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Exploring the scope of open innovation: a bibliometric review of a decade of research

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Abstract The concept of open innovation has attracted considerable attention since Henry Chesbrough first coined it to capture the increasing reliance of firms on external sources of innovation. Although open innovation has flourished as a topic within innovation management research, it has also triggered debates about the coherence of the research endeavors pursued under this umbrella, including its theoretical foundations. In this paper, we aim to contribute to these debates through a bibliometric review of the first decade of open innovation research. We combine two techniques—bibliographic coupling and co-citation analysis—to (1) visualize the network of publications that explicitly use the label 'open innovation' and (2) to arrive at distinct clusters of thematically related publications. Our findings illustrate that open innovation research builds principally on four related streams of prior research, whilst the bibliographic network of open innovation research reveals that seven thematic clusters have been pursued persistently. While such persistence is undoubtedly useful to arrive at in-depth and robust insights, the observed patterns also signal the absence of new, emerging, themes. As such, 'open innovation' might benefit from applying its own ideas: sourcing concepts and models from a broader range of theoretical perspectives as well as pursuing a broader range of topics might introduce dynamics resulting in more impact and proliferation.

Keywords Open innovation · Openness · Bibliographic coupling · Co-citation analysis

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Introduction

Within a mere decade of its first appearance in the scientific literature, the concept of open innovation has developed into a flourishing area of innovation management research today (i.a. Dahlander and Gann 2010; Huizingh 2011). The increased interest in open innovation is revealed in the fast-growing number of scientific publications referring to the concept as well as the many special issues in management journals devoted entirely to it [i.a. R&D Management 36(3):40(3); Technovation 31; Research Policy 43(5)]. Open innovation has been broadly defined as "…the purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation respectively…" (Chesbrough et al. 2006:1) and has been marked as "the new imperative for creating and profiting from technology" (Chesbrough 2003b) and even as "the new paradigm for understanding industrial innovation" (Chesbrough et al. 2006). Whilst this broad definition has undoubtedly contributed to the concept's proliferation, it also lies at the heart of the criticism to which it has become increasingly subject.

This criticism relates either to the lack of coherence in the body of research surrounding the concept of open innovation or a lack of distinctiveness from related fields of research. The first critique is exemplified by Dahlander and Gann (2010) who note that, although "…a variety of definitions and focal points are used [in existing open innovation research],… these do not yet cohere into a usable analytical frame" (Dahlander and Gann 2010:699). They stress that the absence of such a coherent analytical frame makes it difficult to compare and validate the findings of studies on the effects of firms' openness. Groen and Linton (2010) go one step further in explicitly questioning whether open innovation is a field of study or a communication barrier to theory development. The second critique is exemplified most notably by Trott and Hartmann (2009), who suggest that open innovation is simply the "…repackaging and representation of concepts and findings presented over the past 40 years within the literature on innovation management…" (Trott and Hartmann 2009:715). They argue that open innovation research draws especially upon insights from the literature on R&D collaboration. This view is supported by Mowery (2009) who, based on a survey of the development of industrial R&D in the United States in the postwar period, concludes that "…many of the elements of the "Open Innovation" model … are apparent in the early development of US industrial R&D…" (Mowery 2009:5).

Existing qualitative reviews of open innovation research (Gassmann 2006; Elmquist et al. 2009; Dahlander and Gann 2010; Gassmann et al. 2010; Van De Vrande et al. 2010; Huizingh 2011; Lichtenthaler 2011a, b; West and Bogers 2014) predominantly focus on the first critique whilst providing useful insights regarding current themes, definitions, key empirical findings, and avenues for future research. This is illustrated in Table 1, which provides an overview of the themes and the avenues for future research advanced by the most recent reviews of open innovation research. Although the table reveals some coherence in terms of identified themes, it also highlights differing views on how to delineate and characterize the body of open innovation research. This is illustrative of both the lack of conceptual clarity surrounding open innovation as well as the key weakness of

Table 1 An overview of existing qualitative reviews of open innovation research

Authors	Identified themes	Avenues for future research
Gassmann (2006)	Identifies Four Literature Streams on Which Open Innovation Research Builds (1) The Internationalization of Innovation Stream, (2) The Early Supplier Integration Stream, (3) The User Innovation Stream and (4) The External Commercialization of Technology Stream	Developing a contingency approach with respect to the management of open innovation
Elmquist et al. (2009)	Identifies Seven Common Themes Within Open Innovation Research (1) The Notion of Open Innovation, (2) Business Models, (3) Organizational Design and Boundaries of the Firm, (4) Leadership and Culture, (5) Tools and Technology, (6) Intellectual Property, Patenting and Appropriation and (7) Industrial Dynamics and Manufacturing	Re-conceptualizing open innovation research, thereby highlighting strengths, weaknesses, underlying theoretical models and contributions to managerial practice More focus on the 'human side' and 'organizational side' of open innovation
Gassmann et al. (2010)	Identifies Nine Perspectives that are Represented by Open Innovation Research (1) The Spatial Perspective, (2) The Structural Perspective, (3) The User Perspective, (4) The Supplier Perspective, (5) The Leveraging Perspective, (6) The Process Perspective, (7) The Tool Perspective, (8) The Institutional Perspective and (9) The Cultural Perspective	Developing a 'holistic' model of open innovation that simultaneously takes into account the determinants of the process and industry specifics, as well as the limits to opening up More focus on intellectual property issues, small- and medium sized enterprises (SMEs) and the 'spatial aspect' of open innovation
Lichtenthaler (2011a)	Identifies Four Tentative Streams of Open Innovation Research (1) The Technology Transactions Stream, (2) The Users Stream, (3) The Business Models Stream and (4) The Innovation Markets Stream	Developing a clearer understanding of the characteristics of open innovation as well as the practices and tools for managing it Addressing the link between approaches to open innovation and firms' corporate strategy and organizational culture More attention for the determinants of successful open innovation Developing a better theoretical foundation for open innovation research More rigor in academic studies that employ an empirical research design
Dahlander and Gann (2010)	Distinguishes Four Streams of Open Innovation Research Based on Two Dimensions—Inbound versus Outbound and Pecuniary versus Non-pecuniary Open Innovation (1) The Revealing Stream, (2) The Selling Stream, (3) The Sourcing Stream and (4) The Acquiring Stream	Explaining the contingencies under which openness is a fruitful strategy More focus on the decision processes underlying different forms of openness Elaborating on the conceptual frame of open innovation from the perspective of product/technology life cycles Exploring combinations of different forms of openness and studying the conditions under which these different forms are complements or substitutes

Table 1 continued

Authors	Identified themes	Avenues for future research
Van De Vrande et al. (2010)	Does not identify themes but addresses trends in open innovation based on three characteristics of the research performed; focus (large multinationals, SMEs, user communities), type of research (theoretical, qualitative, quantitative) and level of analysis (firms, individuals, dyads, projects, industries, regions)	Explaining how open innovation strategies enable firms to create a competitive advantage Integrating open innovation research into the existing literature about external technology acquisition and cooperation Incorporating different levels of analysis Connecting open innovation to other disciplines or management areas More focus on SMEs
Huizingh (2011)	Distinguishes Four Streams of Open Innovation Research Based on The Level of Openness of Two Artifacts—The Process and/or Outcome of Open Innovation (1) Closed Innovation, (2) Private Open Innovation, (3) Public Innovation, (4) Open Source Innovation	More attention for cases in which open innovation initiatives have failed Developing an integrated framework that helps managers to decide when and how to deploy particular open innovation practices More large-scale quantitative studies in various industries and countries Incorporating the concept into integrated management theories and existing management toolkits
West and Bogers (2014)	Identifies Four Related Streams of Open Innovation Research (1) Obtaining External Innovations Stream, (2) Integrating External Innovations Stream, (3) Commercializing External Innovations Stream, (4) Interaction Between the Focal Firm and its Collaborators Stream	More focus on the role of the business model in open innovation More attention for the entire process of obtaining, integrating and commercializing innovations Moving beyond depictions of innovation as a linear process Exploring the moderators and limits of external sourcing, by focusing more on the potential risks and costs associated with external sourcing More focus on the failures of open innovation

qualitative reviews, which, by their very nature, are characterized by a certain degree of subjectivity and bias, since they rely on the idiosyncratic views and perspectives of the reviewers involved (Vogel and Güttel 2013).

