OSS PRODUCTION AND LICENSING STRATEGIES OF SOFTWARE FIRMS

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ABSTRACT. This study sheds light on the relatively recently emerged new business models employing open source activities in the software industry. We analyze data from 73 Finnish OSS companies' product type (i.e. proprietary vs. OSS product) and license type (i.e. the copyleft vs. non-copyleft licenses) choices. Our data indicate that firm ownership structure has a major influence on software firms' business strategies. Family owned firms tend to rely on the traditional proprietary software in their product selection, whereas diffusely held companies are more likely to supply OSS products. We also find that more service oriented firms are likely to offer more complementary products and further supply their products more often under the OS licenses. Moreover, the market trends concerning a firm's software products affect the license type decisions of the software firms. Consistent with the international data on the dominance of the Apache server that is released under the non-copyleft license, we find that servers are more likely to be licensed under the non-copyleft license. Our estimation results further suggest that a more restrictive form of open source licenses, the copyleft license, is used more often in those companies that have participated in open source software development projects. This finding is consistent with earlier studies that have found that more than 70% of the OSS development projects employ the GPL copyleft license.

1. INTRODUCTION

The roots of open source software (OSS) production lie in the early 1990s when Linus Thorvalds, a student working to improve functionality of his own computer, made the source code for the kernel of his newly developed operating system, made publicly available via an Internet newsgroup. This event marked the birth of a global community that began to develop voluntarily and without any monetary compensation (e.g., by fixing bugs, improving source code and providing new features) the now famous and widely distributed Linux operating system.[1] The Linux open source project was followed by various other international open source software development projects (e.g. the Apache web server project, the Perl programming language project) that were based on the same open source community rules: voluntary participation, no monetary compensation for developers, and free access and utilization of the produced source code and its modifications for everyone.

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[1]See Weber (2004) for a more detailed description of the early phases of development of the Linux operating system.

Economists' attraction to the open source phenomenon arose, by and large, from its peculiar features that seem to contradict some key economic principles. Particularly, the notion that open source software is a typical public good[2] and thus the private incentives for its production should be low due the individuals' strong incentives to free-riding.[3] Not only individual developers but also firms are increasingly providing OSS products and services for open source software and looking for new business strategies in a market environment that is characterized by bipolar production of free and priced software.[4] The motivations of the firms providing OSS are quite different from those of the individuals (Bonaccorsi and Rossi, 2003a) but the economics of the OSS phenomenon in the entrepreneurial context – for example, how OSS providers differ from non-providers, what determines licensing choices of firms – is still quite poorly understood as firm-level studies are scarce. In addition to the interesting studies of Bonaccorsi and Rossi (2003a, 2003b) based on the survey data they have collected from the Italian firms, there are some firm-level case studies (see, e.g., Dahlander, 2004) that aim at providing information on the OSS production strategies at the firm level.

Existing empirical (econometric) research concerning OSS license choices focuses on the project level decisions rather than a firm level decision making. Lerner and Tirole (2005) and Fershtman and Gandal (2004) compile their data from a large, publicly available database of the SourceForge website. Their estimation results suggest that the order of magnitude of restrictiveness of software licenses matter, and affect the behaviour of individual developers as well as the project types and outcomes. Lerner and Tirole find that the programs targeted for end-users are likely to have more restrictive licenses than those meant for developers. The empirical exploration of Fershtman and Gandal further indicates that when licenses are more restrictive, the output of the contributors of OS programs is much smaller. Both studies also find that less commercial projects tend to employ more restrictive licenses. This finding is further supported by the firm-level data of Bonaccorsi and Rossi (2002): it seems that the firms that have chosen more restrictive software licenses produce fewer proprietary software products.

The primary goal of this paper is to shed light on the question of the underlying factors affecting entrepreneurial software product and license decisions among those firms that employ OSS strategies (i.e. among those firms that supply at least part of their products under the open source license). Unlike previous studies concerning the firm-level software license choice, this study uses a systematic empirical (i.e. econometric) analysis to investigate firms' licence decisions. We use data comprising information on the product type (i.e. proprietary vs. OSS product) and license types (i.e. the copyleft vs. non-copyleft licenses) of 18 different product groups

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[2]Since OSS has been produced, anyone can use it without affecting other people's consumption of it (i.e. it's non-rival) and it is not possible to prevent anyone's access to it (i.e. it's non-excludable).

[3]The puzzle of OSS production by a large, voluntary group of developers working without any monetary compensation has provided motivation for various studies investigating the underlying reasons for such voluntary participation (see, e.g., Lerner and Tirole, 2002).

