Adaptive entry strategies under dominant standards.
Hybrid business models in the Open Source software industry

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Abstract

During the '60s and the '70s, basically all software was Open Source and everyone was allowed to copy, modify and redistribute computer programs.

When software ceased to be hardware-specific and the diffusion of computers took off, firms started to produce software independently from hardware and to protect their code through intellectual property rights.

At present a turnaround is taking place: the Open Source production mode is spreading across the software industry and, in some cases, it performs even better than the traditional proprietary one.

Although a growing body of literature is analysing Open Source software (OSS) issues, there is still lack of empirical data on the phenomenon and little is known about firms that enter the software industry by producing under the Open Source license scheme (*Open Source firms)*. This paper is a contribution to fill this gap and focuses on the business models of these firms. We find significant heterogeneity among them, in particular many agents supply both proprietary and Open Source software. We present a model of adoption that studies the intra-firm diffusion of the new paradigm. Explanatory hypotheses are discussed analysing how the characteristics of the Open Source production mode and of network externalities in software demand shape the strategies of firms that entered the OSS field.

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1. Introduction

In the early days of the computer industry, software was not regarded as a separate good*:* computer manufacturers supplied software for free. During the '60s and the '70s, all software was Open Source and everyone was allowed to copy, modify and redistribute computer programs.

When software ceased to be hardware-specific and the diffusion of computers took off, firms started to produce software independently from hardware and to protect their code through intellectual property rights (Hall, 2003).

At present, a turnaround is taking place: individual programmers and even firms have started again to give away their code, releasing it to the Open Source community. The Open Source production mode is spreading across the software industry and, in some cases, it performs even better than the traditional proprietary one.

Although a growing body of literature is analysing Open Source software (OSS) issues, there is still lack of empirical data on the phenomenon. In particular, while empirical evidence is available on profiles and motivations of individual programmers, little is known about firms that enter the software industry by producing under the Open Source license scheme (*Open Source firms)*. This paper is a contribution to fill this gap and focuses on the business models of these firms. We find significant heterogeneity among them; in particular, many agents supply both proprietary and Open Source software. We discuss possible explanatory hypotheses on this issue analysing how the characteristics of the Open Source production mode and of the demand for software shape the strategies of firms that entered the OSS field.

This analysis may contribute to the *theory of diffusion* of technological innovations under conditions of increasing returns to adoption. In particular, models in the tradition of path dependence and lock-in (Arthur, 1989; David, 1985) predict that the long run outcome is characterised by a single dominant technology, which, once established, prevents competing technologies to gain a foot in the market. According to this prediction, firms should either adopt (or switch to) the dominant technology or leave the market. Entry is allowed only with the winning technology. In the case of Open Source, software the dominant standard is represented by Microsoft-based software in the client side of the market. In the server side, the OSS Apache powers 67.43% of the Web sites but Microsoft IS is still holding out. Its market share is round 21%. Because OSS products are not compatible, in general, with commercial ones, they are at disadvantage in penetrating the market. In addition, customers are reluctant to give up proprietary software and switch to Open Source

solutions because of the network externalities that shape the adoption of software goods. Still we observe a massive process of entry of new firms that challenge commercial software by offering Open Source-based products and services.

In several recent papers (Bonaccorsi and Rossi, 2003; Dalle and Julien, 2003) it has been shown that the market dynamics may be characterised by more, not just one, dominant technologies and the coexistence with commercial software is claimed to be the most likely long-term outcome. This paper endeavours to explain the driving forces under the strategic options of firms that challenge the dominant standard represented by commercial software in the expectation that the final competitive equilibrium will *not* be represented by a single standard. The paper is organised as follows.

Section II describes the roots of the entry and the business models of commercial firms in the Open Source arena. Furthermore, it reports about the specificities of software demand with which Open Source firms must cope.

Section III describes the methodology of the survey that we took on Italian Open Source firms. The main characteristics of the sample are reported.

In Section IV, we use the data collected by the survey to validate a model that accounts for the decision of a firm to adopt a more or less oriented Open Source business model. Finally, we summarise the main conclusions of the paper.

2. Firms' business models in the Open Source field and the role of network externality

The Open Source paradigm has a long story behind it. The idea that exchange of software code among the developers improves the quality of programs through investigation an intense collective activity of, bug correction and re-use originated in the early days of the computer industry. After World War II, in the United States, the computer science departments of Universities and the research centres of large corporations, like the MIT Artificial Intelligence Laboratory (AI Lab) or the AT&T Bell Labs, were like *programmer's paradise* (Rosenberg, 2000) where software was shared.

However, the Seventies were the turning point on the way for the dominance of proprietary software. Computer scientists at AT&T Bell Laboratories invented an operating system, UNIX, which, being cross-platform, could be implemented on all machines. Initially UNIX was freely available to the community of

software developers, but soon AT&T recognised its commercial value, a price tag was put on it and intellectual property rights were established and enforced (Lerner, Tirole, 2002b).

After this decision, the computer industry seemed to be *fated* towards a market structure dominated by firms strictly protecting their code through copyright, trade secret or even patents[2], but in 1983, a researcher at the MIT Artificial Intelligence Laboratory, Richard Stallman, reacted against this situation. He established the Free Software Foundation to *develop and disseminate a wide variety of software without* license fees (Tirole, Lerner, 2002) and conceived a license scheme, the GNU General Public Licence (GPL); to prevent that cooperatively developed software could be turned into proprietary. Nowadays a large amount of software is released under the GPL, which has a persistent nature: every program that uses a piece of GPLed code has to be released under the GPL too. Moreover, this license grants the licensee with a large bundle of rights[3]. These characteristics scared the firms, the myth that *getting too close to GPLed software would cause proprietary software to be turned into GPLed software and lost for ever* (Rosenberg, 2000) spread very quickly across the commercial world and restrained Free Software[4] diffusion.

