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An Accounting Perspective for Defining Open Innovation Models in Science Based Industries

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Abstract: The paper suggests an accounting-based methodology for defining open innovation business models, by analysing investments and divestments of intangibles, either in separate transactions (*trading*) or within business combinations, mergers and acquisitions (*incorporation*). The framework is applied to a sample of 274 science based companies in bio-pharmaceutical and technology hardware & equipment industries. Results show that bio-pharmaceutical companies do not adopt either of the two models because their open innovation strategy is far more oriented to revenues and costs. On the contrary, technology hardware & equipment companies mostly rely on incorporation as a mean for absorbing know-how and intellectual capital from outside. The paper contributes to the existing research by suggesting metrics for open innovation, in both inbound and outbound dimensions, which are capable of describing different business models.

Key words: innovation metrics; accounting for intangibles; open innovation; business model; bio-pharmaceutical; technology hardware & equipment

JEL code: M

1. Introduction

The paper comes within the studies concerning innovation metrics and proxies, 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 after an accounting perspective, by focusing on selling and acquisition of innovation-related intangibles, either in separate transactions (*trading*) or within business combinations (*incorporation*).

Open innovation (OI) has been one of the most debated topics in innovation management research in the last decade (Chesbrough, 2003). Firms may open up their innovation processes on two dimensions, namely inbound and outbound. While the former refers to the acquisition of external technology in exploration processes, the latter

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describes the outward transfer of technology in exploitation processes.

Since the definition of the open paradigm, Chesbrough underlines the relevance of its *pecuniary* dimension. Yet, most contributions do not use pecuniary variables to measure the degree of openness of companies, but adopt different perspectives.

A first set of OI metrics can be traced back to *industrial property rights and market*: actually, intellectual property (IP) can be considered as both a pre-requisite (Ebersberger et al., 2012) and a result (Al-Ashaab et al., 2011) of OI. Obviously, not only the technological innovation under the form of patents, but also the degree of commercialization of such innovation in a later stage, should be measured (Simard & West, 2006). Further, some studies suggest operational measurements for OI related to the *collaborative projects* in which the companies are involved (Chesbrough, 2004; Al-Ashaab et al., 2011) and the *human resources* within the companies that take part to such collaborations (du Chatenier et al., 2010; Petroni et al., 2012). Another approach for measuring OI concerns the *practices* (e.g., in- and out-licensing, acquisitions, R&D contracts, spin-outs) that companies have adopted as a result of pursuing an OI strategy (Chesbrough et al., 2006). Moreover, as to inbound OI, there is a strong body of literature based on the Community Innovation Surveys which measures it through the *external sources of knowledge* (Laursen & Salter, 2006).

Yet, if for some approaches to OI the operationalization of the concepts is widely recognized, after a pecuniary perspective a comprehensive measurement system is still lacking. Thus, we aim at filling such gap by providing a methodology for measuring open innovation in its pecuniary dimension (Dahlander & Gann, 2010) by adopting an accounting perspective.

Our primary research questions are: how and to what extent science based companies implement open innovation? Which are the most suitable indicators for defining the openness degree of a firm? Which are the business models adopted after an accounting perspective? What is the relevance of intangibles investments and divestments in the different industries?

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 124 bio-pharmaceutical companies and 150 technology hardware & equipment firms[1] ranked by their investment in research and development (R&D), according to *The 2011 EU Industrial R&D Investment Scoreboard* (JRC, 2011).

The paper is structured as follows: after a brief literature review on innovation metrics, our measurement framework is presented and, then , applied to the sample in order to define the open innovation models in the selected industries. Discussions and conclusions will close the work.

2. Literature Review

In order to measure the openness degree of innovation processes, 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 statements of companies. The most extensively used proxy of innovation effort is no doubt R&D expenditure (Cohen & Levin, 1989; Acs & Audretsch, 1990), which is not only used in literature, but also by government entities to rank companies. A very important role is also played

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

by the value of intangible assets as an investment in innovation capacity (Lev, 2001; Nakamura, 2001; Corrado et al., 2006): the variation in intangible assets between two periods can be considered as a proxy for current innovation effort (Rogers, 1998). It is generally assumed that intellectual capital (IC) has a strong relation with the intangible assets of a company, since it can be understood as the system composed of all of the firm’s intangibles (Meritum Report, 2002). Also, in financial accounting, intangible assets act as a proxy for IC (Brännström et al., 2009); thus, IC and innovation are closely interrelated. 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 on the efforts played out for innovation itself.

