Startups and open innovation: a review of the literature

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Startups and Open Innovation: a review of the literature

Abstract

Purpose: Startup companies represent a powerful engine of open innovation processes. This study represents a first step in building a map of the state-of-the-art knowledge of the "startups in an open innovation context" phenomenon. Through the selection and analysis of relevant literature, this study aims at deepening our understanding of the theme and at providing directions for future research.

Design/methodology/approach: By using an explicit method for the review (Pittaway et al. 2004) we selected a set of papers, which cover the knowledge domain object of this study. Forty-one articles about "startups and open innovation" have been selected and the full papers have been analysed.

Findings: The analysed literature has been synthesized in seven sub-topics, which have been evaluated as the most relevant in explaining the phenomenon of startups in relation to open innovation. Implications for research, for managers and for policy makers conclude the paper.

Practical implications: The review produced valuable knowledge for both managers and policy decision-makers. The paper allows a better understanding of the role of startups in open innovation processes. This improved understanding can help managers of large firms as well as policymakers involved in open innovation in making their decisions. Besides, implications of open innovation strategies for start-up managers have been singled-out.

Originality/value: Startup companies are intrinsically open organizations, necessarily engaged in innovation processes. Research at the intersection between the themes of open innovation and startups is gaining momentum. This review of the literature represents the first attempt to organize the scientific knowledge related to the intersection between the startups and open innovation phenomena systematically.

Introduction

Startups play a key role in innovation processes(Colombo & Piva 2008; Davila et al. 2003; Mustar et al. 2008). According to the well-known definition by Steve Blank (Blank 2010) a startup is a company, a partnership or temporary organization designed to search for a repeatable and scalable business model. Through the startup phase, new ideas are brought to the market and transformed in economically sustainable enterprises. New firms are artefacts for transforming entrepreneurial judgment into profit (Spender 2014). Existing research indicates that forming relationships with external partners is a priority for the success of startups (Teece 2010; Pangarkar & Wu 2012; Kask & Linton 2013).

Due to their smallness, startups suffer a structural lack of tangible and intangible resources (Wymer & Regan 2005). The lack of financial and human resources hinders the development of new innovation processes. Adopting Open Innovation (OI) practices is a necessity for startups in order to overcome both the liability of newness and the liability of smallness (Bogers 2011).

From a scientific point of view, the startup phenomenon and open innovation are closely related.

Research in OI has followed several different strands, giving evidence of the multidimensional nature of the concept of openness. Many studies have examined the complex features of OI (Huizingh 2011; Aslesen & Freel 2012), focusing on its different aspects, such as OI classification in terms of: modulation of openness level (Herrmann et al. 2007); the adoption modality of OI (Bigliardi et al. 2012; Dahlander & Gann 2010); knowledge flows (Lichtenthaler & Ernst 2009); innovation practices (Baldwin & von Hippel 2011; Galati et al. 2015; Saguy & Sirotinskaya 2014); effectiveness of OI activities and practices (Tomlinson 2010; Dahlander & Gann 2010; Tomlinson & Fai 2013; Greco et al. 2015). Besides, other streams of research have taken into consideration the context of OI as for internal and external environmental characteristics (Harison & Koski 2010; Huizingh 2011), and for OI processes.

A complex network of knowledge flows between firms emerges, that needs to be managed and affects the internal choices of the start-up company. While several existing studies have examined the impact of partnerships and networks on the decision to start a new venture (Vissa 2012) and on the outcomes of entrepreneurial processes (Chang 2004), a research gap still exists regarding the mutual influence between the start-ups management decisions and open innovation processes.

Despite this connection, the results produced by this field of research have scarcely been analysed. How and if startups adopt open innovation practices, and how do they manage the knowledge flows among different partners are still an unresolved question.
The aim of this paper is to fill this gap through a review of the literature on startups and open innovation (Pittaway et al. 2004; Rousseau et al. 2008), in order to move forward the field of research on startup and open innovation.
To do so, we review and analyse papers published on startups and open innovation on Web of Science – Social Science Citation Index, Emerald and Elsevier's Scopus. We analyse the literature by providing an overview of the different points of view that authors adopted in conceptualizing open innovation in the startups domain. We develop a frame by structuring the analysis in domains consolidated in the open innovation literature: the startup ecosystem and the role of actors in the network, Knowledge flows management in OI, and performance fostered by OI.

