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A systematic literature review on intangible assets and open innovation

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Abstract
Despite the growing interest, Open Innovation (OI) in Intangible Assets (IAs) research is still fragmented and displays a limited contextual focus. This paper aims to provide a clearer view of these issues and represents a first step toward filling such research gap. A systematic literature review and a synthesis of high-quality contributions with a focus on a general overview of research on OI and IAs in OI processes have been carried out. By critically evaluating the current body of literature and definitions, we have moved a step further toward comprehending the multiple facets of existing research and highlight several promising areas for future development. In particular, we have analyzed the role of IAs in OI practices by selecting a synthesis and a critical review of their different exploitations. We have combined multiple algorithms to produce a clear topical taxonomy of the multiple strands of research lying at the interface of OI and IAs.
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Introduction

The topics of Intangible Assets (IA) and Open Innovation (OI) represent research themes among the most fertile in the last 30 years. Although they have developed almost independently of one another, a common conceptual theme has deeply interconnected their evolution: knowledge, in all its different definitions and interpretations.

Interest in intangible assets (IAs) has casually arisen since the beginning of the past century (Veblen, 1908). But, only in the mid-twentieth century researchers' attention was attracted by the work of Polanyi (1958) on tacit knowledge, which kept inside the seed of the future evolution of intangible assets. At the end of the twentieth century, Nonaka and Takeuchi (1995) presented their highly influential work on "the knowledge creating company" and paved the way for the formulation of tangible/intangible asset principles. Throughout the past 20 years, a wide array of studies by several authors dealt with the concept of non-physical assets, which proved to sustain the competitive advantage of firms. The role of IAs, therefore, has assumed an even more considerable relevance that has led to an increasing rate of publications in academic journals.

As often happens in the evolution of a discipline, a sudden exploit of interest, which is deemed to be caused by a revolutionary cultural acquisition, is, in reality, a consequence of an evolution. This has been the case of Open Innovation (OI) as far as the innovation management field is concerned. Indeed, Dahlander and Gann (2010), in their extensive literature review, put into evidence that, sometime before Gann and Chesbrough burst with their work (2003) into the scientific literature on innovation, many authors had formulated concepts and questions related to

OI, as absorptive capacity (Cohen and Levinthal, 1990), how to obtain economic returns from innovation (Teece, 1986), the opposition between exploration versus exploitation (March, 1991). In particular, Mowery (2009) affirms that in the late 19th and early 20th centuries, "many of the elements of the "Open Innovation" approach to R&D management [were] visible" and that closed innovation activities were even less in number than open innovation ones. Unquestionably, as further explained in the definition given by Chesbrough *et al* (2006), the role of OI paradigm for its capability of fostering technological projects from internal or external origins to market can be considered fundamental to business structures. Actually, an increasing number of firms have recognized the benefit of external knowledge to support their innovation activities (Chen *et al*, 2015).

In contrast to the vertical integrated innovation model (Chandler, 1990), where all knowledge is internalized and controlled by the firm, the OI paradigm is characterized by its porous innovation processes and the strong interaction between the company and its environment (Gassmann, 2006; Von Hippel & von Krogh, 2006; Kong, 2015).

The literature discussing OI has expanded rapidly over the last years. The scientific community started investigating the new paradigm first theoretically (Chesbrough, 2003a; Gassmann & Enkel, 2004), then with both qualitative case studies (Kirschbaum, 2005; Rohrbeck *et al*, 2009) and large-scale quantitative empirical works (Laursen & Salter, 2006). Among those researchers, a number of authors have underlined the importance of Intangible Assets (IAs) for the success of OI strategies and the effectiveness of OI processes (Teece, 2007; Lu *et al*, 2013; Michelino *et al*, 2014; Bader and Enkel, 2014).

Even though IAs play a critical role in OI both as products and as facilitators of innovation, the small number of studies embracing both IAs and OI creates an information gap in the academic investigation and practical needs. In the light of what is illustrated above, the two fields of research of IAs and OI, even though intertwined, have not been sufficiently analyzed in their inter-dependency yet. The present paper aims at obtaining a literature review by systematizing the existing research, focused on IAs and OI, and synthesizing high-quality contributions. By the evaluation of the current body of literature and definitions, we wanted to make sense of the current research landscape and highlight several promising areas for future-related works. The systematic literature review has been combined with the application of a quality threshold, allowing a comprehensive, transparent, and replicable selection (Tranfield *et al*, 2003) of high-quality contributions published in top peer-reviewed journals (De Mauro *et al*, 2016).