In 1998, some leaders of the Open Source community endeavoured to put this right and set up the Open Source Initiative (OSI). They drafted a document, the Open Source Definition, containing the criteria that a software licence must meet to be labelled as Open Source (approved OSI). Several licences schemes less restrictive than GPL[5] were introduced. Moreover OSI recast the expression *Free Software*, chosen by Stallman, as Open Source. Firms, in fact, might have wrongly assumed that the term *free* implied no chance to make profit from the Open Source software while customers might have associated no *"license fee"* with *"no product support"* (Hecker, 2000).

These measures turned out to be successful and commercial firms began to engage in Open Source activities[6]. At present, this process has been involving two groups of firms in the software industry: large

[2] Economic theory states that the very cost structure of the software good leads to concentration (Shapiro and Varian, 1999). Software is information and the production of information involves high fixed costs and negligible marginal costs. The whole mass of cost of a computer program is concentrated in its first copy, while reproduction costs are extremely low. As a consequence, the more copies are produced and sold, the more the high production cost of the first copy will be offset by the low cost of subsequent ones.

[3] See the text of the GNU General Public License (http://www.gnu.org/copyleft/gpl.html).

[4] Authors are aware of the difference between *Free Software* and *Open Source*. Nevertheless the discussion of these difference is outside of the scope of the paper. In the following the two terms will be used as synonymous.

[5] For instance the Berkeley Software Distribution (BSD)

[6] According to the Netcraft Survey, the market share of the Open Source Web server Apache was 67.38% on January 2004. Apache has been leading the Web server market since 1996. The market share of its closer competitor, the Microsoft IIS, is less than 30 percent (Varian et al., 2003).

incumbents and new entrants. The former are releasing the source code of their programs to the Open Source community[7] while the latter are endeavouring to profit from the new production paradigm: their sources of revenues are no more licence fees but other software-related offerings.

Wichmann (2002a) has created an exhaustive taxonomy of the business models of these new actors. He distinguishes between the product and the service side of the software market and positions the firms' Open Source activities at different levels of the software value chain.

Linux distributors are probably the best-known firms in the product side. Their core business[8] is to *package and sell the Linux operating system* (Wichmann, 2002). These firms aggregate, integrate and optimise the newest Linux files that are freely downloadable from the Internet. These activities add significant value and convert raw software fragments in a ready to install operating system[9], usually supplied on a CD Rom together with documentation. *Niche and specialty Open Source distributors* carry on the same activities on the code developed within a wide variety of Open Source projects. Projects' evolution and social dynamics are the critical factors of this business model and firms must commit to coordinate individual developers, release the product on time and not forego the production.

Some distributors are very successful. In August 2001 IDC named the Linux distributor Red Hat the market leader for second consecutive year with 52.4% of the Linux shipments worldwide while the Open Source application server produced by Zope Corporation is now adopted by *Fortune 1000 companies, newspapers, media, telecommunication firms, and the government…*(Zope Corporation, 2003). The enormous saving of development costs is the main competitive advantage of these firms. Wheeler (2001b) estimates that without the contributes of the Open Source community the Red Hat 7.1 operating system *would have required about 8,000 person-years of development time*, and cost about one billion dollar.

Open Source distributions are sold by *retailers*, often together with other Open Source related materials, such as books or gadgets. This business model (*accessorizing business model)* has been successfully set up by

[7] Wichmann (2002), has taken into consideration the world's 25 largest software companies as listed in the Software Magazine's 2001 and investigated their involvement in Open Source development activities. He has found that one third of these firms do engage in major Open Source development activities while three companies have smaller projects. The first group includes IBM, Hewlett Packard, Compaq and Sun Microsystems. See Hawkin (2002) for an exhaustive analysis on the incentives of large software companies to take part in the Open Source movement.

[8] These companies typically target the mass market and the market for individual solutions both for individuals and firms. Moreover they often offer also Linux-related services such as consulting, integration, support and training (Wichmann, 2002).

[9] Usually supplied on a CD Rom together with documentation

O'Really & Associates, which publishes books that document and explain many Open Source program (Wichmann, 2002a).

According to Stallman, the provision of services as *consulting, system implementation and integration, support, maintenance, remote administration, training and application management*[10] (Wichmann, 2002) for Open Source products is the heir to the *for-profit business based on treating software as intellectual property* (Hecker, 2002). Service provision is made effective not only by big distributors but above all, it is the core business of small enterprises that target the private and SMEs market. It is worth to notice that Open Source plays a key role in opposing the concentration of the software industry. Feedbacks and contributions of the Open Source community lower developing costs so that the fixed costs of the first copy of software program decreases. Moreover, firms pay no licence fee for packaging Open Source products or offering services related to them. This reduction in fixed and variable costs means that firms reach the break-even point at a much lower level of production and lower sales volumes are needed to make profits. Moreover, services on software products are a *classical people-selling business with constant and high marginal costs*, given that *the cost of a second project are quite the same as the cost for the first project* (Wichmann, 2002). The critical factor in this case is not the sales volume but the availability of talented human capital. In conclusion, high industry fragmentation is a viable equilibrium.

Anyway, firms that choose to supply OSS product and services in choosing their business model should not leave out of consideration the direct and indirect network externalities that shape the demand for software goods (Church and Gandal, 1992).

On one side, the utility that an agent derives from the adoption of a software package increases with the number of other agents using that package (*direct network externalities*, Katz and Shapiro, 1985). Software users form a two way - virtual network (Economides, 1996) through which files, documentation and knowledge flow. The larger the network, the larger the incentive to join for potential adopters (Varian and Shapiro, 1999). On the other side, there strong *indirect externalities* (Farrell and Saloner, 1986, 1987; David and Greenstein, 1990). The decision to adopt a software good depends on the number of compatible

[10] Some firms have endeavoured to offer services to the Open Source community in terms of marketplaces and organisation of conferences or meetings. Marketplaces aim at matching agents that need a specific software product or service (buyers) with Open Source developers (sellers). Up to now this business model has turned out to be very unsuccessful and *no company …has become profitable so far* (Wichmann, 2002). The shortage of guarantees for the completion of the products typical to thr Open Source production mode scares the buyers while the sellers do not want

applications, which, in turn, is an increasing function of software diffusion. In fact, the more a software is widespread the higher the incentives for software house and individual programmers to develop compatible applications.