This study aims to enhance our understanding of the relationship between startups creation and management on the one hand and open innovation on the other. Such a review can produce valuable knowledge for both managers and policy decision-makers.

Methodology

The study was designed to provide an explicit method for the review (Pittaway et al. 2004; Rousseau et al. 2008). The aim was to select and analyse relevant papers, which dealt at the same time with both themes: startups and OI. Through this study, it was possible to provide a description and an evaluation of the current body of knowledge on the intersection between these two topics.

The following steps have been taken (Pittaway et al. 2004):
(1) The authors identified keywords on the subject based on a preliminary review of the literature and using a form of brainstorming. The keywords included, for example "Open innovation, "startups", "distributed innovation", "networked innovation", "new venture".

(2) The keywords were constructed into search strings. For example, the search string [("start up*") OR ("new venture*") AND (("open innovat*") OR ("network* innovat*") OR ("distributed innovat*"] was the first string used for finding citations.
(3) An initial search of Google Scholar was undertaken using the search string above to identify further keywords for the main search. Additional words, such as early-stage company, inter-organizational innovation, emerging enterprise were added to the search terms.
(4) The basic search string "open innovat?" AND "startup*"was used in three search engines, Web of Science – Social Science Citation Index, Emerald and Elsevier's Scopus, to identify the key citation index for the review. This was chosen based on the volume of citations relevant to the basic search string. The chosen engine was Elsevier's Scopus.
(5) The citation database chosen, Scopus, was reviewed using the search strings identified in steps (2) and (3). These search strings were progressively analysed from the most basic to the most complex. Using the final string 365 citations were obtained.
(6) Inclusion and exclusion criteria were identified (Appendix 1). The logic adopted was to include all the papers that deal at the same time with both the topics, startups and OI, even if the two topics did not assume the same relevance in the paper. The term startup and other search terms used to identify papers about new ventures (like entrepreneur and derived terms) are commonly used to address also other phenomena. For example, entrepreneurship is an individual disposition investigated in several studies. Therefore, exclusion criteria were introduced in order to exclude these papers systematically.
(7) The citations identified were reviewed according to the inclusion and exclusion criteria. Two stages were undertaken to reduce the number of citations. The first analysed the titles and keywords of articles according to the inclusion and exclusion criteria. The second analysed the abstracts of the articles, which were judged potentially interesting in the previous step, in order to check their actual compatibility with the inclusion and exclusion criteria.
(8) The reviewers crosschecked the reference sections of the included articles to assess the search strategy.
After steps (1)–(8), 41citations remained. These 41 articles represent the material used for the review.
The 41 papers were analysed in order to identify frequently addressed issues. These issues were then organized into themes and the results obtained for each theme were summarized and discussed. More precisely the following steps describe the data analysis methodology:
(9) A report structure was identified. The report structure had the aim to guide the analysis of the papers by different reviewers. It indicated the main information to be collected.
(10) A report was written for each paper by each of the authors separately, according to the report structure identified in step (9). In particular, the main topics dealt with in the papers and the main results were reported.
(11) Based on the topics identified in step 9, each author defined a list of relevant topics. The initial lists had a number of topics ranging from 7 to 14.
(12) The reports were circulated among the authors and each author made comments on the others' reports and list. The process continued until convergence on the contents of the papers was achieved.
(12) Also, the lists of topics were circulated and when possible the number of topics was reduced in order to obtain as small a number of themes including homogeneous topics as possible.
(13) Articles were reviewed once again and sections were written as the articles relevant to a particular theme were reviewed.

