Innovativeness of software solutions: evidence from an alternative methodology

Comparing Free/Open Source and proprietary products

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Abstract

The issue of innovation processes taking place in the software sector is currently widely debated. Challenging questions arise about what products/services have to be considered innovative, and whether a specific artefact is innovative or not. In this framework, the widespread success of the Free/Open Source Software (FOSS) put forward new research issues, dealing with whether and how programs developed according to the new production paradigm turn out to be more innovative than traditional ones. In this framework, this paper aims at contributing to the literature by addressing three main research questions: (i) are software solutions produced by Small and Medium Enterprises (SMEs) innovative? (ii) What kinds of innovations are implemented? And, finally, (iii) are programs based on FOSS more innovative than proprietary ones?

Basing on a sample of 134 software solutions produced by Italian SMEs and using an original methodology to asses the problem of evaluating innovation in the software field, we provides some first insights of what emerges if we set aside the traditional innovation indicators and endower to build alternative metrics, specifically developed to target the complexity of the innovation processes in the software markets.

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1. Introduction

The issue of innovation processes taking place in the software industry - and, more generally, in all the sectors related to the so called *New Economy* (Information and Communication Technologies, business and professional services, and so on) - is widely debated by economic scholars (see for instance Bloch, 2007). Challenging questions arise about what products/services have to be considered innovative, and whether a specific artefact is innovative or not. Which is the boundary line between an innovative software solution and a program not at all innovative? Does the process of adapting solutions to different platforms fall into the innovation definition? Which aspects should be taken into account in order to highlight the most important elements of innovation processes in the software sector?

In this framework, the increasing diffusion and adoption (Weeheler, 2007) by individual users and companies of the Free/Open Source Software (FOSS) put forward new research issues, dealing with whether and how programs developed according to the new production paradigm turn out to be more innovative than traditional ones. At present, a lively debate exists about the innovativeness of FOSS projects (Klincewicz, 2005). Namely, whilst some researchers and practitioners agree that FOSS development model leads to faster incorporation of innovative ideas than the proprietary regime, others refer to it as a simple imitation exercise. For instance, is it possible to state that a suite as Open Office[1] is something innovative or is it simple imitation of the Microsoft product? The theme turns out to be fairly intriguing for economic scholars as Free/Open Source software (FOSS) represents in itself a disruptive innovation process currently affecting industrial dynamics within the software sector (Dalle et al., 2007), and it can be regarded as an important instantiation of the Open Innovation framework (West and Gallagher, 2006).

Following this path, the paper focuses on Italian software sector and aims at contributing to the literature by addressing three main research questions: (i) are software solutions produced by Italian firms innovative? (ii) What kinds of innovations are implemented? And, finally, (iii) are programs based on FOSS more innovative than proprietary ones?

Basing on a sample of 134 software solutions produced by Italian firms and using an original methodology to asses the problem of evaluating innovation in the software field, the paper provides some first insights of what emerges if we set aside the traditional innovation indicators (namely, patents and trademarks) and endower to build alternative metrics, specifically developed to target the complexity of the innovation processes in the software market.

The paper is organised as follows. Section 2 reviews the literature on innovation processes in the software sector, section 3 describes data and methodology, while results are discussed in section 4, section 5 concludes.

2.Review of literature: innovation processes in the software sector

The concept of *innovation* is one of the mostly studied by scholars in social science (Rogers, 1995), in general, and in economics, in particular (Fagerberg, 2004). However, in spite of its obvious importance for the growth and development of social and economic systems, it has not always got the defining exactitude it deserves.

The notion has been analysed in several seminal studies, which have highlighted various peculiar aspects, such as the distinction between *invention* and *innovation* (Schumpeter, 1934), the former referring to the first occurrence of an idea for a new product or process, while the latter to its first commercialization; the changes in the characteristics of innovation processes, depending on the different phases of technology development and on a firm's environment and competitive strategies

[1] http://www.openoffice.org

(with initial emphasis on product performance, then emphasis on product variety, and later emphasis on product standardization and costs: Utterback and Abernathy, 1975: 642); the non-linearity of innovation processes (Kline and Rosenberg, 1986); and their fundament role in economic growth (Grossman and Helpman, 1991).