In this paper we aim to address both critiques simultaneously by creating a more systematic and comprehensive picture of the 'open innovation' research agenda. We engage in a quantitative review of the existing literature on open innovation to complement and cross-validate the insights from qualitative literature reviews. In particular, we aim to (1) identify the foundations of open innovation research, (2) identify themes within open innovation research, (3) benchmark open innovation research to related fields and (4) identify fertile areas for future research based on (1), (2) and (3). To this end, we apply two bibliometric techniques—bibliographic coupling and co-citation analysis—that enable us to assess the thematic similarity between scientific publications based on overlaps in their referencing patterns. Whereas co-citation analysis implies an assessment of the similarity of cited documents, bibliographic coupling is an assessment of the similarity of citing documents. Consequently, the former technique is well-suited to identifying the

foundations of a field of research, whereas the second technique is compatible with identifying current themes and future trends within a field of research. Therefore, combining these techniques enables us to obtain relevant insights into both the past traditions and the current trends that characterize open innovation research.

Based on our bibliometric approach, we clearly illustrate that open innovation is primarily rooted in technology- and innovation management streams but also selectively builds on frameworks and concepts from the strategic management literature. It is primarily the integration of insights from the user-centric perspective that distinguishes the open innovation literature from the broader literature on R&D collaboration. In addition, we also show that the first decade of open innovation research is illustrated by a relatively coherent network of seven distinct yet closely interconnected thematic clusters. An analysis of the publication output per cluster over time highlights that the identified themes have been pursued consistently over time. We interpret this as an indication that open innovation has matured into an established field of research that resides mainly in the literature on innovation management. At the same time it can be noted that 'open innovation' as a field, might benefit from applying the principles it advocates: more 'openness'—both in terms of contributing theoretical frameworks as well as pursued themes—might lead to an enriched development of the theme during the next decade.

The remainder of our paper is structured as follows. In the next section, we elaborate on the data that we use and the methods we apply. We discuss the procedures that we adhered to in order to construct the dataset, and we describe the application of bibliographic coupling and co-citation analysis in detail. In the third section, we present the bibliographic network of the references that are cited by our set of open innovation publications, based on co-citation analysis. We analyze this network in order to highlight the foundations of open innovation research. In the fourth section, we present the bibliographic network of our set of publications, based on bibliographic coupling. This network serves as the basis for our subsequent discussion of clusters that represent thematic areas in open innovation research. In the fifth section, we discuss the implications of our findings and relate them to the findings of existing reviews in order to identify fertile areas for future research.

Data and methods

Data

We used the 'topic search option' in the Thomson Reuters Web of Science database in order to search for scientific publications that contain the terms 'open' and 'innovation' in either the title, keywords or abstract fields of the database. Although Rigby and Zook (2002) have introduced the arguably similar concept of 'open-market innovation' already in the year 2002, Chesbrough (2003c) is generally credited with coining the term 'open innovation'. Therefore, we limited our search to publications published between 2003 and 2013 and included only publications of the document type 'article'.[1] However, the topic search option in the Web of Science is conducive to 'false positives' as it not only captures publications that contain the term 'open innovation' but also publications that simply contain the terms 'open' and 'innovation' separately from each other (Dahlander and Gann 2010). Rather than making ex-ante normative judgments with regard to whether

[1] In rare cases, publications are assigned to multiple document-type categories, e.g. 'article/editorial'. We only selected publications that are assigned solely to the document type 'article'.

publications address the concept of open innovation or not, we decided to limit our sample to only those publications that contain the combination term 'open innovation' in either the title, keywords or abstract fields of the Web of Science database. Hence, authors who seek to contribute to open innovation research at the highest level of development are likely to refer to the term 'open innovation' in at least one of these fields. Although our approach may involve missing out on a number of 'false negatives', it ensures that no 'false positives' are captured.

Our search effort using the 'topic search option' resulted in a set of 2013 publications for which we downloaded Web of Science records.[2] These standardized records comprise information about the title, abstract and keywords fields; they also contain basic information about authors, sources, publishers and, most relevant to our study, the cited references. In order to remove false positives, we subsequently read through the title, abstract and keywords fields of each of these 2013 publications and identified all records that contain the term 'open innovation' in at least one of these fields. Based on this effort, we identified 358 publications, which constitute the dataset that we used for further analysis. These publications refer to 11,873 publications and are referred to in 2372 publications.

Figure 1 below visualizes the distribution of our set of publications over time. To put this distribution into perspective, the figure also visualizes the distribution of publications on R&D collaboration over the same time period. This data is derived from the Web of Science entering stemmed synonyms of R&D collaboration, using the same set of parameters. It can be observed from the figure that although the first publication containing the term 'open innovation' was published in 2003, the number of publications only started to flourish from 2006 onwards. Furthermore, the figure clearly shows that the literature on open innovation has developed separately from the broader literature on R&D collaboration. Publications that refer to the term 'open innovation' do not tend to refer to terms that can be associated with R&D collaboration and vice versa. This provides a first indication that open innovation is a field of research that develops relatively independent from research focusing on R&D collaboration.

Methods

Bibliographic coupling and co-citation analysis

As mentioned previously, we combine two bibliometric techniques that build on the analysis of authors' referencing behavior—bibliographic coupling and co-citation analysis. Accordingly, these techniques rely on the fundamental assumption that, to the extent that the cited references of a focal publication provide a background for this publication, they denote at least some degree of relatedness between the focal publication and the publication(s) to which it refers. Based on this assumption, citation-based indicators have been widely applied in the field of bibliometrics as a means of mapping the flow of science and the development of fields and communities (see for instance Kessler 1963; Weinberg 1974; Vladutz and Cook 1984). More recently, citation-based bibliometric methods have also found their way into management research (e.g. Chen et al. 2012; Vogel and Güttel 2013).[3]

[2] We downloaded the Web of Science records on October 1st, 2013. A copy of these records can be obtained by contacting the corresponding author.

[3] See Vogel and Güttel (2013) for a more elaborate overview of management research that draws upon citation-based bibliometric methods.

