Open innovation scorecard: a managerial tool

Abstract

Purpose: The purpose of the paper is to devise a scorecard providing a suite of indicators that give innovation managers a fast but holistic view of open innovation adoption in their organisations.

Design/methodology/approach: The theoretical framework is built after a thorough review of open innovation literature. The managerial tool is developed from the theoretical framework through the on-field validation of the metrics suggested: they all can be easily generated by processing data within information systems of companies.

Findings: The scorecard provides a multi-dimensional conceptualisation of open innovation adoption within organisations, investigating *environment*, *collaboration* and *importing/exporting mechanisms*. Six indicators are defined: *innovation funds*, *open innovation employees*, *collaboration costs*, *collaboration revenues*, *importing costs* and *exporting revenues*.

Research limitations/implications: The devised tool enables the assessment of openness through objective and available data, systematically updated within the information systems of companies and easily exploitable by innovation managers. In order to meet such conditions, several aspects emerged from literature review, although relevant, were left out.

Practical implications: Several dashboards and positioning maps can be derived by exploiting the information available in the scorecard. By the use of such tools innovation managers can both assess the open behaviours of their companies and benchmark different open innovation practices either outside or inside the organisation.

Originality/value: The scorecard allows innovation managers either to identify a virtuous circle between company's commitment and reputation, joint development and OI market opportunities, and to carry out a cost-benefit analysis, evaluating if their organisations are effectively and efficiently generating outputs from open innovation with the committed resources.

Keywords: Open innovation; Scorecard; Managerial tool; Innovation metrics; Open innovation models; Cost-benefit analysis.

Article classification: General review.

1. Introduction

Since its first conceptualisation by Chesbrough (2003), the paradigm of open innovation (OI) has attracted a vast interest, gaining a growing popularity within both academic and business communities. Thanks to compelling research studies and best practice cases carried out over the last decade (see, e.g., Bröring and Herzog, 2008; Chesbrough, 2012; Di Minin et al., 2010; Dittrich and Duysters, 2007; Dodgson et al., 2006; Gianiodis et al., 2014; Huston and Sakkab, 2006; Kirschbaum, 2005; Mergel and Desouza, 2013; Rohrbeck et al., 2009), several organisations have begun to embrace and apply the new principles and methods OI offers. However, obtaining a high degree of openness can be costly and not always easy (see, e.g., Dahlander and Gann, 2010; Faems et al., 2010; Laursen and Salter, 2006). Indeed, the approach chosen by companies should depend on its coherence with the strategic, organisational and managerial contexts and on an acceptable balance between benefits and costs. Hence, the adoption of the paradigm needs to be monitored and controlled in order to be able to come to conclusions concerning the success of the implementation. If no metrics or inadequate metrics are employed, an open question will remain on which actions have to be taken to increase the chances of successfully employing an OI strategy (Brau et al., 2013). Yet, little attention has still been committed on the tools organisations may use to support and monitor the implementation of OI. We address such issue by devising a scorecard providing a suite of indicators that give innovation managers a fast but comprehensive view of OI adoption in their organisations. This managerial tool allows to look at the openness of companies taking into account five different dimensions: outer and inner environment, collaboration, importing and exporting mechanisms. Such aspects were derived from a thorough review of OI literature, interpreting the key issues scholars dealt with in assessing OI adoption within organisations.

The rest of the paper is organised as follows. First, we review the OI literature, building the theoretical framework which constitutes the basis for developing the managerial tool. Second, we describe in detail the OI scorecard, illustrating the indicators assigned to each of the five dimensions. In particular, several OI models emerge by combining the metrics within dashboards after different perspectives. Finally, conclusions - summarising the contribution of this study - close the work.

2. Building the theoretical framework from literature review

We selected a set of 62 studies on OI metrics covering the period 2003-2014, using the key term “open innovation” in title, keywords or abstract within EBSCO database. Thus, we developed a theoretical framework interpreting and classifying the key aspects researchers dealt with in assessing OI adoption within organisations. The framework includes five dimensions (Figure 1), capturing in total 182 indicators.

Outer environment encloses metrics evaluating if the firm actively looks for new ideas, resources and technologies outside its boundaries, assimilating and integrating them into its value chain. Conversely, *inner environment* comprises proxies reflecting the fact that a supportive company’s corporate culture is

argued to be a key element for a successful OI implementation. Both dimensions represent the enabling drivers of OI, which can be both external and internal to the firm.

Collaboration encloses indicators typifying the partners with whom the collaboration takes place, the types of arrangements, the innovation funnel openness, the organisation and the outcomes of companies' collaborative activities. *Importing mechanisms* include metrics estimating both the efforts and the practices related to external knowledge acquisition. These two dimensions concern the authorship of innovation: as a matter of fact, collaboration will result in a joint authorship of the innovation among two or more parties, whilst importing mechanisms are related to the acquisition of innovations whose authorship is external to the focal company. As such, they reflect strategies engendered by the OI model as opposed to innovations developed by the firm alone through in-house research departments (Acha, 2008).

Lastly, *exporting mechanisms* comprise indicators evaluating both the benefits and the practices related to internal knowledge exploitation. This dimension pertains to the outputs of OI.

In what follows, the dimensions of the framework will be delineated through the indicators gathered from the set of OI studies examined.