Data analysis methodology

As for the typology of the methodological/scientific approach adopted in the 41 publications that have been selected, we considered three aspects: data analysis methodology, characteristics of research topics exploration, and data mining techniques (Leonidou et al. 2010; Furrer et al. 2008).

Data and content analysis

We have found that in 23 papers out of the total of the 41 analysed papers, scientific/technologic data/information have been gathered through surveys or interviews (56%); in 9 papers data have been collected from single case studies(22%); in 5 papers data have been extracted from databases (12%); in 1 paper a mix of data from interviews and databases has been obtained. In the remaining 3 papers, information has been derived from the literature analysis, or based on real option approach or on simulation approach. As more than half of papers have made use of surveys, while only 5 papers have had the opportunity of obtaining data from structured databases, it is possible to infer that the topic is relatively recent and that it would be necessary to dispose of an ad-hoc database. In that case, specific variables and dimensions would allow analysing the role of OI practices, which have been put into use by startups.

Finally, as for the research typology of papers, 24 papers out of 41 had the goal of developing a new theory, and 16 papers out of 41 had the aim to test one or more hypotheses by means of a confirmatory approach. Only one paper made use of both approaches. The analysis reveals that the topic "startups and OI" is a subject that generates interest not only in the identification of new theories and in the exploration of new innovative branches of knowledge, but also in testing and confirming the most established theories.

From merging data collection methodology with research design methodology, excluding from the analysis the paper that made use of both new theory and confirmatory approaches, it comes out that there is an equal number of developing theory papers and of confirmatory papers, based on interviews or surveys (11 to 11) (Table 1). Moreover, descriptive papers, based on case-study research design type, revealed to be strongly new-theory-oriented (7) and 2 papers, based on case-study approaches, have tried to confirm existing theories by means of specific field-study analyses. In addition, out of 5 papers, based on statistical data extracted from databases, 3 papers have focused on confirmatory approaches, and 2 papers on "developing new theory" research design type. This confirms the fact that researchers are tackling the exploration of the theme "startups and OI" also by means of quantitative analyses, considering the theme still in progress both from the theoretical/conceptual and practical/managerial points of view. The 3 papers, which used a confirmatory approach and have not made use of input data, along with the only 1 paper that has utilized mixed data from interviews and databases, are based on developing new theory method.

	NEW THEORY	CONFIRMATORY
SURVEY/INTERVIEWS	11	11
CASE STUDY	7	2
DATABASE	2	3
Other	4	0

Table 1 – Data collection and research design methodologies

By considering a content analysis of the characteristics of the selected manuscripts, the following aspects can be highlighted (Table 2).

There is no a majority among the different natures of articles. There is a very similar number of papers that are conceptual, methodological and empirical. They account for a third of the total. The only paper that belongs to a different nature is a review paper.
Moreover, a qualitative methodology (61%) of data analysis was employed in 25 papers out of the 41 papers; a quantitative methodology (37%) was used in 15 papers, while in only 1 paper a mix of quantitative/qualitative has been employed.
The target audience for the majority (58%) of the articles was the academic community, as opposed to 27% that was purely targeting business practitioners. The remaining articles (15%) focused equally on both academics and practitioners.
Finally, as explained above, the vast majority (56%) of the paper adopted a survey approach. Case study papers accounted for 22%, while only few database papers (12%) were published. The remaining papers (10%) had a mixed methodology or a not clear study approach.

	TOTAL (n=41) %
STUDY METHODOLOGY	
Case study	22%
Survey	56%
Database	12%
Not available	10%
NATURE OF ARTICLES	
Conceptual	37%
Methodological	29%
Empirical	32%
Review	2%
RESEARCH DESIGN	
Qualitative	61%
Quantitative	37%
Both	2%
SCOPE OF RESEARCH	
Academic	58%
Practitioner	27%
Both	15%

