Open innovation models: collaboration, market or both?

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Abstract

The paper suggests an accounting-based methodology for defining open innovation adoption modalities, based on economic and financial transactions in inbound and outbound processes. The framework is applied to a sample of 288 science based companies operating in bio-pharmaceutical and technology hardware & equipment industries. Biotech companies are far more open than those belonging to the other segments, especially as to the economic dimensions: they mostly adopt collaboration and outsourcing models. On the other side, the companies belonging to all the segments in the technology hardware & equipment industry more often perform financial transactions, adopting trading or incorporation models. Between them, pharmaceutical companies adopt hybrid models, with both economic and financial transactions, both in inbound and in outbound processes.

1. Introduction

The paper comes within the studies concerning business models for innovation, with a particular focus on open innovation. The aim of the paper is to analyse how and to what extent science based companies are embracing the open innovation paradigm, by either adopting collaborative, networked innovation models or trading research and development, intellectual property and know-how with other companies, or acquiring other companies.

Since the definition of open innovation (OI) by Chesbrough in 2003, different studies focused on the development of measurement tools to help firms in managing open innovation. Yet, a comprehensive measure for the degree of openness in innovation processes is lacking, as pointed out by Chesbrough et al. (2006).

We adopt an accounting perspective for measuring the degree of innovation openness of companies and analysing the different behaviours of companies as to the nature of the transactions and the processes involved. Our primary research questions are: how and to what extent companies implement open innovation? Which are the business models they adopt to leverage external sources of innovation and capture value from innovation exploitation?

In order to answer to such questions we developed a framework for measuring the openness degree and defining the nature of open innovation transactions based on the analysis of companies financial statements. The framework has been applied to a sample of 138 bio-pharmaceutical companies and 150 technology hardware & equipment firms ranked after their investment in research and development, according to *The EU Industrial R&D Investment Scoreboard*. From the comparative analysis of the behaviours of companies in the two industries, different business models emerge, from collaborative to transactional ones.

The paper is structured as follows: after a brief literature review on accounting metrics for innovation, our measurement framework is presented and applied to the sample in order to define both the degree and the nature of open innovation in the selected industries. Discussions concerning the different business models and conclusions will close the work.

2. Innovation metrics: a literature review

In order to measure the openness degree of innovation processes of companies, it is necessary to firstly analyse the measure of innovation as a whole. Different perspectives can be adopted to measure innovation: we focus on the distinction between accounting vs. non-accounting indicators.

Accounting metrics can be derived from the financial statement of companies. The most extensively used proxy of innovation effort is no doubt R&D expenditure (Greve 2003; Hemert and Nijkamp 2010; Koc and Ceylan 2007; Leonard and Waldman 2007), which is not only used in literature, but also by government entities. A very important role is also played by the value of intangible assets as an investment in innovation capacity (Corrado et al. 2006; Lev 2001; Nakamura 2001): the variation in intangible assets between two periods can be considered as a proxy for current innovation effort (Rogers 1998). Overall company profitability, incremental revenue from innovation (BCG 2009) and earnings from the sale of new products (Nystrom 1990; Roehrich 2004) are also examples of innovation accounting metrics which focus on innovation results rather than innovation efforts.

Non-accounting indicators can assume very disparate forms: customer satisfaction (BCG 2009), the uniqueness or novelty of products (Ali et al. 1995), the number of innovations introduced (Nystrom 1990; Roehrich 2004), the number of patents (Brenner and Greif 2006)and the ability of the firm of launching new products in a short time (Hurt et al. 1977) are only some of the non-accounting indicators recognized in literature. Very often, for each non-accounting indicator it