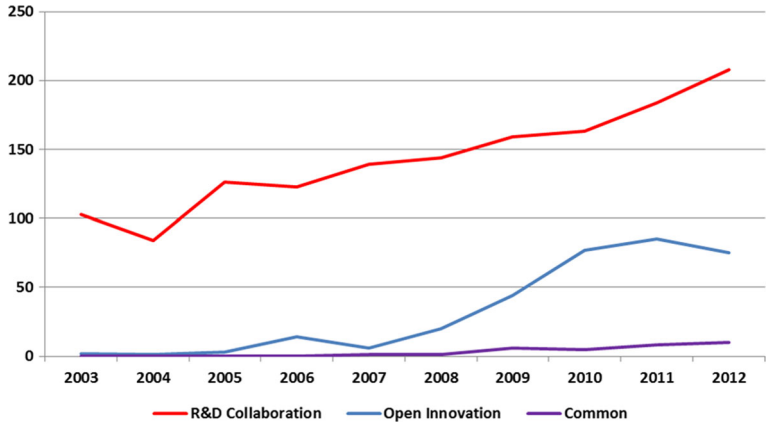

Fig. 1 The distribution of web of science publications on open innovation and R&D collaboration respectively over time

The basic assumption underlying both bibliographic coupling and co-citation analysis is that the greater the degree of overlap in the referencing patterns of a pair of focal publications, the greater the relatedness between both publications.

Bibliographic coupling and co-citation analysis are complements in the sense that, whilst the former approach is suitable for capturing current trends within a field, the latter approach is appropriate when capturing the origins of that field (Sharabchiev 1988; Boyack and Klavans 2010). Hence, bibliographic coupling associates focal publications on the basis of their references to publications, which are by definition older than the focal publications themselves. On the other hand, co-citation analysis associates focal publications on the basis of their future appraisal by publications, which are by definition more recent than the focal publications themselves (see Fig. 2 for an illustration of bibliographic coupling and co-citation analysis). In line with the unique properties of both techniques, we apply co-citation analysis in order to identify the foundations of existing open innovation research and bibliographic coupling to identify themes within open innovation research itself.

Relatedness measures

Several measures have been developed to calculate the relatedness between pairs of bibliographic objects. We apply a measure—known as the *association strength*—that determines the relatedness between a pair of focal publications by normalizing the co-occurrence frequency of the references they make (in case of bibliographic coupling) or the references they receive (in case of co-citation analysis). This measure has been developed by Van Eck and Waltman (2009), who illustrate that it is more suited to normalizing co-occurrence data than the more conventional cosine and Jaccard index-based measures, which are widely applied in the field of bibliometrics.[4] We calculate the association strength between pairs of focal publications by means of the following formula:

[4] See Van Eck and Waltman (2009) for a more elaborate overview of the most widely applied measures of similarity in bibliometric studies.

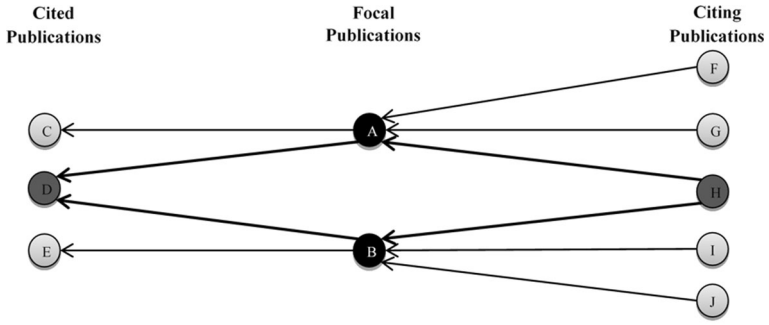

Fig. 2 An illustration of bibliographic coupling and co-citation analysis

$$\mathrm{AS}_{ab} = \frac{C_{ab}}{C_a C_b}$$

In case of bibliographic coupling, C_{ab} relates to the references made that a pair of focal publications A and B have in common, C_a relates to the total number of references made by publication A and C_b relates to the total number of references made by publication B. This means that the association strength of publications A and B is proportional to the ratio between the observed number of overlapping references made, on the one hand, and the expected number of references made by publications A and B, on the other hand. The measure is analogous in case of co-citation analysis, with the only difference being that it pertains to references received instead of references made by publications A and B respectively.

Hence, the higher the value for AS for a given pair of focal publications, the greater the relatedness between these publications. In the example of Fig. 2, the association strength between focal publications A and B equals 0.25 ($1/(2 \times 2)$) based on bibliographic coupling and 0.11 ($1/(3 \times 3)$) based on co-citation analysis. We calculated the association strength for all possible pairs of references cited by the publications in our dataset based on co-citation analysis. The matrix that resulted from this exercise served as an input to visualize and identify the foundations of the concept of open innovation. We also calculated the association strength for all possible pairs of publications that are contained in our dataset based on bibliographic coupling. The resulting association matrix served as the input for the visualization and identification of thematic clusters of open innovation research itself.

Visualization and clustering

We rely on the visualization of similarities (VOS) approach as described by Van Eck and Waltman (2010) in order to identify and visualize thematic clusters based on the relatedness between publications in our set. Essentially, VOS is a unified approach for mapping and clustering bibliometric networks that combines an optimization algorithm with a

clustering algorithm in one software package; VOSviewer.[5] VOSviewer has been used to develop bibliographic mappings in a variety of studies (i.a. Rafols et al. 2012; Wuehrer and Smejkal 2013; Mamtora et al. 2014; Rafols et al. 2014). The VOS optimization algorithm ensures that "…publications are located in a low-dimensional space in such a way that the distance between any two items is a reflection of the relatedness of the items as accurately as possible…" (Van Eck et al. 2010:2407). More specifically, the algorithm minimizes the weighted sum of the squared distances between all pairs of publications and weighs these by the relatedness of these publications. Accordingly, the greater the association strength between a pair of publications, the smaller the distance between these publications in the low-dimensional space. Furthermore, the optimization algorithm ensures that the most connected publications will be located near the center of the low-dimensional space whilst the less-connected publications will be located in its periphery.

Publications are grouped into clusters on the basis of the VOS clustering algorithm, which is based on a weighted version of Newman and Girvan's (2004) modularity function. In this function, modularity is a measure of the quality of the division of a given network into communities (clusters). Specifically, the algorithm eliminates edges in a network that have the highest betweenness[6] until the modularity function of Newman and Girvan is maximized. In other words, the optimal number of clusters is the one in which the maximum value for the modularity function is reached. We have used the default parameters of VOSviewer in order to derive the bibliographic networks that we present in subsequent parts of the paper.[7]

Results

The foundations of open innovation research

The bibliographic network of the references cited by our set of open innovation publications is illustrated in Fig. 3. The network was created based on the cited references that we derived from our set of 358 publications. Since the form of cited references tends to differ between journal sources, there is a need to convert them into a standardized form for further processing. Therefore, all cited references were standardized to a string that contains only a maximum of two initials of the author's first name, as well as the author's full surname and the year of publication. After this standardization effort, 11,873 unique references remained for further analysis. In Fig. 3, however, we only portray references that have been cited a minimum of ten times. This restriction is imposed in order to capture only the most important references, whilst not overly complicating the interpretation of Fig. 3. We do not impose restrictions with regard to the publication date of cited references, meaning that we also include references published after 2003. However, since our primary interest lies in identifying the foundations of open innovation research that are situated outside the field itself, we filtered out 28 publications that are both part of our set of 358 publications and receive a minimum of 10 citations from other publications in our set. Hence, the cited references portrayed in Fig. 3 are not the ones contained by our dataset of 358 publications.

[5] VOSviewer is a freely available computer program for the visualization of bibliometric networks that can be downloaded from http://www.vosviewer.com/.

[6] Hence, the betweenness of an edge is larger, the higher the number of pairs of nodes that it lies between.

[7] See Van Eck and Waltman (2010) for an elaborate discussion of these default parameters.