Finally learning to use a software usually takes a lot of time and effort so the agents bear high switching costs when decide to replace a package with another one. As the typists of David's tale (1985), who learnt to use QWERTY machines because most offices were endowed with them instead with DVORAK ones, software users are usually trained on widely adopted software solutions[11] and must bear high switching costs when shift to other programs.

In short, the probability to adopt a software increases with its installed base. The very early stages of the adoption process shape the whole diffusion path. When a product succeeds in achieving a critical mass of adopters, its market share becomes larger and larger and the market is going to be locked on this solution (Arthur, 1990; 1994).

This situation creates an interesting dilemma for the prospective new entrants in the Open Source field that adopt the OSS model. On one hand, given the widespread diffusion of proprietary products, Open Source firms might accept a compromise and include both OSS and commercial products in their offering. This may be important to fill consumers' needs, taking into consideration their legacy, while waiting for a complete line of products based on Open Source. On the other hand, in this way the firm runs the risk of breaking the cooperation link with the Open Source community. Firms purchasing OSS must conform to the Open Source values of code and knowledge sharing in order not to betray the trust of the community of the developers from which they receive feedback and contributions. This is possible only if there is no overlapping between the activities in the proprietary and Open Source field[12]. Behaviours such as including pieces of Open Source code into proprietary programs or keeping close parts of the code of the programs released to the community are in sharp contrast with the norms ruling Open Source projects. As a consequence, they are likely to bring down cooperation, reducing the incentives of individual programmers to contribute to Open Source projects for firms (Kuster et al., 2002).

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to pay for a service that the Internet network provides for free. For the same reason Open Source programmers are not willing to pay fees for information about conferences and meetings.

[11] Given the widespread diffusion of proprietary software on the client side of the market, the switch to Open Source solutions implies high switching costs at an aggregate level.

[12] It is worth to notice that Open Source Definition allows for double licensing.

Therefore, new entrants must decide whether to follow a hybrid business model, combining different types of licensing schemes, or a pure completely based on GPL-type schemes. Once they have adopted a hybrid model, an interesting question arises, i.e. the intra-firm diffusion of OSS solution, as the proportion between the two production modes.

Firms that adopt a hybrid business model are likely to be are heterogeneous with respect to the extent to which they mix the two production paradigms. This paper analyses what determines a weaker or a stronger orientation towards Open Source Software. Our research hypothesis is that the extent of the intra-firm diffusion of the Open Source Software depends not only on the economic, technological or social incentives that lay at the basis of the Open Source involvement of individual programmers but also on firms' beliefs on the role played by network externality phenomena. Therefore, that firms that attach a larger importance to the specificities of the software demand are likely to offer more proprietary products and vice versa. We test this hypothesis using the data of a large scale survey carried out Italian Open Source firms.

3. Methodology and sample description

Open Source Software is in many respects very challenging for economics scholars. It raises several key theoretical problems that deal with motivations of the developers, coordination within projects, and diffusion of a new technology under a dominant standard (Bonaccorsi, Rossi, 2003). An increasing amount of theoretical studies have been addressing these issues, but there is still lack of empirical data. In particular, few empirical works explore how firms relate to the new paradigm. Moreover most researchers focus on the demand for Open Source Software by companies or public bodies[13] while few data are available on the supply side of the market that is on firms that supply Open Source based products and services. The studies on Open Source firms focus especially on the characteristics of their business models (Rosenberg 2000;

[13] From February to May 2002, the Berlecon Research GmbH together with the International Institute of Infonomics (FLOSS Report, Wichmann, 2002b) collected data on professional Open Source users in Germany, United Kingdom and Sweden in order to study their attitude towards OSS, the motivations leading to its adoption and the benefits coming from its use. 395 operators were interviewed in detail. It has been found that the extent of adoption of Open Source and its perceived benefits vary greatly depending on geographical areas, firm size and line of business.
In Italy, Cogenio (2001) conducted a survey in order to investigate the use of Linux by small-and-medium-enterprises (SMEs). According to this study, 16 SMEs out of 414 use Linux on their servers whereas only one adopt it on the client-side, which is dominated by Windows with a share of about 90%. It is worth to notice that 80% of the interviewed system administrators declare that they are aware of Linux and the Open Source movement in general. Stability and security are the main motivations for the use of Linux on the server-side, while Windows is used on the

Feller, Fitzgerald, 2002), motivations of code releasing (Hawkins, 2002; Mustonen, 2002), and licence choice (Lerner, Tirole, 2002b). At present we are not aware of a comprehensive survey collecting data on the structural characteristics of these firms, their attitude towards the Open Source Software and their links with developers' community.

In order to fill this gap, during 2002, we submitted a large questionnaire to firms supplying, in various ways, Open Source solutions in Italy[14]. Sample selection was a critical task. Because of the novelty of the phenomenon, there is no complete directory of firms working with the Open Source Software and new firms are entering the field each year[15]. Specialised journals are publishing lists of these firms but they are partial or restricted to specific business or geographical area. Given that, we adopted the snowball sampling procedure. We approached a initial short list of firms and asked their collaboration in referring to other firms active in the Open Source field. We stopped when no new referral was originated. Clearly this amounts to say that our sample is not statistically representative of the universe but, given the exploratory nature of the study, this was considered methodologically correct. We succeeded in contacting 275 firms and obtained 146 valid answers representing a good cross-section of the Italian firms operating in the supply-side of the Open Source market.

Table 1 reports descriptive statistics of firms' structural characteristics.