Anyway, it has been claimed that *innovations, almost by definition, are one of the least analyzed parts of economics, in spite of the verifiable fact that they have contributed more to per capita economic growth than any other factor* (Arrow 1988: 281). Specifically, it has been acknowledged that the term *innovation*[2] and *innovativeness* are prone to different interpretations and meanings, depending also on the peculiar industrial sector taken into account (Pavitt, 1984; Garcia and Calantone, 2002).

Let's think, for instance, to the attempts of classifying innovation according to "types". Schumpeter (1934) distinguished between five different classes (new products, new methods of production, new sources of supply, exploitation of new markets and new ways to organize business), whilst several authors have focused on the distinction between incremental and radical innovation (Freeman and Soete, 1997; Koberg et al., 2003) or product vs. process innovation (Edquist et al., 2001); others identify three (Kleinschmidt and Cooper, 1991) or even more possible levels (Kleinknecht, 1993).

Given the extreme complexity of the concept, it is no surprising that a *comprehensive indicator*, able to account for every kind of innovation in every sector, does not exist. A short list of the most used metrics of firms' innovation effort include: (i) data on Research and Development activity both at a firm and sectoral level (e.g. R&D expenditure, R&D employees, OECD, 2002); (ii) patents (Granstrand, 2004; Cohen and Lemley, 2001); (iii) bibliometrical data (also called LBIO:

[2] A fairly comprehensive definition of *innovation* is provided by OECD (1992) according to which *innovation is an iterative process coming from the perception of a new market or opportunity for an invention based on technology, taking to development, production and commercialization, in the idea of a commercial success*. Another definition is in Drucker (1985).

Literature-Based Innovation Output indicators), such as publications in scientific and technical journals (Miyazaki and Klincewicz, 2007).

Moreover, specific surveys and databases have been developed by research groups and public bodies aiming at collecting primary data from firms on their innovative activity. For instance, the Community Innovation Survey (CIS)[3] were developed, for the first time, by the Member States of the European Union in 1992. Data collection is done by the statistical offices or competent research institutes in the Member States, and results of the surveys are treated at national level using a common methodology and further processed by Eurostat to increase cross country comparability. Several studies on innovations processes in the ICT sectors (e.g. Van Leeuwen and Van der Wiel, 2003; Gago and Rubalcaba, 2007) are based on data collected by CIS, even if some limitations have been highlighted. Arundel (1997) has stressed the need of paying attention not only to the economic elements of innovation processes, but also to human capital-related aspects; Tether (2001) has pointed out the difficulty to conflate a wide range of activities into a single definition of innovation, obscuring the differences in behaviour between different types of innovators.

Anyway, all previous indicators suffer from several shortcomings (see Kleinknecht et al., 2002, for a comprehensive survey and comparison of the different methods for measuring innovation), which turn out to be fairly severe when we attempt to measure innovation in the sectors of the so called *new economy* (Haskel, 2007). These markets are characterised by elements that make traditional instruments for measuring innovation (as patents and trademark) almost useless. Indeed, the passing from a commodity-driven to a knowledge-driven economy forces to consider a whole new set of variables related to how knowledge is created, managed and passed through different actors: For instance, special attention should be devoted to the role of knowledge-intensive business services, which are of particular importance for innovation processes (Hipp and Grupp, 2005). For

[3] For more information about CIS: http://cordis.europa.eu/innovation-smes/src/cis.htm. Other interesting databases have been assembled by the Science Policy Research Unit of Sussex University (SPRU, http://www.sussex.ac.uk/spru), and by US Small Business Administration (http://www.sba.gov).

ICT sectors, the very definition of innovation (Preissl, 1998) needs to be renovated, considering aspects related not only to the product itself but also to the services offered with it, treating more deeply all interdependences and knowledge flows (Bloch, 2007; Jordan and Segelod, 2006).