[4]IBM's January 2005 decision to make 500 of its patents freely available for open source software users and developers provides an interesting example of how also large companies with the valuable intellectual property (IP) portfolios protected traditionally by IP law are moving towards new strategies based (at least partly) on open source business models.

supplied by the sampled 73 Finnish software companies. These data were collected through a web survey between November 2004 and February 2005.

Our data suggest that both firm and product specific factors explain differences in the software supply strategies of the companies. The ownership structure of the firm seems to be one of the important determinants: family owned firms with controlling owners (or owners whose main investment object the firm is) are more inclined to supply proprietary software, whereas diffusely held companies tend to supply OSS products more often. Our estimation results also indicate that the copyleft license, the dominant license type in the international OSS projects (Lerner and Tirole, 2005), is used more often in those companies that have participated into the open source software development projects. Moreover, we find – consistent with the world's market dominance of the non-copyleft Apache server – that servers tend to be released under the non-copyleft license.

The paper is organized as follows. Section 2 discusses the firm's choice of software product type and the OSS licensing decision. Section 3 introduces the data and provides some observations from the sampled Finnish software industry. Section 4 introduces the econometric models used in our empirical investigation and discusses the estimation results. Section 5 concludes.

2. Software supply and license choice

Software producers have a variety of options to distribute their products. They may choose a paid proprietary form that does not allow their customers to re-use or modify the source code of the program, or they may decide to release the source code under one of the many open source licensing options from the commonly used license forms (such as the GNU General Public License, GPL) or to design their own license fitting the firm's specific needs. We employ a simple framework for the analysis of a firm's product type and a license decision: a software provider first decides whether it makes software available under an OS license, and if yes, it then decides what type of license it employs.

The fundamental difference between different open source licenses is how freely the user can modify, develop and redistribute its source code. There are two major categories of OSS products: i) products whose source code is released under the non-copyleft license and ii) products whose source code is released under the copyleft license.[5] The copyleft license means that the modified code has to be made fully available under the same copyleft license than the original and is thus a very restrictive license type. The GPL is the most commonly used copyleft license. On the other hand, the non-copyleft licenses such as Berkeley Software Distribution (BSD) or Apache type licenses are relatively unrestrictive as anyone can modify, develop and sell commercial products that comprise the source code released under non-copyleft license.

In our sample, all licensors are firms, so we assume that commercial incentives (e.g., increased sales of supporting services for software products) dominate the

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[5]Unfortunately, our data comprises too few observations on the dual-licensed products for an empirical analysis. The dual license allows the user to decide whether he wants to have software for free and its source code with the defined OSS license or pay for a less restrictive commercial license that allows the customer to use software for producing proprietary products. From the customers' point of view the dual license practice gives the greatest degrees of freedom to decide whether and how to redistribute the source code of software.

decision making, though non-commercial incentives arising from social or ideological motivations are not ruled out. The profitability and business models of OSS provision are still a poorly understood phenomena and there is no single theoretical framework existing that would guide us in the selection of the potential determinants of firm-level software license choices. We therefore choose for our empirical analysis factors found in the existing economic and organizational studies to determine entrepreneurial innovation as well as other potentially influential variables that the discussion on the OSS phenomenon has addressed. Tables 1 provides the descriptive statistics of the models used in our empirical analysis.

Model	Dependent variable: product	Frequency (% of obs)
Model I	0= firm does not supply the product	446 (65%)
	1=firm only supplies a proprietary version of the product	73 (11%)
	2=firm supplies product with non-copyleft license	51 (7%)
	3=firm supplies product with copyleft license	114 (17%)
Model II	0=firm only supplies a proprietary version of the product	73 (31%)
	1=firm supplies product with OSS license	165 (69%)
Model III	0=firm supplies product with non-copyleft license	54 (32%)
	1=firm supplies product with copyleft license	114 (68%)

Table 1: Descriptive statistics

The explanatory variables used in the analysis are the following:

- **size**: Log of firm's turnover in 2003. Mean = 6.677, standard deviation = 2.684, minimum value = 2.303, maximum value = 13.305.
- **year**: Log of the year firm was established (establishment year). Mean = 7.600 (1998.71), standard deviation = 0.002 (4.176), minimum value = 7.594 (1986), maximum value = 7.602 (2001).
- **famowned**: Dummy variable that takes the value 1 if firm is owned by a family or an individual person and if it is a main investment object of its owner. Mean = 0.4615, standard deviation = 0.4987, minimum value = 0, maximum value = 1.
- **pserver**: Dummy variable that takes the value 1 if the product is a web or other kind of server, and 0 otherwise. Mean = 0.111, standard deviation = 0.314, minimum value = 0, maximum value = 1.
- **secsofta**: Dummy variable that takes the value 1 if the product belongs to one of the following categories: back up system, firewall, antispam, antivirus, user and identity management, and 0 otherwise. Mean = 0.277, standard deviation = 0.448, minimum value = 0, maximum value = 1.
- **mansofta**: Dummy variable that takes the value 1 if the product belongs to one of the following categories: (data) management software, workflow systems, office automation packages, and 0 otherwise. Mean = 0.224, standard deviation = 0.417, minimum value = 0, maximum value = 1.