Table 2 – Manuscript characteristics

Research topic exploration

The keywords proposed in each of the papers reviewed for this study have been collected to illustrate the topics studied in the papers (Figure 1). Figure 1represents a cloud, where the dimension of the characters of the keywords is proportional to the number of times each keyword appears in all the selected papers. From the cloud information, it is possible to verify that several papers have few keywords in common, but a high number of keywords appear only in one paper. This depends on that research activity focused on the theme "startups and OI" does not focalize on any particular theme or a specific discipline.
The top eight keywords of the search - in order of importance - are innovation, network, technology, entrepreneurship, open innovation, venture capital, startups, and transfer. This shows that "innovation" and "network " are the most frequent keywords and illustrates the predominance of these two subjects in the theme "startups and OI". By itself, "innovation" is a well-established concept since the end of the past century (Drucker 1988; Christensen 1997), but its weight in literature has been strengthened by the addition of the word "open" which has made it gain the interest of researchers and practitioners quickly (Chesbrough 2003). As for the keyword "network", the word became popular since the beginnings of Internet and its use

has been gradually boosted in many fields where cross-relationships have become a usual way of connection and information exchange, also highlighting the increasing relevance of social capital. Indeed, it is not for nothing that the concept of relationship is embedded also in the other more frequent words that appear in the cloud, such "alliances", "corporate", "entrepreneurship", "firms", "social". Then, the frequency of the keyword "technology" can be taken for granted, given the fields of the selected research works.
A further observation must be made for the keywords "startups" and "open innovation": the former shows a frequency greater than the latter. This depends on the fact that the word "startups" refers to a particular stage of an enterprise, univocally intended and used, while "open innovation" is a concept to which researchers have often referred by making use of synonyms or expressions.

Figure 1 - Cloud of the keywords

Descriptive analysis

As highlighted in Figure 2, the literature review appears to be quite scattered on several journals, some of them containing multidisciplinary topics. The top four journals in terms of coverage that have contributed to this work of review and have illustrated research design types focused on "startups and OI" are Technovation, International Journal of Technology Management, European Planning Studies, and Strategic Management Journal. In addition to these journals, review articles on "startups and OI" have been sourced from other 21 journals that publish works about innovation management, technology management, organizational behaviour, entrepreneurship and business, marketing and strategic management, economic and regional geography, besides a number of fields within social sciences. These results show that there is a growing interest in the theme of "startups and OI" and that this subject is strongly multidisciplinary.