Specifically, as far as the software field, it has been noted (Blind et al., 2004) that patents are often unable to follow the rapid evolution of the software market (Jaffe, 1999; Nalley, 2000) and to account for the complexity of complementary activities (Kash and Kingston, 2001); other problems deal with the fact that software companies often use alternative instruments of protection (as, for instance, patents on hardware in embedded solutions). The idea emerging from various works is that some modifications to the patent system would be needed (Cohen and Lemley, 2001) to address innovation in the software field[4].

As a consequence, new indicators are needed to assess innovation in ICT fields (Maruyama et al., 2007). In the case of software, such indicators should take into account not only general aspects (as, for example, the drivers of the internal innovation process or the comparisons with other solutions available on the market), but also specific elements (as the use of certain programming languages and platforms, the organisation of the software modules, the writing of new code or the reuse of existing libraries, and so on).

In this framework, the rapid pace of diffusion of FOSS represents another source of complexity in analysing innovation processes taking place in the software sector. For instance, the very distinction between innovation and invention, based mainly on commercialisation, needs to be re-defined, as, in the FOSS world, because barriers between companies and users become less important (remember, for example, the wide diffusion of software in peer-to-peer way). In this framework, Klincewicz (2005) has attempted to provide an original classification of innovation in FOSS based on four classes: radical innovation, technological modifications, platform modifications (passing a solution from one platform to another, a common practise among FOSS developers) and market innovations providing new uses for existing technologies. The authors have also analysed 500 projects hosted on SourceForge[5], the largest FOSS repository on the Web, assessing that 436 of them are not innovative, and only 5 can be defined as radical innovations. This result can be linked to other studies showing low confidence in the innovative impact of FOSS solutions: for instance, Tuomi, (2005) explains that, in his view, there is nothing innovative in a system like Linux, because it simply re-implements functions already developed in Windows systems. This debate is far from a conclusion, even if more and more FOSS solutions have proved to be, nowadays, as complex and reliable as proprietary ones.

Data and Methodology

The sample used in this study comes from a large scale survey taken, in 2004, on more than 900 software firms (NACE code 72.2) from Finland, Germany, Italy, Portugal, and Spain (Second European Libre Software Survey, ELISS II, see Bonaccorsi et al., 2006, for details).

Specifically, we focused on the 323 Italian respondents to this survey in order to inquire about the innovativeness of the software solutions that they produce. The rationales behind the decision to restrict the analysis to the Italian case are twofold. On the one side, it depends on database characteristics. Indeed, corporate names or company VAT numbers, which allowed us to link the survey database to other private and public data sources containing information of our interest, are not available for all the countries. On the other side, the choice of focusing on Italian respondents reflects our purpose of exploring in depth a software market, shaped by the presence of Small and Medium Enterprises (SMEs) with low sale volumes and R&D spending, for investigating whether and how these characteristics have an impact on innovation processes.

Characteristics of the Italian firms in the ELISS II sample are reported in table 1.

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[4] As a note, it is important to highlight that, at the moment, software patents are not allowed in Europe, differently to what happens in the United States.

Table 1: Structural characteristics of the Italian firms in the sample.

Variable	*Unit of Measurement*	*No. of obs.*	*Min.*	*Max.*	*Mean*	*St. Dev.*
Age (at the moment of the survey)	Unit	323	0	33	10.8	6.3
Size	Unit	318	1	230	9.3	18.3
Number of founders	Unit	316	1	9	2.6	1.5
Graduate staff	%	300	0	100	36	0.4
Software developers	%	293	0	50	30	0.2

They are mainly SMEs that have entered the market only recently. More than 90% of the firms have a total staff of less than 20 employees, and, in about 16% of cases, they are one-man businesses. About 59% have been founded by one or two promoting partners. 66 firms out of 323 (20.4%) were founded since 2000. The entry process seems to continue: about 6% have entered the market after 2002. 167 of the companies provide to their customers FOSS-based software.

As far as skills, the average percentage of staff with a University degree is fairly high (about 36%), so as that of software developers (almost 30%).

Evidence on firms' main customers is reported in table 2. Respondents serve mainly business customers (81%), particularly SMEs (64%), while very few refer to University (3%) or end users (3%).