- **intsofta**: Dummy variable that takes the value 1 if the product belongs to one of the following categories: email client, instant messaging, web browser, and 0 otherwise. Mean = 0.277, standard deviation = 0.448, minimum value = 0, maximum value = 1.
- **osproj**: Dummy variable that takes the value 1 if firm has participated OSS project(s), and 0 otherwise. Mean = 0.386, standard deviation = 0.487, minimum value = 0, maximum value = 1.
- **licenserev**: Dummy variable that takes the value 1 if the respondent reports that license revenues account for a notable share of firm's revenues, and 0 otherwise. Mean = 0.324, standard deviation = 0.468, minimum value = 0, maximum value = 1.
- **risk**: Legal risks of OSS activities for a firm, calculated as Log of $\sum_i (\text{risk } i)$.[6] Mean = 2.628, standard deviation = 0.183, minimum value = 2.079, maximum value = 2.890.
- **service**: Service provision: Log of the number of service types provided out of 11 service categories (Consultancy, Integration, Installation, Assistance, Maintenance, System Management, Training, Application Management, Adapting codes written by third parties to suit customers' needs, on order software development from scratch, and Generating documentation) + 0,0001.[7] Mean = 1.828 (8.158), standard deviation = 1.548 (3,112), minimum value = -9.210 (0,0001), maximum value = 2.398 (11).

One of the important factors affecting entrepreneurial decision making is the firm's *ownership structure* or its *corporate governance*. Corporate governance defines who makes the investment decisions, how resources are then allocated and how returns from investments are divided. The economic literature on firm organization stresses that separation of ownership and control, conflicting interests of the various self-interested parties in the firm, imperfect and asymmetric information, and costly contracts may give rise to agency problems within the organizations and have non-negligible implications for the firms' investment and innovation behaviour (see, e.g., Jensen and Meckling, 1976; Holmström and Tirole, 1989).[8]

Agency theory suggests that a large shareholder has a greater incentive to monitor managers as he may obtain substantial private benefits from control, whereas a minority shareholder sharing the returns with many other small investors rarely finds the shared benefits of monitoring exceeding the costs he bears totally by himself. In particular, controlling owners who have tied their personal wealth to one firm may monitor its managers more closely than the well-diversified owners and they may also be more risk averse in their decision making since their personal

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[6]This variable is formed by adding the respondents' evaluation of the importance of 6 legal risk factors OSS activities may involve for a firm using scale 1 = very serious risk, 2 = quite serious risk and 3 = not important. The evaluated statements were the following: risk1: "Our product violates software patent", risk2: "We are unaware that our product comprises source code of which IPR belongs to a third party", risk3: "We are unaware that our product comprises source code which is a trade secret of a third party", risk4: "OS licenses are incompatible with one another, risk 5: "the court will decide that our OS licenses are not valid", risk 6: "the court case of SCO against IBM and other companies".

[7]We have added 0,0001 to the "service" variable to be able to take logarithm also in those cases in which the firm does not provide any services, i.e. the variable gets value 0.

[8]The previous empirical studies also provide some evidence of the role of a firm's ownership structure in innovation and adoption of new technologies (see, e.g., Loh and Venkatraman, 1993).

wealth is closely tied to the single investment object. The firm that is owned by an individual or a family and that is the main investment object of its owner – i.e. if the firm's owner has a poorly or non-diversified portfolio – is an ultimate example of the firm whose owner has an incentive to both monitor and control decision making in the firm. We use the dummy variable "famowned" – that takes the value 1 if a firm is owned by a family or an individual person and if it is a main investment object of its owner – to capture the impact of firm ownership structure with a large controlling owner.

We assume that the variable "famowned" is negatively related to OSS provision for various reasons. First, the adoption of an OSS business model can be seen as a risky investment with highly uncertain returns as the supply of OS products means that the product is given away for free and no license revenues are flowing to the firm. Therefore, it seems possible that those companies that have more risk averse owners tend to be more hesitant to offer their products with the OSS license.

Second, it is possible that a firm's decision to begin providing software with the OSS license is used for *signalling* to the investors that the firm has innovative capabilities and knowledge base, and thus future potential to compete in the changing software business. The OSS success stories such as Red Hat and the news of the substantial open source investments of venture capitalists[9] have hardly been missed by the software companies that try to convince markets and investors of their (future) potential to be the next superstar in the highly competitive software markets.[10] A software company may thus aim at giving a positive signal of its (future) value by choosing to provide products with the open source license. Signalling is particularly important for the diffusely held companies that have many small individual shareholders to whom it is too costly to directly monitor managers' performance. Instead, when the firm's ownership is highly concentrated, and especially if its manager is also the firm's owner as is often the case when a firm is family owned, there is no need, or at least less need, for signalling.