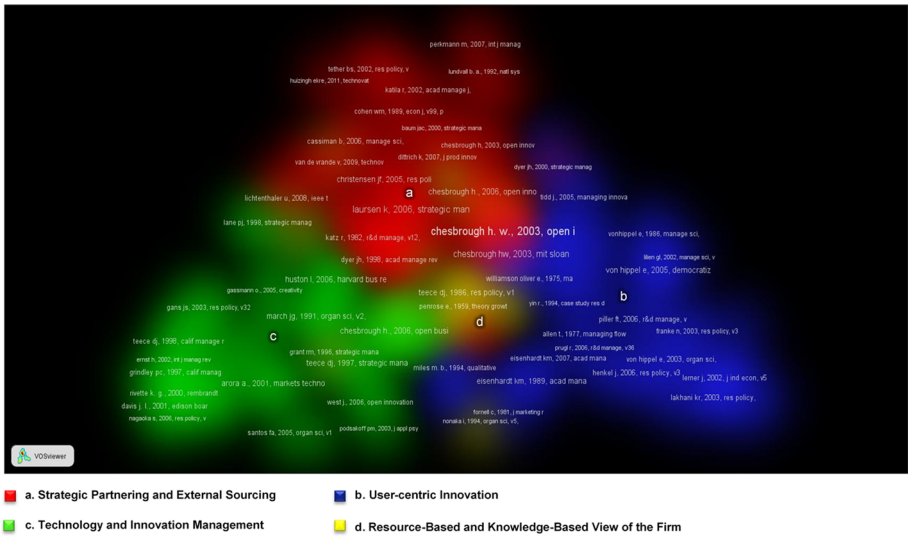

Fig. 3 Bibliographic network of the references cited by publications on open innovation between 2003 and 2013

In Fig. 3, each label represents a reference that is cited at least ten times overall by our set of publications. The greater the size of the fonts of a label, the more often the reference is cited by our set of publications. The distance between a pair of cited references represents the likelihood that these references are cited together by our set of publications. Thereby, a shorter distance corresponds with a greater likelihood of being cited together. Lastly, the colors and corresponding lowercase letters in the figure indicate clusters of cited references that can be distinguished. The grouping of a reference into a cluster indicates that this reference is more likely to be cited in combination with other references that are grouped in this cluster than with references that are grouped in other clusters. It can be observed from Fig. 3 that the clustering resulted in four clusters, represented by the red, blue, green and yellow colors respectively. Figure 3 displays a relatively coherent network in which the red, blue and green clusters are tied together by the yellow, which is located near the center of the network. In order to interpret and label the clusters, we downloaded Web of Science records for the 123 cited references represented in the figure[8] and listed the most frequent terms in the keywords, title and abstract sections of these references per cluster. In addition, we read the abstracts and introductions of the cited references. Based on this effort, we labeled the clusters as follows: 'Cluster a—Strategic Partnering and External Sourcing', 'Cluster b—User-centric Innovation', 'Cluster c—Technology and Innovation Management' and 'Cluster d—Resource- and Knowledge-based View of the Firm' respectively. In what follows, we describe and discuss the cited references captured by each cluster. Although we aim to describe every cluster in as much detail as possible, we acknowledge that our description cannot fully capture the richness of every cluster.

[8] We were only able to download Web of Science records for 92 of the 123 cited references since the remaining references are books that are not held by the Web of Science.

Cluster a: Strategic partnering and external sourcing (37 items)

The thematic orientation of this cluster of references is best captured by the label 'Strategic Partnering and External Sourcing' as most publications that are included in this cluster address different kinds of interorganizational collaboration arrangements. Most of these publications examine the contingencies influencing strategic partnering behavior (Hagedoorn 1993; Powell et al. 1996; Dyer and Singh 1998; Gulati 1998; Tether 2002; Hagedoorn 2002), the effects of strategic partnering on firm performance (Ahuja 2000; Baum et al. 2000; Dyer and Nobeoka 2000; Belderbos et al. 2004; Faems et al. 2005; Dittrich and Duysters 2007), and the ways of governing interorganizational collaboration agreements (Van De Vrande et al. 2006). Others focus specifically on the external sourcing of knowledge, often referred to as the inbound dimension of open innovation. These studies explore the complementarity between internal and external R&D (Veugelers 1997; Cassiman and Veugelers 2006) and study the effects of external knowledge sourcing on firm performance (Katila and Ahuja 2002; Laursen and Salter 2004; Fey 2005; Laursen and Salter 2006; Van De Vrande et al. 2006). Taken together, these studies provide empirical evidence of the increased reliance of firms on external sources of knowledge, which is, at least in part, the trend that the open innovation concept aims to address. Therefore, it is not surprising that open innovation research draws upon these studies.

Whereas most of the aforementioned publications indicate that firms can benefit significantly from external knowledge sourcing, the cluster also contains publications which stress that realizing these benefits should not be taken for granted. Cohen and Levinthal's (1990) seminal contribution on the concept of absorptive capacity is the most prominent of these publications and is the second most-cited reference by our set of open innovation publications. Additional references to contemporary works on the concept (Szulanski 1996; Lane and Lubatkin 1998; Tsai 2001, Zahra and George 2002; Lane et al. 2006) highlight its recognition as a necessary condition for successful external knowledge sourcing in open innovation research. In similar vein, the presence of Katz and Allen's (1982) well-known contribution on the 'not-invented-here' syndrome arguably indicates that the concept is often regarded within open innovation research as a potential obstacle to successful knowledge sourcing.

Cluster b: User-centric innovation (34 items)

This cluster is labeled as 'User-centric Innovation', since the majority of the references that it comprises focus explictly on the role of end users within firms' innovation processes. It captures Von Hippel's (1988, 2005) books, entitled 'Sources of Innovation' and 'Democratizing Innovation'—the most-cited contributions in the cluster—as well as contemporary works that center on user communities and open source software (OSS) platforms. Most of these contemporary works study the motivation of users in participating in OSS platforms (Hars and Ou 2002; Harhoff et al. 2003; Hertel et al. 2003; Lakhani and Von Hippel 2003; Von Krogh et al. 2003; Jeppesen and Frederiksen 2006) and ways of engaging users to participate in them (Von Hippel and Katz 2002; Franke and Shah 2003; Lee and Cole 2003; Prugl and Schreier 2006). Others explore the conditions under which OSS platforms should be preferred to proprietary platforms (Lerner and Tirole 2002; West 2003) and the potential implications that this holds for organization science and theory (Von Hippel and Von Krogh 2003). The inclusion of the above-listed publications among

the references most cited by our set of open innovation publications indicates that users are considered important sources of external knowledge in existing open innovation research.

In addition to the contributions on user-centric innovation, the cluster also contains cited references that provide insights into the methodological foundations of open innovation research. Referencing to Glaser and Strauss' (1967) book on grounded theory, Miles and Huberman's (1994) book on qualitative research designs, and Eisenhardt's (1989, 2007) and Yin's (1994, 2003) contributions on case study methodology indicates that qualitative research, and especially case studies, play an important role in open innovation research. The inclusion of these contributions in this cluster may indicate that case studies are especially predominant in open innovation research that is also based on user-centric innovation.

Cluster c: Technology and innovation management (34 items)

Compared to the other clusters, this cluster is relatively more heterogenous with respect to the thematic areas that it covers. However, the majority of cited references grouped in this cluster can be placed under the umbrella of technology and innovation management and, therefore, the cluster has been labeled accordingly. The most-cited references of the cluster are those that put forward frameworks for the organization of innovation from a strategic management point of view. To this group of references belong publications on the exploration–exploitation dilemma of organizational learning (March 1991; Rothaermel and Deeds 2004), the dynamic capabilities framework (Teece et al. 1997; Eisenhardt and Martin 2000; Teece 2007) and the recombinative capabilities framework (Kogut and Zander 1992). In essence, these frameworks describe how organizations can (re-)develop capabilities in order to survive in the wake of rapid technological change. The fact that they are cited extensively indicates that the insights from these general frameworks are relevant to open innovation research.