is possible to identify a corresponding accounting one (e.g. earnings from the sale of new products and number of new products introduced).
Since our framework is based on accounting proxies of innovation, we focus on literature contributions analysing accounting for R&D and intangibles (Høegh-Krohn and Knivsflå 2000; Penman 2009; Pozza et al. 2008; Stolowy and Jeny-Cazavan 2001). A particular attention is paid in literature to the differences in the treatment of intangible assets between countries - which can seriously limit the comparability of financial statements in an international context (Brunovs and Kirsh 1991; Emenyonu and Gray 1992). A second area of interest is the capitalization of internally generated intangibles, that, depending on the standards, may be mandatory or optional (Stolowy and Jeny-Cazavan 2001). Obviously, treating intangibles as either an investment or an expenditure brings out different results, because assets are supposed to provide economic returns even in the future, while expenditure effects only a particular time period (Gupta 2009).
Although a significant theoretical attention has been given to intangibles in the field of financial accounting, few studies are reported in literature on the measurement of innovation based on financial statements and, consequently, on the ability of accounting standards to accurately reflect the innovation activities of companies. Two papers give the most significant contributions. Cañibano et al. (2000) focus on the information provided by financial reports, in the attempt of assessing the total innovative effort of companies. The authors point out that financial statements could provide a sound basis for the measurement of innovation if they included more relevant information on the intangible determinants of the companies value. In fact, in most countries, accounting standards prescribe the immediate expensing of the amounts invested in intangible activities and, thus, a significant part of the intangible investments made is absent from the balance sheet of the company. Therefore, in industries in which knowledge is the main source of future benefits, the information provided by financial statements may have little or no relevance at all, as investments in R&D and other innovative activities are not appropriately reflected in them: as a matter of fact, they are either fully expensed as incurred, or amortized over short periods of time. Michalisin (2001), by conducting a content analysis of annual report text (ART) data, shows that there is a positive relationship between ART emphasis on innovativeness and two independent measures of innovativeness: the number of trademarks the firm generates and the firm reputation for innovativeness. Therefore, the author underlines that ART data are valid sources of information about firm innovativeness, despite there is the possibility for managers to manipulate them in opportunistic ways and despite the fact that independent auditors provide little, if any, assurance that such data are accurate.
After an open perspective, different studies focused on the development of metrics for the measurement of innovation openness, and the same distinction between accounting vs. non-accounting indicators can be observed.
Accounting metrics for OI include the percentage of sales from external technologies, the percentage of net income generated from proprietary technology licensed to other firms (Chesbrough 2004) and the investments per year in collaborative R&D (Al-Ashaab et al. 2011). Conversely, the number of projects offered to external parties for further development (Chesbrough 2004), the number of patents as a result of collaborative projects, the number of collaborative projects in the company per year (Al-Ashaab et al. 2011) and the open innovation climate measure (Remneland-Wikhamn and Wikhamn 2011) are some examples of non-accounting indicators.
Yet, as pointed out by Chesbrough et al. (2006), a comprehensive measure for the degree of openness is still lacking. This paper aims at filling such gap, by identifying the openness degree of a company through accounting data. In line with previous literature (Cañibano et al. 2000), we focus on innovation-related intangibles disclosed in the balance sheet, but we also introduce the economic dimension of innovation, by measuring costs and revenues from open innovation, disclosed in the income statement. Introducing such dimension allows to partially overcome the problems deriving from the unequal treatment of innovation-related intangibles in different countries.

3. The measurement of open innovation

3.1. Theoretical framework and open innovation models

The methodology we suggest is intended to provide a comprehensive measure of open innovation through the quantification of the economic and financial flows characterizing the transactions in the innovation market.
Open innovation transactions can be divided in inbound and outbound ones, the former characterized by innovation-related costs and intangible investments, the latter by innovation-related revenues and intangible divestments Revenues and costs affect the income statement of the company and will be defined economic measures, additions and disposals affect the balance sheet and will be defined financial measures of open innovation (Table 1).

Table 1.The four dimensions of open innovation

	Outbound processes	Inbound processes
Economic transactions	Revenues	Costs
Financial transactions	Disposals	Additions

In what follows each of the four items will be analysed.

As to costs, the starting point of our analysis was the research and development cost, which is generally explicitly disclosed in the income statement, when defined by destination. Yet, such figure is not suitable to define the openness effort of a company, for a number of reasons.