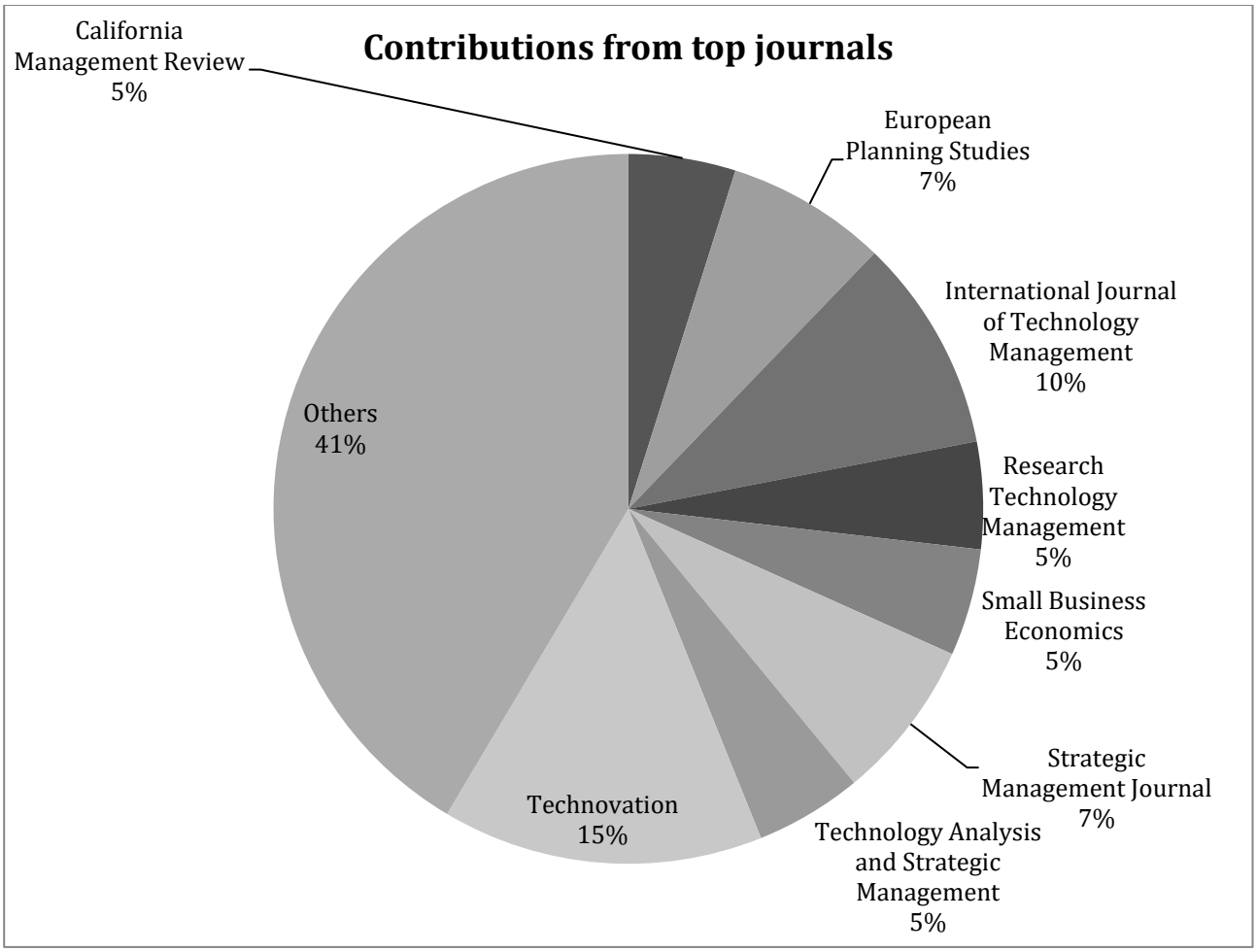

Figure 2 - Contributions from top journals

The reviewed papers are also analysed according to the countries that feature within studies (Figure 3).