Also, in diffusely held companies, the managers may have greater degrees of freedom in choosing and undertaking projects that may not maximize the profits of a firm but instead provide the managers with some private benefits such as improved career opportunities. It is possible that a negative relationship between the OSS provision and the "famowned" variable may also appear due to managerial incentive problems: the manager might be more enthusiastic to join OSS projects to signal and increase his own reputation and future career opportunities even if the expected benefits for the shareholders from OSS activities would not be sufficiently high to justify these activities.

Various empirical studies support the hypothesis that *firm size* matters: small firms are more innovative and likely to employ drastic innovations (see, for example, Cohen and Klepper, 1996). There is another reason why firm size may affect

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[9]The article from NewsForge ("ActiveGrid plans to develop open source grid computing" by Tina Gasperson, November 24, 2004) provides an example of these types of news: "ActiveGrid is a new open source software company that hopes to capitalize on an idea it calls 'commercial open source.' It has already convinced a couple of venture capitalists to front $3 million to develop a tool called the Grid Application Server."

[10]The open source phenomenon continued to attract investors even after the dot.com boom, and in 2004, some analysts worried that the re-vitalized interest of the venture capitalists (VCs) might lead to the new disastrous "Internet bubble". This topic is discussed, e.g., in the article "After the Drought", Economist, April 1, 2004.

a firm's decision to whether or not to choose an open source license: particularly small firms might be attracted by a (potentially) large user base of OSS products that may provide free contributions and feedback for the firm improving its ability to compete with the large software providers. Large companies, instead, already have an existing large installed user base, and they may be afraid that open source software use erodes this user base and that their own OSS activities would cannibalize the markets for their proprietary products. For these reasons, we assume that the variable "size", which we measure by the firm's turnover, is negatively related to the OSS product provision and license choices.

Organizational theory provides two contradictory views on how aging affects the firm's ability to be innovative and utilize new technologies (Sørensen and Stuart, 2000). On the one hand, older firms may have acquired superior resources and capabilities (e.g., more experienced work force, reputation, access to extensive distribution channels) that improve their organizational competence and capability to innovate. On the other hand, older organizations may become more rigid and less able to adapt to changing business environment and to utilize innovative solutions and technologies. Whether the relationship between firm's age and open source software provision is positive or negative is thus an empirical question. The establishment year of the firm (variable "year") measures the firm's age.

A firm's *business model* and particularly the *importance of license revenues* are also likely to play an important role in defining the firm's product and license type decisions. We assume that those firms to which license revenues account for a notable share of the firm's revenues are less likely to offer OSS products than others. The dummy variable "licenserev" distinguishes those firms that have reported a positive answer to the question "Do licenses contribute notably to the sales of your products" from others. A firm's *participation in open source project(s)* is also likely to increase the chances that the firm itself distributes products under the open source license(s). The dummy variable "osproj" gets value 1 if the respondent reports that the firm do participate or has participated to the open source projects.[11]

Also, the *role of services in the firm's business strategy* may affect its product type and licence decisions. We assume that the firms that base their business more extensively on software service provision are more likely to offer OSS licensed free software as this strategy may help them to create a larger user base more easily and to increase the revenue streams from complementary service provision. The importance of services is captured by the variable "service" that measures the variety of services which a firm provides. It is a sum of the dummy variables for 11 different service categories[12] that are given values from 0 to 11 depending on how many of the service types the firm offers (i.e. if a firm does not provide any of the service categories the variable takes the value 0 and if it provides services in all categories, the variable takes the value 11).

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[11]Our questionnaire defines an OS project as follows: "An open Source project is a software development project showing the following features: The code is freely available on the Internet, the code is released under an open source license, everyone is allowed to take part in the project, and collaboration among developers shapes the software production model."

[12]Our study comprises the supply of the following 11 service types: Consultancy, Integration, Installation, Assistance, Maintenance, System Management, Training, Application Management, Adapting codes written by third parties to suit customers' needs, On order software development from the scratch, and Generating documentation.

As discussed above, open source business models are still not well known and also the legal status of open source licenses has not yet been tested in courts, and this creates a certain degree of uncertainty around OSS activities. The firm may also avoid the provision of OS products because of some other potential legal risks OS activities may involve. The OS products may, for instance, violate existing software patents or comprise a source code that is a trade secret of some other company. To evaluate a firm's attitudes towards the (potential) legal risks of OSS provision we created the variable "risk", which is formed by the respondents' evaluation of the importance of 6 risk factors (see Table 1b for a detailed description of this variable).