First, R&D costs, as disclosed in the income statement, include internal costs, i.e. costs carried for the use of internal resources dedicated to internal R&D activities of the company. Given that such costs do not have an open nature, they have to be excluded from our analysis. Second, R&D costs also include amortization of capitalized costs which have, once again, only an internal nature. Yet, while excluding amortization is generally a simple matter, since it is disclosed in the notes to the financial statements, the definition of the cost generated by internal resources for internal activities is quite tricky, since even a definition of costs by nature does not explicitly separate internal and external costs: for example, R&D staff costs can refer to costs born for both those employees who work for internal development projects, and for those who are dedicated to external projects for third parties.

Thus, in order to quantify the open nature of R&D costs, rather than subtracting closed items from the total R&D costs, we have to add only items that are definitely open, which can be broadly divided into two categories: 1) collaborative and contract development costs, which refer to joint development projects with third parties under long-term agreements; 2) costs deriving from the outsourcing of some R&D services, which refer to a more spot behaviour than the previous one. Actually, R&D costs are not the only innovation-related costs, given that a significant role in open innovation is played by intellectual property (IP) costs, deriving from in-licensing activities; thus, we included in our framework 3) in-licensing costs and royalty fees paid.

Obviously, being our perspective open, no costs carried by the company to internally develop intellectual property rights that will be used by the company itself were included in the analysis.

The analysis of open innovation revenues is very similar to that of costs, since they include: 1) collaborative and contract development revenues; 2) revenues deriving from developing R&D services on behalf of third parties; 3) out-licensing revenues and royalty fees received.

Actually, within revenues, a further item has to be considered which does not have a counterpart in costs: the grants received by the company for R&D activities, provided by the government under the form of either research funding or tax credit. We can include grants as open revenues deriving from R&D activities developed on behalf of third parties, by considering the government as an entity that remunerates the company for its innovation efforts, even if it is not interested to come into possession of the outcomes of such innovation. As a matter of fact, differently from a private entity, the government aims at the development of innovation for the community, rather than for itself.

Our analysis is not limited to only revenues and costs, acknowledging that transactions in the innovation market can also come under the form of investments and divestments of intangibles which occur in either separate acquisition or business combinations, mergers and acquisitions (BCMAs). Actually, not all the intangibles have to be considered, since only some of them are usually traded in the innovation market. In particular, we defined three broad classes of innovation-related intangibles: 1) R&D, development costs and in process research and development (IPR&D); 2) IP, licenses, patents, trademarks, product rights and technology; 3) goodwill.

The first two categories have a clear connotation within innovation, while the innovative nature of goodwill can be questionable. Given the definition itself of goodwill as “future economic benefits arising from assets that are not capable of being individually identified and separately recognized” (IFRS 3), we think that it can be identified with the skill, the know-how, the technical and organizational expertise of the workforce. After this perspective, goodwill can be defined as a proxy of the know-how transferred from the acquired company to the purchasing one. This is consistent with most of the definitions of goodwill found in the annual reports of companies, as well as with the intangibles tri-partition proposed in literature (Stolowy and Jeny-Cazavan 2001). When a specific reference was made to an acquisition which, rather than being related to innovation, copes with the purchase of distribution and commercial channels, we did not include the value of goodwill in the measure of open innovation.

Being interested in what is actually traded between the company and third parties, we excluded all the additions that come from the capitalization of either development costs or internally developed intellectual property rights. Further, we also excluded impairment charges, reclassifications and currency translations. Note that, in order to have a likely value of the returns from what is divested, disposals are considered net of amortization, but we were not able to include the gains and losses because they were reported as a unique value comprising all intangibles divested and not only the one we were interested in, or even both intangible and tangible assets. On the contrary, additions are considered at their gross value, since we are interested in defining the total value of the effort sustained by the company for acquiring new intangibles. Thus, within our theoretical framework, five models can be defined, depending on the prevalence of some annual report items over other ones (Table 2).