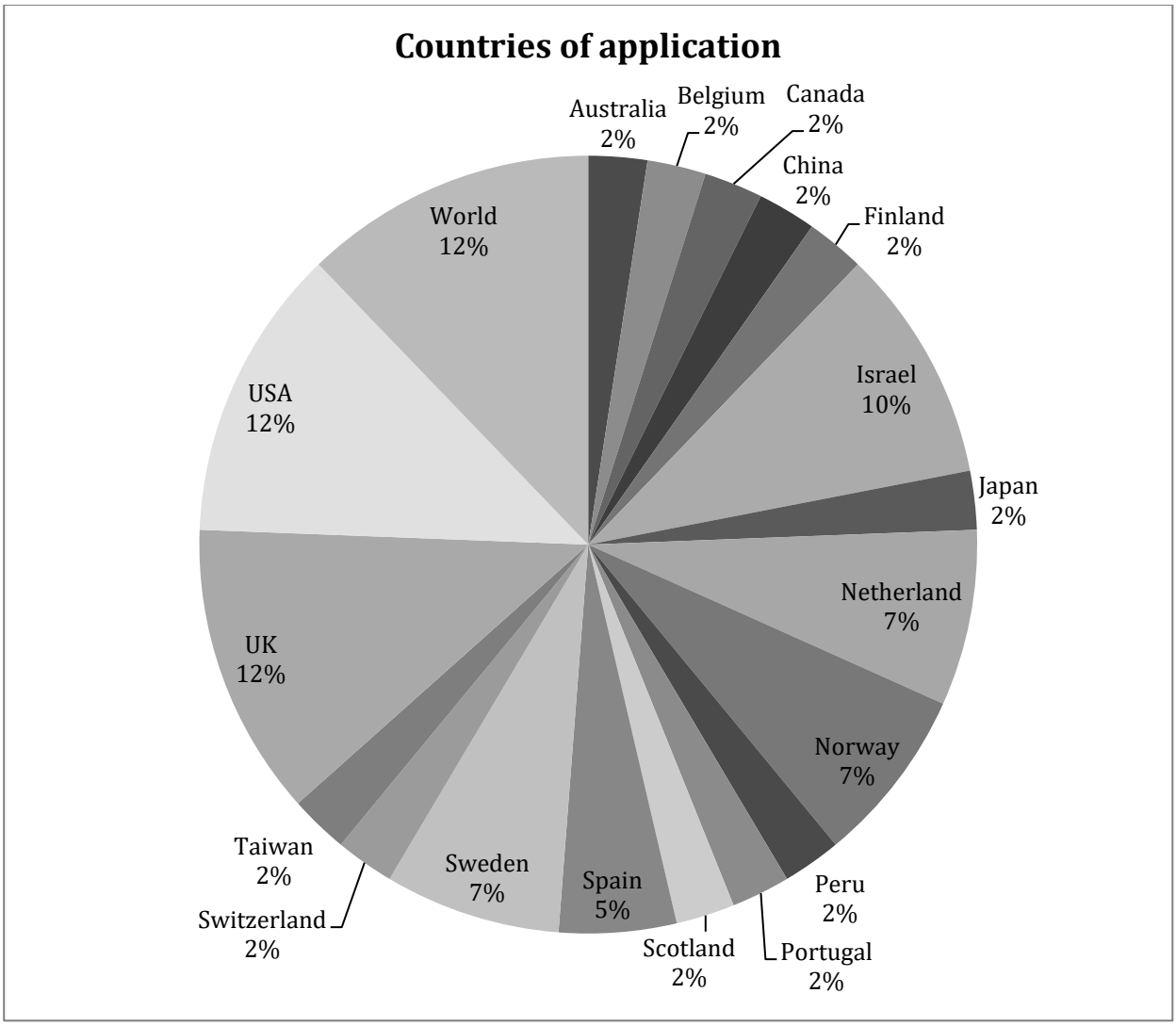

Figure 3 - Countries of application

When the year of publication is considered, analysing the frequency of the retrieved papers makes clear that this subject of study and the evidence base is relatively recent (Figure 4). Up to 2002, only three papers has been published on the theme "startups and OI"; this is not a consequence of the fact that Chesbrough has sanctioned the expression "Open Innovation" in 2003, as in the query also synonyms of the term "open innovation" have been input. We have made this choice in order to avoid the case of skipping contributions antecedent to the introduction of the expression "Open Innovation" by Chesbrough (2003). Further, for the period comprised between 2003 and 2008, the data show a shortage of papers. As of 2009, our search retrieved at least 3 papers/year on the topic of our interest, with a maximum value of 6 papers, and a higher expected value of the selected paper in 2015. The topic is well entrenched by now and calls the attention of several researchers.

