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PRIVATE-COLLECTIVE SOFTWARE BUSINESS MODELS: COORDINATION AND COMMERCIALIZATION VIA LICENSING

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ABSTRACT: The private-collective business models that involve both private investment incentives and the production of public goods are not well understood. This empirically oriented research uses the unique data from the software industries of five European countries (Finland, Germany, Italy, Portugal and Spain) to illuminate the patterns of private, entrepreneurial provision of software placed in the public domain. The estimation results strongly suggest that the highly restrictive GPL (General Public License) works as an efficient coordination mechanism for the (leading) developers of the OSS community and spreads particularly via the firms that have participated in the OSS development projects. The software companies supplying the OSS, instead, tend not to aim at using the GPL to coordinate the further development of their own OSS. The firms are rather the origin of more flexibly licensed OSS products though generally the software firms' OSS business strategies relate to the restrictive licensing strategy choices.

KEY WORDS: Open Source software, licensing, business strategies

JEL Classification: D21, D23, L23, L86

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TIIVISTELMÄ: Samanaikaisesti sekä yksityisiin investointikannustimiin että julkishyödykkeiden tuotantoon perustuvista liiketoimintamalleista on olemassa varsin vähän taloustieteellistä tutkimustietoa. Tämän tutkimuksen tarkoituksena on valottaa yritysten avoimen lähdekoodin ohjelmistojen tuotantoa käyttäen ainutlaatuista viiden Euroopan maan (Suomi, Saksa, Italia, Portugali ja Espanja) ohjelmistoyrityksistä kerättyä aineistoa. Aineistoanalyysi viittaa vahvasti siihen, että avointa lähdekoodia kehittävän yhteisön laajalti käyttämä lähdekoodin jatkokäyttöä voimakkaasti rajoittava GPL-lisenssi (General public license) toimii tehokkaana koordinointimekanismina ja leviää erityisesti avoimen lähdekoodin ohjelmistoja kehittäviin projekteihin osallistuneiden yritysten kautta. Ohjelmistoyritykset eivät sen sijaan pyri koordinoimaan itse tuottamiensa avoimen lähdekoodin ohjelmistojen jatkokehitystä GPL-lisenssin käytön avulla. Yritykset pyrkivät pikemminkin soveltamaan joustavampia lisenssejä itse kehittämiinsä avoimen lähdekoodin ohjelmistoihin, vaikka avoimen lähdekoodin tarjontaan perustuviin liiketoimintastrategioihin liittyy yleisesti rajoittavien lisenssistrategioiden valinta.

AVAINSANAT: Avoimen lähdekoodin ohjelmistot, lisensointi, liiketoimintamallit

JEL-koodit: D21, D23, L23, L86

1. Introduction

A licensing strategy forms one of the core elements of a firm's IPR (Intellectual Property Right) strategy and, in many cases, also overall business strategy in high-technology industries. Licenses enable a firm to receive compensation for its R&D expenses[1] and further control its intellectual property, who is using it and how it is used. Currently, one of the most interesting industries in which the firms' license choices is not only tightly linked to the firm-specific business strategies but also substantially affect the development of the markets for the end-user products and related services is the software industry. The license field of software flourishes as the software providers are increasingly using along with and instead of the commercially priced licenses the open source license options that allow users to see, use, modify and redistribute the source code of the software programme with a zero license fee.

The decision makers of the public OSS development projects are typically their leading software developers whose motivations are likely to deviate from those of the commercial software producers of OSS.[2] Gambardella and Hall (2006) suggest that these leading developers tend to choose the restrictive General Public License (GPL) to coordinate and sustain the development of software in the public domain. Software firms that supply the OSS, however, are likely to have different incentives though there are reasons why they may also benefit from the GPL coordination (e.g., reduction of their own costs when software is maintained and developed in the public domain). The private-collective

[1] The Survey of The Economist evaluates that in the United States the annual technology licensing revenues are about $ 45 billion, whereas the annual worldwide revenues reach $ 100 billion (*The Economist*, Oct 20th 2005, "A market for ideas").

[2] The literature lists a multitude of factors driving software developers to participate into the OSS development projects from non-economic (e.g., fun, intellectual challenge) to economic (e.g. signalling and future career opportunities) motivations (see, e.g, Lerner and Tirole, 2002; Maurer and Scotchmer, 2006).

business models that involve both private investment incentives and the production of public goods are not well understood.[3]

This paper addresses various questions: Does the GPL coordination arising from the OSS community affect the software firms' licensing strategies? Do software firms use the GPL to coordinate the further development of the software products originating from them? Why software firms providing OSS differ in the degree of restrictiveness of their software licensing strategy? In other words, why some software companies supply software primarily with highly restrictive open source licenses, whereas others rely mainly on the unrestrictive OSS licenses? This empirically oriented research uses the unique data from the software industries of five European countries (Finland, Germany, Italy, Portugal and Spain) to illuminate these patterns of private, entrepreneurial provision of software placed in the public domain. The database comprises information from 918 European software firms of which 361 (or about 39%) were the suppliers of the OSS solutions at the time of the survey, the end of the year 2004.

There are only few previously reported studies that systematically, using econometrics, analyse factors affecting the software license choices. Lerner and Tirole (2005) tackle the question of a project-level decision making in licensing the output of the open source software projects. Their study using an extensive database of SourceForge website suggests that less commercial projects tend to offer software with more restrictive licenses (see also Fershtman and Gandal (2004) for a similar conclusion). This seems logical as the restrictive licenses such as the GPL prevents commercialization of software and restraints its supplier to receive any direct rents from it. The data of Bonaccorsi and Rossi (2003) further hints that the Italian firms employing the GPL-licenses supply less proprietary products, on average, than other firms.