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 (Griliches, 1990) 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., number of new products introduced and earnings from the sale of new products).

Since our framework is based on accounting proxies of innovation, we focus on literature contributions analysing accounting for R&D and intangibles (Høegh-Krohn & Knivsflå, 2000; Stolowy & Jeny-Cazavan, 2001; Pozza et al., 2008; Penman, 2009). 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 & Kirsh, 1991; Emenyonu & 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 & 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 affects 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 in products and services from external technologies, the percentage of net income generated from proprietary technology licensed to other firms (Chesbrough, 2004), the new revenues opportunities deriving from licenses, spin-off and sales divestiture and the cost savings from leveraging external development (Chesbrough, 2006), and the investments per year in collaborative R&D (Al-Ashaab et al., 2011). Conversely, time savings from leveraging external development (Chesbrough, 2006), the number of collaborative projects in the company per year and the number of patents as a result of collaborative projects (Al-Ashaab et al., 2011), the number of projects offered to external parties for further development (Chesbrough 2004), the number and the intensity of use of external sources of knowledge (Laursen & Salter, 2006), the number and the type of phases of the innovation process opened to external contributions (Lazzarotti & Manzini, 2009), and the open innovation climate measure (Remneland-Wikhamn & Wikhamn, 2011) are some examples of non-accounting indicators.

From this brief overview of the literature it is clear that different approaches are used to measure the degree of openness of companies. Yet, after a pecuniary perspective a comprehensive measurement system for OI is still lacking. This paper aims at filling such gap, by identifying the openness degree of a company through accounting data. In particular, we focus on the metrics that can be derived from new investments and divestments of innovation-related intangibles, since such transactions play a relevant role for IC and, consequently, for innovation itself.

3. Framework

The methodology we suggest is intended to provide a comprehensive measure of open innovation through the quantification of the accounting flows characterizing the transactions in the innovation market.

Open innovation transactions can be divided into inbound and outbound ones, the former characterized by innovation-related costs and intangible investments, the latter by innovation-related revenues and intangible divestments. Thus, OI transactions can have an effect on both the income statement and the balance sheet of a company, resulting in a twofold nature: economic and financial. In this work we focus our attention on the role of intangibles in OI (see Figure 1) and, thus, the items linked to open costs and revenues are neglected[2].

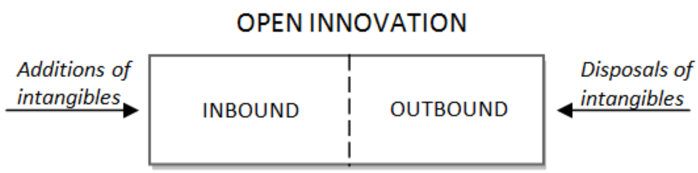

Figure 1 Open Innovation Framework

Not all the intangibles have to be considered, since only some of them are usually traded in the innovation market. In particular, consistently with the intangibles tri-partition proposed in literature (Stolowy &

[2] A detailed description of open innovation costs and revenues can be found in Michelino et al. (2014). In particular, they can be broadly divided into three categories: (1) collaborative and contract development costs and revenues, which refer to joint development projects with third parties; (2) costs from the acquisition and revenues from the sale of R&D services, which regard to the outsourcing of some phases of the R&D process; (3) in-licensing costs and out-licensing revenues.

Jeny-Cazavan, 2001), 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 and patents, trademarks and product rights, and technology; and (3) goodwill. While the first two categories have a clear connotation within innovation, 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. This is consistent with most of the definitions of goodwill found in the annual reports of companies, as well as with Brännström et al. (2009), claiming that goodwill, arising from a business combination, can be considered as a black box containing a bundle of intangible assets, and that a significant part of goodwill contains IC (Boekestein, 2009). 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.

Actually, not all the increases and decreases of intangibles can be considered as open, since we have capitalization of development costs or internally developed intellectual property rights, amortization, impairment charges, reclassifications and currency translations, which are all linked to internal accounting operations and adjustments, rather than to exchanges with third parties.

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.