Variable	*Acronym*	*Unit of Measurement*	*Min.*	*Max.*	*Mean*	*St. Dev.*
Year of foundation	YF	Unit	1957	2003	1996	6.4
Year of Open Source adoption	YOSSA	Unit	1986	2003	1999	2.6
Staff	E	Unit	1	320	17.3	36.6
Graduate staff	DG	%	0	73	6.7	12.0
Average age of partners	AAP	Unit	22	58	36.1	7.5
Average age of employees	AAE	Unit	20	43	29.8	4.1
Average age of freelances	AAF	Unit	20	58	30.2	5.9

client-side especially because of its easiness of use. Moreover almost all Linux users on the server-side are in favour of its utilization also on the client-side.

[14] The questionnaire consists of two parts. The former includes questions dealing with firm's characteristics. Variables such as year of foundation, size, entrepreneurs' competencies, products and services supplied are gathered. The latter explores firms' attitude towards the Open Source Software and its community as measured by perceived obstacles to OSS diffusion, incentives to choose of the new paradigm, number of OSS projects joined and coordinated, expectations about the evolution of the OSS market. The whole questionnaire collected more than 200 variables. Following the approach used in surveys taken on Open Source developers (Hertel et al., 2003), we prepared the questionnaire on line: a Website was set up containing all the information about our study and the link to the data gathering system. In order to increase the response rate, announcements of the survey containing the link to the Website were posted on specialized portals and mailing lists. Moreover, we enabled the operators to take telephone interviews or to fill in and return the questionnaire by fax or e-mail.

[15] According to our data, 59 firms out of 146 were born in 2002

Open Source turnover in 1998	OSST98	%	0	100	35.7	36.5
Open Source turnover in 2001[16]	OSST01	%	0	100	46.5	37.0
Change in turnover (in the last 3 years)	TC	%	-25	600	121.3	155.1
Change in Open Source turnover (in the last 3 years)	OSSTC	%	-10	700	91.4	138.5

Table 1: Descriptive statistics.

Most firms entered the market recently. The median year of foundation is 1996 while 1995 is the 25° percentile. About 40% of the firms have been on the market since 2000 while 80 out of 146 were born as from 1998, the year in which Open Source Initiative was set up to bring the business world near to the Open Source community. At the same time, the median year of adoption of the Open Source technologies is 1999 and 2000 is the modal one[17], 62.3% of the firms adopted Open Source solutions since the very year of the foundation (early adopters).

Different from surveys taken on OSS developers[18], few members of firms' staffs have a degree (6.7%)[19], this is at odds with the stereotype that only computer-skilled hackers can work with Open Source. Open Source evangelists (Raymond, 1999, 2001), claims that the *hacker culture* is very important element of the OSS movement. Hackers, who regard programming as an art form and fill *artistic satisfaction* in solving complex computer problems, keep the flag of code sharing flying high. Nevertheless our data show that they do not seem to play a leading role within the Italian Open Source paradigm. Less than 30% of the firms in the sample have a promoting partner group composed only of technicians while most respondents number also individuals skilled in economics and finance among their founders. Only 6.2% of firm promoters came from Universities and research centres or were employed in public bodies or non-profit organisations. Nevertheless individuals skilled in computer science are undoubtedly needed in the entrepreneurial core for entering the Free Software market: 130 firms (89%) number at least one technician among their promoting partners.

Most firms (78%) come from the software sector. The new paradigm has been diffusing in Italy for a short time and the firms not involved in the software sector probably suffer from lack of information. They are less likely to have access to the traditional information sources of the developers' community (websites, mailing lists, newsgroups) and are less aware of the business opportunities that ensue from the Open Source. Our

[16] Firms born after 2001 were asked for their Open Source turnover in the last year.
[17] In addition 27.6% of the firms adopted during 2000.
[18] Ghosh et al. (2002) surveyed 2,784 Open Source developers. They have found that 33% of them have a degree, 28% have a master and 9% attended a Ph.D. program.
[19] Very few individuals (0.4%) attended a Ph.D. program.

findings are in line with the results on individual developers[20] as far as the age distribution of individuals involved in firms' activity is concerned. On average people are about 32 years old, partners form the oldest groups while employees and freelances are in their early Thirties. Firms born after 1999 and early adopters of the Open Source technologies number younger individuals among their partners, employees and freelances.

The average number of individuals working for each firm is quite low (17.3)[21]. Table 2 summarizes turnover classes; about 70% of the firms belong to the three lowest turnover classes while only five agents belong to the highest one. Crossing staff with turnover classes[22], it turns out that 99.3% of the sample consists of Small and Medium Enterprises. This size distribution corroborates that Open Source paradigm opposes the tendency towards concentration in the software industry.

[20] Ghosh et al. (2002) have found out that average age of the developers responding to their survey is 27.1 while the median age is 26.

[21] 81.9% of the firms have less than 20 individuals working for them. Different from developer surveys, women are not under-represented, accounting for 21.5% of the total workforces. It is worth to notice that over 75% of the firms have been established by less than 5 promoting partners.

[22] We followed the European Commission Recommendation of June 25th 2002 amending Recommendation 96/280/EC for definition of small-medium-sized enterprises; http://europa.eu.int/comm/enterprise/consultations/sme_definition/consultation2/153_sme_definition_25_6_2002_pp1_11_en.pdf, accessed on 29th March 2003.

Turnover class	*Frequency*	*%*	*Cumulate %*
Less than 129	54	39.7	39.7
130- 258	18	13.2	52.9
259- 516	23	16.9	69.8
517 - 2,582	33	24.26	94.1
2,583 - 5,164	3	2.2	96.3
More than 5,165	5	3.7	100.0
Total	136	100	

Table 2: Turnover classes. Unit of measurement: thousand euros.