[3] Von Hippel and von Krogh (2003) discuss "private-collective" innovation model primarily from the perspective of the open source community and its individual developers.

The empirical exploration of Koski (2005) finds that both firm and product specific-factors explain differences in the license type choices of software companies. This study deviates from the study of Koski in a few important ways. First, this previous study uses data only from the Finnish software companies, whereas this study analyses an international database that has collaboratively and simultaneously been collected from five European countries (Finland, Germany, Italy, Portugal and Spain). Second, Koski (2005) was analysing the firms' license (i.e. the copyleft vs. non-copyleft licenses) and product type (i.e. commercial vs. OSS products) decisions at the product level, whereas this paper focuses on the open source licensing strategy choices at the firm level.[4]

Our estimation results show that the GPL typically used in the OSS development projects (see, e.g., Lerner and Tirole, 2005) is, indeed, an effective coordination mechanism affecting not only the choices of the individual software developers but also those of the commercial players. Software companies participating in the OSS development projects tend to offer their own software with more restrictive licenses than other software companies. The empirical research further hints that software firms do not, however, try to coordinate the further development of their own software by using the GPL but rather aim at responding to their customers' needs by offering more flexible licensing terms.

This article is organized as follows. Section 2 discusses the software firms' licensing strategy options and illustrates what our data tell about the licensing choices of the sampled companies. Section 3 introduces the private-collective business model types that may relate to the firm's licensing strategy and also briefly discusses other potential factors that may

[4] The list of explanatory variables deviates in certain respects from the study of Koski due to the availability of data. For instance, the Finnish data set of Koski's study comprised information from the ownership structure of the firm and the firm's evaluation of the importance of legal risks associated to the OSS activities. These data were not collected from the other sample countries and thus are omitted from the estimated model in the reported research.

explain different license choices of software firms. Section 4 presents the results of the estimated models. Section 5 concludes.

2. Entrepreneurial software licensing choices

The open source licenses deviate from the commercial or proprietary ones not only for their licence price that is always set to zero but also, and even more importantly, in how the intellectual property rights are used for controlling and coordinating the further development and use of software. The commercially licensed software comprises a closed source code invisible for the software users, and typically only one (the original software developer or his employer) or a very limited set of property right owners (those parties to which the copyright holder transfers or sells these rights) are allowed to modify and further develop the source code. The open source licenses, instead, give everyone a freedom to see, use, modify and re-distribute the source code. The restrictiveness of the open source license determines conditions under which the user can combine his own intellectual property with the OSS licensed software and whether he has to maintain the same licensing rules as the copyright owner when he redistributes the source code or whether he is allowed to modify and convert the source code to his own intellectual property.

The restrictively licensed open source software such as software using the General Public License (GPL), or the copyleft license types, do not allow anyone to combine the source code with the other code unless the final product is licensed similar to the original one. The publicly available source code cannot be privatized or commercialized by anyone so the property right restrictions set by the licensor of a program applies to all software comprising a piece of the original copyleft licensed software code. The unrestrictive, so

called non-copyleft license types (such as the Berkeley Software Distribution, BSD), instead, give users flexibility to use the source code for their own purposes without imposing any strict license restrictions for the further developments and distributions of the software. The developer can contribute to the OSS community by releasing his improvements or additions to the software under the same non-copyleft license if he wants - but this is not required. Anyone is permitted to use the source code even for generating software products that maintain the source code as a trade secret and are sold under the commercial licenses. In other words, the non-copyleft license allows individual developers or commercial companies to convert intellectual property from the public domain to their own private IP and thus to become the property right owners who have right to decide upon the commercialization and licensing terms of the (public IP based) products though there may be restrictions set by the original copyright holder on how the original piece of work has to be notified in the new versions of software[5]. The unrestrictive licenses thus deviate from the restrictive ones in a sense that anyone can act as a property rights owner of the IP (or its parts) placed in the public domain, whereas in the case of the restrictive GPL license, each contributor has a copyright only to the piece of code he has developed himself and a single party maintains the property rights of the original code and coordinates the development of software using this code via its license choice.[6]

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[5] Some non-copyleft licenses such as Apache license require that the developer has to clearly state that he has changed the original source and retain all copyright, patent, trademark, and attribution notices from the source form of the work in the redistributed piece of software irrespective of its (new) license type.

[6] According to the GNU General Public License (Version 2, June 1991), a developer has a freedom to license the code he has developed for the GNU GPL licensed programme if it is an independent piece of work and he distributes it separately from the GPL licensed program: *"If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it."*

The license type choice also dominates the location of software development from a firm's perspective, i.e. whether it happens primarily in-house or outside the firm boundaries. The proprietary software is, by and large, developed in the private organizations. The development and maintenance of open source software happens largely outside of any individual company though many of the software developers participating in the development project may work for the software companies. Via the choice of the restrictiveness of the license, the licensor may further coordinate the software development. The copyleft license forces the users and developers to maintain all modified, distributed versions of software in the public domain for everyone to see, use and further develop.[7] Instead, the non-copyleft license allows individual developers and firms to absorb the code from the public domain and privatize the source code for in-house development.