Therefore, two measures of openness can be defined dividing the additions (disposals) deriving from open transactions by the total intangibles of the company:

$$Open\ additions\ intensity = \frac{Additions\ of\ intangibles\ from\ OI}{Total\ intangibles}$$

$$Open\ disposals\ intensity = \frac{Disposals\ of\ intangibles\ from\ OI}{Total\ intangibles}$$

Such indicators have a dynamic nature, since they show how the stock of intangibles and, consequently, of IC is reduced or increased for the effect of open innovation.

From all the previous considerations, OI can be considered as a four-dimensional phenomenon, since it can be defined in terms of costs, revenues[3], additions and disposals.

All the ratios range from zero to one, corresponding, respectively, to a totally closed and a totally open behaviour. Thus, open innovation can be represented in the space R^4, where each of the basic ratios is a Cartesian coordinate and each company can be represented as a point, whose distance from the origin is proportional to its total degree of openness:

$$Openness\ intensity = \sqrt{\frac{open\ revenues\ int.^2 + open\ costs\ int.^2 + open\ disposals\ int.^2 + open\ additions\ int.^2}{4}}$$

[3] Two further measures of openness can be defined (Michelino et al., 2014), i.e., *open costs intensity* and *open revenues intensity,* dividing the open costs (revenues) carried (earned) by the company by its total R&D and IP costs (revenues).

Since we aim at analysing the relevance of the open innovation transactions involving intangibles, we will focus on additions and disposals of: development costs and IPR&D, licenses and patents, trademarks and product rights, technology and goodwill.

Given that intangible investments can occur in separate acquisitions or within business combinations, mergers and acquisitions (BCMAs), two further indicators can be calculated:

$$Separate\ additions\ intensity = \frac{Separate\ additions\ of\ intangibles\ from\ OI}{Total\ intangibles}$$

$$BCMA\ additions\ intensity = \frac{BCMA\ additions\ of\ intangibles\ from\ OI}{Total\ intangibles}$$

Moreover, the indicators can be further decomposed in their basic elements defining 14 ratios, e.g.:

$$R\&D\ separate\ additions\ intensity = \frac{Separate\ additions\ of\ R\&D}{Total\ intangibles}$$

We also considered frequency as the number of occurrences of each specific separate addition, BCMA addition or disposal in a set of companies. For example, if we have a sample of N companies with $n \leq N$ of them having R&D separate additions, we can define:

$$R\&D\ separate\ additions\ frequency = \frac{n}{N}$$

Being focalized on the transactions of intangibles under the form of investments and divestments, two open innovation business models can be pursued by companies: the *trading model* and the *incorporation model*. The former is characterized by additions and disposals of intangibles within separate acquisitions, which differ from the BCMA addition for a more focalized interest on the specific intangible acquired or divested. Differently, incorporation is pursued by those companies acquiring other companies for taking over not only their recognized intangibles, but also the knowledge and the expertise of people.

4. Application of the Framework

The suggested framework was applied to a sample of 274 science based companies from bio-pharmaceutical and technology hardware & equipment industries[4]: the two industries were selected for their high R&D intensity. We downloaded their 2011 consolidated annual reports from the internet and analysed them by recording all the transactions related to the trading of research and development, intellectual property rights and goodwill in all their forms.

Five segments have been defined. The pharmaceutical segment (PH) is dominated by so-called ethical drugs or conventional drugs: ethical drugs constitute the pharmaceutical industry in the strict sense, in which the multinational pharmaceutical companies operate. The biotechnology segment (BIO) includes drugs produced by complex natural molecules which are often created from living cells. Computer hardware & office equipment segment (HW) is characterized by businesses involved in designing and manufacturing computer hardware and components, such as monitors, data storage, hard drive disks, printers, photocopiers and computer networking infrastructures. Semiconductors segment (SC) is represented by companies engaged in design and fabrication of semiconductor devices, such as digital and analog integrated circuits. Finally, telecommunications equipment segment (TLC) concerns businesses involved in designing and manufacturing hardware used for

[4] See Appendix for the complete list of companies.

telecommunications, such as switching and transmission equipment, mobile phones, routers and modems.

Descriptives for the sample are provided in Tables 1 and 2.