In addition to the more general frameworks on the organization of innovation, the cluster also contains a subset of publications that focus specifically on external technology commercialization. This subset encompasses Arora et al. (2001) seminal contribution on 'markets for technology' as well as a number of contemporary works that explore the implications of these markets for external technology commercialization. These works examine the antecedents and determinants of external technology commercialization (Gans and Stern 2003; Lichtenthaler 2005; Fosfuri 2006; Gambardella et al. 2007; Nagaoka and Kwon 2006), the challenges associated with managing external technology commercialization (Grindley and Teece 1997; Koruna 2004; Lichtenthaler 2005) and the ways to capture value from technology commercialization (Teece 1998). Hence, these publications address the outbound dimension of open innovation, whereas the publications belonging to the first cluster address its inbound dimension.

Cluster d: Resource- and knowledge-based view of the firm (18 items)

This cluster predominantly captures references that relate to the *Resource-based View* (*RBV*) and the *Knowledge-based View of the Firm* (*KBV*) and is, therefore, named after these theoretical frameworks. The cluster comprises both the seminal works on the RBV (Penrose 1959; Wernerfelt 1984; Barney 1991) and the KBV (Grant 1996) as well as works that incorporate a resource-based/knowledge-based perspective (Nonaka 1994; Hargadon and Sutton 1997; Nahapiet and Ghoshal 1998; Rosenkopf and Nerkar 2001; Howells 2006). Both the RBV and the KBV are based on the central premise that a focal firm can

Table 2 Indicators of publication output and citation impact per cluster of cited references

Cluster	Label	Number of items	Top 3 most-cited articles	Average number of citations per item (open innovation set)	Ratio to average (open innovation set)	Average number of citations per item (R&D collaboration set)	Ratio to average (R&D collaboration set)
a	Strategic partnering and external sourcing	37	Cohen and Levinthal (1990), Laursen and Salter (2006), Powell et al. (1996)	20.03	1.08	40.61	1.63
b	User-centric innovation	34	Eisenhardt's (1989), Von Hippel and Von Krogh (2003), Lerner and Tirole (2002)	17.00	0.92	5.71	0.23
c	Technology and innovation management	34	Gassmann (2006), March (1991), Teece et al. (1997)	18.16	0.98	17.24	0.69
d	Resource-and knowledge-based view of the firm	18	Huston and Sakkab (2006), Teece (1986), Barney (1991)	18.17	0.98	30.83	1.24
Total		123	n/a	18.57	n/a	24.84	n/a

establish a position of sustainable competitive advantage through the creation and exploitation of idiosyncratic firm attributes (Wernerfelt 1984; Barney 1991). The fact that several of the key contributions on both the RBV and the KBV are grouped together in this cluster indicates that a considerable proportion of open innovation research takes into account this premise.

In addition to the seminal works on the RBV and the KBV, the cluster contains two other highly cited publications—Nelson and Winter's (1982) book entitled 'An Evolutionary Theory of Economic Change' and Teece's (1986) publication entitled 'Profiting From Technological Innovation—Implications For Integration, Collaboration, Licensing and Public Policy'. This indicates that our set of open innovation publications builds at least in part on Nelson and Winter's (1982) conceptualization of 'routines' as a framework for understanding technological change as well as Teece's (1986) conceptualization of 'appropriability' as a framework for understanding how to capture value from technological innovation. Lastly, the cluster contains Chesbrough's (2003b) and Chesbrough et al. (2006) seminal publications on open innovation. Since both of these publications are books, they are not part of our sample and are displayed as such in Fig. 3. Clearly, these works are amongst the most-cited references by our set of open innovation publications.

The relative importance of clusters of cited references

In order to assess the relevance of each cluster of cited references as a foundation for open innovation research, we calculated a number of publication-output and citation-based statistics per cluster. These statistics are presented in Table 2. Column 5 of the table shows the average number of citations that a reference received from our set of open innovation publications, whilst Column 6 provides the ratio between this average and the total sample average. From these columns, it can be derived that, on average, references belonging to

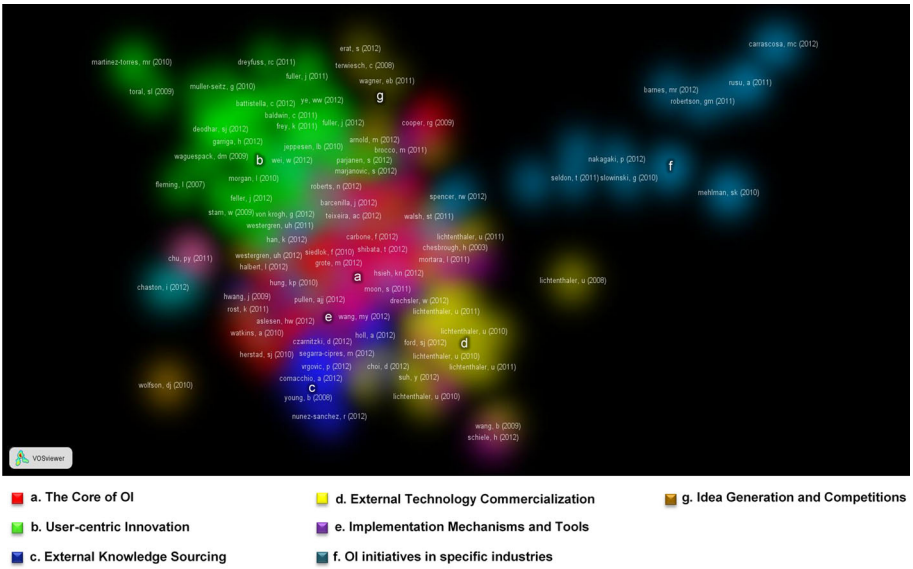

Fig. 4 Bibliographic network of web of science publications on open innovation between 2003 and 2013 based on bibliographic coupling

'Cluster a—Strategic Partnering and External Sourcing' are cited the most by our set of open innovation publications. An average reference belonging to this cluster is cited 20 times while an average reference belonging to the other clusters is cited only 17 or 18 times. Furthermore, only references belonging to Cluster a are cited more than the average reference (18.57).

To put the above observations into context, we analyzed the extent to which the R&D collaboration literature builds upon the foundations of the open innovation literature. Column 7 shows the average number of citations that a reference received from publications on R&D collaboration between 2003 and 2013, whilst Column 8 gives the ratio between this average and the total sample average. It follows from Columns 7 and 8 that the references belonging to 'Cluster a—Strategic Partnering and External Sourcing' have, on average, received by far the most citations from publications on R&D collaboration. Interestingly, references belonging to 'Cluster b—User-centic Innovation' have received the least citations from publications on R&D collaboration between 2003 and 2013. In fact, taken together, the information presented in Columns 5–8 of Table 2 indicates that it is primarily the enhanced focus on the user-centric perspective which distinguishes the open innovation literature from the broader literature on R&D collaboration.

