18] Analysis of over 85 million websites shows that the OSS Apache is the leading server application with 61.25% of the hosted websites. Microsoft's Windows server follows with 29.7% market share (Netcraft Server Survey, June 2006; Available in: http://news.netcraft.com/archives/web_server_survey.html).

Table 3. Estimation results for the probit model: pure OSS vs. hybrid firms

Variable	Coefficient (t-value)
C	-999,062 (-0,999)
EDUC	0,024 (0,048)
DEVELOPER	0,113 (0,572)
IPR	0,174 (0,274)
SIZE	-0,319 (-0,311)
ESTABL_YEAR	130,602 (0,999)
FAMILY_OWN	-0,161 (-0,295)
SERVICES	0,022 (0,292)
Number of observations	44
Fraction of correct predictions	81,8 %
Log-likelihood	-19,30

Table 3 shows the estimation results for the probit model of which dependent variable gets value 1 if a firm provides only OSS solutions and 0 if a firm provides both OSS and proprietary solutions. This estimation aims at detecting factors that explain the differences between pure OSS solution providers and firms that apply hybrid strategies that involve both OSS and proprietary solutions. None of the explanatory variables manages to explain statistically significantly the differences between the pure OSS and hybrid OSS companies. Of course, it is possible that those two types of companies do not differ much from one another due to the independent variables that are used in this analysis, but the small sample size remaining for this estimation (44 OSS providers and only 10 pure OSS companies among them) might also be the reason for the poor explanatory power of the variables. Hence, a larger sample will be needed for further investigation and in order to arrive to far-reaching conclusions.

5. Conclusions

This paper addresses the following question, which is of major significance for understanding firms' motivation to adopt and develop OSS: Which types of software firms adopt OSS supply strategies, and what are the firm attributes that foster or hinder the decision to implement OSS-based strategy?

This paper is the first to systematically analyze how software firms that have chosen OSS strategy differ from providers of proprietary software solutions, by using econometric estimations. Our data was collected from a survey that included Finnish software and services providers. Our study concludes that younger, smaller and more service-oriented companies tend to base their software supply strategies on OSS more than other firms that focus merely on provision of proprietary software solutions.

Our main hypothesis concerns the role that *absorptive capacity* of software firms plays in their decision to adopt an innovative and relatively risky business strategy, such as OSS-based supply strategy. We find that the quality of human capital in the firm indeed affects its strategy. Those companies that have relatively more highly-educated employees choose to supply OSS solutions. However, our data do not indicate that a firm's accumulated intellectual property affects its OSS strategy choice in any significant way.

References

Antonelli C. (1995), *The Economics of Localized Technological Change and Industrial Dynamics*, Dordrecht, Kluwer Academic Publishers.

Arthur W.B. (1989), "Competing Technologies, Increasing Returns, and Lock-In by Historical Events", *Economic Journal,* Vol. 99, pp. 116-131.

Baum J.A.C. (1996), "Organizational Ecology", In: Clegg S.R., Hardy C., Nord W.R. (eds.), *Handbook of Organization Studies,* London, Sage.

Bonaccorsi, A. and C. Rossi (2003a), "Comparing Motivations of Individual Programmers and Firms to Take Part in The Open Source Movement. From Community to Business", mimeo, Laboratory of Economics and Management, Sant'Anna School of Advanced Studies, Pisa, Italy.

Bonaccorsi, A. and C. Rossi (2003b), "Licensing Schemes in The Production and Distribution of Open Source Software. An Empirical Investigation", Sant' Anna School of Advanced studies, Institute for Informatics and Telematics (IIT), Pisa, Italy.

Bonaccorsi, A. and C. Rossi (2003c), "Why Open Source Software Can Succeed", *Research Policy*, Vol. 32, No. 7.

Brooks F.P. (1995), *The Mythical Man Month and Other Essays on Software Engineering*, Addison Wesley.

Bruderl J., Schussler R. (1990), "Organizational Mortality: The Liabilities of Newness and Adolescence", *Administrative Science Quarterly*, Vol. 35, No. 3.

Cohen, W.M. and Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning an innovation. *Administrative Science Quarterly*, Vol. 35, No. 1, pp. 128-152.

Cowan, R. (1990), "Nuclear Power Reactors: A Study of Technological Lock-In", *Journal of Economic History*, Vol. 50, pp. 541-566.

Cowan, R. (1991), "Tortoises and Hares: Choice Among Technologies of Unknown Merit, *Economic Journal*, Vol. 101, pp. 801-814.

Cowan R. Harison E. (2001), "Protecting the Digital Endeavour: Prospects for Intellectual Property rights in the Information Society", The Dutch Advisory Board on Technological Policy (AWT), *Background Study*, No. 22.

Dahlander, L. and M.G. Magnusson (2005), "Relationships Between Open Source Software Companies and Communities: Observations from Nordic Firms", *Research Policy*, Vol. 34, No. 4, pp. 481-493.

Dalle J.M and N. Julien (2003), "Libre' software: Turning Fads into Institutions?", *Research Policy*, Vol. 32, No. 1, pp. 1-11.

David P.A.(1985), "Clio and the Economics of QWERTY", *American Economic Review Papers and Proceedings*, Vol. 75, pp. 332-337.

David P.A., Spence M. (2003), "Towards Institutional Infrastructures for E-Science: The Scope of the Challenge", *Research Report*, Oxford Internet Institute, September 2003.

DiBona C., Ockman S., Stone M. (eds.) (1999), *Open Sources: Voices from the Open Source Revolution*, Sebastopol, O'Reilly and Associates.