We assume that not only firm-specific factors matter in the firm's software product type and license choices but also various product-specific factors may matter. For instance, some product markets are dominated by the proprietary products, whereas others may have primarily products with a specific OSS license type (e.g., the world's market for the web servers are dominated by the Apache server that is released under the non-copyleft license). Our data comprise 18 different product categories from which we have formed four dummy variables for the following types of products (see Table 1b for the details of these variables): i) the web and other kind of servers (variable "pserver"), ii) the products that enhance security of PC and Internet use (variable "secsofta"), iii) the management software products (variable "mansofta"), and iv) communications or Internet use related software ("intsofta").

3. Data and observations from the Finnish software companies

Our data were collected by a web survey[13] during the period of November 2004 – February 2005. We approached 591 Finnish companies providing software products and/or services by e-mail messages asking them to respond to our questionnaire in the Internet. 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. We received a response from 170 firms (this represents a response rate of almost 30% and covers about 8% of all firms in the industry in Finland) of which 73 were OSS product and/or service providers and 97 produced only proprietary software or services. Among the proprietary software producers, there were 7 firms that had previously supplied OSS products/services but had decided to discontinue OSS activities and focus merely on the proprietary software business.

The largest individual group of respondents was CEOs (41% of the respondents) followed by different types of managers from business development managers to R&D/sales/production managers (39% of the respondents of which more than one third were R&D or technology managers). The firms' owners or entrepreneurs made up 10% of the responses that were received, and 4% of the respondents were IT specialists/planners or experts. The rest of the respondents (about 5%) comprised employees, consultants etc.

The OSS providers are smaller than the non-OSS firms that are excluded from the empirical analysis of this paper. The median turnover of the OSS firms was about 315,000 Euros, whereas a typical proprietary software provider was almost

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[13]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.

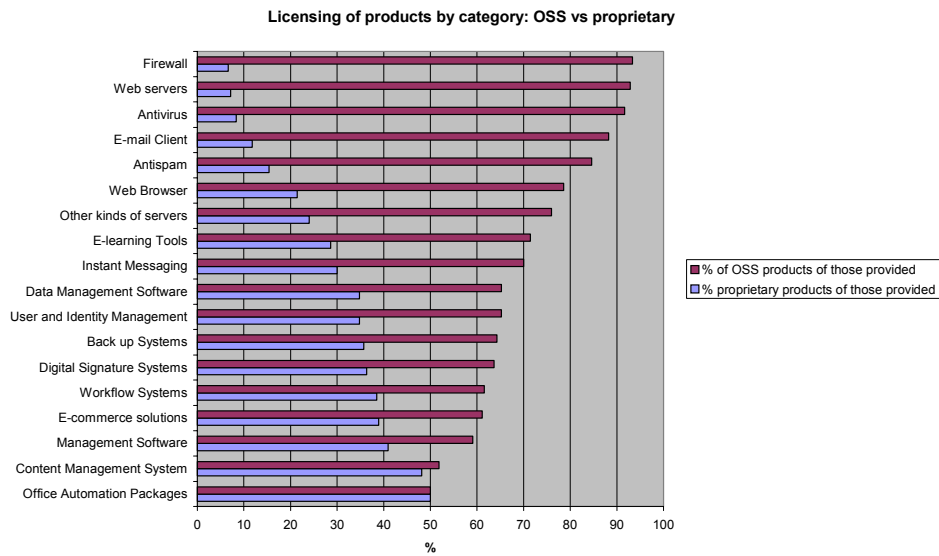**Licensing of products by category: OSS vs proprietary**

FIGURE 1. Provision of software products: OSS vs. proprietary solutions.

twice as large with a median turnover of 700,000 Euros. The responses from the OSS firms also indicated that the importance of the OSS has rapidly increased during the past years. Only 16% of the sampled OSS firms evaluated that in the year 2000 over half of their turnover was generated by the OSS activities, whereas 32% of the firms was reporting this to be situation in 2003.

Table 1 describes the data used in the estimated models. The dependent variable for these models is formed by using the responses to the question of which products the firm provides of the 18 different product categories listed in Figure 1, and in what form the firms supplies the products. The respondent was asked to report whether it supplies products specified in each category using the following options: "proprietary products", "open source products under the copyleft license (GPL and GPL-like)", "open source products under the non-copyleft license (e.g. BSD, Apache)", "dual-licensed products". The OSS firms release products most often under the copyleft license (46% of supplied products), whereas proprietary products are more common (31% of products) than products with the non-copyleft license (22% of products). 68% of the OSS products are released under the copyleft license. This percentage is interestingly close to the finding of Lerner and Tirole (2005) that about 72% of their sample of over 38,000 open source projects employ the GPL license.