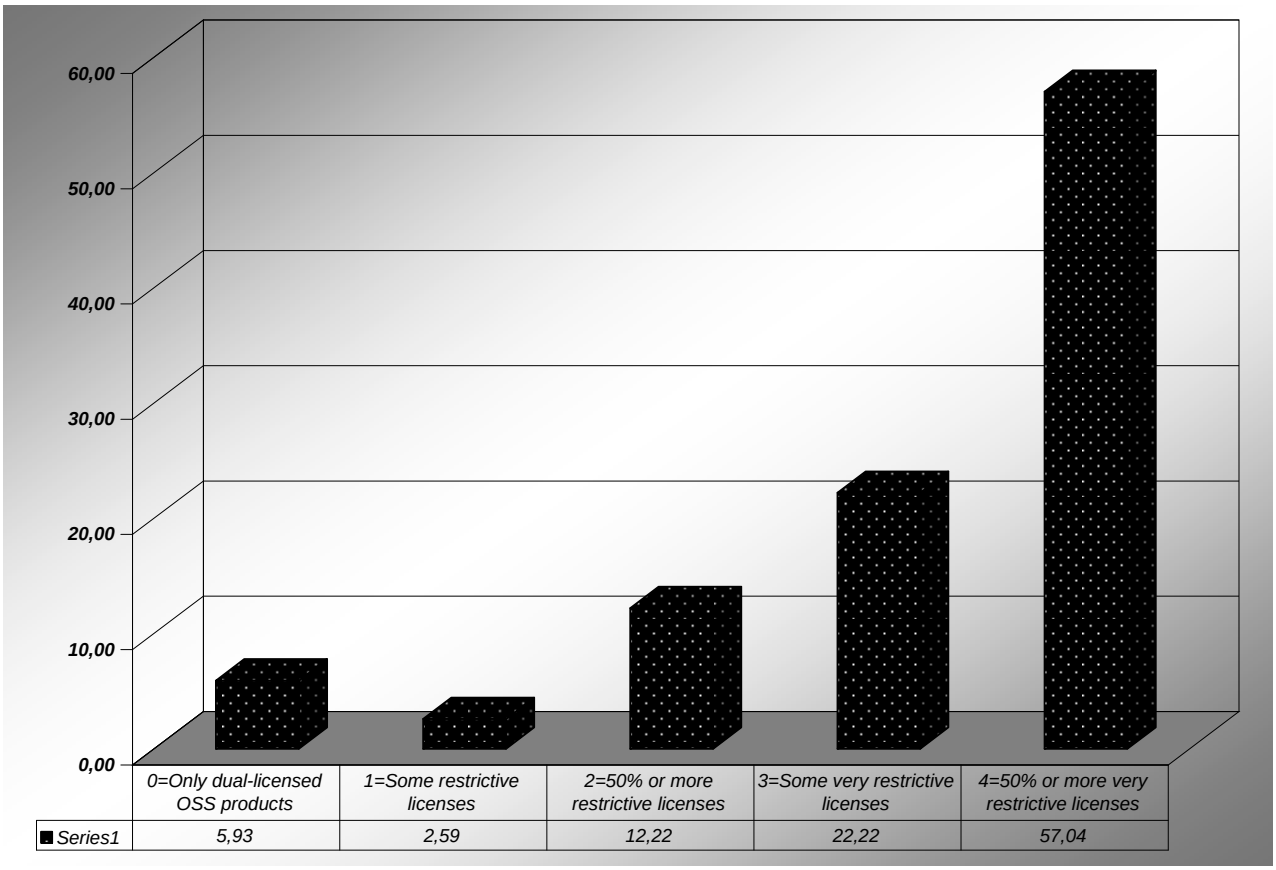
In addition to the GPL- and BSD-type licenses[8], firm may maximize the flexibility of choice from the users' perspective by offering the dual-licensed software products. Dual licensing means that the buyer can choose between the OSS-licensed software and the commercially licensed software. The latter one is often more user-friendly and thus requires less expertise from the buyer (or the buyer has to acquire less supporting services) or includes more advanced features than the free version of the product. Figure 1 introduces the dependent variable (coded from 0 to 4) of the estimated ordered probit

[7] However, anyone can develop the copyleft licensed software code for his own use without releasing the results of development to the public domain – e.g. a firm can keep its own software version based on the copyleft licensed source code as a trade secret - as long as this developer does not distribute the developed program.

[8] The firms providing software with the OSS licenses do not necessarily employ the most commonly used GPL and BSD license types but they may design their own product-specific licenses. There are currently almost 60 different open source licenses that have been certified by OSI (Open Source Initiative). OSI organization checks that a license conforms to the Open Source Definition and (if yes) grants it then a certification mark "OSI Certified" that signals to the users that the license of software truly fulfils OS requirements. (http://www.opensource.org/, 12.10.2006)

model for the restrictiveness of the firm's licensing strategy. It shows that relatively few (about 6%) of the sampled 270 firms of our database[9] use only dual-licensing, and that the firms' OSS licensing strategies follow a general tendency of the OSS projects favouring the use of the very restrictive GPL-licenses. About 57% of the firms use the GPL-type licenses in at least half of the product categories they offer and over 20% of the companies employ some very restrictive licenses.

Figure 1. Firms' licensing strategies



[9] Due to missing variables, we have data from 270 of, in total, 361 OSS suppliers of our database that can be used for the estimations explaining the restrictiveness of a firm's licensing strategy.

The disadvantage of our dual-license measure is we cannot distinguish the dual-licenses with the GPL-type and BSD-type open source licenses from each other. Thus, though dual-licensing offers flexibility for the buyers, we cannot make conclusions about how flexibly they can further use and license the dual-licensed OSS products. Therefore, we also estimate the ordered probit model that excludes those firms offering only dual-licensed products from the estimations and the primary dependent variable of our empirical research gets values 0 to 3 according to the restrictiveness of the strategy as follows. The variable gets value 3 if the firm has employed in 50% or more of their product categories the very restrictive GPL-type licenses, 2 if it has some very restrictive licenses, 1 if 50% or more of its licenses are restrictive BSD-type, and 0 if it has some restrictive licenses.