Table 2. Five models for open innovation

Model	Annual report item
Collaboration	R&D collaboration and contract revenues or costs
Outsourcing	R&D services sale revenues or acquisition costs
Licensing	Out-licensing revenues or in-licensing costs
Trading	Disposals or separate additions of intangibles
Incorporation	Additions of intangibles within BCMAs

A collaborative model occurs when collaboration revenues and costs prevail within joint R&D programs with other companies or with research centres and universities. The outsourcing model occurs when R&D services are either outsourced from the focal company - thus resulting in an open cost - or developed by the company on behalf of third parties, thus resulting in open revenues. The licensing model occurs when either the intellectual property of the company is out-licensed or the company in-licenses IP of other companies. The trading model is characterized by additions and disposals of intangibles within separate acquisitions, which differ from BCMA additions for a more focalized interest on the specific intangible acquired or divested. Finally, the incorporation model is pursued by those companies acquiring other companies for incorporating not only their recognized intangibles, but also the knowledge and the expertise of people.

3.2. Metrics for open innovation

According to our framework, open innovation is a four-dimensional phenomenon, since it can be defined an outbound vs. inbound nature of the innovation process, but also an economic vs. financial nature of the transaction. On one hand, outbound processes are characterized by revenues and disposals, inbound ones by costs and additions; on the other hand, economic transactions are characterized by revenues and costs, financial ones by disposals and additions.
Thus, in order to quantify the degree and the nature of open innovation, four basic indicators can be calculated by comparing, for each of the four components, the items deriving from open innovation to the total items of the company:

$$Revenues\ ratio = \frac{revenues\ from\ open\ innovation}{total\ revenues}$$

$$Costs\ ratio = \frac{costs\ from\ open\ innovation}{total\ R\&D\ and\ IP\ costs}$$

$$Disposals\ ratio = \frac{disposals\ of\ intangibles\ from\ open\ innovation}{total\ intangibles}$$

$$Additions\ ratio = \frac{additions\ of\ intangibles\ from\ open\ innovation}{total\ intangibles}$$

In the space $\mathbb{R}^4$ where each of the four ratios is a Cartesian coordinate (Figure 1) each company can be represented as a point whose distance from the origin is a measure of its total openness degree:

$$Openness\ ratio = \sqrt{\frac{Revenues\ ratio^2 + Costs\ ratio^2 + Disposals\ ratio^2 + Additions\ ratio^2}{4}}$$

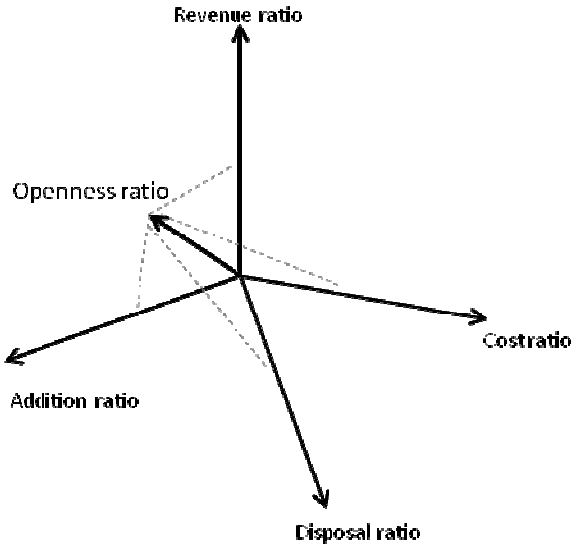

Figure 1. The four-dimensional space of open innovation

All the ratios range from zero to one, corresponding to a totally closed and a totally open behaviour respectively.
In order to define the adoption model for each company, five ratios can be considered as the composition of openness:

$$Collaboration\ ratio = \frac{revenues\ and\ costs\ from\ joint\ development\ projects}{revenues, costs, disposals\ and\ additions\ from\ open\ innovation}$$

$$Outsourcing\ ratio = \frac{revenues\ and\ costs\ from\ R\&D\ outsourcing}{revenues, costs, disposals\ and\ additions\ from\ open\ innovation}$$

$$Licensing\ ratio = \frac{revenues\ and\ costs\ from\ IP\ licensing}{revenues, costs, disposals\ and\ additions\ from\ open\ innovation}$$

$$Trading\ ratio = \frac{disposals\ and\ separate\ additions\ of\ intangibles}{revenues, costs, disposals\ and\ additions\ from\ open\ innovation}$$

$$Incorporation\ ratio = \frac{additions\ of\ intangibles\ within\ BCMAs}{revenues, costs, disposals\ and\ additions\ from\ open\ innovation}$$

4. Open innovation in science based industries

4.1. Sample

The suggested framework was applied to two R&D intense industries: bio-pharmaceutical and technology hardware & equipment[1]. We considered a sample of 288 world top R&D spending companies, according to *The EU Industrial R&D Investment Scoreboard* and defined five segments: pharmaceutical (PH), biotechnology (BIO), computer hardware & office equipment segment (HW), semiconductors segment (SC) and telecommunications equipment segment (TLC). Descriptive statistics for the sample are provided in Table 3.