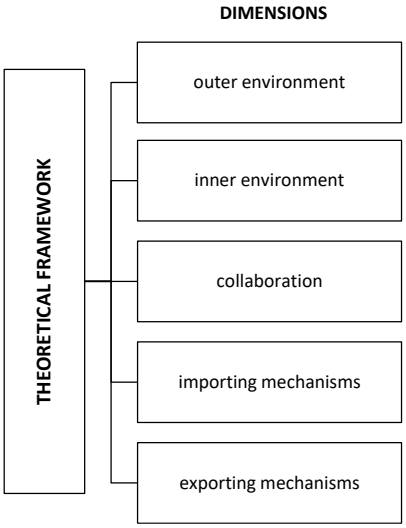

Figure 1. The theoretical framework

2.1 Outer environment

Outer environment plays a relevant role in fostering OI adoption, since - by definition - OI breaks down company's boundaries and implies an active interaction with external entities. Within such dimension, the OI studies analysed suggest indicators assessing both *external sources* of knowledge firms rely upon and the *context* in which companies operate (Table 1).

External sources are evaluated in terms of:

- variety of sources the firm has drawn on to fuel its innovative activities (external search breadth), also examining the use of prior innovation linkages;

- importance attached to external sources both in an absolute way (external search depth) and in a relative way, by comparing either external vs. internal sources (Poot et al., 2009) or different types of external sources (Spithoven et al., 2010; Spithoven, 2013);
- location of the sources, since it may affect the development of innovations (Idrissia et al., 2012);
- practices companies perform for tapping external sources (e.g. technology scouting).

Context is examined in terms of industry's characteristics able to foster the adoption of the OI model by firms. In addition, the government intervention in supporting innovative activities is taken into account (Kim and Park, 2010). Since research and development (R&D) subsidies are principally bestowed on the basis of management expertise and productivity, they provide the recipient company with an externally validated signal of quality, thereby encouraging collaboration and venture investment into the company's R&D.

Table 1. The indicators assigned to outer environment

Outer environment	What is measured	Which metrics are used	Meaning	OI studies
External sources	Variety	Applied external knowledge from NGO or industry organizations; Competitors; Conferences; Customer involvement; External search breadth; Fairs; International network; Participated in exhibitions for innovation; Reading of technical magazines or similar; Search openness; Search strategy; Suppliers and end-users; University; Used innovations brokers; Used internet to search for new trends or technologies	Variety of external sources firms rely upon in their innovative activities	Laursen and Salter (2006; 2014); van der Meer (2007); Acha (2008); Tether and Tajar (2008); Keupp and Gassmann (2009); van de Vrande et al. (2009); Bahemia and Squire (2010); Belussi et al. (2010); Chiang and Hung (2010); Hwang and Lee (2010); Lee et al. (2010); Sofka and Grimpe (2010); Schweitzer et al. (2011); Idrissia et al. (2012); Köhler et al. (2012); Salge et al. (2012); Tranekjer and Knundsen (2012); Garriga et al. (2013); Spithoven et al. (2013); van Hemert et al. (2013); Love et al. (2014)
		User-type	Characteristics of the users involved in NPD: launch, request, pioneer, first buyer and lead user	Jespersen (2010)
		Prior linkages	Use of external innovation linkages in a previous period compared to that analysed	Love et al. (2014)
	Importance	Customer and supplier integration; External search depth; External sources; Incoming knowledge spillovers; Information sources; Knowledge externalities; Search openness; Universities; User	Extent to which firms draw deeply from the different external sources	Laursen and Salter (2006); Acha (2008); Keupp and Gassmann (2009); Poot et al. (2009); Bahemia and Squire (2010); Belussi et al. (2010); Chiang and Hung (2010); Hwang and Lee (2010); Ili et al. (2010); Lee et al. (2010); Sofka and Grimpe (2010); Spithoven et al. (2010); Mention (2011); Schweitzer et al. (2011); Idrissia et al. (2012); Köhler et al. (2012); Garriga et al. (2013); Janeiro et al. (2013); Salge et al. (2013); Spithoven (2013)
		Ratio of external sources vs. internal sources of innovation	Relative importance of external information sources vs. internal ones	Poot et al. (2009)
		User-involvement intensity	Volume and intensity of user-involvement in NPD	Jespersen (2010)
		Complex research	If a firm sources from universities, government, and professional conferences, this is viewed as an indication that it performs complex research	Spithoven et al. (2010); Spithoven (2013)
	Location	Regional proximity; Provincial and national proximity; World proximity	Importance of the role played by clients and suppliers located regionally, at provincial and national level, and elsewhere in the world, for the development of innovations	Idrissia et al. (2012)
	Practices	Outside-in methods	Which methods are used for tapping external sources	Ili et al. (2010)
		User-involvement in NPD stages	How users are involved in idea, development, and launch	Jespersen (2010)

		External idea sourcing; Idea sourcing from university and research institutes	Whether or not: the firm carried out an external activity in the idea generation stage of the innovation process; the firm carried out idea sourcing from university and research institutes in the idea generation stage of the innovation process	Kim and Park (2010)
		Intra-industry spillovers; Inter-industry spillovers	External knowledge originating from the industry in which the firm operates or from other sectors that can be exploited without having to pay for it	Kafouros and Forsans (2012)
		Technology scouting	Process of observing technology trends, viewing external sources for ideas and knowledge, and collecting information about the technological environment	Parida et al. (2012)
Context	Characteristics	Industry's idiosyncrasies	The more the industry's idiosyncrasies correspond to developments and trends like (1) globalization, (2) technology intensity, (3) technology fusion, (4) new business models and (5) knowledge leveraging, the more appropriate the OI model seems to be	Ili et al. (2010)
		Governmental support	Whether or not the firm received governmental support	Kim and Park (2010)
		Approaches to OI	Identification of two different approaches to OI explained not only by looking at the R&D intensity of the industry, but also at the differences in the technologies primarily used in the industry in terms of technological uncertainty, appropriability, and clock-speed	Buganza et al. (2011)

2.2 Inner environment

The **inner environment** of a company is also argued to be a relevant factor for successful OI implementation. Actually, moving from a closed to an open way of innovating is not easy and often involves a significant cultural and organisational change. For instance, the not invented here (NIH) syndrome - which occurs when members of a firm are resistant to ideas, technologies and knowledge coming from outside (Katz and Allen, 1982) - is one of the greatest obstacles to OI adoption. Within such dimension, the OI studies analysed provide metrics evaluating both *resources* and *culture & climate* (Table 2).