Figure 1 shows that the three products most commonly distributed under the OSS license among our sampled firms are firewall software, web servers, and antivirus software; more than 90% of these products offered by the sampled firms are based on the open source code.

Figure 2 illustrates that almost 80% of the Finnish OSS firms that provide web servers use the non-copyleft license option. This finding reflects a more general
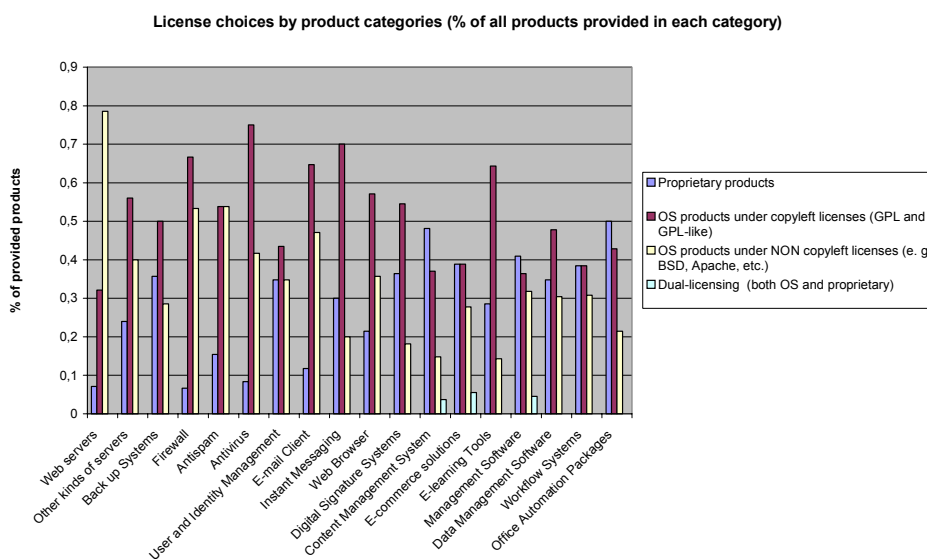
License choices by product categories (% of all products provided in each category)

FIGURE 2. Licensing choices by product category: proprietary, OSS (copyleft vs. non-copyleft) and dual licensing.

"Apache phenomenon": in March 2005, the world's web server markets were dominated by Apache with the market share of about 70% (Web Server Survey[14]).

In the next section will briefly introduce the analytical methods we have used in our empirical exploration and discuss the estimation results.

4. ECONOMETRIC MODEL AND ESTIMATION RESULTS

Our dependent variable captures the supply and the license mode of 18 different software product categories among the sampled 73 Finnish OS companies. We estimated three different econometric models and coded the dependent variable according to our estimation purpose as follows:

Model I: The multinomial logit model for the product and license choices of the OSS firms in which the dependent variable takes the following values:

0 if the firm does not supply the product,

1 if the firm supplies a proprietary version of the product,

2 if the firm supplies product with the non-copyleft license, and

3 if the firm supplies product with the copyleft license.

Model II: The probit model for the product type and license choice of the OSS firms in which the dependent variable takes the following values:

0 if the firm supplies a proprietary version of the product, and

1 if the firm supplies product with OSS license.

Model III: The probit models for the license choice of OSS products in which the dependent variable takes the following values:

1 if the firm supplies product with the non-copyleft license, and

0 if the firm supplies product with the copyleft license.

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[14]See http://news.netcraft.com/survey.

The purpose of Model I is to shed light on the question how various firm and product specific factors (discussed above) affect the firm's product supply decision, i.e. whether or not to provide a specific product, and if the product is supplied, whether or not to provide a proprietary version or release it under the OSS license. We estimate this model using the multinomial logit approach including observations from the firm's that do not provide a specific product category. The estimated model includes 684 observations.

Model II limits the analysis to those products that are supplied by the sampled OSS companies (i.e. product categories not supplied by a firm are excluded from the analysis). Here our aim is to investigate the factors that define the proprietary vs. OSS product supply decision among the software companies. The model is estimated using the probit approach. The number of observations is substantially reduced when we exclude those product categories that are not supplied by the sampled firms: the estimation involves 238 observations.

Model III further limits analysis to only OSS products to focus on the firm and product specific differences in the license choices of those firms that have decided to employ open source licenses. We estimate the probit model that distinguishes the product licensed under the copyleft license from those employing the less restrictive non-copyleft license. The number of observations in the estimated model is 168.