The growth of firms in our sample is remarkable. In the last three years, their turnover increased, on average; by 121.3%[23]. Further investigations are needed to understand the relationship between such a fast pace of growth and the specificities of the Open Source production mode. Our data make this task particularly challenging. In fact, no statistically significant difference emerges in the average growth rates of firms born before and after 1999 (new and old firms), early adopters and laggards, firms established by technicians and firms with mixed promoter groups, firms that enter the market right to work with Open Source and other companies. This seems to point to a diffuse pattern of rapid growth. It is worth to notice that firms offering exclusively or prevalently Open Source solutions grow more slowly than the ones that mix open and proprietary software (78.6% vs. 169.6%, p value = 0.005). This is indicative of the viability of hybrid business models.

Firms in our sample follow the typical Open Source business models and offer the services singled out by the literature on Open Source firms (table 3).

Service	% of firms supplying the service
Installation	80.1
Support	82.9
Maintenance	76
Development of ad hoc solutions	87.7
Distribution	63
Marketing of software produced by other companies	39
Consulting	84.9
Training	64.4
R&D	51.4

Table 3: Services offered by the firms. Multiple choice question.

[23] Excluding the outlier value 666%. Part of the growth is due to newly created firms, whose turnover starts from zero at the initial period. It is worth to notice that Assinform (2004) estimates that, in Italy, the whole software product and service market experienced a negative growth rate of about -3.7% in 2003. In the United States, the global sale volume of software products and services was expected to growth annually by 17.8 by the end of 2001 (Iventosh et al., 2002).

Figure 1 summarizes product offering. In confirmation of success of the Open Source in the Internet segment of the software market, many firms supply Internet based products.

In 40% of the cases firms' activity in the Open Source field originates from the adoption of Open Source technologies by firms that previously supplied proprietary solutions[24]. In most cases the shift to the new paradigm was only partial. This corroborates the notion that hybrid business models, which mix Open Source and proprietary elements play a crucial role in the feasibility of commercial applications of OSS, being the

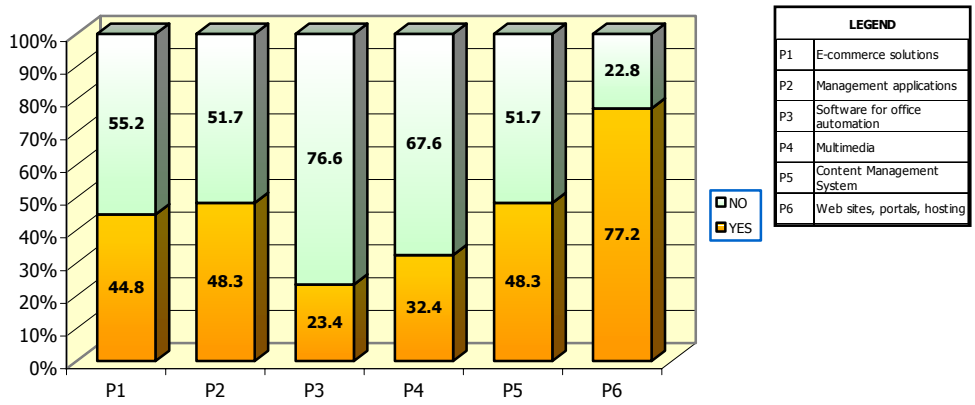

Figure 1: Products offered by firms. Multiple choice question.

coexistence of the two paradigms very likely to be the outcome of the market.

Further researches are needed in order to investigate whether a pure Open Source model can stand up to competition in the software market.

Anyway, in the last three years the percentage of Open Source products and services on sales increased from 35.7% to 46.5%.[25].

Percentage of Open Source turnover		
Group	*Mean*	*Mann- Whitney test P value*
Early adopters	57.9	0.000
Laggards	23.3	
Firms born to work with OSS	67.8	0.000
Firms not born to work with OSS	36.7	
Firms set up by technicians	66.1	0.000
Firms with mixed promoting partner groups	37.6	
Firms born after 1999	61.6	0.003
Firms born before 1999	38.7	
Firms in the three lower turnover classes	53.1	0.002
Firms in the three highest turnover classes	28.7	

Table 4: Percentage of OSS turnover for different groups of firms.

[24] The sample includes 42 firms entered the market right to work with Open Source software, 64.3% of them were born after 2000.

[25] The average rate of growth of the Open Source turnover is about 90%. Excluding an outlier value of 900%.

Early adopters, firms born to right work with OSS or set up by technicians, new firms and smaller ones exhibit higher percentages of Open Source turnover (table 4). On one side this suggests the importance of computer science skills in seizing the business opportunities related to new paradigm and, on the other side, is indicative the role played by OSS in opposing concentration in the software industry[26].

4. *Heterogeneity in business models in the Open Source market: a model of Open Source intra-firm diffusion*

The previous discussion highlights that Italian Open Source firms choose mainly hybrid business model and endeavour to profit from both the two production paradigms. In this section, we look deeply into the factors that affect the firms' choice of mixing proprietary and Open Source production modes. We argue that the adoption of a more or less Open Source-oriented business model is rooted both in the appreciation of the Open Source software and in the awareness of the role played by network externality phenomena in shaping software demand. Our argument is that the specificities of the diffusion paths of software technologies are a key factor in leading firms to choose a hybrid business model.

In the following, we attempt to classify *hybrid* firms on the basis of their weaker or stronger Open Source-orientation. Further, we endeavour to model firms' choice to adopt a more or less Open Source-oriented business model as the result of the interplay of: i) heterogeneity in motivations that lay at the basis of the choice of the Open Source paradigm, ii) different degrees of participation in Open Source projects and iii) different importance attached to network externality phenomena.