Table 1 No. of Companies and Mean Values of Employees, ROA, R&D Intensity and Openness Intensity

Segment	No. of companies	No. of employees	Return on Assets	R&D intensity	Openness Intensity
BIO	55	1,526	-24.5%	23.6%	33.7%
PH	69	18,587	6.7%	15.3%	17.8%
HW	30	43,204	4.8%	3.5%	13.4%
SC	72	8,964	11.1%	15.1%	17.2%
TLC	48	14,878	5.4%	13.1%	11.1%
Total	274	14,679	1.1%	11.8%	19.2%

Table 2 Mean Values of OI Metrics

Segment	Open disposals intensity	Separate additions intensity	BCMA additions intensity	Open additions intensity
BIO	1.9%	5.0%	11.8%	16.8%
PH	1.1%	3.0%	10.5%	13.5%
HW	1.7%	6.2%	18.8%	25.0%
SC	2.1%	4.5%	23.9%	28.4%
TLC	0.9%	5.0%	15.3%	20.3%
Total	1.5%	4.5%	16.0%	20.5%

Biotech companies are far more open than those belonging to other four segments; 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. Intangibles transactions, characterizing primarily technology hardware & equipment industry, occur mainly under the form of investments, in particular within BCMAs, while divestments are negligible.

Tables 3, 4 and 5 show frequency and intensity, i.e., the percentage of companies that have registered disposals, separate additions and BCMA additions of R&D, IP and goodwill in their annual reports and the mean values of OI metrics calculated for the set of companies that have registered the above transactions—respectively. Frequency and intensity give us information on the extent to which a specific OI transaction is widespread and relevant for both a specific segment and the whole sample.

As regards frequency, most companies in the sample are dynamic in IP management, by renewing their IP portfolio through acquisition and sale of patents. Also, by forming combinations with other firms, most companies acquired goodwill. Yet, the outbound behaviour of the five segments is quite differentiated: most biotech and computer hardware & office equipment companies sold patents, most pharmaceutical companies disposed trademarks, most semiconductors companies sold technology and, finally, most telecommunications equipment companies disposed R&D and patents. On the contrary, the inbound behaviour is quite homogeneous, since for each segment most companies separately acquired patents and incorporated goodwill. In addition, as to BCMAs, most biotech companies also acquired R&D, most pharmaceutical companies also acquired trademarks, and most technology hardware & equipment companies also acquired technology.

As to intensity, the most significant items are technology disposals, separate patents additions and BCMA goodwill additions for the sample as a whole, but from the comparative analysis of the five segments very different behaviours emerge.

Biotech companies are mainly characterized by patents disposals, separate trademarks additions and BCMA additions of patents.

Table 3 Frequency and Intensity of Intangibles Disposals

Segment	R&D disposals		Patents disposals		Trademarks disposals		Technology disposals		Goodwill disposals	
	freq.	*int.*	*freq.*	*int.*	*freq.*	*int.*	*freq.*	*int.*	*freq.*	*int.*
BIO	7.3%	5.0%	14.5%	9.5%	1.8%	0.0%	0.0%	0.0%	3.6%	3.8%
PH	13.0%	1.7%	20.3%	0.7%	26.1%	0.8%	4.3%	0.4%	5.8%	8.2%
HW	6.7%	0.5%	23.3%	0.7%	13.3%	9.6%	13.3%	1.7%	0.0%	0.0%
SC	15.3%	1.1%	11.1%	0.9%	4.2%	0.7%	18.1%	9.0%	4.2%	3.1%
TLC	14.6%	2.9%	14.6%	2.4%	8.3%	0.1%	10.4%	1.0%	12.5%	0.5%
Total	12.0%	2.1%	16.1%	2.6%	10.9%	1.8%	9.1%	5.2%	5.5%	3.5%

Table 4 Frequency and Intensity of Separate Intangibles Additions

Segment	Sep. R&D additions		Sep. patents additions		Sep. trademarks additions		Sep. technology additions	
	freq.	*int.*	*freq.*	*int.*	*freq.*	*int.*	*freq.*	*int.*
BIO	10.9%	8.8%	27.3%	8.1%	5.5%	34.0%	5.5%	0.1%
PH	15.9%	1.6%	42.0%	4.5%	27.5%	2.9%	4.3%	0.6%
HW	16.7%	2.6%	43.3%	11.2%	13.3%	4.5%	10.0%	3.3%
SC	8.3%	2.8%	38.9%	8.0%	1.4%	0.0%	22.2%	5.3%
TLC	6.3%	13.7%	37.5%	8.0%	12.5%	6.3%	14.6%	2.6%
Total	11.3%	4.6%	37.6%	7.4%	12.0%	6.5%	11.7%	3.6%