This paper is structured as follows. In "Methodology" section, the adopted methodology is described. The outputs of the methodology are illustrated and explained in "State-of-the-art review" section. Finally, "Conclusion" section concludes and discusses the implications and limitations of the paper.

Methodology

Following a principle of methodological rigor in reviewing literature (Pittaway *et al*, 2004), our methodology was organized in the following steps: first, we have selected a set of articles by means of a systematic procedure (Pittaway *et al*, 2004). Second, we have identified indices for ranking of publications (Ball, 2005; Garfield, 2006) to refine the research. Third, we have reviewed the articles according to their relevant subject theme and grouped related articles into macro themes (Grimaldi *et al*, 2015).

Selection of papers

Papers selection was carried out in two phases. In the first phase, we have retrieved papers dealing with both Intangible Assets and Open Innovation. For our search, we used Elsevier Scopus, a citation database containing more than 50 million records from around 5000 publishers, for publications in peer-reviewed journals, omitting books, book chapters, discussion papers, and non-refereed publications (Ordanini *et al*, 2008). We have considered synonyms of "Intangible Assets" and "Open Innovation" as search items. The keywords included "Open Innovation," "Networked Innovation," "Distributed Innovation," or "Collaborative Innovation," in conjunction with any of the terms "Intangible," "Intellectual," or "Knowledge." The keywords were constructed into search strings. Through this procedure, we identified a list of 1271 entries. This list was used as an input for the analysis based on the Latent Dirichlet Allocation (LDA) (Blei, 2012) as described in "Classification of papers" section.

The objective of the second phase of the process was to select papers which high scientific quality. As a consequence, we have kept only those articles in the sample that were published in academic journals (removing Conference Proceedings as Source Type) ranked at a "C" level or higher (using the conversion list between Impact Factors and German letter rating of the major German business magazine "Handelsblatt" 2012) in at least one of three following major journal rankings (see Table 1).

We have thus reduced the sample to 85 high-quality scholarly articles.

Only papers in journals listed in the SCImago Journal Rank (SJR) were considered (Ball, 2005). This step left us with a corpus of 6 journals, for a sample of 30 articles. Finally, we have used the Citation Index, to assess the importance of each article (Bar-Ilan, 2008): we have selected articles with the cut-off of $\geq$10 (Ball, 2005). We have agreed that the final sample resulting of 18 articles (Table 2).

Classification of papers

Our selection of papers produced two lists: a list of 1271 documents, which represent the entire body of knowledge we retrieved, and a second list of 18 "high quality" papers obtained by applying a quality threshold.

The first set of documents was analyzed through quantitative techniques with the aim to identify relevant topics in the investigated knowledge domain and to group them in macro themes.

Table 1 Conversion table of leading academic journal rankings

German Academic Association for Business Research (VHB) "Journal 2.1"	*British Association of Business School (ABS) "Academic Journal Quality Guide v.4"*	*Thomson Reuters "Journal Citation Reports (JCR) Impact Factors"*
A+	4*	≥3
A	4*	≥2
B	3*	≥1.5
C	2*	≥0.7
D	1*	≥0

Table 2 List of articles (*n* = 18)