Table 2: Firms' customers

Customers' typology	*No.*	*%*
Small and medium enterprises	207	64
Large firms	54	17
University and research centres	9	3
Public sector	38	12
End users	10	3
Other customers	5	2
TOTAL	323	100

In order to address whether traditional innovation indicators are really not suitable for assessing innovation in the software industry, in general, and in the Italian case, in particular, data on three main innovation metrics have been collected for Italian firms in the sample: (i) trademarks, using the database of the European Office for Trademarks and Design[6]; (ii) patents, referring to the Delphion database[7]; (iii) scientific and technical publications hosted on Scopus[8]. This data gathering is very important as it provides evidence on whether and how Italian software companies

[5] http://www.sourceforge.net

[6] http://oami.eu.int.

[7] http://www.delphion.com.

[8] http://www.scopus.com/scopus/home.url

rely on traditional instruments for protecting and communicating their innovations. Hence, it allows to inquire about the real need for the development of alternative indicators.

Following this path, we set up a methodology based on evaluations by a group of experts of the software solutions developed by firms basing on information recorded through companies' Web sites. Namely, we visited the Web sites of the 323 Italian respondents searching information that could be useful to asses innovativeness level of their products. The Internet surfing allowed us to collect comprehensive information on 134 solutions developed by a sub-sample of 70 companies. It is important to underline that, according to this methodology, the unit of analysis is no more the firm as a patent or trademark holder, but its software solutions whose innovativeness we are aiming at addressing.

Three practitioners expert of the software markets[9] were involved and each of them was asked to evaluate the level of innovativeness of the 134 software solutions. These programs target mainly business customers: in fact, only 8% (11 software solutions) are intended for home users. Looking at the product category, managerial systems are the most widespread ones (e.g. ERP systems), constituting the 45% of the sample; other relevant groups are Web oriented applications (9%) and software for security (e.g. anti-virus systems; 3%), followed by a plethora of heterogeneous applications.

Moreover, as far as intellectual property rights on these solutions, most of them (107 out of 134) are released under a proprietary license, while the remaining ones (27) are distributed under Open Source licenses.

Each expert, after an in depth colloquium during which we explained her the main aims of our project, received a table to be filled and a guide for its compilation. For each of the 134 software

[9]The first expert graduated in Telecommunication Engineering, and is currently employed in a big company providing solutions for electronic trading, position and risk management, pricing. The second graduated in Computer Science. After an experience in a university laboratory as responsible of construction and management of scientific databases and a first level master in Internet Technologies, is currently working as a system administration for a large public

solutions, the table contained the name of the product, the link to its Web page, a brief description of the product itself and of the producing firm (an example is in table 3). Using this information, evaluators were asked to assign a mark ranging from 1 (*not at all innovative*) to 5 (*very innovative*) to each product, referring to three main dimensions defined on the basis of the literature and leading to a set of five innovation indicators.

Table 3: Example of a record of experts' table

Field	*Content*
Product index	081
Firm index	051
Name of the product (with link to its Web page)	XXX
Product typology	Software for e-commerce
Brief description of product	Web oriented application for the business to business commerce, targeted to the fashion sector; possibility of acquisition of orders and real time checks; interoperability among different databases (postgreSQL, ms-SQL, IBM DB2, Oracle) and operative systems (it runs on both Windows and Linux); multi-language; modular structure; possibility of documents tracking; based on the managerial system as400 or stealth v.3; it uses a php 4 technology; possibility of SSL cryptography
Brief description of firm	XXX: development of Web oriented applications, in particular targeted to the fashion sector; development of software for e-learning and content management
Indicator 1: product new to the firm	2
Eventual notes on Indicator 1	-----
Indicator 2: product new to the market in what it does	2
Eventual notes on Indicator 2	-----
Indicator 3: product new to the market under technological viewpoint	4
Eventual notes on Indicator 3	-----
Indicator 4: modules new to the world	2
Eventual notes on Indicator 4	-----
Indicator 5: platform new to the world	3
Eventual notes on Indicator 5	-----

The first dimension is related to the internal level of innovation: the idea is to compare each software solution with other programs developed by the same companies, in order to highlight peculiarities and differences (*Indicator 1: is the product new to the firm?*).