Table 5 Frequency and Intensity of BCMA Intangibles Additions

Segment	BCMA R&D additions		BCMA patents additions		BCMA trademarks additions		BCMA technology additions		BCMA goodwill additions	
	freq.	*int.*	*freq.*	*int.*	*freq.*	*int.*	*freq.*	*int.*	*freq.*	*int.*
BIO	12.7%	31.2%	9.1%	36.8%	5.5%	0.4%	7.3%	9.9%	21.8%	17.0%
PH	21.7%	7.6%	13.0%	4.6%	29.0%	12.0%	10.1%	10.1%	44.9%	8.4%
HW	26.7%	4.1%	13.3%	4.3%	26.7%	1.3%	36.7%	11.2%	56.7%	22.4%
SC	29.2%	5.5%	18.1%	4.9%	19.4%	3.0%	41.7%	13.0%	61.1%	25.2%
TLC	25.0%	2.6%	18.8%	4.6%	22.9%	1.0%	37.5%	9.2%	54.2%	18.6%
Total	23.0%	8.1%	14.6%	8.7%	20.4%	5.5%	25.5%	11.2%	47.4%	18.7%

Pharmaceutical companies are mainly represented by goodwill disposals, separate patents additions and BCMA additions of trademarks.

Technology hardware & equipment companies are mainly characterized by BCMA additions of goodwill. In particular, computer hardware & office equipment and semiconductors companies are mainly represented by separate patents additions, while telecommunications equipment companies by separate R&D additions. As to the outbound behaviour, computer hardware & office equipment companies are mainly characterized by transactions involving trademarks, semiconductors companies by technology and telecommunications equipment companies by R&D and patents.

5. Discussion

Within the presented framework two dimensions of openness are considered, additions and disposals of intangibles, after which two business models can be analysed: *trading* and *incorporation*.

By combining the information deriving from frequency and intensity analysis, we defined the *frequency/intensity matrix*. Each of the 14 intangibles transactions (i.e., disposals, separate additions and BCMA additions of R&D, IP and goodwill) can be positioned in one of the four quadrants of the matrix, in function of two thresholds[5]:

- the first one, marking transactions of intangibles that are more frequent in a specific segment from those which are less;
- the second one, separating high and low intense intangibles transactions.

This allows to define the OI business models pursued by each segment, by underlining what are the transactions of intangibles that are more relevant, i.e., more frequent and intense. Three frequency/intensity matrixes are shown in Figure 2, respectively for the two segments in the bio-pharmaceutical industry and the whole technology hardware & equipment industry, since no significant differences were found as to its three segments.

Bio-pharmaceutical companies have not registered relevant intangibles transactions. As a matter of fact, even if biotech companies are the most open in the sample, their openness has a completely different nature: collaboration and contract costs and revenues, R&D services acquisition costs and sale revenues, denoting the operating and continuous nature of open innovation. Consistently, the transactions that characterize these companies can be detected in the income statement, as components of the EBIT. Usually they enter into different kinds of agreements with universities, medical and research centres and other bio-pharmaceutical companies, and work with many providers in pre-clinical and clinical development, thus resulting in external development costs related to clinical trials. On the other side, pharmaceutical companies are characterized by both economic and financial transactions, yet the latter are not relevant. In particular, in order to strengthen their research capabilities, most pharma companies form combinations with other bio-pharmaceutical firms, and enlarge their portfolio, by separately acquiring patents. Despite these transactions are very diffused, they have not a significant weight and, thus, they can be considered as ancillary to the core business of these companies.

Conversely, the companies from technology hardware & equipment industry adopt trading and incorporation models, which are characterized by operations accounted in the balance sheet. As a matter of fact, BCMA goodwill additions strongly characterize most companies, relying on incorporation as a mean for absorbing know-how and intellectual capital from outside. Such a behaviour can be explained in terms of both product development pace and 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, the focus is on ready-made solutions, acquirable within BCMAs. Further, BCMAs additions of technology and separate additions of patents are very widespread transactions among these companies, but their relevance is quite low. Therefore, they can be considered as subsidiary to the main business of these firms.