No.	*Article*	*Authors*	*Year*	*Source of the article*
1	Crowd science: The organization of scientific research in open collaborative projects	Franzoni, C., Sauermann, H.	2014	Research Policy 43 (1), pp. 1–20
2	Open service innovation and the firm's search for external knowledge	Mina, A., Bascavusoglu-Moreau, E., Hughes, A.	2014	Research Policy 43(5), pp. 853–866
3	Closed or open innovation? Problem solving and the governance choice	Felin, T., Zenger, T. R.	2014	Research Policy 43(5), pp. 914–925
4	Co-ownership of intellectual property: Exploring the value-appropriation and value-creation implications of co-patenting with different partners	Belderbos, R., Cassiman, B., Faems, D., Leten, B., Van Looy, B.	2014	Research Policy 43(5), pp. 841–852
5	Open to suggestions: How organizations elicit suggestions through proactive and reactive attention	Dahlander, L., Piezunka, H.	2014	Research Policy 43(5), pp. 812–827
6	How constraints and knowledge impact open innovation	Garriga, H., Von Krogh, G., Spaeth, S.	2013	Strategic Management Journal 34 (9), pp. 1134–1144
7	Cui Bono? The selective revealing of knowledge and its implications for innovative activity	Alexy, O., George, G., Salter, A. J.	2013	Academy of Management Review 38 (2), pp. 270–291
8	Toward an open R&D system: Internal R&D investment, external knowledge acquisition, and innovative performance	Berchicci, L.	2013	Research Policy 42(1), pp. 117–127
9	Managing open incremental process innovation: Absorptive Capacity and distributed learning	Robertson, P. L., Casali, G. L., Jacobson, D.	2012	Research Policy 41(5), pp. 822–832
10	Openness, knowledge, innovation, and growth in UK business services	Love, J. H., Roper, S., Bryson, J. R.	2011	Research Policy 40(10), pp. 1438–1452
11	Forms of network resource: Knowledge access and the role of inter-firm networks	Huggins, R.	2010	International Journal of Management Reviews 12(3), pp. 335–352
12	Learning at the boundaries in an "Open regional innovation system": A focus on firms' innovation strategies in the Emilia Romagna life science industry	Belussi, F., Sammarra, A., Sedita, S. R.	2010	Research Policy 39(6), pp. 710–721
13	How open is innovation?	Dahlander, L., Gann, D. M.	2010	Research Policy 39(6), pp. 699–709.
14	Experimental methods in innovation research	Sørensen, F., Mattsson, J., Sundbo, J.	2010	Research Policy 39(3), pp. 313–322
15	Determinants of proactive and reactive technology licensing: A contingency perspective	Lichtenthaler, U.	2010	Research Policy 39(1), pp. 55–66
16	A capability-based framework for open innovation: Complementing absorptive capacity	Lichtenthaler, U., Lichtenthaler, E.	2009	Journal of Management Studies 46 (8), pp. 1315–1338
17	Transformation networks in innovation alliances – The development of Volvo C70	Harryson, S. J., Dudkowski, R., Stern, A.	2008	Journal of Management Studies 45 (4), pp. 745–773
18	Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organizations, and the public science-base	Tether, B. S., Tajar, A.	2008	Research Policy 37(6–7), pp. 1079–1095

The second group of papers was analyzed qualitatively with the goal to make explicit and organize their theoretical and empirical contribution to the macro themes singled out through the analysis of the first sample.

Identification of topics

To identify topics that are covered within the selected publications we applied, a text mining solution consisting of building a Document-Term Matrix (i.e., a table that

describes the relative presence of keywords in a corpus of documents) and then to apply a mixed membership model (Airoldi *et al*, 2008) where the assumption that a unit (a document in our study) belongs to a single cluster (a topic) is violated (Airoldi *et al*, 2014). In particular, we used Latent Dirichlet Allocation (LDA) (Blei, 2012). LDA uses Bayesian Estimation Techniques to infer a vector representing the degree of membership (topic proportion) of each element (document) to each group (topic). The list of the most likely words in a topic (keywords) can give an indication of the core meaning of that topic. By looking at the topic keywords and considering those documents treating the topic at the highest degree, a human user can deduce a meaningful description of the topic. The description of the topics and the relation between them is the fundamental output of a literature review based on LDA.

The inputs to LDA are the documents to be analyzed (the 1.271 documents obtained from the first phase) and the number of topics k to be extracted. As suggested by the experiments of Chang *et al* (2009) and confirmed by Blei (2012), we can select k using a reasonable practice of evaluation among alternative values in such a way that the interpretation of the machine-generated model results becomes as easy as possible from the point of view of a human reader. The authors have evaluated multiple outputs of LDA with k ranging from 10 to 30 and have consensually agreed that the most meaningful set of topics is reached with $k = 16$.

Definition of themes

We grouped the 16 topics that we have identified into a number t of groups of related topics. By analyzing the topic proportions for all papers in the corpus, an output of LDA, we were able to infer the degree of relationship among topics. In order to do so, we have computed the Pearson Correlation Coefficient r across topic proportions and noticed that two related topics will happen to appear more often in the same documents, and this would lead to a higher value of r. The triangular "similarity" matrix $\mathbf{R}$ was built by computing r for each combination of topics (i, j):i, j $\in$ [1, k], i < j. In order to group-related topics together, we have chosen to adopt a traditional algorithm for hierarchical clustering using $\mathbf{D} = \mathbf{1} - \mathbf{R}$ as dissimilarity matrix, (Glynn, 2005). The number of clusters t was chosen by the authors through human evaluation, in a similar way as done for the choice of topics k. In our case, we have consensually agreed to use the model with $t = 5$.