	Proprietory		Non copyleft license		Copyleft license	
Variable	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Constant	-202.859	-0.418	-155.370	-0.268	-512.494	-1.219
size	-0.009	-0.162	-0.018	-0.279	0.045	1.099
year	25.669	0.403	19.249	0.253	66.384	1.201
famowned	1.456	4.950	0.381	1.139	-0.345	-1.367
pserver	0.415	0.700	2.199	3.250	0.494	1.065
secsofta	-0.203	-0.402	0.657	0.986	0.013	0.034
mansofta	0.604	1.259	0.488	0.699	-0.222	-0.539
osproj	-0.508	-1.712	0.129	0.391	0.974	3.979
licenserev	0.798	2.455	0.974	2.634	-0.299	-0.954
risk	1.154	1.428	0.483	0.539	1.058	1.538
service	0.907	2.810	2.118	3.893	1.501	3.879
Number observations = 684; Log likelihood = -614.536						

Table 2: Estimation results of the multinomial logit model for the product and license choices of the OSS firms

The estimation results of Models I, II and III are presented, respectively, in Tables 2, 3, and 4. Our estimation results in all of the estimated models indicate that the ownership structure of a firm does affect the software product type (OSS vs. non OSS) choices of the firms. In Models I and II (Table 2 and 3), the estimated parameters of the variable "famowned" suggest that family owned firms which are their owners' main investment object tend to be more traditional and provide more often proprietary solutions than other OSS companies. These findings support the signalling hypothesis but they may also reflect a higher level of risk aversion of firms of which owners have tied their personal wealth to the company. Also, this means that the diffusely held companies whose managers are harder to control and may

have their individual interests are more likely to provide the OSS products. It is then also possible that the managers in diffusely held companies employ the OSS business strategies for their personal interests (e.g. for their own reputation and career) rather than act merely for the best interest of the company. The ownership type variable is not statistically significantly related to the firm's license choice between copyleft and non-copyleft licenses.

Variable	Estimate	t-statistic
Constant	193.507	0.525
size	0.012	0.335
year	-25461	-0.526
famowned	-0.945	-4.336
pserver	0.467	1.213
secsofta	0.078	0.225
mansofta	-0.414	-1.214
intsofta	-0.247	-0.743
osproj	0.673	2.991
license	-0.454	-1.945
risk	-0.409	-0.662
service	0.904	3.127
N^o observations=238; Log likelihood=-119.918; Fraction of correct preditions=73%		

Table 3: Estimation results of the probit model for the product type and licence choice of the OSS firms (Value categories of the dependent variable: 1 = OSS products; 0 = a proprietary product).

Variable	Estimate	t-statistic
Constant	206.801	0.447
size	0.012	0.297
year	-26.984	-0.445
famowned	-0.248	-1.043
pserver	-1.071	-2.459
secsofta	-0.424	-1.014
mansofta	-0.545	-1.241
intsofta	-0.119	-0.277
osproj	0.471	1.882
license	-0.711	-2.438
risk	-0.140	-0.192
service	-0.210	-0.502
N^o observations=168; Log likelihood=-93.811; Fraction of correct preditions=71%		

Table 4: Estimation results of the probit model for the license choice of the OSS firms (Value categories of the dependent variable: 1 = a products with the copyleft license; 0 = a product with non-copyleft license).

The variable "licencerev" capturing the importance of license revenues for a firm is, as expected, positively and statistically significantly related to the supply of

proprietary software (Models I and II). This seems very logical: those firms to which license revenues account for a substantial part of their revenues tend to provide proprietary products to continue having the license cash flow. Those companies for which license revenues are not important source of income, instead, tend to choose OS licenses. The estimation results of Model I and III further indicate that those companies that value relatively more license revenues than others also tend to use non-copyleft licenses more often. This finding possibly indicates that companies employing relatively unrestrictive non-copyleft licenses use this license type as it gives them greater degrees of freedom to use the source code as a part of commercial products.

The variable "osproj" is positively and statistically significantly related to the choice of the copyleft license (Model I and III), and more generally to the choice between OSS and non OSS products (Model II). It thus seems that those firms that are or that have been involved in the open source development project(s), are more likely to release their products under the restrictive open source licenses. This finding is consistent with the previous study of Lerner and Tirole (2005) that finds that over 70% of the open source projects use the GPL copyleft license. The firm's attitudes towards legal risks (variable "risk"), instead, does not seem to differ notably between the providers of different software product types and licenses.

Our data indicate that the firm's service provision is closely related to its product type and license choices. The estimation results of Model I emphasize the importance of complementarity of software products and services: the coefficient of the variable "service" is positive and statistically significant in all columns that compare supplied software products to those not supplied. In other words, the greater the variety of services a firm offers, the more likely it is that it also supplies complementary software products. The estimation results of Model II further show that when the variety of services offered increases, the likelihood that the firm offers its products under the OSS license increases. The OSS license type choice, instead, is not statistically significantly related to the service variety variable.