The second dimension refers to the market in which the firm operates. Namely, we ask the experts whether a product is innovative compared with other similar solutions available on the market. This dimension was addressed by two indicators: the first referring to innovation in *what* a software solution does (*Indicator 2: is the software innovative in the sense that it better satisfies needs or requests from users?*), the second referring to *how* a software succeeds in accomplishing a given

institution. The third graduated in Computer Science too, and it is currently Research assistant at the Institute of Computer Science and Telematic of the Italian National Council of Research. Please, ask the authors for further details.

task. In this latter case, the aim is to explore technical aspects, trying to evaluate the peculiarities in the implementation of a given solution (*Indicator 3: is the product new to the market under a technological viewpoint?*).

The third dimension has the very wide perspective. Indeed, we asked the experts to evaluate the level of innovativeness of the products referring not only to the specific market in which they compete, but to the general state of the art of technology and knowledge in the software sector (*is the product new to the world?*). Two indicators account for this dimension, specifically we asked the experts to report about innovation in: (i) the modules composing the software (*Indicator 4: is the software innovative as it contains peculiar and original modules, which can be hardly found in other solutions, also in different market segments?*); (ii) what we synthetically labelled as *platform*, meaning those aspects not related to software modules and their organization, but to the other technological characteristics, such as programming language, implemented algorithms, use of libraries, databases or other applications, and so on (*Indicator 5: how the software platform is new with respect to those of other software solutions, also in different market segments?*).

In this framework, it would also be useful to relate our indicators to other classical classifications, such as *radical vs. incremental innovations*, in order to link our analysis to the wide literature on innovation processes in high-tech sectors. For instance, innovations more related to technical aspects (indicator 3) can be considered as a sign of a more radical innovation process. A software with an implementation which can be considered new referring to the general level of knowledge, can be more reasonably labelled as a *radical innovation* with respect to a solution having original modules as the only element of novelty (in this case is more correct to refer to *incremental innovation*).

We are aware that the main shortcoming of this methodology is the subjective nature of experts' evaluations. However it is worth noting that all the software have been evaluated by three experts: their in depth knowledge of the market and multiple opinions mitigate the subjectivity problem.

Moreover, metrics of accordance of their judgement have been computed, showing that they were consistent and correlated[10]. Hence, we are confident that every evaluator has performed her task conscientiously, avoiding to simply assign the numbers by chance.

Moreover, other qualitative methodologies, such as surveys taken on firms' partners and employees or case studies, would have run the risk to be useless because of the need of information both deep (e.g. about technical aspects) and wide (e.g. having a large sample of solutions).

We reflected about the possible ways to aggregate evaluations made by the three practitioners involved (e.g., using median, mode, etc.), and finally we chose to compute, for each indicator, the sum of the three evaluations: in this way, we obtained synthetic scores ranging between three (all three experts assigned one) and fifteen (all assigned five). This solution has the advantage of preserving variability even if mitigating the effect of outlier evaluations.

[10] Measures of *interrater agreement* (Fleiss, 1981) were conducted as our study is characterised by multiple ratings per subject. We referred to *intraclass correlation coefficients* and *kappa statistics*, obtained by coding a positive rating as 1 (experts' evaluation equal to 3 or more) and a negative rating as 0 (experts' evaluation equal to 2 or less). The k value assumes its minimum value in the case that disagreement within the evaluations for the same product is higher than whose of different products, while it assumes the value 1 in the case of perfect agreement within products (same evaluations of all three experts for the same product).

4. Empirical results

As mentioned in the previous section, data on traditional innovation indicators (patents, trademarks, scientific and technical publications) were collected for the sample of 323 Italian respondents to the ELISS II survey.

We found that traditional instruments for protecting and communicating innovations are used in very few cases. Only 9 firms out of 323 (less than 3%) refer to them. As for as trademarks, only 5 companies out of 323 registered distinctive elements at the European Office for Trademarks and Designs. Specifically, the five firms registered, globally, 35 trademarks: 26 figurative elements (logos), and 9 names (the name of the company itself, not of the product). As far as patents and publications, we observed that only 3 firms hold a patent (for a total of 15 patents) and only 3 respondents were involved in scientific and technical publications. Moreover, two out of the three firms that published in scientific and technical journals are divisions of multinational companies and are also part of the group of five firms with a trademark.