Resources are assessed in terms of:

- personnel, focusing either on the number of full time equivalents (FTEs) involved in cooperation with third parties, or on the recruitment of engineers and experts available on the market, or on the internal resistance against externally developed knowledge. Furthermore, since firms rich in graduates are more likely to seek out and form relationships with other firms and organisations rich in graduates (Tether and Tajar, 2008), the level of education also deserves particular attention;
- capacities, since companies have to develop different capabilities in order to implement specific OI modes: for example, absorptive capacity will enhance the exploitation of external knowledge.

Regarding culture & climate:

- both the studies by van der Meer (2007) and Ili et al. (2010), by comparing the principles of closed and open innovation, argue that it is possible to understand if a company exhibits the characteristics of OI culture;
- Enkel et al. (2011) devise a tool to measure and benchmark excellence in OI, defining the level of OI maturity of an organisation;
- Remneland-Wikhamn and Wikhamn (2011) propose an OI climate measure, consisting of three dimensions - innovation/flexibility, outward focus and reflexivity.

Table 2. The indicators assigned to inner environment

Inner environment	What is measured	Which metrics are used	Meaning	OI studies
Resources	Personnel	Intensity of cooperation	No. of FTEs involved in cooperation with third parties for each category of R&D projects	de Wit et al. (2007)
		Proportion of science and engineering graduates in the workforce; Proportion of 'other graduates' in the workforce	Percentage of science and engineering graduates in the total workforce; Percentage of 'other graduates' in the total workforce	Tether and Tajar (2008)
		Hiring personnel	Acquiring new knowledge embodied in new personnel	Santamaría et al. (2010)
		NIH	Employees' negative attitudes toward acquiring external knowledge	Tranekjer and Knundsen (2012)
	Capacities	Inventive capacity; Absorptive capacity; Transformative capacity; Connective capacity; Innovative capacity; Desorptive capacity	Ability to generate knowledge within a firm; Ability to acquire and assimilate external knowledge; Ability of a firm to protect its knowledge; Ability of a firm to retain knowledge within itself; Ability of a firm to commercialise from its products; What is necessary for external exploitation	Ahn et al. (2013)
Culture & climate	Culture	Employee involvement; Nursing of special talents in the firm; OI culture; Supported entrepreneurial activities in the firm; Supported that employees can work on own ideas for the firm	The six principles taken from Chesbrough are considered to illustrate the set of norms, beliefs and values working well in an OI system	van der Meer (2007); van de Vrande et al. (2009); Ili et al. (2010); Tranekjer and Knundsen (2012)
	Climate	OI maturity framework	Methodology combining three core elements of OI (climate for innovation, partnership capacity, and internal processes) with five maturity levels (initial/arbitrary, repeatable, defined, managed, and optimizing)	Enkel et al. (2011)
		OI climate measure	Assessment tool with three interrelated and arguably reinforcing dimensions: innovation/flexibility, outward focus and reflexivity	Remneland-Wikhamn and Wikhamn (2011)

2.3 Collaboration

Since the definition of the OI paradigm, firms are becoming more and more aware that they are unable to hold in-house all the competencies they require and, thus, are increasingly collaborating with third parties within their innovation processes. Joint development can be a source of competitive advantage, since it enables companies to both incorporate external sources and share significant amounts of information (Zhao, 2014).

Within the **collaboration** dimension, the OI studies examined propose indicators assessing the *partners* with whom the collaboration takes place, the *forms* of arrangements, the *innovation funnel* openness, the *organisation* and the *results* of firms' collaborative activities (Table 3).

Similarly to external sources, the external players involved in companies' innovation activities are analysed in terms of variety, importance and location. Other aspects are included, such as the number of new vs. existing partners of the firm (Bahemia and Squire, 2010) and the technological skills of each partner type (Chen et al., 2011). The occurrence of the collaboration practice and its forms are also assessed, distinguishing between non-equity alliances, networking and joint ventures. In addition, the phases of the innovation funnel opened to external collaborations are characterised (Lazzarotti and Manzini, 2009). The internal organisation of collaboration, pertaining to both managerial actions and objectives, also deserves particular attention. Finally, the outputs of collaboration are estimated, e.g., in terms of joint patents (Yun et al., 2014), new products, services and technologies resulting from collaborative projects and joint publications (Al-Ashaab et al., 2011).