Figure 2. License type choices of software firms

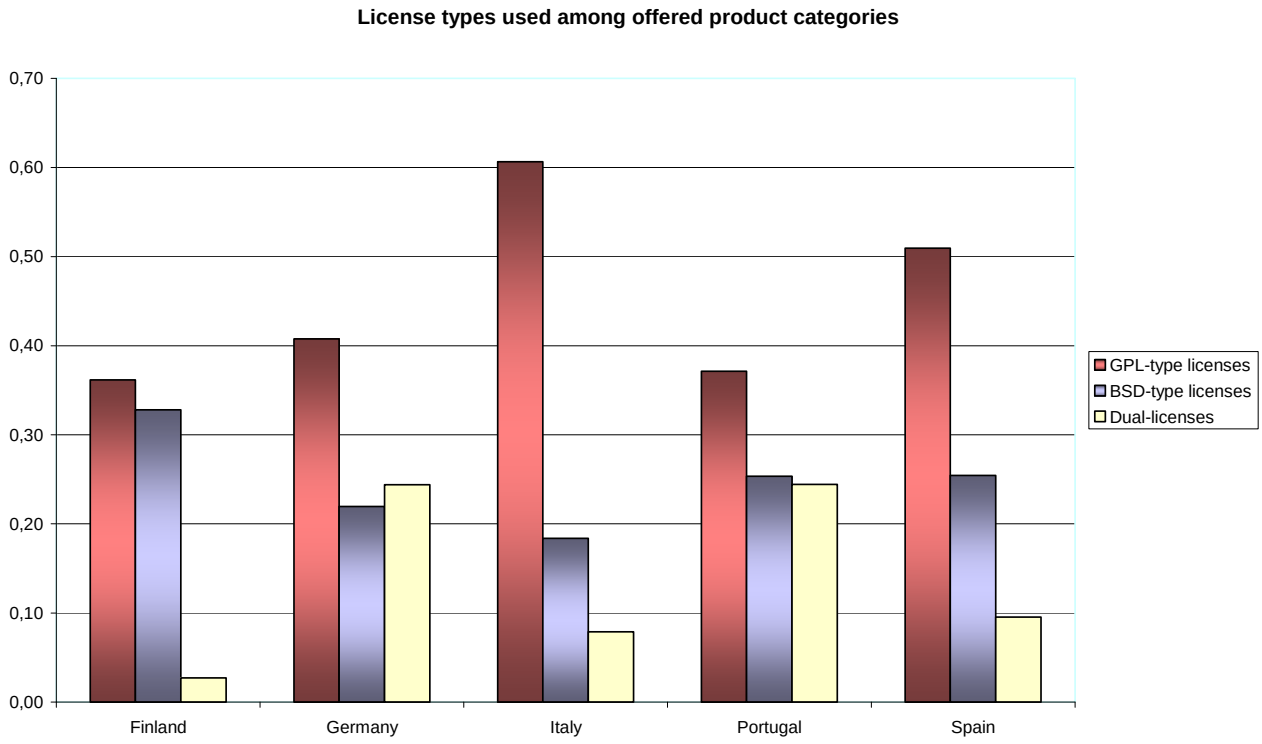


Figure 2 presents the distribution of the other three dependent variables of our empirical estimations – the number of product categories a firm supplies under the GPL-, BSD-, and dual-licenses - among the sampled countries. These variables measure how extensively a firm employs each OSS license type in its software supply. Figure 2 shows that the more restrictive GPL-type licenses are more often adopted in Italy and Spain than in other countries. Finnish software companies seem to favour relatively more often the BSD-type licenses than firms in other countries but very few of them release software with the dual-license option. The dual-licensing strategy seems to be most popular among the German and Portuguese software firms. The empirical estimations of which results are reported in Section 4 resolve whether these differences are statistically significant.

3. Private-collective business models and licensing strategy

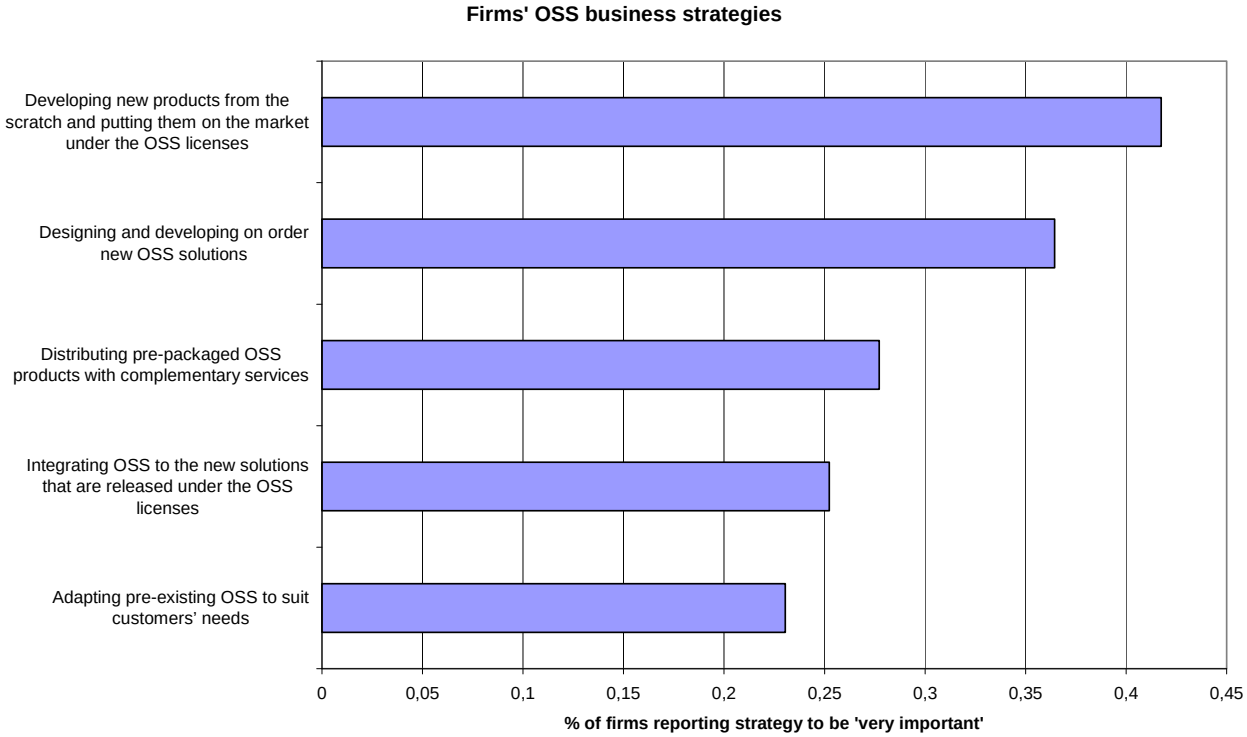
The open source software development enables various possibilities for software firms to combine the traditional private investment model and the production of public goods to a single model that we call here a private-collective business model. This section discusses how different OSS (supply based) business models may affect a firm's software licensing strategy. It also presents various other factors (controlled for in the empirical estimations) that may affect the restrictiveness of the firm's licensing strategy.