Dougherty, D. (1992), "Interpretive barriers to successful product innovation in large firms", *Organizational Science*, Vol. 3, No. 2, pp. 179-202.

Feller, J. and B. Fitzgerald (2002), Understanding Open Source Software Development, Addison Wesley.

Fink, M. (2003), The Business and Economics of Linux and Open Source, Prentice Hall.

Fitzgerald B., Kenny T. (2003a), "Open Source Software can Improve the Health of the Bank Balance - The Beaumont Hospital Experience", *mimeo*.

Fitzgerald B., Kenny T. (2003b), "Open Source Software in the Trenches: Lessons from a Large-Scale Implementation", *Proceedings of the Twenty-Fourth International Conference on Information Systems*, Seattle, December 2003.

Freeman C., Soete L. (1997), *The Economics of Industrial Innovation*, Cambridge, MIT Press, 3rd Edition

Gartner (2003), "Examining Where Desktop Linux and Open-Source Office Products Make Sense", Research No. G00129106.

Garzarelli, G. and R. Galoppini (2003), "Capability Coordination in Modular Organization: Voluntary FS/OSS Production and the Case of Debian GNU / Linux", mimeo, Università degli Studi di Roma "La Sapienza".

Ghosh R.A., Glott R., Krieger B., Robles G. (2005), "Free Software Developers: Who, How and Why", In: Soete L., Ter Weel B. (eds.), *The Economics of the Digital Society*, Edward Elgar, *forthcoming***.**

Granstrand O. (2000), "The Shift Towards Intellectual Capitalism - The Role of Infocom Technologies", *Research Policy*, Vol. 29, pp. 1061-1080.

Hall B.H. (1999), "Innovation and Market Value", *NBER Working Paper*, No. 6984, NBER, Washington D.C.

Hannan M.T., Freeman J. (1977), "The Population Ecology of Organizations", *American Journal of Sociology*, Vol. 82.

Hannan M.T., Freeman J. (1984), "Structural Inertia and Organizational Change", *American Sociological Review*, Vol. 49.

Hannan M.T., Freeman J. (1989), *Organizational Ecology*, Cambridge, Harvard University Press.

Harison E., Cowan E. (2004), "On Substitution of Intellectual Property and Free Disclosure in Software Platforms: An Ex-Ante Analysis of R&D Strategies", *Economics of Innovation and New Technology*, Vol. 13, No. 5.

Henderson A.D. (1999), "Firm Strategy and Age Dependence: A Contingent View of Liabilities of Newness, Adolescence and Obsolescence", *Administrative Science Quarterly*, Vol. 44, No. 2.

Henkel J., Tins M. (2004), "Munich/MIT Survey: Development of Embedded Linux", *Report*, Institute for Innovation Research, Technology Management and Entrepreneurship, University of Munich, May 2004.

Koski H. (2005), "OSS Production and Licensing Strategies of the Software Firms", *Review of Economic Research on Copyright Issues* 2, 111-125.

Kuan, J. 2001, “Open Source Software as Consumer Integration into Production”, working paper, Available in: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=259648.

Lakhani K., Von Hippel E. (2003), “How Open Source Software Works: “Free” User-to-User Assistance,” *Research Policy*, Vol. 32, No. 6.

Lerner J., Tirole J. (2002), “The Simple Economics of Open Source”, *Journal of Industrial Economics*, Vol. 50, No. 2, pp. 197-234, June 2002.

Lerner J., Tirole J. (2005), “The Scope of Open Source Licenses”, *Journal of Law, Economics and Organization*, Vol. 21, No. 1, pp. 20-56.

McKelvey M. (2001), “The Economic Dynamics of Software: Three Competing Business Models Exemplified Through Microsoft, Netscape and Linux”, *Economics of Innovation and New Technologies*, Vol. 10.

Nelson R.R. and S.G. Winter (1982), *An Evolutionary Theory of Economic Change*, Belknap Press of Harvard University Press Cambridge, Mass.

Nonaka I., Toyama R. and A. Nagata (2000), “A firm as a knowledge creating entity: a new perspective on the theory of the firm”, Industrial and Corporate Change Vol. 9, No. 1, pp. 1-20.

Raymond E. (2001), “The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary”, Sebastopol, O’Reilly

Schulze W.S., Lubatkin M.H., Dino R.N., Buchholtz A.K. (2001), “Agency Relationships in Family Firms: Theory and Evidence”, *Organization Science*, Vol. 12, No. 2.

Scotchmer S. (1991), “Standing on the Shoulders of Giants: Cumulative Research and the Patent Law”, *Journal of Economic Perspectives*, Vol. 5, No. 1.

Sorensen J.B. and T.E. Stuart (2000), “Aging, Obsolescence, and Organizational Innovation”, *Administrative Science Quarterly*, Vol. 45, pp. 81-112.

Välimäki M. and Oksanen V. (2005), “The impact of free and open source licensing on operating system software markets”, *Telematics and Informatics*, Vol. 22, No. 1-2.

Von Westarp F. (2003), *Modeling Software Markets: Empirical Analysis, Network Simulations, and Marketing Implications*, Heidelberg, Springer / Physica-Verlag.

West J. (2003), “How Open is Open Enough? Melding Proprietary and Open Source Platform Strategies”, *Research Policy*, Vol. 32, No. 7.

Whinston M.D. (2001), “Exclusivity and Tying in U.S. v. Microsoft: What We Know, and Don’t Know”, *Journal of Economic Perspectives*, Vol. 15, No. 2.

Young R. (1999), “Giving It Away: How Red Hat Software Stumbled Across a New Economic Model and Helped Improve an Industry”, In: DiBona C., Ockman S., Stone M. (eds.).

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