Table 3. The indicators assigned to collaboration

Collaboration	What is measured	Which metrics are used	Meaning	OI studies
Partners	Variety	Collaboration breadth; Collaboration depth; Collaboration with external partners; Competitor partnership; Cooperation with industrial agents; Cooperation with scientific agents; Cooperation: type of partner; Cooperation; Customer partnership; Diversity of technology alliance portfolio; External and internal collaboration; Horizontal technology collaboration; Inbound cooperation: suppliers, clients/customers, lead users, competitors, consultants, commercial laboratories & R&D institutes, universities, general public, opinion leaders; Innovation collaboration breadth; OI partnership; Partner variety; Research networking; Scope of openness; Stakeholder cooperation intensity: customers, suppliers, competitors, cross-industry firms, consulting firms, universities; Supplier partnership; URI partnership; Vertical technology collaboration	Different types of collaboration partners with whom the collaboration takes place	Laursen and Salter (2006; 2014); Acha (2008); Lazzarotti and Manzini (2009); Poot et al. (2009); Su et al. (2009); Vega-Jurado et al. (2009); Belussi et al. (2010); Faems et al. (2010); Lazzarotti et al. (2010); Chen et al. (2011); Inauen and Schenker-Wicki (2011); Mention (2011); Schroll and Mild (2011); Parida et al. (2012); Spithoven et al. (2013); Temel et al. (2013); Du et al. (2014); Garcia Martinez et al. (2014)
	Importance	Collaboration depth; Depth of openness	Extent to which firms draw on each of the external partner types for their innovation activities	Chen et al. (2011); Garcia Martinez et al. (2014)
	Location	Occurrence and spatial distribution of research collaborations	No. of research collaborations established with other firms and PROs and geographical location of each partner	Belussi et al. (2010)
		Cooperation: geographical region	Different locations of cooperation partners for innovation activities	Temel et al. (2013)
	Ambidexterity	Ambidexterity	Development of new vs. longstanding relationships	Bahemia and Squire (2010)
	Capabilities	Orientation of openness	As different types of partners have different technological skills and capabilities, it is important that innovating firms choose the right type of partners for the specific help they need	Chen et al. (2011)
	Embeddedness	Relational embeddedness	Degree of reciprocity and closeness among new product alliance participants	Tranekjer and Knundsen (2012)
	Experience	Previous experience	Whether or not the firm previously cooperated with the specific partner	
	Mutuality	Mutuality in exchange	Whether or not the partner contributes to the firm's own product development activities	
	Projects	Number of projects	No. of other firms' product development projects in which the firm is actively involved	
Forms	Collaboration	Authorship: collaborate to innovate (product or process); Collaboration patterns: strategic alliance; Collaboration; Collaborative practice; Heterogeneous alliances; Homogeneous alliances; Open; Research cooperation	Whether or not the firm has engaged in collaboration arrangements on innovation activities	Laursen and Salter (2006); Acha (2008); Kim and Park (2010); Lee et al. (2010); Santamaría et al. (2010); Spithoven et al. (2010); Sandulli et al. (2012); Garriga et al. (2013); Spithoven (2013); Teirlinck and Spithoven (2013)
	Networking	Networking; Network usage in innovation processes	Whether or not the firm has engaged in any formal networking with other businesses	Huang and Rice (2009); van de Vrande et al. (2009)
	Joint venture	Joint ventures; Participation in other firms	Whether or not the firm decided to form a joint venture	van de Vrande et al. (2009); Santamaría et al. (2010)
Innovation funnel	Phases	Phase variety	No. and type of phases of the innovation process open to external collaborations	Lazzarotti and Manzini (2009); Lazzarotti et al. (2010)
Organisation	Actions	Organisational and managerial actions for OI	Top management is committed towards the maximisation of the collaborations results; Personal relationship of the R&D manager are exploited to start technological collaborations; For each collaboration, there is a ''champion'' acting as a facilitator for the collaboration success; The company formally evaluates the objectives and risks of the collaboration; The company analyses and selects the potential partners with a formal and explicit process	Lazzarotti et al. (2010)
	Objectives	Objectives of collaboration	Enlarge the company's competence base; Increase the flexibility of the internal organisation; Stimulate creativity and idea generation capability; Reduce or share the risks and costs of innovation	Lazzarotti et al. (2010); Chaston and Scott (2012)
Results	Outputs of collaboration	Collaborative balanced scorecard	Set of KPIs to measure the university-industry collaboration results	Al-Ashaab et al. (2011)

		Co-patenting	Whether or not the firm had at least one co-assigned patent in its patent portfolio	Wang et al. (2013)
		Ratio of OI based on collaborative patents; Intensity of OI based on collaborative patents; Total level of OI based on collaborative patents	It is the ratio of OI patents jointly applied for with outside agencies to the total no. of patent applications by firms; It is the average no. of applicants at the specific firm; It represents the combined effect of the previous two metrics	Yun et al. (2014)

2.4 Importing mechanisms

When pursuing an internalisation strategy, **importing mechanisms** are employed by firms to acquire external knowledge and technology in order to strengthen internal competencies and accelerate the innovation process. In this sense, a distinction can be made between the acquisition of intangible (or disembodied) knowledge in the form of patents, licenses, or other intellectual property (IP), and the purchase of tangible knowledge embodied in physical artefacts such as machinery, equipment and components. Within such dimension, the OI studies analysed give indicators assessing both the *costs* and the *strategies* related to the retrieval of knowledge from outside (Table 4).

Costs represent the monetary efforts incurred for the purchase of IP or artefacts developed outside the company, while strategies are evaluated in terms of:

- the models firms apply when trade on technology (Podmetina et al., 2011);
- the practices companies perform to get access to external knowledge, with R&D outsourcing being the most monitored one (Berchicci, 2013).