We have categorized the OSS business models into the five main types: 1) *Complementary service provision*, 2) *Adapting pre-existing OSS to suit customers' needs*, 3) *Integrating OSS to the new solutions* that are released under the OSS licenses, 4) Designing and developing *on order new OSS solutions,* and 5) *Developing new products from the scratch*

and putting them on the market under the OSS licenses, and. Our questionnaire asked about the importance of each strategy offering the respondents three options to choose: “not important”, “nice to have” and “very important”. For almost 50% of the respondents one or two of these strategies are very important, whereas very few firms (only 1.5% of the respondents) reported that all five strategies are important for them.

Figure 3 illustrates the share of firms that found each OSS strategy to be very important for them. Interestingly, those strategies that are based on the use of the pre-existing OSS code are important for fewer companies than the ones relying on the OSS-licensing of the firms’ own software products.

Figure 3. The OSS strategies employed by the firms



Complementary service provision to the pre-packaged OSS products is often mentioned as one of the fundamental ways to commercially exploit the OSS development. Contrary to our expectation, less than 30% of the respondents from the OSS firms report that this OSS strategy is of high importance for them. The dummy variable COMPL_SERVICE takes value 1 if the distribution of pre-packaged OSS products with complementary services is a very important activity for the firm and 0 otherwise. (The dummy variables for other OSS strategies are created in a similar way.) Our hypothesis is that, as the majority of the OSS projects and consequently pre-packaged OSS products employ the restrictive GPL license (see Lerner and Tirole (2005) among others that have made similar conclusions), those firms for which offering complementary services for the pre-packaged OSS is important are more likely to provide restrictively licensed software than other companies. If this is the case, COMPL_SERVICE is positively related to the restrictiveness of the firm's licensing strategy.

Adapting pre-existing OSS to suit customers' needs and integrating OSS to the new solutions mean that a firm absorbs the OSS code from the Internet for its own software production and the license type of the code influences the firm's licensing options. For those firms that integrating OSS to the new solutions is very important, also the license compatibility of the integrated parts affects their license choice. The firm can distribute the copyleft licensed software only under the similar license, whereas it can choose any (compatible) license type for the non-copyleft licensed software. On the one hand, as most OSS projects employ the GPL-license[10], we could assume that companies using the pre-existing OSS also tend to use the GPL-type licenses. On the other hand, it is possible that the firms purposely choose primarily the less restrictively licensed OSS software either

[10] Over 70% of the open source projects of the SourceForge database use the GPL license (Lerner and Tirole, 2005).

because of their customers' preferences or because of the compatibility reasons, to be able to integrate OSS to their own software solutions that are incompatible with the GPL-type licenses. Whether the restrictiveness of a firm's licensing strategy relates positively or negatively to the variables ADAPT_OSS and INTEGRATE_OSS is thus an empirically solved question that illuminates the nature of the firm's strategic actions in the OSS provision.

Those firms that design and develop OSS solutions on order for their customers and develop new OSS products from the scratch may license software as they wish. A firm may decide to use the GPL-type license to maintain the full property rights of and to coordinate the further developments of the original piece of software while simultaneously reducing its own development and maintenance costs of software. Or, a firm may prefer less restrictive licenses or dual-licensing to respond to (heterogeneous) user preferences that are leaning towards a flexible usage of the software (Franke and von Hippel, 2003), to attract more contributors to their products (Lerner and Tirole, 2005) and to retain possibilities for itself to distribute software under the commercial license while software development and maintenance takes place primarily outside of the company. Lerner and Tirole (2005) find slight, but not statistically significant, support for their hypothesis that the OSS projects originating with proprietary software developed by a corporation are likely to employ more restrictive licenses. It is thus an empirical question which licensing strategies OSS production on order and development from the scratch to the market are related to. We assume that on order development reflects strongly the license preferences of the firm's specific customers, whereas from the scratch development to the market relates more to the preferences of a large heterogeneous user population.

The primary interest of the reported empirical exploration is to investigate the relationship between the above OSS business models and the firm's licensing strategy. The first three business models relate to the license choices of the OSS community and whether and how these are mediated to the market via the software companies using the code originating from the OSS community. The last two business models reflect the licensing choices of a firm when it distributes it own software.