Figure 1 corresponds to dendrogram obtained as an output of the hierarchical clustering, where each node reports the top 3 keywords for each topic.

The five themes were also evaluated against the content f the 18 papers selected in the second phase of the documents selection (see "Classification of papers" section. We have found that the topics of the 18 papers were consistent with our classification in five themes. In other words, the topics addressed by the 18 papers could always be associated with one or more of the five themes. This observation is based on a subjective evaluation. Nonetheless, it suggests that the five themes framework developed here describes rather well the investigated knowledge domain.

Figure 1 Dendrogram resulting from Hierarchical clustering of topics with $k = 16$ into $t = 5$ themes.

Classification of the eighteen high-quality papers

The last phase of our analysis consisted in classifying the list of 18 selected articles according to the main topic they deal with. Each author has associated separately each article to one of the 5 macro "themes." When two or more authors had not classified a paper in the same theme, the classification was discussed until an agreement was achieved. Each paper could be classified in more than one theme.

Figure 2 illustrates the analytical methodology used to build the 5-theme model we adopted. Such methodology can be summarized as follows: an extensive list of relevant paper abstracts was retrieved and used to create a list of topics through text mining and Latent Dirichlet Allocation (LDA), a mixed membership model (Blei, 2012). The resulting topics were then clustered within 5 macro themes by inferring the degree of relationship across topics with a regression analysis.

We have consensually concluded that the articles we selected during phase 1 and 2 were solidly fitting within the topic model of 5 themes that will be described in detail in the next section.

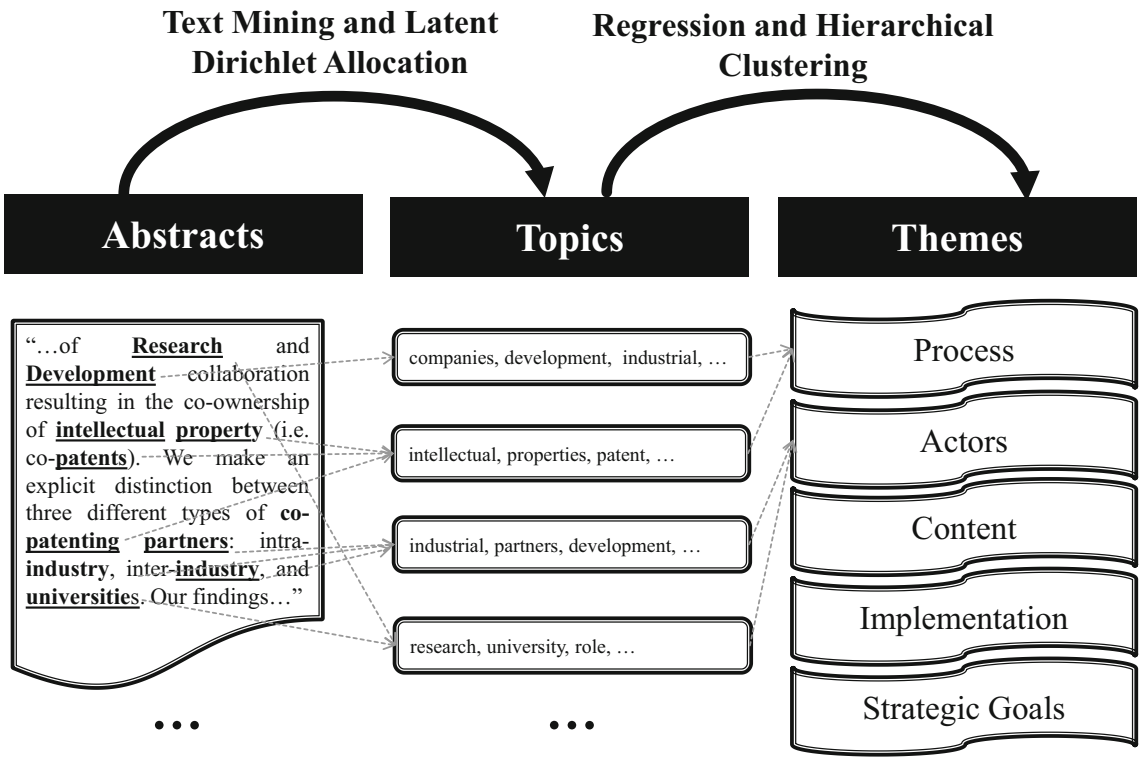

Figure 2 Analytical process for obtaining the 5-theme topic model of "Intangible Assets in Open Innovation," (Grimaldi *et al*, 2015).