At a glance, we found that in the bio-pharmaceutical industry the most significant part of open innovation transactions has an economic nature and, thus, for the companies in this industry, open innovation strategy is far

[5] The two thresholds equal 50% of the maximum observed frequency and average intensity respectively.

more oriented to revenues and costs. These results are consistent with literature, which reports an increasing frequency of inter-firm partnerships between large established pharmaceutical firms and biotechnology companies in recent decades (Hagedoorn & Roijakkers, 2002; Powell et al., 2005). As a matter of fact, although large pharmaceutical companies play a dominant role in the commercialization process, they are often unable to create an internal research environment that would foster constant discovery and innovation. Thus, biotech firms, can make up for this lack of internal capabilities and resources through various kinds of partnerships (Arora & Gambardella, 1994; Powell et al., 1996). On the contrary, as to technology hardware & equipment industry, open innovation transactions are mainly financial and represented by goodwill: thus, in this industry, BCMAs occur to acquire know-how and, therefore, goodwill can be effectively considered as a proxy of IC. This is consistent with literature, which reports the desire to obtain valuable resources, including know-how, technologies, and capabilities possessed by target firms, as a relevant driver of BCMAs activities (Chaudhuri & Tabrizi, 1999; Ahuja & Katila, 2001). In particular, the incorporation strategy is a better solution for technology hardware & equipment firms because of the modularity of IT design: many computer and chip designs are based on compatible independent components, and this makes it simpler to buy technology that can be readily integrated (Bower, 2001).

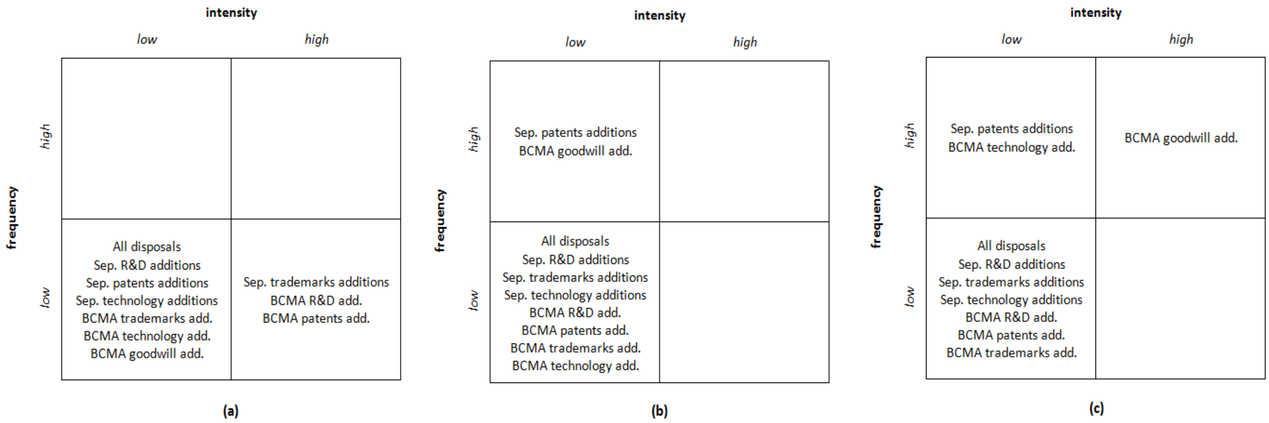

Figure 2 Frequency/Intensity Matrix for (a) Biotech Companies, (b) Pharmaceutical Companies, (c) Technology Hardware & Equipment Companies

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 intangibles transactions in inbound and outbound processes. Such framework was applied to a sample of 274 science based companies in bio-pharmaceutical and technology hardware & equipment industries.

From a theoretical point of view two open innovation models can emerge, depending on the features of intangibles transactions, namely *trading* and *incorporation*.

Being focused on accounting indicators, our framework can be used to analyse only the pecuniary dimension of open innovation (Dahlander & 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, 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 is now under study, in order to highlight the trends in open innovation strategies pursued by companies.