It seems logical that the participants of the OSS projects particularly benefit from the code that is developed in the public domain. The GPL, the most commonly employed open source license type among the open source development projects, however, effectively prevents the project participants from privatizing or commercializing their contributions as all modifications of or new programs based on the GPL licensed code have to be distributed with the same license conditions (Gambardella and Hall, 2006). Therefore, it is plausible that the firms participating into the OSS projects are more likely provide GPL-licensed solutions than those firms that supply the OSS products but do not actively participate into the OSS development projects. We thus expect that a firm's participation into the open source software development project(s) relates closely to its software licensing strategy increasing the use of the restrictive open source licenses.[11]

Next, we introduce other potential explanatory variables used in the estimated models (see also Table 1 for a brief description of the variables including their descriptive statistics). The target audience of the developed software is likely to be one of the key factors affecting the firm's licensing decision. The project level analysis of the determinants of the license choice using the database of the SourceForge website indicates that programs

[11] The product category level empirical analysis of Koski (2005) using data from the Finnish software companies as well as the conclusions Bonaccorsi and Rossi (2003) derive from the Italian data find support for this view.

Table 1. The definitions and descriptive statistics of the variables used in the estimations

Variable name	Description of variable	Mean	Standard deviation
Dependent variables			
Ordered probit models, Model I: Restrictiveness of the licensing strategy coded: 0= Some restrictive licenses, 1= 50% or more restrictive licenses, 2= Some very restrictive licenses, 3= 50% or more very restrictive licenses		2,409	0,822
Model II: Restrictiveness of the licensing strategy coded: 0= Only dual licensed products, 1=Some restrictive licenses, 2= 50% or more restrictive licenses, 3= Some very restrictive licenses, 4= 50% or more very restrictive licenses		3,207	1,141
Negative binomial models:			
Number of copyleft licensed product groups		4,915	4,739
Number of non-copyleft licensed product groups		2,022	3,372
Number of dual licensed products groups		1,074	2,547
The explanatory variables:			
COMPL_SERVICE	Dummy variable that gets value 1 if distributing pre-packaged OSS with complementary services is very important for a firm and 0 otherwise).	0,259	0,439
ADAPT_OSS	Dummy variable that gets value 1 if adapting pre-existing OSS to suit customers' needs is very important for a firm and 0 otherwise).	0,215	0,411
INTEGRATE_OSS	Dummy variable that gets value 1 if integrating OSS to the new solutions that are released under the OSS licenses is very important for a firm and 0 otherwise.	0,241	0,428
OSS_ORDER	Dummy variable that gets value 1 if designing and developing on order new OSS solutions is very important for a firm and 0 otherwise).	0,356	0,480
OSS_SCRATCH	Dummy variable that gets value 1 if developing new products from the scratch and putting them on the market under the OSS licenses is very important for a firm and 0 otherwise.	0,433	0,496
MAIN_ENDUSER	Dummy variable that gets value 1 if firm's main customers are end users and 0 otherwise.	0,026	0,159
MAIN_FIRM	Dummy variable that gets value 1 if firm's main customers are other firms and 0 otherwise.	0,752	0,433
SIZE	Log The number of firm's employees.	2,209	1,387
ESTABL_YEAR	Log The year firm was established.	7,599	0,003
OSPROJ	Dummy variable that gets value 1 if firm has participated OSS project(s), 0 otherwise.	0,456	0,499
SERVICE	Log The number of software service categories provided by firm.	1,923	0,690
PRODUCTS	Log The number of software product categories provided by firm.	1,940	0,801
PSERVER	Dummy variable that gets value 1 if firm offers a web or other kind of server, 0 otherwise.	0,778	0,417

MANSOFTA	Dummy variable that gets value 1 if a firm offers software that belongs to one of the following categories: back up system, firewall, antispam, antivirus, user and identity management and 0 otherwise.	0,852	0,356
SECSOFTA	Dummy variable that gets value a firm offers software that belongs to one of the following categories: (data) management software, workflow systems, office automation packages and 0 otherwise.	0,752	0,433
INTSOFTA	Dummy variable that gets value 1 a firm offers software that belongs to one of the following: email client, instant messaging, web browser and 0 otherwise.	0,748	0,435

targeted for end-users tend to have more restrictive licenses than those of which primary users are software developers (Lerner and Tirole, 2005). We thus assume that if a firm's main customers are end-users (the dummy variable MAIN_ENDUSER) the firm is more likely to use restrictive licensing. Those firms of which main customers are other firms (the dummy variable MAIN_FIRM) may face demand for less restrictive licenses that allow combination of software with the customer's own software.

Smaller and younger firms are likely to have less resource for in-house software development and they may thus rather want to use the GPL-type licenses that keep the development and maintenance of their software primarily in the public domain. On the other hand, smaller and younger firms also tend to have smaller revenue streams from the existing software products and they may therefore rather welcome the less restrictive licensing strategy that allows them to privatize and commercialize the OSS and thus obtain licensing revenues. The variables SIZE (the log number of the firm's employees) and ESTABL_YEAR (the log the establishment year of the firm) are used for exploring how firm size and age are related to the different OSS licensing strategies of software firms.

We assume that a firm's service and product variety may also notably affect its OSS licensing decision. The more complementary services the firm offers the more likely it is to

choose the restrictive GPL licenses as it can then both reach the goal of wide-spread diffusion of software, that increases its revenues from complementary services, and to keep the development of software in the public domain via the coordination power of the restrictive GPL. However, if the benefits from complementarity arise from software products that can be merged with the licensed software and possibly offered as a bundled package, then the firm benefits from the less restrictive license choice that allows the firm itself re-utilize the software (of which development the open source community takes care of, by and large). The GPL coordination may thus benefit those firms of which software business strategy is heavily service-oriented, whereas the BSD-type license choices should relate to the more product-oriented software business strategy. The variable SERVICE measures the variety of services which a firm provides, or the firm's service orientation. It is a sum of the dummy variables for 11 different service categories[12] getting value 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 gets value 0 and if it provides services in all categories, the variable gets value 11).