State-of-the-art review

In this section, the five themes are described and analyzed. Each theme is explained by making reference to the keywords, which emerged in the analysis of the topics. Indeed, we assume that the keywords associated with a topic represent a synthesis of the main points discussed in the literature and can be used to build a reliable interpretation of the same topic or theme. Besides, we consider the results from the analysis of the 18 "high quality" papers to confirm and sometimes integrate the interpretations derived from the analysis of the keywords.

Each of the following five themes was singled out through quantitative techniques. Their meaning, however, is the result of human interpretation for two reasons: (1) because the authors decided what topic a group of keywords (or what theme a group of topics) represented and (2) because the description of the five themes which follows is based on an interpretation of the keywords associated with each topic and of the topics associated with each theme.

Intangible assets as antecedents of open innovation processes

The first theme includes the papers that focus on how IAs affect the organization of open innovation processes. IAs are antecedents of OI since variability in the way organizations implement open innovation is, at least partly, explained by IA-related factors.

A starting point for the idea of openness is that a single organization cannot innovate in isolation. External actors can leverage a firm's investment in internal R&D through expanding opportunities of combinations of previously disconnected silos of knowledge and capabilities (Fleming, 2001; Schiuma and Lerro, 2011). External institutions such as intellectual property rights (IPR), venture capital (VC), and technology standards allow for the organization to trade ideas: new technologies allow for new ways to collaborate and coordinate across geographical distances (Dahlander & Gann, 2010). Some scholars have argued that there are significant transaction costs involved in open innovation (Gambardella *et al*, 2007) as well as risks (in particular associated with loss of control) and higher coordination costs (Dodgson *et al*, 2005). These costs and risks can be significantly higher depending on the nature and structure of the intangible resources an organization owns or has access to.

Several OI practices can be interpreted as ways to create, reveal, acquire, and experiment with new knowledge. Emerging theories (Lavie, 2006) recognize that knowledge accessing, acquisition, exchange, and creation are key reasons why firms build or enter networks with other firms or actors. External resources can be acquired both from individuals and from organizations. The leveraging of inter-firm relationships and organizations is increasingly considered as a strategic resource (Gulati, 2007) sometimes referred to as network capital (Huggins,

2010). These networks concern the interactions, relationships, and ties existing between firms, and may arise from the need to access new assets and skills and keep pace with competitors (Huggins, 2010). These inter-organizational systems support collaborative efforts in R&D, outsourcing of R&D to acquire external knowledge, inward licensing of IP (Van de Vrande *et al*, 2009). Network capital and social capital development is positively related to the corporate and national/regional cultures within which firms operate (Huggins, 2010). However, the nature of the networks will also be dependent upon the size of network partners (e.g., suppliers, customers, collaborators, and partners become more important). Partners' involvement can provide valuable knowledge, in particular on market needs, helps generate new ideas and solutions (Almeida *et al*, 2003). Similarly, communities of customers and users represent a valuable source of social and knowledge resources, which make the New Product Development process more efficient and effective (Thorpe *et al*, 2005).

Summarizing, the analysis of the existing literature on IAs in OI has focused on investigating them:

- As a source of innovation: network capital is investigated as a source of resources, in particular, ideas and knowledge, needed to create innovative products or services;
- As facilitators of innovation processes: network relationships enable the external sourcing of valuable knowledge and technologies, by lowering risks and coordination/transaction costs.

Intangible assets as features of actors involved in open innovation

The second theme includes papers that focus on the intangible features of actors involved in OI. By intangible features, we mean any human, structural, or relational (intangible) resource which affects that the role an actor (either individual or collective) plays in OI processes.

Firms in control of these resources should be able to generate higher rents from innovation (Alexy *et al*, 2013).

Scholars (Belderbos *et al*, 2004; Cassiman & Veugelers, 2006; Chesbrough, 2003b; Faems *et al*, 2005; Laursen & Salter, 2006) emphasize the need for inter-organizational collaboration, which facilitates the synergistic blending of external and internal ideas into new products, processes, and systems.