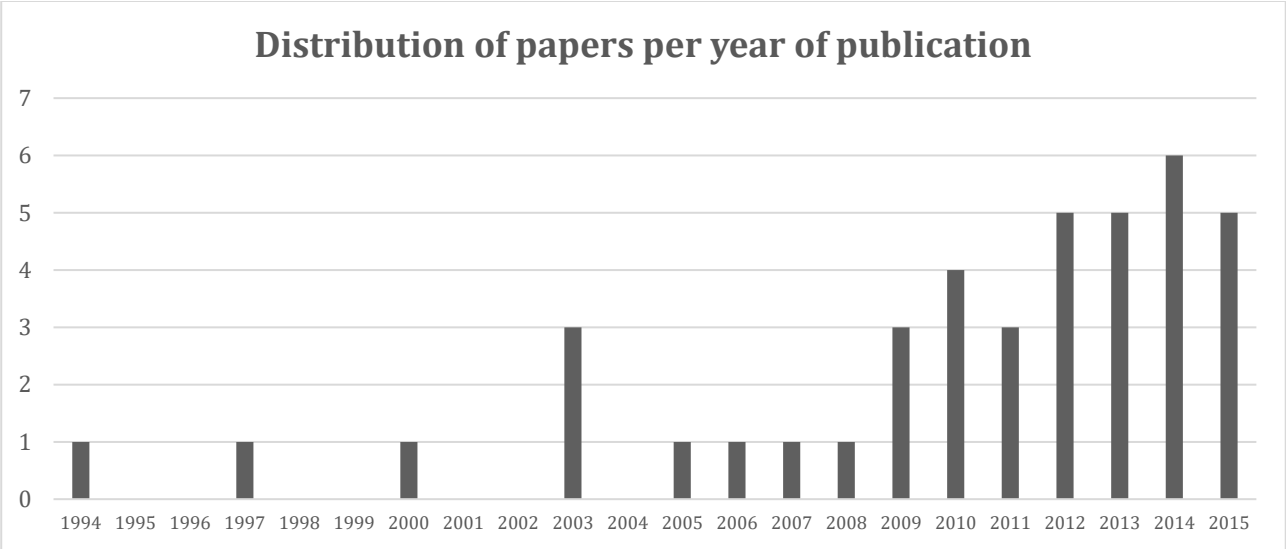

Figure 4 - Distribution of papers per year of publication

In summary, from the examination of evidence base, it can be concluded that the topic under analysis feels the effect of the short time of investigations. This is demonstrated by descriptive-qualitative/quantitative types of research methods adopted in almost all the selected papers, where interviews, observations, and reviews have been frequently used. Therefore, in order to improve and expand the subject area of "startups and OI" there is a need to tackle its exploration by means of the scientific support of a remarkable number of academic and non-academic researchers over a prolonged period of time.

Results

This section presents the results of our analysis on startups and OI based on the full texts of the 41 papers selected for this review.

Theme 1: The role of startups' networks

In the Open Innovation literature, networks have often been considered as instrumental to the success of innovation processes (West & Gallagher 2006). They have been considered instrumental either to the acquisition of resources (e.g. knowledge or financing) (Soetanto & van Geenhuizen 2015) or to the introduction of new products in the market (Lundberg 2013). For startup companies as well as for other actors involved in innovation processes it is important to understand how the structure and processes of the network affect their own processes and outcomes.

The surveyed literature focuses on two main aspects when discussing networks in the context of startups in Open Innovation:

1) The impact of quantitative/structural differences in the network on innovation processes and outcomes.

2) The impact of qualitative differences in a single organization's relations with the other actors on innovation processes and outcomes.

The role of structural aspects in startups' networks

According to La Rocca and Shenota (2014), networks are the locus of innovation. Innovation processes and network structure mutually shape each other: actors in the network define the requirements for new products or services, produce new artefacts, accept or refuse them and

in the process modify their relations. This phenomenon is especially relevant when considering new ventures, which necessarily change the structure and processes of the network when entering the market (La Rocca & Shenota 2014).

With reference to academic spin-offs, Soetanto and van Geenhutzen (2015) analysed the impact of the characteristics of the network on the ability of new firms to attract funding. They found that the four characteristics they studied (i.e. network size, density, the strength of ties a multiplexity) affect the ability to attract funding. The strength of ties and multiplexity, however, showed diminishing returns. Therefore the authors concluded that relationships tend to be beneficial as long as they are not too strong or too complex (Soetanto& van Geenhutzen 2015).

The impact of the structure of the network on startups' open innovation processes seems to be affected by contingent factors. Again van Geenhutzen and Soetanto (2012) in a study about networks in two different urban areas, observe that the structure of the network impacts on new ventures' job growth (Van Geenhuizen & Soetanto 2012). The relation between network structure and job growth, however, is complex. Contextual factors affect its strength and direction. Indeed, the authors found that "*while networks in Delft (in a large metropolitan area) tend to be stronger compared to those in Trondheim (isolated city), the influence of network strength on growth tends to be negative in Delft but positive in Trondheim*". Wang and Fang (2012) have found that network structure affects new firms' innovativeness. In particular, they studied the impact of startups' network centrality and cooperative network (i.e. strength of network ties) on innovative performance. The authors have found that network centrality positively affects innovative performance, while the influence of cooperative network is negative. Moreover, they found that when uncertainty is higher both the positive influence of network centrality and the negative influence of cooperative network are stronger.