Table 4. The indicators assigned to importing mechanisms

Importing mechanisms	What is measured	Which metrics are used	Meaning	OI studies
Costs	Monetary efforts	Financial commitment to innovation	Natural log of the firm's expenditure on innovation: intramural R&D; acquired R&D services; acquired machinery and equipment directly linked to innovation; expenditures on other external technologies such as software and licences; expenditure on design related to innovation; expenditure on training related to innovation; and expenditure on the market introduction of innovations	Tether and Tajar (2008)
		Technology purchase	Dividing the total expenditure on the development of new products and processes by the value of patents, trademarks and licenses acquired	Huang and Rice (2009)
		External scientific knowledge	Both current and past expenditure on royalty and technical know-how fees	Kafouros and Forsans (2012)
		Additions ratio; Costs ratio	Ratio between the new investments of intangibles - such as development costs, licenses, patents, trademarks, technology and goodwill - and the total value of intangibles of the company; Ratio between the costs for collaborative development, outsourcing of R&D services, and in-licensing and the total R&D and IP costs of the company	Michelino et al. (2014)
Strategies	Models	No buy; Seldom buy; Open buy	% of companies tending to be self-sufficient with their in-house R&D and stating that their in-house R&D completely matches with technology requirements; % of companies having a need in acquisition of external technologies sometimes; % of companies doing it on the regular basis, stating that "the utilisation of external technologies is vital for their business"	Podmetina et al. (2011)
	Practices	Authorship: external sources used to innovate (product or process)	How the product or process innovations were developed: mainly by other enterprises or institutions	Acha (2008)

		Acquisition of companies; Acquisition of external R&D and knowledge; Acquisition of licenses; Acquisition of patents; Bought and obtained licensees on models, designs, and know-how; Bought R&D work from others; Buy: external R&D, technology embodied in machinery and equipment, and intangible technology in the form of patents, trademarks, software, etc.; Collaboration patterns: technology purchasing; Consultant; Creative sessions networking with universities and scientific institutes; External knowledge sourcing; External R&D; Knowledge clusters "Open Day"; License IP from other firms; Licensing in; Openness; Outsourced other activities; Outsourced R&D; Outsourcing; Outsourcing R&D; Partnering; Patent search; R&D outsourcing; Spinning in; Technology sourcing; Venturing in	Different manners in which companies can gain access to external knowledge: acquisition of advanced machinery or computer hardware or software needed to innovate; acquisition of firms; acquisition of patents or licenses; new processes developed by others; new products/services developed by others; outsourced R&D expenditures; use of a technological consultant	van der Meer (2007); Acha (2008); Huang and Rice (2009); van de Vrande et al. (2009); Vega-Jurado et al. (2009); Kim and Park (2010); Lee et al. (2010); Santamaría et al. (2010); Schroll and Mild (2011); Kafouros and Forsans (2012); Parida et al. (2012); Tranekjer and Knundsen (2012); Berchicci (2013); Garriga et al. (2013); Spithoven et al. (2013); Teirlinck and Spithoven (2013)

2.5 Exporting mechanisms

When pursuing an externalisation strategy, firms open up their boundaries to allow internal know-how, products or innovations flowing outside: this may generate either monetary or non-monetary benefits. Hence, **exporting mechanisms** focus on how internal innovations are externally commercialised or otherwise disseminated. Within such dimension, the OI studies analysed suggest indicators assessing both the *benefits* and the *strategies* referred to the transfer of knowledge outside the company (Table 5).

Benefits are divided into:

- monetary results achieved when internal knowledge is sold to another organisation, e.g. the new revenues opportunities firms derive from licenses, spin-off, and sales divestiture;
- non-monetary results, since the company may also disseminate its internal innovation to the outside based on non-pecuniary motivations. In this sense, Schroll and Mild (2011) include the free revealing of innovations by firms as a proxy of outbound OI.

Strategies are evaluated in terms of:

- the models firms apply when trade on technology (Podmetina et al., 2011);
- the practices companies perform to commercialise technologies via external pathways, e.g. creating and spinning out new ventures. Licensing out the right to use the relevant IP is also a common process for allowing external partners to commercialise a focal firm's innovation.

Table 5. The indicators assigned to exporting mechanisms

Exporting mechanisms	What is measured	Which metrics are used	Meaning	OI studies
Benefits	Monetary results	What percent of your sales of products and services last year came from externally licensed technologies? Is this percent increasing or decreasing from 2-3 years ago?; What percent of your net income last year came from technology licensed out to other companies? Is this percent increasing or decreasing from 2-3 years ago?	Focusing on the outputs of the OI process, whether that be growth in product sales or growth in licensing activity	Chesbrough (2004)
		New revenues from outside	Revenues from licenses, spin-off, and sales divestiture	Chesbrough (2006)

		Disposals ratio; Revenues ratio	Ratio between the divestments of intangibles - such as development costs, licenses, patents, trademarks, technology and goodwill - and the total value of intangibles of the company; Ratio between the revenues deriving from collaborative development, development of R&D services on behalf of third parties, and out-licensing and the total revenues of the company	Michelino et al. (2014)
	Non-monetary results	Contributing to the general public; Made own innovation available to outsiders for free	Revealing knowledge away for free	Schroll and Mild (2011); Tranekjer and Knundsen (2012)
Strategies	Models	No sell; Seldom sell; Open sell	% of companies with no sales of technology; % of companies commercialising technologies sometimes; % of companies doing it on the regular basis	Podmetina et al. (2011)
	Practices	Cluster projects; Financing/founding spin-offs; Industry groups; Inside-out methods; License and know-how; Licensing out; Patent brokers; Public/private co-operation; Sale/divest; Sold one or more patents; Spinning out; Venturing out	Mechanisms for transferring knowledge, ideas and projects to the external market	van der Meer (2007); van de Vrande et al. (2009); Ili et al. (2010); Schroll and Mild (2011); Tranekjer and Knundsen (2012)

3. Building a managerial tool to measure OI

In order to give innovation managers a fast but holistic view of OI adoption in their organisations, we designed an OI scorecard. The structure of the tool is based on the theoretical framework emerged from the literature review and captures the five OI dimensions by the use of six metrics (Figure 2). Conscious that an easy-to-use dashboard for managers should include only a limited number of key indicators, from the broad range of proxies suggested by literature, a strict selection was made. An on-field evaluation was made in order to include only indicators easily exploitable by innovation managers. Therefore, only proxies based on objective and available data, which are systematically updated within the information systems of companies, were suggested. Moreover, as they have been conceived, these metrics enable a cost-benefit analysis.