In general, scholars (Cassiman *et al*, 2014) suggest that innovation impulses heavily depend on the type of partner involved in the collaborative activities. Product knowledge about new market opportunities is perhaps most likely to stem from forward linkages to customers, while information on new technological developments is perhaps more likely to emerge from the intra-industry partnership (Cassiman *et al*, 2014). At the same time, appropriation issues play a more limited role in partnerships with universities and in public research centers, which are less likely to actively engage in (competing) commercialization trajectories (Cassiman *et al*, 2014).

In conclusion, specialist knowledge providers (private research organizations, public research centers, and universities) are more likely to be engaged by firms with more open approaches to innovation, those with high levels of absorptive capacity, those with greater social capital and networking capabilities, as well as by those with deeper commitments to innovation. Overall, the use of specialist knowledge providers tends to complement firms' own internal innovation activities and to complement other external sources of knowledge (Tether & Tajar, 2008).

Moreover, there are significant differences in the types of specialist knowledge providers used by manufacturing and service firms. Although service firms are more likely than manufacturers to use specialist knowledge providers, they are more likely to engage consultants, while their links with research-based organizations, are weaker (Tether & Tajar, 2008).

Summarizing, when considering the actors participating in OI, the interest of the existing literature has focused on the way IAs affect:

- Inter-organizational collaboration: inter-organizational collaboration facilitates the synergistic blending of external and internal ideas into new products, processes, and systems. Firms in control of these resources should be able to innovate more and generate higher rents from innovation;
- Knowledge integration: each actor brings in OI processes her knowledge. On the other hand, actors with high levels of absorptive capacity, with greater social capital and networking capabilities, are more likely to be engaged by firms with more open approaches to innovation.

As a result, and to advance the research field through 18 scientific articles, synergic collaboration and type of partners involved are positively related to the competitive advantage of firms. Firms acquire, increase, and maintain a competitive advantage through access to markets, resources, and technologies if supported by specialist knowledge providers (private research organizations, public research centers, and universities).

Intangible assets as content of open innovation processes

Within the analyzed literature, several papers focus on the contents of OI processes. By content, we mean the type of resources produced or exchanged.

As firms start to open up their borders systematically, they adapt to build new or reinforce existing relationships with a diverse range of partners. Given the importance of R&D processes, the difficult task for managers is

to find a balance between internal and external activities in order to capture the benefit from external technology sources (Berchicci, 2013). Moreover, investigation, acquisition, and conveyance of knowledge within the firm are supposed to be consistent with the firms' strategic objectives, and their potentiality for producing strategic value should be recognized carefully.

Firms that invest in building an internal R&D stock of knowledge are better able to recognize and evaluate its openness to external sources and in turn to integrate and use their knowledge sources and relationships (Berchicci, 2013).

Thus, firms build strongly on inter-organizational knowledge transactions to extend their internal knowledge bases (Argote *et al*, 2003). In a similar vein, absorptive capacity is an influential concept: as such, it neglects other important knowledge processes, e.g., internal knowledge generation, whose synthesis may provide new insights into managing knowledge in OI processes (Lane *et al*, 2006; Zahra & George, 2002). A dynamic and integrative view may deepen knowledge strategies, their modification over time, and their effects on innovation performance (Argote *et al*, 2003; Zahra *et al*, 2006). Absorptive capacity defined as a firm's ability to value, assimilate, and commercially utilize new, external knowledge (Cassiman & Veugelers, 2002; Escribano *et al*, 2009). Although absorptive capacity is intertwined and linked with R&D capacity, its measurement presents a number of identification problems in the current setting. First, to be able to capture absorptive capacity, it is necessary to clearly separate the internal production of new knowledge and the external acquisition of new knowledge (Berchicci, 2013). Without such separation, it is difficult to evaluate the effect of absorptive capacity fully. Second, absorptive capacity was measured originally in a single industry. Since the current data cover a broad range of industries, it is difficult to capture absorptive capacity due to the high level of firm's heterogeneity (Berchicci, 2013). Instead, R&D capacity directly measures the effort of a firm to build a stock of knowledge, which allows one to produce and acquire new knowledge across industries (Lazzarotti *et al*, 2015).

Summarizing, the interest of the existing literature has focused on:

- The tacit/explicit dichotomy and its impact on innovation;
- The role of IAs in generating absorptive capacity. In this sense, not only existing stocks of knowledge but also relational assets are considered to be a factor increasing absorptive capacity.

Intangible assets and implementation of open innovation

Implementation of OI refers to the development of new innovation processes based on an open approach, which include changes in business models (Dahlander & Piezunka, 2014), strategy, and technologies (Gruber *et al*, 2008).