Table 3. Sample description by segment (mean values)

Segment	No. of companies	Employees	Return on assets	R&D intensity	Openness ratio	Revenues ratio	Disposals ratio	Costs ratio	Additions ratio
BIO	68	1.324	-29,93%	25,63%	33,78%	53,51%	1,82%	14,99%	16,20%
PH	70	18.325	4,79%	15,29%	18,18%	18,16%	1,07%	10,97%	13,50%
SC	72	8.964	5,97%	15,11%	17,22%	6,32%	2,05%	1,43%	28,41%
HW	30	43.204	11,06%	3,51%	13,38%	1,78%	1,70%	0,00%	25,02%
TLC	48	14.878	5,41%	13,06%	11,07%	2,46%	0,94%	0,05%	20,29%
Total	288	13.987	-1,45%	11,86%	19,94%	18,51%	1,12%	6,21%	20,20%

Biotech companies are far more open than those belonging to other four segments, especially as to open revenues; they are also the smallest, less profitable and most R&D intense companies of the sample. The bio-pharmaceutical industry as a whole is more open than the technology hardware & equipment one: the former is more characterized by economic transactions (revenues and costs), the latter by financial ones, in particular additions. Disposals are all in all negligible for the whole sample.

4.2. Cluster analysis

Only 17 companies in the sample (5,9%) showed a completely closed behaviour, not having any open revenue, cost, disposal or addition; for the remaining 271 firms, a cluster analysis was performed in order to identify the companies adopting the different open innovation models.

Table 4. Open innovation models by segment (no. of companies)

Model	BIO	PH	SC	HW	TLC	Total
Collaboration	21	11	1	-	-	33
Outsourcing	15	7	6	-	2	30
Licensing	14	15	12	3	5	49
Trading	5	12	13	10	13	53
Incorporation	12	25	35	16	18	106
Total	67	70	67	29	38	271

The most widespread model is incorporation, which is adopted by almost 40% of open companies (Table 4), but significant differences emerge in the behaviour of the different segments, with biotech companies mostly relying on all the economic models (collaboration, outsourcing and licensing), firms from the whole technology hardware & equipment industry mainly adopting financial models (trading and incorporation) and pharmaceutical companies showing a hybrid behaviour, including almost all the models.

Table 5. Sample description by open innovation models (mean values)

Model	Employees	Return on assets	R&D intensity	Openness ratio
Collaboration	1.923	-11,95%	25,23%	30,70%
Outsourcing	9.348	-28,39%	14,98%	28,36%
Licensing	12.292	-10,17%	17,01%	24,60%
Trading	16.555	8,25%	9,25%	9,07%
Incorporation	19.490	7,85%	10,83%	20,67%

[1] 3-digit ICB codes 457 and 957 respectively.

The degree of openness is higher in mean for companies adopting collaboration models, which are the smallest and most R&D intense in the sample (Table 5). On the contrary, large companies adopting the trading model are the least open and R&D intense.