In what follows, the indicators will be delineated: their values range from 0 to 1, respectively denoting a totally closed and totally open behaviour as to the investigated dimension.

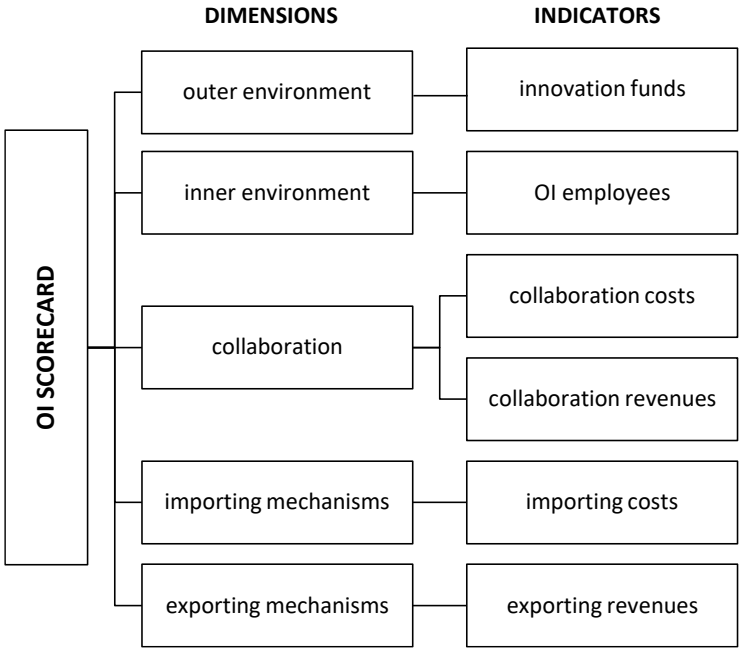

Figure 2. The OI scorecard

The first indicator assesses outer environment in terms of the company's ability to raise resources from outside as a consequence of its reputation for innovation. Hence, the metric proxies the direct government support of firms' innovation activities by comparing the amount of grants and subsidies bestowed by the government for company's research activities and the total revenues of the company in the analysed period:

$$innovation\ funds = \frac{research\ grants}{total\ revenues}$$

The second indicator evaluates inner environment in terms of the organisational commitment to OI measured through human resources involved in open activities. The metric is defined as the ratio between the number of FTEs of R&D personnel working on OI activities and the total number of FTEs of R&D personnel in the investigated period:

$$OI\ employees = \frac{FTEs\ of\ R\&D\ workers\ in\ OI\ activities}{total\ FTEs\ of\ R\&D\ workers}$$

Further, considering R&D collaborations as a set of activities that generates costs and revenues for companies, the other two indicators proposed proxy the weight of collaboration costs and revenues on the total business of firms:

$$collaboration\ costs\ = \frac{costs\ for\ R\&D\ collaboration}{total\ R\&D\ and\ IPcosts}$$

$$collaboration\ revenues\ = \frac{revenues\ from\ R\&D\ collaboration}{total\ revenues}$$

The former is the ratio of the costs sustained by a firm for R&D collaboration to the total R&D and IP costs in the analysed period, whereas the latter is the ratio of the revenues from R&D collaboration to the total revenues. Therefore, cost/profit sharing agreements, reimbursements to/from development partners, development milestones payments/achievements, up-front payments/receipts are taken into account (Michelino et al., 2015). Such metrics evaluate the pervasiveness of R&D collaboration within the total business of the company.

The last two indicators respectively refer to the monetary efforts incurred for the purchase of knowledge developed outside the company and the results achieved when internal knowledge is sold to another firm:

$$importing\ costs\ = \frac{costs\ for\ importing\ mechanisms}{total\ R\&D\ and\ IPcosts}$$

$$exporting\ revenues\ = \frac{revenues\ from\ exporting\ mechanisms}{total\ revenues}$$

The former is the ratio between the costs for acquisition of external R&D and know-how, licensing in and external knowledge sourcing and the total R&D and IP costs of the company in the investigated period. The latter is the ratio between the revenues deriving from inside-out methods and licensing out and the total revenues. Such metrics estimate the pervasiveness of both R&D outsourcing and licensing activities within the total business of the firm.

Apart from evaluating the single metrics, innovation managers may also derive specific information by combining the indicators within dashboards. This enables to monitor the different models firms may adopt when pursuing an OI strategy. Particularly, three dashboards may be obtained by aggregating the information available either on environment or on collaboration or on importing/exporting mechanisms.

As for environment (Figure 3):

• the *inner innovator* model corresponds to companies exhibiting a significant internal commitment to OI, with human resources almost entirely devoted to open activities;

• the *outer innovator* model refers to firms for which the high reputation for innovation enables them to benefit from government subsidies;

• the *surroundings innovator* model regards those companies for which both internal and external environmental factors foster OI adoption. As such, they behave either as both inner and outer innovators.