These findings corroborate the idea that traditional metrics are not suitable to capture innovative processes in a software sector formed by SMEs and, in some sense, justify the turning to an alternative methodology for assessing innovation.

In presenting the results of experts' evaluations, we follow the repartition previously mentioned: innovation within the firm (dimension 1, indicator 1); innovation within the referring market (dimension 2, indicators 2 and 3); overall innovation (dimension 3, indicators 4 and 5). Descriptive statistics of the (sum of the) scores attributed to the 134 software solutions are reported in table 4[11].

[11] We used the standard statistical descriptive for ordinal variables.

Table 4: *Descriptive statistics of innovation indicators*

Dimension	*Indicator*	*Min.*	*Max.*	*Mode*	*Mean*[12]	*Std. Dev.*	*Median*	*75th perc*	*90th perc*	*99th perc*
I	*1*	*4*	*14*	*7*	*8.4*	*2.11*	8	*10*	*11*	*14*
II	*2*	*3*	*14*	*8*	*8.8*	*2.46*	*9*	*10.7*	*12.7*	*13.7*
	3	*3*	*14*	*8*	*8.0*	*2.78*	*8*	*10*	*12*	*13.7*
III	*4*	*5*	*13*	*8*	*8.4*	*2.04*	*8*	*10*	*11*	*13*
	5	*3*	*14*	*8*	*7.8*	*2.46*	*8*	*9*	*11*	*13.7*

The first dimension deal with innovation inside the firm itself (*Is the product new to the firm?*). The maximum value of 14 occurs 3 times, giving a 99th percentile of 14 (the highest for all the dimensions), while no solution receives three evaluations equal to 1 (the minimum is 4, obtained by only one software). Standard deviation is fairly low, showing concentration around mean values (more than 50% of the sample received values between 6 and 8).

Other interesting insights emerge when focusing on the second dimension, referring to the market in which firms operate. As it has been underlined in the previous section, this dimension has been captured by two indicators: innovation in *what* a software does (*indicator 2*), and innovation in its technical aspects (*how does the software what it does? Indicator 3*). The two indicators show equal values for minimum, maximum, and mode, while differences in percentiles emerge. In particular, in both 50th, 75th and 90th percentiles, indicator 2 has higher values than indicator 3 (respectively, 9 vs. 8, 10.7 vs. 10, and 12.7 vs. 12). This finding is confirmed by other analysis on distributions: 69% of software solutions have received a mark of 7 or more for indicator 2, while the proportion decreases to 52% for the third indicator. Moreover, values between 7 and 9 are more frequent for indicator 2 (44% vs. 37%), while the opposite happens for the interval 5-7 (28% vs. 40%). Data seem to show that, as far as the second dimension, the innovative process is more effective for aspects related to what a software does, instead of for strictly technological aspects.

[12] We are aware that it is not entirely correct to compute the mean of ordinal variables. However, it allows us to provide an insightful and synthetic representation of the data.

Concerning the third dimension, we distinguished between innovation in modules (*indicator 4*), on one hand, and in all other technical aspects (labelled as platform, *indicator 5*), on the other. Modules show higher values for minimum (5 vs. 3), while the opposite happens for the maximum (but the highest value of 14 for indicator 5 is reached only two times). 50^{th} is equal for the two indicators, while 75^{th} is higher for indicator 4 (10 vs. 9), but, as previously, this pattern is not still true when focusing on values closer to the upper limit (99^{th} percentile is, respectively, 13 and 13.7). Anyway, it is worth noting that some biases are likely to emerge. Indeed, in some cases, experts claimed that Web sites provided only few information about modules. This probably have generated a *central tendency bias,* leading evaluators to assign score 3. This finding is also confirmed by standard deviation that is lower for the indicator relating to modules (2.04 vs. 2.46 of the platform indicator): indicator 4 has a more concentrated distribution. Moreover, it obtains higher scores than indicator 5. The proportion of evaluations between 5 and 7 is predominant for the indicator 5 (respectively, 32% vs. 38%), while indicator on modules presents more values between 7 and 9 (53% vs. 43%). In short, data seem to confirm a higher propensity to innovation in modules. Probably this may be related to the peculiar structure of the Italian software sector. Indeed, in a market dominated by SMEs, it is likely to observe more customization and adaptation of solutions made through the insertion of new modules, than radical innovations based on leading-edge technologies.