Implementing OI can push organizations to elicit suggestions from individuals located outside organizational boundaries. Suggestions from such external contributors enable organizations to access knowledge held by people other than internal employees (Dahlander & Piezunka, 2014).

Research has shown that suggestions from external contributors are critical to innovation (Chesbrough *et al*, 2006), and that sourcing suggestions from external actors more generally – customers, venture capitalists, inventors, or tournaments participants – may result in more effective problem identification and problem solution, to reconsider their strategies and internal processes (Jeppesen & Lakhani, 2010; Shane, 2000; von Hippel, 2005).

Firms are increasingly looking for knowledge in their network relationships (Chesbrough, 2003a, 2006) and for strategic approaches with the potential value from the broader environment in which they operate (Mina *et al*, 2014). Vertical disintegration pressures (Langlois, 2003), modularization and outsourcing (Prencipe *et al*, 2003; Sturgeon, 2002), growth of specialized technology markets (Arora *et al*, 2001; Brusoni *et al*, 2001), and difficulties in appropriating internal investments in intangibles (Chesbrough, 2003c) would appear to have strengthened firms' incentives to increase their reliance on external knowledge for innovation: this requires the implementation of an effective business model (Mina *et al*, 2014).

With the development of open business models, enterprises are relying on Information and Communication Technology (ICT) to achieve efficient communication and collaboration among enterprise networks (Closs *et al*, 2005). These new technological channels have effectively replaced the private channels between a lone individual and an organization with a public debate in which external contributors not only submit suggestions but also vote for and comment on suggestions made by others. On the other hand, in these new kinds of communication channels, trust plays a crucial role (Cremonini *et al*, 2005). In this sense, firms are encouraged to protect their resources from other organizations through a series of appropriation mechanisms to ensure and sustain their favorable competitive position (Cassiman & Veugelers, 2006). As a consequence, considering that the need for inter-organizational collaboration facilitates the synergistic blending of external and internal ideas (Belderbos *et al*, 2004), the adoption of semantics-aware formalisms to describe the business vocabularies and rules for modeling business relationships (Cisternino *et al*, 2009) could help firms to collaborate profitably.

In the very best cases, these interactions evolve into a vibrant initiative, granting the host organization a rare and valuable window into external contributors' ideas and needs (Dahlander & Piezunka, 2014).

Acquiring knowledge from external communities is important for organizations: this process can positively affect the innovative capabilities of a company (Lichtenthaler & Lichtenthaler, 2009). For example, communities

of entrepreneurs are a source of innovativeness and entrepreneurial knowledge (Lichtenthaler & Lichtenthaler, 2009). In this sense, some studies pointed out that Absorptive Capacity provides an adequate foundation for the discovery and analysis of routines and capabilities needed for incremental process innovation in open contexts (Robertson *et al*, 2012).

Summarizing, the interest of the existing literature has focused on the following:

- Enablers: suggestions from external actors enable organizations to access external knowledge and implement OI. Relationships with partners (both individual and organizations) are essential for inbound OI. Relationships with customers and recipients of innovation are essential to turn OI outputs into value;
- Facilitators: Information and Communication Technology (ICT) channels achieve efficient communication and collaboration among enterprise networks.

Based on the contribution of 18 scientific articles, suggestions from external partners contribute positively to organizational strategy, internal processes, and intangibles appropriability. This context implies an effective business model implementation.

Intangible assets and strategic goals of open innovation

The last theme highlights that OI provides strategic advantages and improves the economic performance of firms. In particular, OI allows organizations to acquire strategic resources, which improve a firm's competitive position and/or improves its value-adding capabilities. Strategic resources are often of an intangible nature (Garcia & Calantone, 2002; Zahra *et al*, 2006).

A central advantage of OI is the possibility to lead to the improved innovative output and firm performance for companies (Zahra *et al*, 2006), similar to the advantage of alliances (Brolos, 2009).

Companies are likely to have a more common knowledge base, which enables successful knowledge sharing and integration more easily and supports the generation of new knowledge, product innovation, and technological innovation (Calantone & Stanko, 2007). These elements contribute significantly to technological innovation and economic growth (Robertson *et al*, 2012).

Furthermore, openness raises generally important organizational challenges: market conditions, customer needs, and uncertainty problems support a common perception of future changes and help design of coordination mechanisms between activities and tasks (Baumard, 2009). With regard to the strategic goals of OI, IAs are considered for their role of strategic resources.