The estimation results of all models show that firm size and age (the variables "size" and "year") fail to explain statistically significantly variation in the product and license types supplied by the OSS companies. The variable "pserver" is the only product-level dummy variable of which estimates are statistically significantly. It seems that the web and other kind of servers are more likely to be licensed under the non-copyleft license than the other sampled products. This finding is consistent with "the Apache phenomenon", the dominance of the web servers licensed under the non-copyleft license.

5. CONCLUSIONS

This study sheds light on the relatively recently emerged new business models employing open source activities in the software industry. We analyze data on the 73 Finnish OSS companies' product type (i.e. proprietary vs. OSS product) and license type (i.e. the copyleft vs. non-copyleft licenses) choices. It seems that factors other than those typically found to explain differences in entrepreneurial innovation behaviour such as firm size and age account for the differences in the product and license type strategies of the software companies.

Our data indicate that the firm ownership structure has a major influence for the software firms' product-level business strategies. Family owned firms which are

their owners' main investment object tend to rely on the traditional proprietary software in their product selection, whereas diffusely held companies are more likely to supply OSS products. The underlying motivation of the managers of diffusely held companies to provide OSS products is hard to detect. They may use OSS provision to signal to the investors and the market their innovativeness and the value of firm's knowledge base. Also, it is possible – as the managers in diffusely held companies are hard to monitor and may not always act on the best interest of the company only – that they employ OSS business strategies for their personal interests (e.g. for their own reputation and career).

Also, we find that a firm's software service provision strategy is closely related to its software product provision. The more service oriented firms are likely to offer more complementary products and further supply their products more often using OSS licenses. Also, the market trends concerning a firm's software products affect the license type decisions of the firm. Consistently with the international data on the dominance of the Apache server that is released under the non-copyleft license, we find that the servers are more likely to be licensed under the non-copyleft license. Our estimation results also suggest that a more restrictive form of the open source licenses, the copyleft license, is used more often in those companies that have participated into the open source software development projects. This finding is consistent with the earlier studies that have found that more than 70% of the OSS development projects employ the GPL copyleft license (see Lerner and Tirole, 2005).

Our empirical analysis gives some new insights on the open source phenomenon in the entrepreneurial context. Further exploration investigating not only the product-based strategies of the OSS companies but also in a more detail level their service strategies would complement nicely the reported study and enhance our understanding on the OSS-related business strategies. The importance of the firm ownership structure variables also call for further analysis on how the organizational structure and firm ownership relates to the OSS business models.

References

Bonaccorsi, A. and C. Rossi (2003a), "Altruistic Individuals, Selfish Firms? The Structure of Motivation in Open Source Software", MIT Free/Open Source Research Community Online Papers: http://opensource.mit.edu/online_papers.php.

Bonaccorsi, A. and C. Rossi (2003b), "Licensing Schemes in the Production and Distribution of Open Source Software. An Empirical Investigation" MIT Free/Open Source Research Community Online Papers: http://opensource.mit.edu/online_papers.php.

Cohen, W.M. and S. Klepper (1996), "A Repraise of Size and R&D", *Economic Journal,*106; 925-51.

Dahlander, L. (2004), "Appropriating The Commons: Firms In Open Source Software", Mimeo, School of Technology Management, Chalmers University of Technology, Gothenburg, Sweden.

Ferhstman, C. and N. Gandal (2004), "The Determinants of Output-Per-Contributor In Open Source Projects: An Empirical Examination", *CEPR Discussion Paper*, No. 4329.

Holmström, B.R. and J. Tirole (1989), "The Theory of the Firm", In R. Schmalensee and R. Willig (eds.), *Handbook of Industrial Organization*, Volume 1, Amsterdam; North Holland: pp. 61-133.

Jensen, M.C. and W.H. Meckling (1976), "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure", *Journal of Financial Economics*, 3; 305-360.

Lerner, J. and J. Tirole (2002), "Some Simple Economics of Open Source", *Journal of Industrial Economics*, 52; 197-234.

Lerner, J. and J. Tirole (2005), "The Scope of Open Source Licensing", *Journal of Law, Economics and Organization*, 21; 20-56.

Loh, L. and N. Venkatraman (1993), "Corporate Governance and Strategic Resource Allocation: The Case of Information Technology Investments", *Accounting, Management & Information Technologies*, 3; 213-28.

Sørensen, J.B. and T.E. Stuart (2000), "Aging, Obsolescence, and Organizational Innovation", *Administrative Science Quarterly*, 45; 81-112.

Weber, S. (2004), *The Success of Open Source*, Cambridge, MA, Harvard University Press.

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