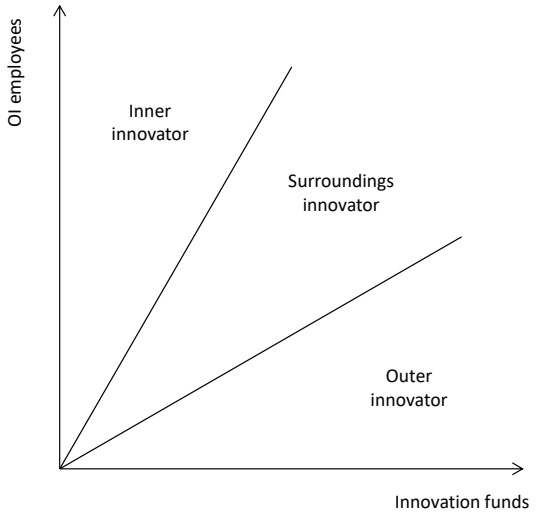

Figure 3. OI dashboard: environment perspective

As to collaboration (Figure 4):

• the *downstream collaborator* model corresponds to companies acting in the supply chain of innovation as buyers if compared to their partners;

• the *upstream collaborator* model represents the counterpart to the previous one, referring to firms acting in the supply chain of innovation as suppliers;

• the *collaborative innovator* model regards companies heavily active in the supply chain of innovation, where they behave both as downstream and upstream collaborators.

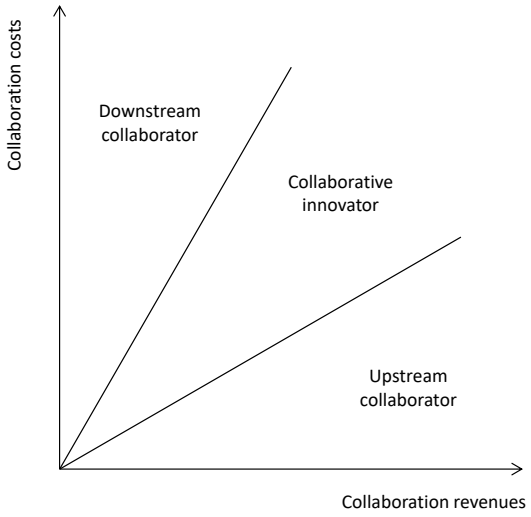

Figure 4. OI dashboard: collaboration perspective

At last, as of importing and exporting mechanisms (Figure 5):

• the *innovation buyer* model corresponds to companies relying on R&D outsourcing and in-licensing to acquire knowledge from outside;

• the *innovation seller* model constitutes the counterpart to the previous one, referring to firms transferring their own technologies to the external market;

• the *innovation trader* model regards companies very active in the OI market, behaving as both buyers and sellers of knowledge.

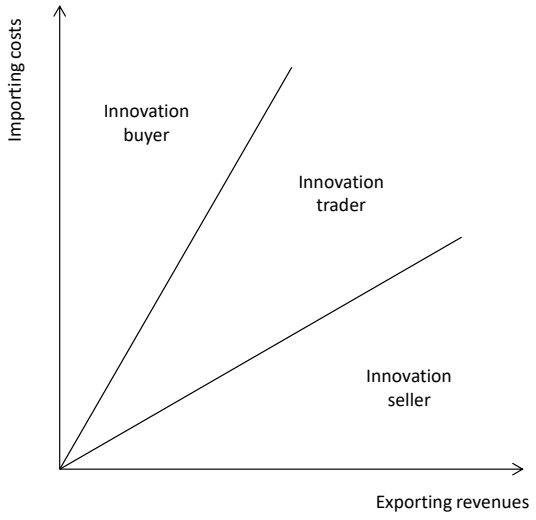

Figure 5. OI dashboard: importing/exporting mechanisms perspective

3.1 Cost-benefit analysis

The suggested tool can also enable a cost-benefit analysis of OI adoption within an organisation. Actually, the six indicators can be aggregated by distinguishing between those measuring the efforts made for OI - in terms of both workload and monetary resources - and those assessing the benefits deriving from OI in terms of both government subsidies and revenues. In this way, two different dashboards are obtained.

After the costs perspective, three OI models can be delineated, as illustrated in Figure 6. From a theoretical point of view, each area has significantly different characteristics:

• the *committed importer* model corresponds to companies exhibiting high internal commitment to OI - since they employ R&D workers in open activities - but also registering costs for importing knowledge from outside;

• the *committed collaborator* model differs from the previous one since firms decide to engage in joint development within a formal cooperation agreement rather than merely buying external knowledge;

• the *importer & collaborator* model regards those companies resorting to a mix of practices for external knowledge acquisition, based on both technology purchasing and R&D collaboration, rather that devoting full-time employees to OI activities.

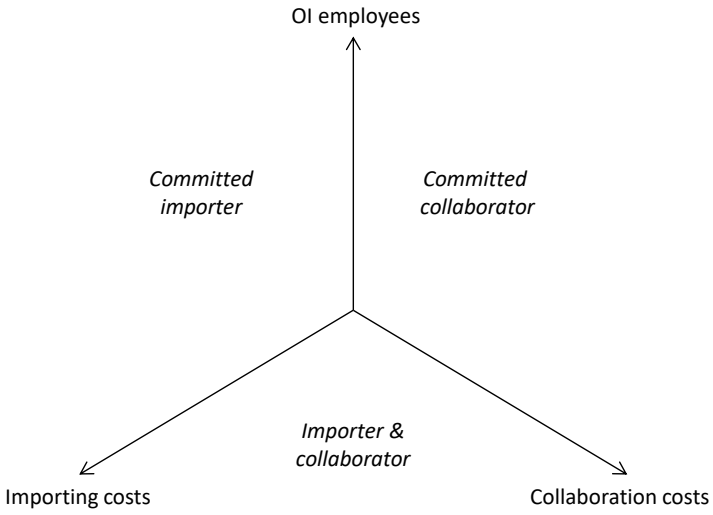

Figure 6. OI dashboard: costs perspective

Shifting the unit of analysis to the benefits perspective, once again three OI models can be pointed out, as exhibited in Figure 7:

• the *acknowledged exporter* model corresponds to companies having established a reputation for innovation which allows them to benefit from both the government, financing their research activities, and third parties, who purchase their own technologies;

• the *acknowledged collaborator* model refers to firms that - as in the previous case - are acknowledged by both the government bestowing research grants and external actors which, in this instance, choose to engage them in formal cooperation agreements rather than simply acquiring their proprietary knowledge;

• the *exporter* & *collaborator* model regards those companies benefiting not only from the involvement in R&D collaboration activities but also from the selling of internally created innovations.