Summing up, data from expert evaluations allow us to answer the first two research questions. As far as the former (*are software solutions produced by Italian firms innovative?*), whilst results obtained with traditional instruments are fairly useless, using a methodology based on experts' evaluations, we succeed in painting a more complex picture and in disentangling innovation into its main dimensions. Also the latter issue (*what typologies of innovation are implemented*) can receive an answer as experts' assessment captures highlight in innovation typologies. Specifically, two main aspects drive our conclusions. On one hand, when focusing on the innovation in the referring market, indicator 2 shows higher values than indicator 3, supporting the idea of innovation processes more targeted to *what* a software solution does, than to *how* to do it. On the other, considering the *new to the world* dimension, innovation seems to be more focused on modules than in technical aspects. According to our findings, the Italian software sector seems to be characterized mainly by adaptations, customizations, transfer of solutions into different platforms or of technologies into different markets rather than by sharp technological concerns. In brief, results corroborate the idea of an innovation that can be appointed as incremental, more than radical.

After this first general analysis, in order to address our third research questions (*are software based on FOSS more innovative than proprietary ones?*); we have performed comparisons between proprietary and FOSS solutions. As mentioned in the previous section, the sample of 134 software solutions was formed by 109 proprietary and 27 FOSS solutions. This latter group is much smaller than the former, and its numerousness makes it impossible to reach generalizable conclusions. However, to the best of our knowledge, we are not aware of studies performing an in depth analysis of innovativeness of FOSS as compared to proprietary software. Thus, acknowledging the exploratory nature of our analysis, this can be regarded as a fairly acceptable sample.

Table 5, reports statistical descriptive of the 5 indicators for the sub-sample of proprietary and FOSS solutions.

Table 5: *Descriptive statistics of innovation indicators. Proprietary vs. FOSS solutions*

		Proprietary solutions							*FOSS solutions*							*Mann Whitney P value*	*Nonparametric equality of medians P value*
Dim.	*Ind.*	*Min.*	*Max.*	*Median*	*Mean*	*Std. Dev.*	*75th perc.*	*90th perc*	*Min.*	*Max.*	*Median*	*Mean*	*Std. Dev.*	*75th perc*	*90th perc*		
I	*1*	*4*	*14*	*8*	*8.1*	*2.03*	*10*	*11*	*6*	*14*	*10*	*9.4*	*2.15*	*11*	*12*	*0.007*	*0.027*
II	*2*	*3*	*14*	*8*	*8.5*	*2.30*	*10*	*11*	*5*	*14*	*11*	*10.1*	*2.66*	*12.5*	*13*	*0.004*	*0.002*
	3	*3*	*14*	*7*	*7.6*	*2.55*	*9*	*11*	*3*	*14*	*11*	*9.6*	*3.14*	*12*	*13*	*0.003*	*0.001*
III	*4*	*5*	*13*	*8*	*8.4*	*2.03*	*10*	*11*	*5*	*13*	*9*	*8.6*	*2.12*	*10*	*11*	*0.428*	*0.061*
	5	*3*	*14*	*7*	*7.3*	*2.21*	*9*	*10*	*4*	*14*	*10*	*9.6*	*2.58*	*11*	*12.4*	*0.000*	*0.000*

Figures support the idea that FOSS solutions are more innovative than proprietary ones: indeed, in all the three dimensions, experts' evaluations are higher for FOSS than for proprietary software.

Specifically, indicator 1 has higher median and mean evaluation for FOSS software and statistical tests show that these differences are significant. This is corroborated by data distribution. For instance, focusing on the score range 5-7, the proportion for FOSS (26%, with only one evaluation equal to 6 and none to 5) is much lower than the one for proprietary programs (44%), while the opposite emerges for values equal to 10 or more (51% vs. 27%).