We control for the product-specific factors affecting licensing by adding the four dummy variables for the following software product categories: 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). It is possible that the proprietary products dominate some software market segments, whereas others - such

[12] Our study concerns 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 the market for web servers which are dominated by the copyleft license due to the success of Apache – may rely on a certain OSS license type.

In addition, the (log) number of product categories a firm offers (the variable PRODUCT) is used in the estimations of the count data models for the number of product categories the firm sells with each license type to control for the size of the firm's product variety. Potential country-specific differences in the software licensing patterns are controlled by the country-dummies with the self-explanatory names: Finland, Italy, Portugal and Spain (leaving German firms to act as a reference group).

4. Empirical findings

Table 2 presents the estimation results of the two ordered probit models for the restrictiveness of a firm's licensing strategy and Table 3 those of the negative binomial model for the counts of a firm's product categories using the BSD-, GPL and dual-licenses. The estimated ordered probit models I and II result in mainly similar conclusions – a couple of notable divergences are discussed below.

The estimation results of the ordered probit models indicate that the firms reporting that the OSS supply on order is very important for them seem to be employing less restrictive licensing strategy than other firms. Our estimation results do not suggest that the importance of any other of the five OSS-based business models for a firm would relate to statistically significantly its licensing strategy. The estimation results of the negative binomial model for the number of GPL-licensed products (see Table 3) further supports this finding as the estimated coefficient of the OSS_ORDER is the only business model

Table 2. The estimation results for the ordered probit models for the restrictiveness of the firms' licensing strategy

	MODEL I: Dependent variable values: 0= Only dual-licenses 1= Some restrictive licenses 2= 50% or more restrictive licenses 3 = Some very restrictive licenses 4 = 50% or more very restrictive licenses	**MODEL II: Dependent variable values:** 0= Some restrictive licenses 1= 50% or more restrictive licenses 2 = Some very restrictive licenses 3 = 50% or more very restrictive licenses
	Estimate (t-statistic)	Estimate (t-statistic)
C	-155,058 (-0,721)	-259,836 (-1,110)
COMPL_SERVICE	0,077 (0,418)	0,009 (0,047)
ADAPT_OSS	-0,187 (-0,938)	0,054 (0,244)
INTEGRATE_OSS	-0,104 (-0,565)	0,026 (0,129)
OSS_ORDER	-0,480 (-2,817)	-0,504 (-2,766)
OSS_SCRATCH	0,057 (0,341)	0,060 (0,338)
OSPROJ	0,501 (3,150)	0,481 (2,869)
MAIN_ENDUSER	-0,784 (-1,618)	-0,741 (-1,418)
MAIN_FIRM	-0,352 (-1,845)	-0,331 (-1,671)
SIZE	-0,131 (-2,199)	-0,110 (-1,662)
ESTABL_YEAR	20,804 (0,735)	34,592 (1,122)
SERVICE	-0,603 (-2,627)	-0,446 (-1,867)
PSERVER	0,072 (0,350)	0,101 (0,456)
MANSOFTA	0,269 (1,195)	0,426 (1,806)
SECSOFTA	0,160 (0,798)	-0,182 (0,840)
INTSOFTA	0,090 (0,449)	0,217 (1,022)
FINLAND	-0,074 (-0,224)	-0,341 (-0,963)
ITALY	0,107 (0,400)	0,113 (0,392)
PORTUGAL	-0,612 (-1,454)	-0,274 (-0,567)
SPAIN	-0,181 (-0,614)	-0,293 (-0,318)
Mu2	0,243 (2,929)	1,062 (6,108)
Mu3	0,875 (6,987)	1,888 (10,070)
Mu4	1,600 (11,345)	1,600
Number of obs	270	254
Log-likelihood	-294,300	-236,465

Note: Mu2-Mu4 are the estimated parameters for the boundary values between the different categories of the dependent variable.

Table 3. The estimation results for the negative binomial models for the firms' license choices

	Dependent variable: Number of copyleft-licensed product groups	Dependent variable: Number of non-copyleft-licensed product groups	Dependent variable: Number of dual-licensed product groups
	Estimate (T-statistic)	Estimate (T-statistic)	Estimate (T-statistic)
C	-362,803 (-2,232)	-240,012 (-0,739)	196,760 (0,454)
COMPL_SERVICE	0,122 (0,835)	-0,047 (-0,169)	0,158 (0,432)
ADAPT_OSS	0,076 (0,472)	0,138 0,454	0,508 (1,101)
INTEGRATE_OSS	-0,040 (-0,272)	-0,151 -0,548	0,382 (1,072)
OSS_ORDER	-0,408 (-2,998)	0,236 (0,973)	0,612 (1,893)
OSS_SCRATCH	-0,059 (-0,461)	0,117 (0,492)	-0,013 (-0,041)
OSPROJ	0,189 (1,635)	0,208 (0,909)	0,169 (0,547)
MAIN_ENDUSER	-0,228 (-0,634)	0,610 (0,828)	0,274 (0,294)
MAIN_FIRM	-0,173 (-1,278)	0,112 (0,411)	0,000 (0,000)
SIZE	-0,059 (-1,346)	-0,131 (-1,391)	0,070 (0,645)
ESTABL_YEAR	47,701 (2,230)	31,437 (0,735)	-26,754 (-0,469)
SERVICE	-0,113 (-1,050)	-0,016 (-0,071)	1,582 (2,564)
PRODUCTS	1,200 (6,982)	0,646 (2,364)	1,125 (2,474)
PSERVER	0,081 (0,459)	0,224 (0,665)	1,093 (1,714)
MANSOFTA	0,007 (0,036)	-0,364 (-0,997)	0,648 (1,012)
SECSOFTA	-0,184 (-0,954)	0,620 (1,696)	-0,885 (-1,479)
INTSOFTA	-0,210 (-1,090)	0,056 (0,160)	0,470 (0,850)
FINLAND	-0,260 (-1,015)	0,172 (0,347)	-3,616 (-4,210)
ITALY	0,115 (0,558)	-0,356 (-0,850)	-1,394 (-2,599
PORTUGAL	-0,263 (-0,829)	0,409 (0,692)	-0,501 (-0,635)
SPAIN	-0,081 (-0,367)	0,045 (0,098)	-1,638 (-2,670)
ALPHA	0,475 (6,429)	1,979 (6,896)	2,540 (4,789)
Number of observations	301	301	301
Log-likelihood	-666,034	-471,389	-283,335