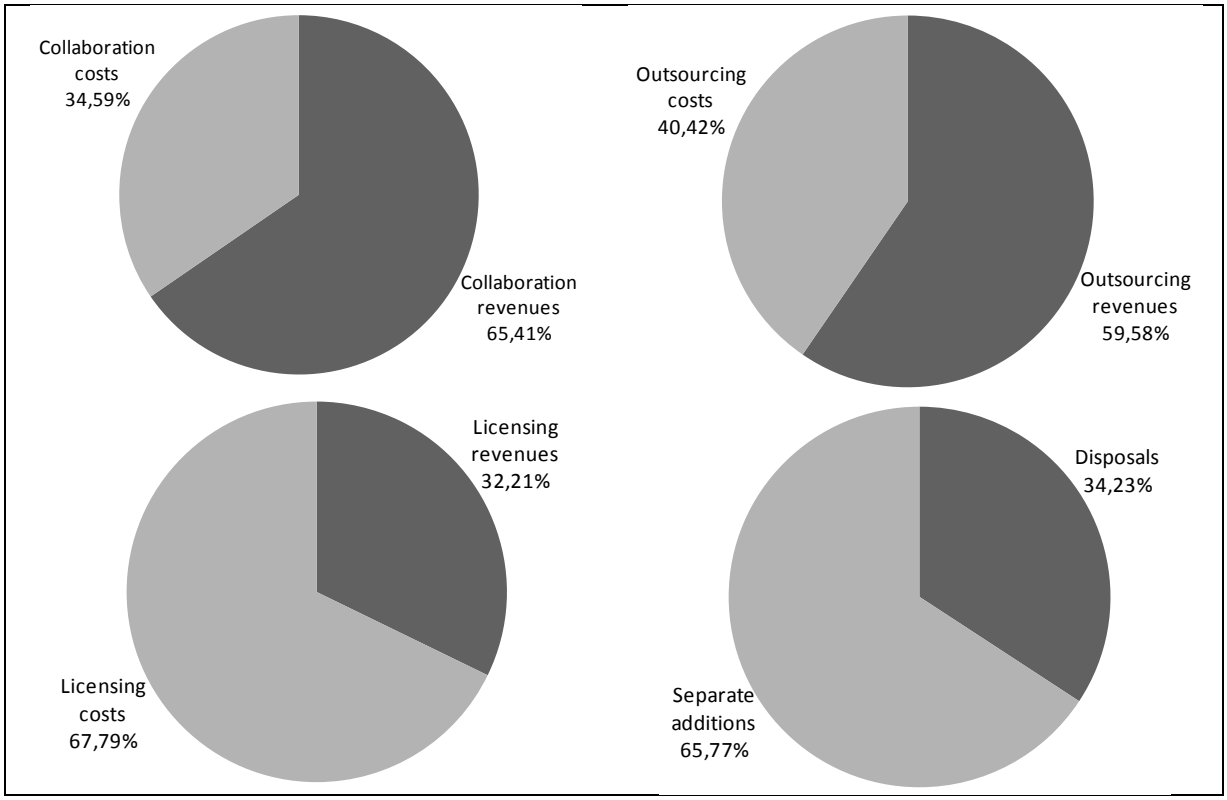

Figure 2. Outbound vs. inbound composition of open innovation models

Collaboration and outsourcing models are mostly characterized by revenues (Figure 2), i.e. the companies adopting such models are innovation sellers. On the contrary, licensing and trading models are mostly characterized by costs and additions respectively, being adopted by innovation buyers. Finally, given our definition, the incorporation model is a pure inbound model, being characterized only by additions: as a matter of fact, a company which is incorporated no more exists and no annual report is drawn up.

5. Discussion

Biotech companies are mainly characterized by collaboration and outsourcing models. Here open innovation is not only an innovation strategy, but rather the core business model for companies: as a matter of fact, most biotech companies do not sell innovative products, but innovation processes. Usually they enter into different kinds of agreements with universities, medical and research centres and other bio-pharmaceutical companies, after a collaborative long-term perspective. Most of such agreements are a source of revenues for them, since they can be considered innovation sellers. Yet, in some cases, they also behave as acquirers of innovation services, mainly in the clinical and pre-clinical trials, since they do not have the internal resources to internally develop these phases. For biotech companies collaboration and outsourcing revenues and costs are often the most consistent components of EBIT: actually, in some cases these firms have a 100% revenues ratio, denoting that the whole business of the company is based on open innovation.

Pharmaceutical companies show a more hybrid open behaviour, with some companies adopting strategies similar to biotech firms and others adopting trading or incorporation. Such an hybrid behaviour within the segment can be explained with their product focalization. As a matter of fact, even if pharmaceutical companies have the same long development time horizon as biotech ones, they are far more focused on products than biotech firms. This implies, from one side, the need of maintaining the control over long development processes, and, from the other, the need of achieving tangible results in terms of products. Their strategy is thus twofold, addressed to both continuous and discontinuous transactions of innovation processes and results.