The existing literature underlines that

- OI is able to lead and improve the IAs stock of organizations;
- A mutual reinforcement cycle exists between IAs stock and OI strategies.

Conclusion

This paper provides a review of the scientific literature about the role of Intangible Assets in Open Innovation, by presenting a thorough and unique synthesis and a critical review. The past decade has witnessed a steady growth of publications dedicated to these issues. As a result, the current body of literature is vast, but to the best of the authors' knowledge, systematic reviews of literature in this field do not exist. This study provides an overview of what has been studied in this field and what has been left out.

To examine the field's current state, we conducted a systematic literature review that was based on a sample of 18 high-quality peer-reviewed scholarly articles obtained through a rigorous data collection process and selection. In particular, we combined multiple algorithms to produce a clear topical taxonomy of the multiple strands of research lying at the interface of OI and IAs. Then, we synthesized the selected articles according to a number of topics relevant to this research field. We classified them in five macro themes (Grimaldi *et al*, 2015) with reference to OI research. For each theme, we considered the specific role of IAs researchers focused their attention on. Results are summarized in Table 3.

Table 3 Summary of the five themes in OI research and role of IAs

Theme in OI research	*Role of IAs*
1. IAs in OI as a PROCESS	IAs as Source of Innovation
	IAs as Facilitators of OI
2. IAs as features of OI ACTORS	IAs in relation to Inter-organizational Collaboration
	IAs in relation to Knowledge integration
3. IAs as CONTENT of OI	IAs in relation to the tacit/explicit dichotomy
	IAs and absorptive capacity
4. IAs in the IMPLEMENTATION of OI	IAs as Enablers of OI implementation
	IAs as Facilitators of OI implementation
5. IAs and STRATEGIC GOALS of OI	Impact of OI on the IAs stock of organizations
	Mutual reinforcement between IAs and OI strategy

Without claiming that these are the only streams in open innovation and intangible assets research, we believe that these paths are major avenues in the current literature base. The results of the current study confirm that intangible assets aspects and open innovation processes are intertwined. Indeed, the most interesting findings are represented by the identification of five themes that put into evidence the characteristics of the relationships between intangible assets and open innovation.

The theoretical implications of this paper reside in a contribution to the debate on both IAs and OI in several ways. By organizing the analyzed literature in five themes, we defined five areas of development for future research. As summarized in Table 3, IAs play different roles in the context of OI. Researchers should be aware of the multi-faceted nature of this relation. The research models to be used when investigating this area further should not always hypothesize one-way causal relation, but should consider the possibility of inverted relations, mediation, and moderation roles for the considered variables. Indeed, qualitative studies could be especially suitable. Among these five areas, the fifth one (i.e., Intangible Assets and strategic goals of Open Innovation) is the least developed. Even if the strategic dimension of Intangible Assets for Open Innovation is undeniable, there seems to be a shortage of studies on the topic. Consequently, there is a strong need for high-quality, empirical studies on the strategic dimension of IAs in OI.

The practical implications of this work derive mainly from the possible analysis of the various application modalities of intangibles in open innovation contexts, as suggested by the five-theme model we introduce. As shown in Table 3, in open innovation managerial practices, intangible assets can be shaped in the form of processes, actors, contents, implementations, and strategic goals.

The main limitation of this paper regards the choice of Scopus as the database from which we have extracted data. Indeed, even though Scopus includes a large number of works, the study should be replicated using different databases in order to validate the obtained results. Moreover, the systematic literature review could be criticized for not including all relevant work on intangible assets and open innovation. However, through the rigorous procedure of our systematic data collection, we believe we have obtained a good representation of papers illustrating as completely as possible the most prevailing and influential thoughts within this research field. Therefore, the probability of having omitted critical studies that would have strongly altered our conclusions is limited. Moreover, we recognize the limitations concerning the objectivity of the analyses' results.

Clearly, the choice of data, the allocation of the main themes, and the interpretation of the results are subjective. Other researchers might conduct these steps in a different manner, based on their individual and subjective assessments. The paper only investigates the main theme addressed by the existing literature. Future research should analyze, organize, and summarize the results, in particular, empirical results, obtained by previous studies.

These limitations notwithstanding, this paper contributes to the debate on both IAs and OI in several ways. By organizing the analyzed literature in five themes, we defined five areas of development for future research.

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