For the purpose of the analysis, we single out firms adopting a *pure Open Source* business model and exclude them from the sample. In order to identify the *pure Open Source* firms we have combined three variables: the share of turnover due to the provision of Open Source products and services (OSST01), the percentage of Open Source products on the total (%OSSP), firms' statement about the typologies of solutions provided to the customers (SOL_C)[27]. A firms is purely Open Source if it holds that OSST01=100%, %OSSP= 100% and provide only Open Source solutions. We single out 8 agents (about 5.5% of the sample). Although interesting under many respects, the analysis of the characteristics of this small group of

[26] Just as expected, the percentage of the Open Source turnover is positively correlated with the percentage of use of the GPL (r=0.314, p value = 0.08).

firms is out of the scope of this paper that aims at determining the factors that carried firms to adopt hybrid model chosen and, as a macro result, lead to the coexistence of two technological paradigms in the software industry.

To go further ahead with out analysis we group the rest of the respondents (hybrid firms, 138 out of 146 firms) through hierarchical cluster analysis[28] using a set of variables that are indicative of agents' attitude towards Open Source paradigm. That is

a. Percentage of Open Source turnover on the total in year 2001 (OSST01)

b. Share of OSS products on the overall products supplied by the firm (%OSSP)

c. Typologies of solutions supplied by the firms (SOL_C): only Open Source solution (SOL_C=3), mainly Open Source solutions (SOL_C=2) and indifferently proprietary and Open Source solution (SOL_C=1)

d. Strategic importance attached to Open Source Software (SI_OSS). This variable ranges from 1: not at all important to 5 = very important.

e. Habits towards the use of GPL (LICENSE). We mean both the licenses under which firms distribute their software and the ones used to carry on the production process. This variable is coded 3 if the firm uses only the GPL, 2 if the firm uses it together with other Open Source licenses, and 1 if firm does not use GPL.

All the variables but the last one do not pose interpretation problem but we must explain why we chose GPL use as a proxy of the OSS focus. On one side GPL is the flag of the Open Source movement that answers for the survival of this new production paradigm. Its persistent nature assures that community developed code will never be hijacked and turned into proprietary. Keeping the code open preserves developers' incentives to write valuable software in order to gain reputation among peers and signal their talent to software houses (Lerner and Tirole, 2002). A firm that choose to work with GPLed code shows it agrees with the knowledge sharing values of the OSS community. On the other side, a firm that inserts even a single one line of GPLed code in a program must release the whole software under the GPL. Given that empirical analyses show that

[27] Exclusively Open Source solutions (SOL_C=3), mainly Open Source solutions (SOL_C=2) and indifferently proprietary and Open Source solutions.

[28] An application of the cluster analysis for classifying firms is in Bonaccorsi and Giuri (2001) while Von Hippel and Franke (2003) use this technique for exploring heterogeneity of the user needs in the field of the Apache security software. We chose hierarchical cluster analysis instead of partitioning because we preferred not to fix a priori the number of cluster. Moreover it is more appropriate when the number of observations is smaller than 200 (Everit, 1993).

the GPL is the most widespread of the Open Source licenses[29], its use is indicative of the exploit of the code developed by the OSS community.

As expected, the five variables are correlated[30], so we run a principal component analysis (PCA1) to derive the factors to be included in the cluster analysis. It is worth to notice that two components are extracted from the data, meaning that the heterogeneity in the sub-sample of *hybrid* firms, as measured by the selected variables, has *two* different dimensions (see table 2A of the Appendix). Our interpretation of the results is that the use of the GPL is not related in any way with firms' Open Source orientation, given that LICENSE is the only variable significantly correlated with the second factor extracted. The first component is, indeed, positively and significantly correlated with all the variables but LICENSE. This leads to the conclusion that the most reliable indicator of firms' focus on Open Source technologies is the first factor extracted by PCA, whereas GPL use seems to be independent of the firms' strategic choices. Different explanations of this result are possible. First, the use of GPL might answer the purpose of signalling to the Open Source community that the firm agrees with its value. Such behaviour aims at obtaining feedbacks and contributions from developers, independently of the true firms' market behaviour. Further, the persistent nature of GPL reduces firms' power to freely choose their preferred licensing scheme and force them to use this license scheme independently of any ideological consideration.

Cluster analysis is performed using the Average Linkage method[31] and reveals two distinct sub-groups. Table 5 summarizes descriptive statistics of the two clusters, Mann-Whitney tests corroborate that the two clusters are well characterized, supporting the presence of significant differences between the variables in the two sub-groups.

[29] On 12th March 2004, the SourceFourge repository (http://sourceforge.net) numbered 77,026 registered projects. Almost 80% of them are released under the GPL.

[30] Correlation matrix is reported in the Appendix (table 1A, table 2A, table 3A).

[31] Different aggregation methods are based on different measure of distance between observations and groups. In the Average Linkage Method the distance between two cluster is the average distance of all pairs of observations, one observation in the pair taken from the first cluster and the other from the second cluster. The application of other methods, would have produced a cluster including almost all the observations.

Variable	*Acronym*	*More Open Source Oriented firms (MOSS)* N=74		*Less Open Source Oriented firms (LOSS)* N=64		*Mann- Whitney Test P-value*
		Mean	*St. dev.*	*Mean*	*St. dev.*	
Percentage of Open Source turnover on the total in year 2001	OSST01	60.93	31.67	13.59	14.51	0.000
Share of OSS products on the overall products supplied by the firm	%OSSP	0.90	0.177	0.67	0.28	0.000
Typologies of solutions supplied by the firms	SOL_C	4.64	0.56	3.09	0.95	0.000
Strategic importance attached to Open Source Software	IS_OSS	2.01	0.56	1.13	0.34	0.000
First factor extracted by the principal component	PCA1	0.79	0.49	-0.92	0.55	0.000

Table 5: Descriptive statistics of MOSS and LOSS firms.

It stands to reason that the firms in the former cluster (MOSS) are more Open Source-oriented than the firms in the latter one (LOSS).