Thematic areas in open innovation research itself

The bibliographic network of our set of open innovation publications, based on bibliographic coupling, is presented in Fig. 4. The principles that apply in interpreting Fig. 4 are the same as those that apply in interpreting Fig. 4, except that in Fig. 4, the sizes of the fonts of labels are equal. It is important to note that Fig. 4 visualizes the bibliographic-coupling network for 344 of our 358 publications only. Firstly, we dropped a number of publications because their Web of Science records did not contain information on the references cited. We treated these publications as missing observations. Secondly, we dropped a number of publications because they had no cited reference in common with any other publication in our set. We treated these publications as outliers. Although the bibliographic coupling resulted in the identification of ten clusters, we decided to exclude three less coherent clusters—representing 27, 8 and 2 publications, respectively—from further analysis. These three clusters had the lowest coherence of all clusters, and a close examination of their contents revealed that they cover miscellaneous applications of open innovation that cannot be linked in a meaningful way. By excluding these clusters, we were left with 307 publications, grouped in seven clusters.

Figure 4 displays a relatively coherent bibliographic network in which each of the seven clusters is represented by a color and corresponding lowercase letter. In order to interpret and label the clusters, we followed the same approach we used to interpret and label clusters of cited references. We listed the most frequent terms in the keywords, title and abstract sections of these publications per cluster. In addition, we read the abstracts and introductions of the publications. Based on this effort, we labeled clusters as 'Cluster a—The Core of Open Innovation', 'Cluster b—User-centric Innovation', 'Cluster c—External Knowledge Sourcing', 'Cluster d—External Technology Commercialization', 'Cluster e—Implementation Mechanisms and Tools', 'Cluster f—Open Innovation Initiatives in Specific Industries' and 'Cluster g—Idea Generation and Idea Competitions', respectively. In the following section, we discuss our interpretation of the themes that the clusters represent. Again, we acknowledge that, although we attempt to describe every cluster as elaborately as possible, our descriptions cannot fully capture the richness of each and every cluster.

Cluster a: The core of open innovation (94 items)

This cluster is both the largest—in terms of the number of publications that it contains—and the most centrally placed cluster; it has, therefore, been labeled as the 'Core of Open Innovation'. The cluster comprises Chesbrough's (2003c) seminal contribution 'The Era of Open Innovation', which introduces the concept of open innovation, and a number of literature reviews that address the concept's basic dimensions (Dahlander and Gann 2010; Van De Vrande et al. 2010). Furthermore, it includes a set of publications that address the implications of open innovation on the systemic level. These publications highlight the relevance of open innovation for public policy (Clausen and Rasmussen 2011; Karo and Kattel 2011), provide frameworks that describe how policy makers should respond to open innovation (De Jong et al. 2010; Herstad et al. 2010), examine the policy initiatives that are currently in place for addressing open innovation (Mayer 2010; Zhao and Zheng 2011; Lee et al. 2012; Wang et al. 2012), and explore the implications of open innovation for regional innovation systems specifically (Cooke 2005; Belussi et al. 2010; Isaksen and Onsager 2010; Todtling et al. 2011; Halbert 2012).

Although publications that focus on the concept of open innovation constitute the main part of the cluster, it also contains publications that elaborate on the concept of open business models. These publications explore how firms can create and capture value from an open innovation approach. Some publications outline how firms should develop and implement open business models in general (Chesbrough 2004; Chesbrough and Schwartz 2007; Munsch 2009; Sandulli and Chesbrough 2009). Others focus on the viability of open business models in specific industry (Davey et al. 2011), economic (Di Minin et al. 2010), product (Jaspers and Van Den Ende 2010) and geographic (Li and Kozhikode 2009) settings. Finally, another subset of studies explores the link between business models and corporate venturing initiatives (Anokhin et al. 2011; Napp and Minshall 2011; Van De Vrande et al. 2011).

Cluster b: User-centric innovation (78 items)

This cluster captures contributions pertaining to user communities, user platforms, crowdsourcing and open-source software (OSS) development. Out of these topics, publications on OSS comprise the largest part of the cluster. Most of these publications describe the business models and strategies that firms should adopt in order to create and capture value from OSS development in general (Dahlander and Wallin 2006; Gruber and Henkel 2006; West and Gallagher 2006; Stam 2009; Haefliger et al. 2010; Harison and Koski 2010; Morgan and Finnegan 2010; Perr et al. 2010; Rolandsson et al. 2011; Deodhar et al. 2012; Rajala et al. 2012). Others focus specifically on a key part of OSS development; the involvement of experienced and qualified users. These studies explain the conditions under which users are motivated to freely contribute their knowledge to OSS projects (Henkel 2006, 2009) and the modes through which this contribution actually takes place (Toral et al. 2009a, b; Martinez-Torres et al. 2010). A final segment of OSS-related studies explores the applicability of the principles of open source in non-software-related areas (Penin and Wack 2008; Raasch et al. 2009; Müller-Seitz and Reger 2009, 2010a, b).

Although the remaining publications grouped in this cluster do not focus on OSS development, the key topics addressed by these publications are very similar to those addressed by the publications on OSS. Many contributions focus on the motivation of users in participating in communities/platforms (Spaeth et al. 2010; Frey et al. 2011; Füller et al.

2011; Battistella and Nonino 2012; Füller et al. 2012), the identification of key participants (Fleming and Waguespack 2007; Fichter 2009) and the effects of users' contributions on contemporary platform development (Boudreau 2012). Other contributions present concrete cases to illustrate the frameworks and business models that have proven successful in benefitting from the contributions of users (Angehrn et al. 2009; Ebner et al. 2009; Hildrum 2009; Kohler et al. 2009; Leimeister et al. 2009; Lohmann et al. 2009; Adenbanjo and Michaelides 2011; Basole and Karla 2011; De Couvreur and Goossens 2011; Faraj et al. 2011; Hutter et al. 2011; Kohler et al. 2011; Tickle et al. 2011; Bullinger et al. 2012; Feller et al. 2012; Parjanen et al. 2012; Shu and Chuang 2012; Ye et al. 2012). Finally, the remaining publications clarify the meaning of user communities (West and Lakhani 2008) and crowdsourcing (Marjanovic et al. 2012), and position these concepts within the broader frame of collaborative innovation (Baldwin and von Hippel 2011) and the private-collective model of innovation (von Hippel and von Krogh 2006; Garriga et al. 2012).

Cluster c: External knowledge sourcing (42 items)

The common denominator of the majority of publications captured by this cluster is that they focus their attention on the inbound dimension of open innovation; the external sourcing of knowledge. The majority of publications focus either on (1) the determinants/antecedents of firms' openness to external sources of knowledge or (2) the effects of external knowledge sourcing on firm performance. The determinants-oriented publications link the openness of firms' external knowledge sourcing strategies to a number of firm characteristics such as firm size (Barge-Gil 2010; Moon 2011), firm age (Moon 2011), firms' R&D intensity (Barge-Gil 2010; Segarra-Cipres et al. 2012), the severity of firms' internal weaknesses (Keupp and Gassmann 2009), firms' appropriability strategy (Moon 2011), firms' absorptive capacity (Bogers and Lhuillery 2011), the type of knowledge concerned (Bonesso et al. 2011) and the complementarity between firms' external and internal R&D (Cassiman and Valentini 2009; Choi et al. 2012).