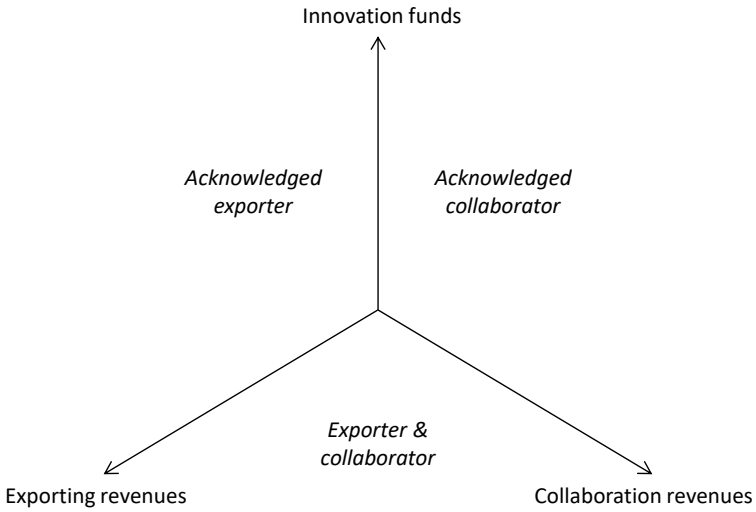

Figure 7. OI dashboard: benefits perspective

Apart from examining separately the two above perspectives, innovation managers can make informed decisions by comparing them. Firstly, a virtuous circle between company's commitment and reputation, joint development and OI market opportunities (Figure 8) can be triggered by overlapping both perspectives. In fact, the internal commitment of the firm (i.e. the internal resources devoted to relate to the outside) and its external reputation (that is the credibility it enjoys in the OI market) increase both the opportunity to engage partners in joint R&D projects and the visibility it has on the OI market. In turn, positive results obtained through joint development and OI market exploitation enforce both internal commitment and external reputation.

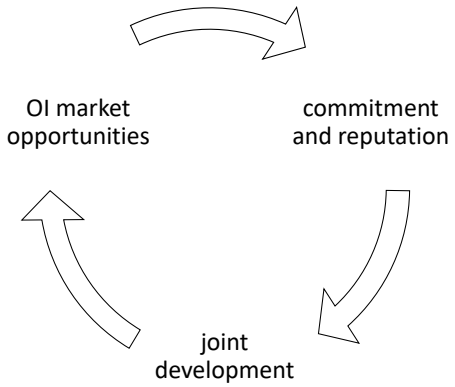

Figure 8. OI virtuous circle

Secondly, depending on the specific object of evaluation, innovation managers can choose which indicators employ to assess OI costs and which ones to measure OI benefits, and then match the two values to determine whether the benefits outweigh the costs. Hence, a benefit/cost ratio, taking the form of a productivity index, can be easily calculated:

$$OI\ productivity = \frac{OI\ benefits}{OI\ costs}$$

The higher the ratio the more effectively and efficiently the organisation is generating outputs from OI with the committed resources.

4. Conclusions

The paper seeks to answer the question of how to give innovation managers a practical tool to monitor the implementation of OI within their organisation.

In a first step, through an in-depth literature review, we categorised a large number of OI measures into five dimensions - *outer* and *inner environment*, *collaboration*, *importing* and *exporting mechanisms* - that may act as the basis for a holistic evaluation of the openness degree of a firm. Actually, they take into account enabling drivers, activities and outputs of OI. In this way, we built a theoretical framework. Hence, from an academic point of view, the work takes the difficult step of incorporating a vastly diverse literature into a single framework.

In a second step, a scorecard was developed by selecting a limited number of metrics from the broad range of proxies suggested in literature. We defined six indicators trying to balance different criteria, such as objectivity, availability and systematic updating of data within the information systems of companies. This clearly leads to the practical implication of the study: such a tool is easily exploitable by innovation managers since it enables the measurement of openness through data they already have and systematically collect. Moreover, both dashboards and positioning maps can be derived by exploiting the information available in the scorecard. These tools 1) allow to assess the OI models adopted by companies, by combining the indicators after different perspectives - environment, collaboration, importing/exporting mechanisms, costs, and benefits - and 2) enable the benchmarking of OI practices either outside or inside the organisation. Furthermore, as it has been conceived, the scorecard allows both to identify a virtuous circle between company's commitment and reputation, joint development and OI market opportunities, and to perform a cost-benefit analysis, evaluating if an organisation is effectively and efficiently generating outputs from OI with the committed resources.

A further remark pertains to the fact that, if innovation requires communication (Allen, 1977), OI requires even more communication. Hence, in order to increase the chances of successfully employing the paradigm, the tool can be exploited to communicate the OI strategy to various parts of the company and also to the outside. We also believe that incorporating the suggested measures into the information systems will foster the implementation process. In addition, a staff position could be responsible for monitoring the indicators and regularly report to the executive in charge. In this way, it is also possible to predispose a reward system for employees.

The paper has some limitations as well. Indeed, several measurement aspects, emerged from literature review, although important, were excluded from the scorecard since they do not meet the criteria followed to build the tool.

A final observation concerns the fact that the six metrics suggested may be referred to the broader context of innovation, where even today there is a lack of objective measurement systems for managers. Hence, in our future research, we want to complement the OI metrics with other indicators, analysing the innovative practices as a whole.

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