The literature on Open Source phenomenon (Lerner and Tirole, 2001, 2002a; Gosh et al., 2002; Dalle and David, 2003; Hertel et al., 2003) have explained the involvement of individual developers in Open Source activities on the basis of a set of intrinsic and extrinsic motivations that resemble the ones that generate research efforts in the scientific community. So, a heavy Open Source programming activity has been mostly related to stronger motivations. However, tracing firm's decision to invest more or less massively in OSS only back to the motivational dimension and the subjective appreciation of the new paradigm does not fully account for the heterogeneity in the OSS business model. Namely, this approach overlooks the environment where Open Source firms do operate. The strong network externalities and lock-in effects that push forward the demand for proprietary solutions force firms to adapt their choices to market conditions and not give up proprietary technology. Consequently, the size of firms' investment in OSS depends *also* on firms' perceptions of the strength of environmental obstacles to the diffusion of Open Source Software. Our research hypothesis is, indeed, that firms belong to the MOSS group not only because have a better appreciation of the OSS paradigm but also because they attach less importance to network externality obstacles to Open Source diffusion while the opposite happens for LOSS firms.

We test this hypothesis through a model of adoption of a more/less Open Source-oriented business model, that includes the following classes explanatory variables that turn out to be statistically different in the two groups (table 6)

Variable class	*Variable*	*Acronym*	*MOSS*			*LOSS*			*SAMPLE*			*Mann- Whitney test p-value*
			N	*Mean*	*Std. Dev*	*N*	*Mean*	*Std. Dev*	*N*	*Mean*	*Std. Dev*	
A	Because we want to be independent of the price and licence policies of the large software companies	M1	73	4.0	1.2	59	3.5	1.2	132	3.8	1.2	0.010
	Because we wish to place our skills at the at the disposal of the Open Source community and hope that others will do the same	M5	74	3.5	1.2	59	3.2	1.2	133	3.4	1.3	0.073
	Because we agree with the values of the Free Software movement	M6	73	3.9	1.2	59	3.5	1.4	132	3.7	1.3	0.079
	Because contributions and feedback from the Free Software community are very useful to fix bugs and improve our software	M8	74	4.1	1.1	59	3.6	1.3	133	3.8	1.2	0.031
	Because of the reliability and quality of Open Source Software	M10	74	4.1	1.1	59	3.5	1.2	133	3.8	1.2	0.004
B	No. of projects the firms joined since the very start of their OS activity	ALL_A_PM	44	7.3	10.2	11	4.5	6.9	55	6.7	9.6	0.100
	No. of projects the firms joined last year	C_PM	68	2.0	3.0	47	0.5	1.3	115	1.4	2.5	0.000
	No. of projects the firms coordinated since the very start of their OS activity	ALL_A_CP	65	1.2	3.8	45	0.6	3.0	110	1.0	3.5	0.006
	No. of projects the firms coordinated during 2002	C_CP	66	0.4	1.0	47	0.3	1.2	113	0.4	1.1	0.062
	% of Line of Codes (LOCs) the firms contributed to each project on average	%_LOCs	55	10.5	22.4	42	4.1	14.5	97	7.7	19.6	0.001
	Contributions by the firms incorporated in the official versions of the projects	N_C_OV	50	1.4	2.6	42	0.1	0.3	92	0.8	2.0	0.000
C	Importance attached by firms' customers to direct network externalities	WDP	73	2.5	1.2	56	3.4	1.3	129	2.9	1.3	0.000
	Importance attached by firms' customers to direct network externalities	MCA	73	2.2	0.9	54	2.9	1.6	127	2.5	1.3	0.009

Table 6: explanatory variables of the adoption model: Mann-Whitney tests.

A. *Motivations leading firms to supply Open Source-based products and services*. The questionnaire collected data on eleven different motivation variables of firms' involvement in Open Source activities[32], 5 items out of 11 eleven are different in the two groups. As expected MOSS firms have stronger incentives of working this Open Source software than the MOSS ones (table 6). Since these variables are highly correlated, we perform a principal component analysis (PCA2). As expected, a unique factor is extracted (MOTIV), explaining almost half of the variance of the data (see table 5A of the Appendix)

B. *Firms' involvement in the Open Source community*. We use six metrics of firms' project participations (Bonaccorsi and Rossi, 2003). MOSS are more engaged in project activities. However these variables are prone to endogeneity. Project participation is indicative of a larger engagement in the movement but MOSS firms that bases their business model on the OSS paradigm is likely to be forced to participate in projects because it needs code developed within them. However we argue that involvement in Open Source projects is a key resource for young and small firms supplying Open Source solutions. Active participation in the

[32] The taxonomy of motivations is as follows [Feller]: Economic motivations: because Open Source software allows small enterprises to afford innovation; because we want to be independent from the price and licensing policies of large software companies; because in the field of Open Source good IT specialists are easy to find; because opening our source code allows us to gain a reputation among our customers and competitors. Social motivations: because we agree with the values of the Open Source movement; because we want to place our source code and skills at the disposal of the Open Source community and hope that others will do the same; because we think that software should not to be a proprietary commodity. Technological motivations: because contributions and feedback from the Open Source community are very useful to fix bugs and improve our software; because of the reliability and quality of the Open Source software; because we want to study the code written by other programmers and use it for developing new programs and product; to obtain products not available on the proprietary software market.

community allows collecting information about products, services, customers and eventual openings of market niches. As a consequence having pursued in the past a strategy of active participation, is likely to be an important asset for firms, which allows and explains a larger adoption of Open Source technologies. As in the case of the variables measuring motivations, we check for linear correlations and apply a Principal Component Analysis (PCA3) to overcome correlation problems (see table 6A of the Appendix). Two components are extracted, dealing respectively with projects participation that is, number of projects joined or coordinated (INV) and firms' contributions effort (CONTRIB) as measured by the percentage of Line of Codes contributed by the firms on the total.

C. *Evaluation of the strength of network externality obstacles*. As a proxy of network externalities we use two variables measured on a 5-point Likert scale. Firms were asked to give a mark from 1 (*not important at all)* to 5 (*very important*) to the importance attached by their customers to the availability of large software packages (*direct network externalities*) and of a wide number of compatible applications (*indirect network externalities*). Once again mean differences show the expected sign.