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Appendix List of Companies

Bio-pharmaceutical		Technology hardware & equipment	
4SC	Krka	Adtran	Logitech international
Abbott	Laboratorios Farmaceuticos Rovi	ADVA Optical Networking	LSI Corp
Ablynx	Lexicon Pharmaceuticals	Advanced Digital Broadcast	Marvell Technology
Actelion	Life Technologies	Advanced Micro Devices	Maxim Integrated Products
Affymetrix	Lundbeck	Advanced Semiconductor Engineering	MediaTek
Agennix	Meda	Advantest	Melexis
Alexion	Medicines	Aixtron	Mellanox Technologies
ALK-Abello	MediGene	Alcatel-Lucent	MEMC Electronics Materials
Alkermes	Medivir	Altera	Microchip Technology
Allergan	Merck DE	Amino Technologies	Micron Technology
Almirall	Merck US	Amper	Micronic Mydata
Amgen	Merz	Analog Devices	Microsemi
Amylin	Morphosys	Anoto	Motorola
Arena	Mylan	Apple	Muhlbauer
Ark Therapeutics	Nektar	Applied Materials	Murata Manufacturing
AstraZeneca	Neovacs	ARM	NCR
Basilea	Newron	Arris	Neopost
Bavarian Nordic	NicOx	Aruba Networks	Net Insight
Biogen Idec	Novartis	ASM International	NetApp
Bioinvent	Novo Nordisk	ASML Holding	Nokia
Biomarin	Novozymes	Atmel	NVIDIA
Biotest	NPS Pharmaceuticals	austriamicrosystems	NXP Semiconductors
Biotie Therapies	Oasmia Pharmaceutical	Avago Technologies	Oclaro
Bioton	Omega Pharma	Avaya	OmniVision Technologies
Boehringer Ingelheim	Onyx	Axis	ON Semiconductor
Bristol-Myers Squibb	Orexo	Broadcom	Option
BTG	Orion Oyj	Brocade Communications Systems	PACE
Carmat	Oxford Biomedica	Bull	Parrot
Celgene	Paion	Calix	Pitney Bowes
CHR Hansen	Perrigo	Canon	Plantronics
Cosmo Pharmaceuticals	Pfizer	Cavium Networks	PMC-Sierra
CSL	Pharming	Ciena	Polycom
Cubist	Proximagen	Cisco Systems	Promethean World
Dako	Qiagen	Corning	Psion
Dechra Pharmaceuticals	Recordati	Cree	Qlogic
Diamyd Medical	Roche	CRS UK	Qualcomm
DiaSorin	Salix	Cymer	Quantum
Egis	Sanofi-Aventis	Cypress Semiconductor	Radiall
Elan	Shire	Dell	Rambus
Eli Lilly	Silence Therapeutics	Delta Electronics	Research in motion
Endo	SkyePharma	Dialog Semiconductor	RF Micro Devices
Epigenomics	Stada Arzneimittel	Electronics for imaging	Ricoh

(Appendix to be continued)

(Appendix continued)

Evotec	Swedish Orphan Biovitrum	ELMOS Semiconductor	Riverbed technology
Exelixis	Sygnis Pharma	Emulex	SanDisk
Forest	Symphogen	Ericsson	Semiconductor Manufacturing SMIC
Galapagos	Targacept	F5 Networks	Sepura
Galenica	Teva	Fairchild Semiconductor	Sierra Wireless
Gedeon Richter	ThromboGenics	FEI	Silicon Image
Gen-Probe	TiGenix	Filtronic	Silicon Laboratories
Genus	TopoTarget	Finisar	Skyworks Solutions
Gilead	Transgene	GN Store Nord	Smartrac
GlaxoSmithKline	UCB	Harmonic	Sonus Networks
Guerbet	United Therapeutics	Harris	Spirent Communications
GW Pharma	Valeant Pharmaceuticals	Hewlett-Packard	Spreadtrum Communications
Hikma	Vectura	Himax Technologies	STMicroelectronics
Hospira	Vernalis	HTC	Suss MicroTec
Illumina	Vertex	Huawei Technologies	Synaptics
Impax Laboratories	Vetoquinol	Hynix Semiconductor	TCL Communication Technology
Intercell	Warner Chilcott	Imagination Technologies	Tecnotree
Ipsen	Watson	Infineon Technologies	Telit Communications
Isis	Wilex	Integrated Device Technology	Tellabs
Johnson & Johnson	Zeltia	Intel	Teradyne
		Intermec	Tessera Technologies
		International Rectifier	Texas Instruments
		Intersil	Triquint Semiconductor
		JDS Uniphase	VeriFone Systems
		Juniper Networks	Vislink
		Kla-Tencor	Western Digital
		Kontron	Wistron
		Kulicke & Soffa	Wolfson Microelectronics
		Lam Research	Xaar
		Lattice Semiconductor	Xerox
		Lenovo	Xilinx
		Lexmark	Xyratex
		Linear Technology	ZTE