Note: The parameter "ALPHA" is a dispersion parameter used for testing whether the Poisson model that limits the mean of the dependent variable to be equal to its variance would be sufficient.

variable that gets a statistically significant value. These empirical findings are likely to relate to the preferences of the firms' customers ordering customized software. Given that about 78% of the sampled firms' customers are firms, the buyer's need for flexibility may relate to the integration of the ordered OSS software to the buyers' own software programs that the less restrictive licensed software solutions enable.

The empirical results further show that a firm's participation to the OSS projects clearly increases the restrictiveness of its licensing strategy. This hints that, indeed, the GPL is an effective coordination mechanism affecting not only the choices of individual software developers but also those of the software firms. The software firms themselves developing the OSS from the scratch or on order, instead, tend not to choose the GPL to coordinate the further development of software that originates from the firm. The firms, especially those developing customized OSS on order, rather rely on less restrictive licensing to satisfy the customer needs. In other words, the GPL-licensing primarily arises from the OSS community and spreads via the firms, not the vice versa. The firms are rather the origin of the more flexibly licensed OSS products.

Slightly disappointingly, the variables capturing the types of main customers appear not to be statistically significantly related to the firm's licensing decision in any of the estimated equations. The data show that the sampled firms are relatively homogenous in terms of their main customer base: in the majority of the cases other firms are the main customer group. Therefore, given the dataset, these empirical results may not be that unexpected. To make further conclusions about the role of the firm's main customers in their licensing decision, an empirical exploration of a dataset comprising more heterogeneous firms in regard to their main customers would shed more light on this question.

The estimation results of the ordered probit model I further indicate that firm size is negatively and statistically significantly related to the restrictiveness of a firm's licensing strategy (though in the case of model II, the estimate of the coefficient of the variable is significant only at p=0.10). The smaller firms tend to employ more restrictive licensing strategy. One possible explanation underlying this observation is that the smaller firms tend to choose the restrictive license to benefit from the less costly development and maintenance of software within the open source community. Another, maybe even more plausible explanation is that the small firms lack resources to produce and maintain their own software programs and then rather build their business strategy around the available OSS solutions that are mostly GPL-licensed. This may also indicate that only large software firms have sufficient resources and find it profitable to develop and provide competing software under the commercial licenses for certain GPL-licensed software (such as Linux[13]).

Some other interesting, statistically significant findings are that the service heterogeneity variable is negatively related to the restrictiveness of the firm's licensing strategy (Table 2) and positively related to the number of dual-licensed products. As the estimated coefficient of the variable SERVICE is not statistically significant in the case of the ordered probit model II, i.e. when the category "only dual-licenses" is removed from the estimated model, the service variety variable clearly relates to the dual-licensing. It seems thus that the firms that offer a greater variety of services tend to also offer extra flexibility for the buyers by letting them to decide between the OSS and proprietary licensed solutions. This makes sense: if a firm's revenues arise largely from its services, the firm is less dependent on the

[13] Despite of the fact that the Linux operating system development has grown into the one of the most successful, coordinated collaborative open source projects on a global scale, the commercially licensed Microsoft Windows operating system continues to dominate the global markets for the operating systems. There are only few other providers of operating systems.

license revenues and it may benefit most when it allows the customer affect the licensing terms of the delivered software solutions.

Figure 2 hinted that there are large country-specific differences in the license type choices of software firms. When various firm-specific factors are controlled for, the country dummies are not statistically significantly explaining differences in the software firms' licensing strategies with the exception of the negative binomial model for dual-licensed software: the estimation results suggest that software companies in Finland, Italy and Spain tend to provide less dual-licensed software products than companies in Germany or Portugal. There are thus some country-specific differences in how the markets for the OSS products have developed. Our data do not unfortunately enable further investigations of the underlying reasons for these observed country-specific differences in the OSS supply patterns but this would definitely be an interesting topic of research as such.

5. Conclusions

This empirical study has used a survey data to explore the licensing strategies of the software companies in five European countries. The estimation results strongly suggest that the GPL works as an efficient coordination mechanism for the (leading) developers of the OSS community and spreads particularly via the firms that have participated in the OSS development projects. The software companies supplying the OSS, instead, tend not to aim at using the GPL to coordinate the further development of their own OSS developed either on order or from the scratch.

The firms are rather the origin of more flexibly licensed OSS products though generally the software firms' OSS business strategies relate to the restrictive licensing strategy choices. Particularly companies offering OSS on order tend to employ less restrictive licensing strategies and service-oriented software firms further favour the dual-licensing. Customers are typically in a close contact with both the suppliers of on-order delivered software and software service providers and, as the sampled firms' customers are mostly other companies, we may conclude that software firms' customers preferences and particularly their need for flexibility – possibility to integrate the less restrictively licensed software to the firm's own software programs and/or to choose between the proprietary and open source licensed versions of software – strongly affects the licensing choices of those software firms that produce and supply their own open source solutions.

Empirical analysis reported in this article has provided some new pieces of information on the mechanisms of the open source software supply and licensing and the software firms' role in that. Further systematic theoretical and empirical economic analyses on firms' choices and behaviour in situations when the open source products are supplied alongside with their proprietary substitutes are definitely needed.

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