We run a logit estimation, having coded the dependent variable as being 1 if the firm chooses a more Open Source-oriented business model (MOSS) and 0 otherwise. Table 7 reports the coefficient estimates. All explanatory variables have the expected sign.

The coefficient of variable MOTIV is positive and significant. Incentives to work with Open Source software due to ideological reflections, reliability of Open Source production mode and independence from proprietary products suppliers, drive firms choice to adopt a more Open Source-oriented business model. Firms having stronger motivations are also more likely to focus their strategic choices on this technology.

Dependent Variable: Business model orientation (coded 1 if MOSS, 0 if LOSS)			
Independent Variable	*Coefficient*	*Standard Error*	*P-value*
WDP	-0.489	0.194	0.012
MCA	-2.419	0.196	0.218
MOTIV	0.534	0.221	0.016
CONTRIB	1.005	0.431	0.020
INV	0.671	0.274	0.014
constant	2.503	0.626	0.000

Table 7: Logit estimates of business model adoption. P-values are calculated for t-test for the significance of the coefficients. Notes: number of observations = 127, pseudo R-squared = 0.22.

Just as expected, participation to the community positively affects the probability that a firm will choose to invest more in Open Source Software. Both coefficients of CONTRIB and INV are positive and significant, meaning that having actively participated to community projects, both in terms of number of projects coordinated and lines of code contributed, allows for and sustains a more Open Source-oriented business model. This result are in line with our research hypothesis that participation to the Open Source community allows firms to gather information about market and technological opportunities in the OSS fields. Firms participating more to the OS community and taking advantage of this informative channel are more likely to be on the market with a more Open Source oriented business model.

As far as network externalities are concerned, our predictions are corroborated by the estimates: both WDP and MCA coefficients have the expected negative sign. Firms attaching lower importance to role played by direct and indirect externalities in restrain Open Source diffusion are more likely to focus their business model on the new production paradigm. Even though only the proxy measuring direct externalities turns out to be statistically significant, we find that the empirical evidence substantially supports the hypothesis that firm's choice of business model is *also* an adaptive strategy to software economies of scale on demand side. Firms' aptitude towards the Open Source production mode, both in terms of motivation and participation to the community, are not the only determinants of firm's choice to adopt Open Source technologies. Environmental conditions play an important role: namely, the idea that network externalities in the software demand is an important obstacle to the diffusion of OSS technology shape firm's strategy on the market.

Appendix

Correlation matrices

Variable	*%OSSP*	*LICENSE*	*SOL_C*	*SI_OSS*	*OSST*
%OSSP	1.000	0.157	0.273**	0.364**	0.188
LICENSE	0.157	1.000	-0.008	0.187*	0.116
SOL_C	0.273	-0.008	1.000	0.488**	0.325**
SI_OSS	0.364	0.187*	0.488**	1.000	0.540**
OSST	0.188	0.116	0.325**	0.540**	1.000

Table 1A: Correlation matrix of the variables used in the cluster analysis. Notes: ** p value <0.01, * p value< 0.05.

Variables	M1	M5	M6	M8	M10
M1	1.000	0.259**	0.232**	0.364**	0.110
M5	0.259**	1.000	0.588**	0.400**	0.219*
M6	0.232**	0.588**	1.000	0.297**	0.368**
M8	0.364**	0.400**	0.297**	1.000	0.322**
M10	0.110	0.219*	0.368**	0.322**	1.00

Table 2A: Correlation matrix of the motivation variables. Notes: ** p value <0.01, * p value< 0.05.

Variables	NPOR	NPIC	NPCO	NPCOIC	PLOC	NCVU
NPOR	1.000	0.493	0.436	0.292	-0.072	0.157
NPIC	0.493	1.000	0.310	0.454	0.331	0.426
NPCO	0.436	0.310	1.000	0.695	0.257	0.423
NPCOIC	0.292	0.454	0.695	1.000	0.271	0.167
PLOC	-0.072	0.331	0.257	0.271	1.000	0.442
NCVU	0.157	0.426	0.423	0.167	0.442	1.000

Table 3A: Correlation matrix of the variables dealing with project participation. Notes: ** p value <0.01, * p value< 0.05.

Factor loadings of Principal Component Analyses

Variable	*Acronym*	*Principal Components*	
		1	2
Percentage of Open Source turnover on the total in year	FSL01	0.609	-0.71
Share of OSS products on the overall products supplied by	%POSS	0.585	0.222
Typologies of solutions supplied by the firms	SOL_C	0.706	-0.366
Strategic importance attached to Open Source Software	SI_OSS	0.826	-2.089e-02
Habits towards the use of GPL	LICENSE	0.279	0.896

Table 4A: Factor loadings of PCA1.

Variable	*Acronym*	*Principal Components*
		1
Because we want to be independent of the price and licence policies of the large software companies	M1	0.537
Because we wish to place our skills at the at the disposal of the Open Source community and hope that others will do the same	M5	0.771
Because we agree with the values of the Free Software movement	M6	0.767
Because contributions and feedback from the Free Software community are very useful to fix bugs and improve our software	M8	0.707
Because of the reliability and quality of Open Source Software	M10	0.565

Table 5A: Factor loadings of PCA2.

Variable		*Principal Components*	
Acronym		*1*	*2*
No. of projects the firms joined since the very start of their OS activity	ALL_A_PM	0.580	-0.407
No. of projects the firms joined last year	C_PM	0.711	4.77e-02
No. of projects the firms coordinated since the very start of their OS activity	ALL_A_CP	0.781	-0.293
No. of projects the firms coordinated during 2002	C_CP	0.808	-0.186
% of Line of Codes (LOCs) the firms contributed to each project on average	%_LOCs	0.446	0.732
Contributions by the firms incorporated in the official versions of the projects	N_C_OV	0.355	0.715

Table 6A: Factor loadings of PCA3.

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