The performance-oriented publications examine the relationship between external knowledge sourcing and firm performance, although there is considerable variation in the type of knowledge sourcing studied and the type of performance metrics used. Most studies examine the relationship between external knowledge sourcing and firms' innovative performance, without going into the specific dimensions of external sourcing behavior (Spithoven et al. 2010b; Bae and Chang 2012; Czarnitzki and Thorwarth 2012; Parida et al. 2012). Others examine the link between specific dimensions of firms' search behavior—most notably, search scope and depth (Chen et al. 2011) and search diversity (Ebersberger and Herstad 2011)—and firms' innovative performance. Yet, others study the performance effects of knowledge sourcing in conjuction with the performance effects of other approaches to open innovation (Faems et al. 2010; Neyens et al. 2010; Love et al. 2011). Interestingly, very few studies—with the notable exception of Faems et al. (2010) and Kafouros and Forsans (2012) examine the effects of external knowledge sourcing on financial performance.

Lastly, the cluster contains contributions that specifically address the implications of open innovation for small- and medium-sized enterprises (SMEs). These contributions provide accounts of SMEs' open innovation initiatives (Van de Vrande et al. 2009) and examine the effects of these initiatives on SMEs' innovative performance (Parida et al. 2012; Pullen et al. 2012) or financial performance (Lee et al. 2010). Other contributions focus on more specific issues, such as the role of absorptive capacity in SMEs (Spithoven et al. 2010a) and the utilization of innovation intermediaries by SMEs (Lee et al. 2009).

Cluster d: External technology commercialization (33 items)

Whereas publications belonging to the previous cluster concentrate on the inbound dimension of open innovation, the publications in this cluster address the outbound dimension of open innovation—external technology commercialization. This cluster's publications tend to (1) describe best practices for managing external technology commercialization, (2) investigate its determinants/drivers and (3) explore its complementarity with external technology sourcing. Best practices for managing external technology commercialization relate to the integration of product and technology roadmaps (Lichtenthaler 2008b, d, e, 2010) and the development of 'desorptive capacity' (Lichtenthaler and Lichtenthaler 2009; Lichtenthaler and Muethel 2012). The determinants of firms' strategic approaches to external technology commercialization relate to environmental characteristics concerning appropriability and technology markets, the level of integration of product marketing and licensing (Lichtenthaler 2007) and the personal characteristics of licensing managers (Bianchi et al. 2011).

Finally, the contributions that aim to integrate the outbound dimension of external technology commercialization with the inbound dimension of external technology sourcing discuss the implications of such an integrative perspective for the management of external technology commercialization in general (Lichtenthaler 2008a, Lichtenthaler and Lichtenthaler 2010) or describe the implications for the governance of knowledge flows (Lichtenthaler and Ernst 2006; Lichtenthaler 2008c, 2009, 2011b; Tukel et al. 2011) and the management of intellectual property in particular (Chesbrough 2003a; Alexy et al. 2009).

Cluster e: Implementation mechanisms and tools (33 items)

In the main, this cluster captures publications that describe the challenges associated with implementing open innovation in different organizational contexts and put forward a variety of mechanisms, best practices and tools that should be applied to overcome these challenges. A first subsection of publications describes the determinants of successful implementation mechanisms, best practices and tools in general (Traitler and Saguy 2009; Hopkins et al. 2011; Mortara and Minshall 2011; Remneland-Wikhamn and Wikhamn 2011; Hsieh and Tidd 2012). These publications denote the novelty of projects, the nature of existing resources, the timing of implementation and the existing organizational culture as the most important determinants. A second subsection of publications focuses specifically on the managerial challenges associated with implementing open innovation in SMEs (Bianchi et al. 2010; Igartua et al. 2010; Minshall et al. 2010; Albors-Garrigos et al. 2011; Caetano and Amaral 2011). These publications highlight the idiosyncrasies of SMEs—most notably, focused business portfolios, specialized knowledge and limited resources—that impose unique challenges with respect to the implementation of open innovation initiatives (Bianchi et al. 2010; Minshall et al. 2010). Whereas the first two subsections of publications present implementation tools and mechanisms for open innovation in general, the third and final subsection of publications presents implementation tools and mechanisms for specific facets of the open innovation process. These publications tend to focus specifically on the inbound perspective (Schiele 2010; Sjodin et al. 2011; Jeon et al. 2011; Ford et al. 2012; Robertson et al. 2012; Schiele 2012; Wang 2012) or the outbound perspective of open innovation (Bianchi et al. 2010, 2011; Lichtenthaler 2011b).

Cluster f: Open innovation initiatives in specific industries (19 items)

This cluster is distinct in that it is the least connected to the other clusters. This is explained by the fact that the publications belonging to this cluster study open innovation initiatives in specific industries, with most publications exploring open innovation in the biopharmaceutical context. These publications either explore the trend towards open innovation on the industry level (Ghauri and Rao 2009; Robertson and Mayr 2011; Rusu et al. 2011; Barnes 2012; Carrascosa et al. 2012; Zdrazil et al. 2012) or describe tools and best practices for managing open innovation on the level of biopharmaceutical firms/institutes (Lee et al. 2011; Simiyu et al. 2010; Allarakhia and Walsh 2011; Calderon et al. 2011; Seldon 2011; Nakagaki et al. 2012). In addition to contributions focusing on biopharmaceuticals, the cluster encompasses studies that focus on open innovation initiatives in the oil and gas industry (Gronlund et al. 2010) and the space industry (Holmes 2009) respectively. The cluster is connected to the rest of the bibliographic network by a number of publications that are situated on its borderline with 'Cluster e—Implementation Mechanisms and Tools'. These publications describe best practices for managing open innovation in general (Slowinski et al. 2009; Slowinski and Sagal 2010) and the management of intellectual property within the framework of open innovation in particular (Slowinski and Zerby 2008; Mehlman et al. 2010).

Cluster g: Idea generation and idea competitions (8 items)

This cluster captures publications that focus on how to manage ideas originating from users. The focus lies specifically on ideas developed within the framework of idea competitions that aim to generate solutions to problems from a crowd of external actors. The publications that are grouped in this cluster are very much related to the publications grouped in 'Cluster b—User-centric Innovation'. However, the fact that publications on idea generation and idea competitions are grouped into a separate cluster indicates that this topic is sufficiently distinctive from the topics covered in Cluster b. Most of the publications describe how to manage idea competitions and the resulting ideas effectively (Wagner 2011; Alexy et al. 2012; Erat and Krishnan 2012; Lampel et al. 2012). They investigate a broad spectrum of issues pertaining to the design of idea competitions, ranging from the specification of the problem to be solved to the number and type of rewards that should be offered. The remaining publications address the contingencies under which idea competitions are beneficial to firms (Terwiesch and Xu 2008), examine the characteristics of the winners of these competitions (Jeppesen and Lakhani 2010), and investigate the influence of social ties on the market efficacy of online knowledge marketplaces (Dushnitsky and Klueter 2011).