Biotech and pharmaceutical companies can be considered as both customers and suppliers of each other, with a focalization of biotech companies on early research phases and pharmaceutical companies on pre-clinical and clinical development. For this reason, open revenues and costs are exchanged between the two sub-segments in the industry: in our analysis it often occurred to find the names of some biotech companies as main development partners of pharmaceutical firms and vice versa.

The behaviour of companies from technology hardware & equipment industry is somehow in antithesis with the one of biotech firms: they mainly adopt trading and incorporation models, while collaboration and outsourcing are negligible. While biotech companies mainly capture value from open innovation by achieving open revenues, technology hardware and equipment firms operate as innovation buyers, by acquiring innovation-related intangibles from other companies. From an accounting point of view, the biotech open adoption modalities have a continuous, operational effect on the income statement, while for hardware discontinuous operations are accounted in the balance sheet. Such a different behaviour can be explained in terms of innovation and product development pace, as well as product life cycle: while the development of a new drug can take more than twenty years, the life cycle of hardware is often less than one year. Thus, in the first case the focus is on the long-term development process, in the second one it is on the results of the process and on ready-made solutions. Open innovation for technology hardware & equipment companies is mostly related to the scouting of what is developed by other companies and the occasional acquisition of developed solutions, or, even of the developing company as a whole.

Even if most of the companies in the hardware industry adopt the same two models, the specific behaviours are somehow different, as to the kind of intangibles acquired.

Semiconductors companies mostly focus on technology: because of high innovation and product development pace, products are often obsolete before the patents related to them expire, and may sometimes be obsolete before the patents related to them are even granted. For this reason competitive position depends more upon technology than upon intellectual property.

On the contrary, as to computer hardware & office equipment companies, patents are incorporated into products and services, improving competitive position, maintaining differentiation of products and services, enhancing the ability to access technology of third parties, and maximizing return on R&D investments. Semiconductors and computer hardware companies can be considered as suppliers and customers along the same pipeline, with semiconductors companies providing high tech products to computer hardware ones. For this reason the former are more focused on internal technology development and the latter on intellectual property protection.

Finally, telecommunication equipment companies are characterized by hybrid behaviour between the other two segments, since they focus on both technology and patents. The research and development pipeline of such companies is more integrated than the one of the other two segments of the industry, with the same companies developing both components and finished products and thus focusing on both technology development and intellectual property protection.

6. Conclusions

Since the definition of the open innovation paradigm, a lively debate raised in literature as to the ways in which open innovation can be implemented by companies.

We suggest an accounting-based methodology for defining open innovation business models, based on revenues, costs, intangibles investments and divestments. Such framework was applied to a sample of 288 science based companies from bio-pharmaceutical and technology hardware & equipment industries.

From a theoretical point of view five open innovation models can emerge, depending on the entities which mostly characterize open innovation transactions, namely collaboration, outsourcing, licensing, trading and incorporation.

Being focused on accounting indicators, our framework can be used to analyse only the pecuniary dimension of open innovation (Dahlander and Gann 2010) and thus it cannot be generalized to such industries as software where sourcing and revealing are widespread. On the other side, the application to different industries where open innovation has a pecuniary nature allows to underline the differences in the adoption of the open innovation paradigms.

The application to the selected industries shows that in practice companies tend to adopt hybrid models which vary over a continuum, ranging from economic-oriented (biotech companies) to financial-oriented (semiconductors and computer hardware), where the terms economic and financial are used to denote effects on the income statement or the balance sheet of the company. The adoption of different models is industry-specific, linked to the main features of the innovation pipeline.

A longitudinal analysis (2008-2012) is now under study in the bio-pharma industry, in order to highlight the trends in open innovation strategies pursued by companies. Preliminary results show that while the degree of open revenues or costs is quite constant for companies over time, additions and disposals have a more intermittent trend, confirming that collaboration, outsourcing and licensing models are a continuous way of doing business, while trading and incorporation models are sporadic, discontinuous events in the life of a science based company.

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