As far as the second dimension, FOSS solutions seem to be more innovative too. For both indicator 2 and 3, statistical tests confirm a higher level of innovativeness. Also percentiles show an identical pattern: while values for 75^{th} and 90^{th} percentiles, in the case of FOSS software, are always between 12 and 13, they decrease to the interval 9-11 for proprietary ones. Leaving the distinction between the two sub-samples apart, and focusing on differences between indicators 2 and 3 within the same group, we notice that, in both cases, evaluations for the indicator 3 are lower than those of indicator 2, confirming the considerations made for the entire sample.

Nothing new emerges comparing the two groups with respect to the third dimension. Again, FOSS solutions prove to be more innovative, with higher values for at least every statistics. However, it is worth noting that, whilst statistical tests confirm the existence of significant differences in mean and median values for indicator 5, no significant difference between the two sub-samples emerges for indicator 4. Anyway, this result should be carefully evaluated. Indeed, as mentioned above, information about modules seemed to be less accurate, leading the experts to assign value 3. Then, it is possible results are invalidated by the central tendency bias.

If the comparison between the two groups is interesting, it is also of interest to consider the differences between the two indicators within each group. Indeed, proprietary solutions show higher evaluations for modules than for other technological aspects, as emerged for the entire sample (e.g. values over 7 constitute the 65% for indicator 4, while only the 46% for indicator 5), while FOSS programs follow an opposite pattern. Indeed, in this second sub-sample, indicator 5 shows higher values, as highlighted, for example, by median (9 for indicator 4 vs. 10 for indicator 5), 75th percentile (10 vs. 11), and 90th percentile (11 vs. 12.4). A more in depth analysis allows to notice that a large part for this difference comes from the highest values: while, for indicator 4, evaluations over 10 constitute the 15% (only 4 software solutions out of 27), they reach the 48% for indicator 5 (13 out of 27). This last consideration can be regarded as an insight that proprietary and FOSS software not only show different levels of innovativity, but, as far as, *new to the world products* are concerned, they are also shaped by different innovation processes: radical innovation in the FOSS vs. incremental innovation in proprietary field.

5. Conclusions

Economic literature has widely acknowledged as innovation in ICT sectors, in general, and in software industry, in particular, can be hardly defined and measured. This paper adds to the current debate by proposing an original methodology for assessing innovativeness of a set of software solutions produced by Italian SMEs.

Our findings show as, whilst traditional innovation indicators fail to capture innovative potentials, experts' evaluations paint a different picture. First of all, we have provided evidence that innovative processes do exist and it is possible to assess them under different perspectives: within the firm, within the market in which it operates, and within the entire software sector. Moreover, it has been also possible to delineate some general characteristics and patterns of these processes, showing that innovations related to hard technical aspects (for both the referring market and the global level of technology) are less prominent than those related to other aspects (specifically: innovations related to what a program does, considering the market in which firm operates; innovations in modules, focusing on the global software sector). This consideration leads to the idea of the existence of innovation processes that can be labelled as incremental: a conclusion that is in agreement with a software sector dominated by Small and Medium Enterprises.

Moreover, our analysis has highlighted some intriguing differences between innovativeness of FOSS and proprietary software. Specifically, FOSS solutions display higher level for all the examined indicators, and almost all statistical tests indicate that the two groups of software can be considered as two populations with different characteristics. Differences emerge, not only in the level of innovation, but also in the relationships between indicators: specifically, focusing on the global level of technology (third dimension), FOSS solutions show higher values for technical aspects, than for modules as, on the contrary it happens for proprietary software and the entire sample).

Clearly, as it was underlined in previous sections, the characteristics of the sample made results hardly generalizable; however, they help in shed light on intriguing questions posed by the very existence of the FOSS paradigm. Do the most innovative software solutions come from the Free/Open Source world? Does the open fashion of the FOSS production mode foster innovation processes? Does the FOSS represent a really valid alternative for software SMEs whishing to operate with leading-edge technologies?

Hence, building on these preliminary evidence it would be very interesting for future researches to apply the methodology (or a refined version of it, using, for instance a wider set of experts) on larger source of information, containing data on a higher number of solutions produced by firms from different countries.

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