The development and impact of clusters over time

In order to assess the relative importance of the themes identified, we calculated a number of citation-based statistics per cluster. These statistics are presented in Table 3. Firstly, it can be observed from Column 4 of the table that publications belonging to Clusters a, b and d capture the 'oldest' publications on open innovation, on average. The publications that belong to these clusters have an average age of 4.12, 4.05 and 4.79 years respectively, which is higher than the sample average of 3.86 years. Moreover, Clusters a, b and d are those that have received the most citations of all clusters in total (see Column 5). This also

Table 3 Indicators of publication output and citation impact per thematic cluster

Cluster	Cluster label	Number of items	Average age of items	Total number of citations	Average number of citations per item	Average Number of citations per item per year
a	The Core of Open Innovation	94	4.12	1490	15.85	2.57
b	User-centric innovation	78	4.05	1032	13.23	2.54
c	External knowledge sourcing	42	3.28	340	8.10	1.93
d	External technology commercialization	33	4.79	562	17.03	3.09
e	Implementation mechanisms and tools	33	2.91	107	3.24	1.03
f	Open innovation initiatives in specific industries	19	3.42	92	4.84	1.47
g	Idea generation and idea competitions	8	3.25	114	14.25	3.20
Total		307	3.86	3737	12.17	2.32

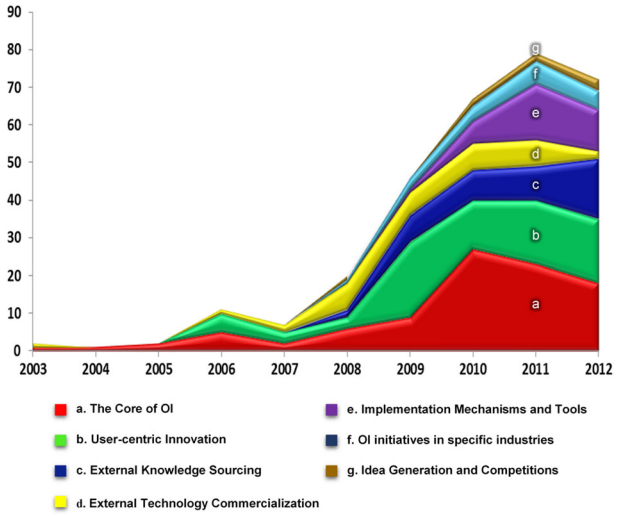

Fig. 5 The distribution of the number of publications per cluster over time

holds if we control for the number of publications per cluster (see Column 6), as well as the average age of publications (see Column 7). However, in the latter case, publications belonging to Cluster g score above the sample average. In fact, if we control for the age of publications, publications from Cluster g are cited the most, with an average of 3.20 citations received per year. The publications of Clusters a, b and d also receive more citations per year than the sample average of 2.32. However, publications belonging to

Clusters c, f and e have a below average citation rate per year. Taken together, the statistics in Table 3 indicate that publications focusing on the themes of idea generation and idea competitions, external technology commercialization, the 'core' of open innovation and user-centric innovation have the highest citation impact, on average, of all the publications in our dataset.

We also plotted the distributions of the number of publications per year per cluster in order to assess the thematic development of research on open innovation over time. This plot is presented in Fig. 5. It can be observed from the figure that the distribution of publications on open innovation follows a 'double boom' pattern, with peaks in terms of publication output arising in both 2006 and 2011. It is clear from Fig. 5 that all seven themes that we have identified followed a similar pattern of growth in terms of publication output from 2008 onwards. Consequently, no notable fluctuations in the relative importance of themes can be observed in Fig. 5, with the possible exception of Clusters c and d, which seem to have gained in importance in recent years. In other words, no significant shifts in the thematic orientation of open innovation research can be observed over the past decade.

Discussion

Our bibliometric review of the first decade of open innovation research complements and cross-validates existing reviews in two ways. First, whereas many of the existing reviews express the need for open innovation research to become more explicitly grounded in theory (Elmquist et al. 2009; Dahlander and Gann 2010; Van De Vrande et al. 2010; Huizingh 2011; Lichtenthaler 2011a; West and Bogers 2014), our review is the first to assess the foundations of open innovation research in an exhaustive way. Based on a co-citation analysis of the references cited by open innovation publications, our analysis reveals that open innovation research is primarily rooted in technology and innovation management, but also builds—selectively—on frameworks and concepts from the strategic management literature. Furthermore, our analysis highlights that it is primarily the enhanced focus on the user-centric perspective which distinguishes the open innovation literature from the broader literature on R&D collaboration.

Second, although existing reviews identify different strands of open innovation research, our review goes one step further by quantifying the relative improtance of clusters as well as exploring the connections between them. On the basis of bibliographic coupling, we show that the first decade of open innovation research can be depicted by a relatively coherent network of publications. A subsequent comparative analysis of the publication output and citation impact of clusters suggests that publications focusing on the themes of idea generation and idea competitions, and external technology commercialization are cited most by contemporary publications. Lastly, an analysis of the distribution of publication output per cluster over time reveals that the identified themes have been pursued consistently over the last decade.

Limitations and implications for future research

While a systematic bibliometric review of open innovation research has distinct advantages, there are undeniably a number of limitations to our study. First, as our dataset includes only publications that contain the term 'open innovation' in the title, abstract and

keyword sections of the WOS database, we do not include publications of authors that deliberately refrain from using the label whilst covering related topics. Second, opting for a minimum threshold of ten citations for a cited reference to be included in our analysis of the foundations of open innovation research means that we may miss out on covering references that have been published more recently and, therefore, have had less time to be cited. Lastly, citation-based bibliometric methods might overstate the significance of relationships between publications to the extent that authors may refer to existing contributions for reasons other than mere recognition (i.a. Broadus 1983; Brooks 1986; Bonzi and Snyder 1991; Bornmann and Daniel 2006).

Keeping these limitations in mind, our findings have clear implications with regard to the future direction of open innovation research. Firstly, as already noted above, existing reviews of open innovation research emphasize the need for future research to address the theoretical foundations underlying open innovation research by integrating it with prior research in existing fields. Van De Vrande et al. (2010) propose that open innovation research should rely more on transaction cost and value theory (Williamson 1975; Zajac and Olsen 1993), the resource-based view of the firm (Wernerfelt 1984; Barney 1991; Grant and Baden-Füller 2004), the dynamic capabilities approach (Teece et al. 1997; Eisenhardt and Martin 2000; Teece 2007), the relational view of the firm (Dyer and Singh 1998), organizational learning theory (Levinthal and March 1993) and real options theory (Folta 1998). The results of our co-citation analysis clearly indicate that existing open innovation research already builds to a large extent on these (strategic) management theories. At the same time, our analysis reveals a lack of reliance on perspectives from the disciplines of economics and sociology, most notably transaction cost economics and network analysis; an observation which also signals potential for enrichement and further development.

Second, existing reviews argue that there is a need for a more encompassing perspective that integrates the inbound and outbound perspectives of open innovation into a single framework (Gassmann et al. 2010; Huizingh 2011; West and Bogers 2014). Not only do scholars claim that open innovation research often addresses only one of these perspectives, they also claim that there is a bias in favor of the inbound perspective. While our findings confirm that the inbound and outbound perspectives are often adressed seperately, the imbalance between research on the inbound and outbound perspectives is not confirmed.

Third, open innovation is claimed to rely mainly on case studies and qualitative research methods. Thus, existing reviews tend to call for large-scale quantitative studies as a complement to existing case study research on open innovation (Huizingh 2011; Lichtenthaler 2011a). Our findings confirm that qualitative research, and case studies in particular, have been explicitly present in open innovation research during the past decade. However, our review also reveals that quantitative studies are present in our sample, but they tend to be located mainly in the 'External knowledge sourcing' and 'External technology commercialization' clusters. This suggests that research on some thematic areas might be more conducive to the application of large-scale quantitative approaches than others.

Finally, in terms of topics pursued, our study reveals that dominant themes have been pursued consistently during the last decade. While such persistence is undoubtedly useful to arrive at in-depth and robust insights, the observed patterns also signal the absence of new, emerging, themes. As such, our findings suggest that the open innovation research stream could benefit from applying its own ideas: sourcing concepts and models from a broader range of theoretical perspectives as well as pursuing a broader range of topics

might introduce dynamics resulting in more impact and proliferation. We hope our study inspires scholars to engage in such endavours.

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