Neyens and colleagues (2010) considered the impact of the duration of alliances on startups' innovation performance. They found that while continuous (i.e. long duration) alliances with customers, suppliers and competitors have a positive effect on startups' ability to generate radical innovation, discontinuous (i.e. short duration) alliances with customer, suppliers and competitors have a positive effect on startups' ability to generate incremental innovation (Neyens et al. 2010).

A relevant issue is the presence and relations of intermediary organizations, including technology service firms, accounting and financial service firms, law firms, and talent search firms. Zhang and Li (2010) have found that having relations with this type of organizations is positively related to new ventures' product innovation (Zhang & Li 2010). Intermediary organizations play a boundary-spanning role. Boundary spanners affect startups' network processes by pooling interest in new-ventures' innovation projects and by translating knowledge from different knowledge domains (Lundberg 2013). Venture Capitalists play an intermediary role as well. Strömsten and Waluszewski (2012) found that the structure of a Venture Capitalist's network "influences a start-up's possibilities to develop organizational and technical resource interfaces to critical counterparts such as suppliers and customers" (Strömsten & Waluszewski 2012).

Overall, according to the surveyed literature, network structure affects startups' innovativeness, job growth and ability to attract funding. While having a larger network, a central position and a balanced portfolio of long and short term relations, seems to have a positive effect, the strength and complexity of the relations in the network have a positive effect below a certain threshold but a negative effect above it (i.e. the relation is inverted U-shaped). Besides, the context, in particular, environmental uncertainty, affects the causal link between network structure and the considered measure of performance.

The role of qualitative aspects in startups' networks

If the number and strength of relations startups hold with other actors affects open innovation processes, no less important is the nature of these relations and the mechanisms used to manage them.

The study by Soetanto and van Geenhutzen (2015) cited above, for example, investigated quantitative aspects (e.g. network size and density) as well as qualitative aspects (e.g. multiplexity). As reported above multiplexity was found to reduce firms' ability to attract funding (Soetanto & van Geenhuizen 2015).

Kaufmann and Schwartz (2008) suggested that startuppers should receive formal training to develop their networking abilities (Kaufmann & Schwartz 2008).

Sharif and Tang (2014), in their study of Chinese university spinoffs, analysed the different institutional models regulating the relations between universities and startups. They found a great variety in the institutional models adopted by different groups of universities and startups. In general, however, the relations are managed top-down, with the university playing the leading role (Sharif & Tang 2014).

In a study based on data from 56.611 entrepreneurs in 61 countries, Schott and Sedeghat (2014) found that not all the types of network relations were useful. In particular while public networking (i.e. networking with colleagues, institutional and international actors) improved innovativeness, private networking (i.e. networking in the personal sphere, with family and friends) had a negative effect. In particular, "networking in the professional area" and "international relations" have a positive effect on innovativeness (Schott & Sedaghat 2014).

Startups' networks evolve in time. For example, in the case of academic spinoffs, they involve mainly academic partners in the early stage of the firm's growth, while later there is a shift towards customers (Pérez Pérez & Sánchez 2003).

Chesbrough's study of GE's experiment with startups, Ecomagination Challenge, proves that not all the links with startups are fructuous and that relevant relationships between large incumbent firms and startups need to evolve from simple links to complex relations in order to be beneficial for both parties (Chesbrough 2012).

Overall the literature focusing on qualitative aspects of the relations in the network underlines the importance of two factors: the actors involved and the evolution of the relations in time. Startups and large companies need to adapt their network strategies when dealing with different actors and in different stages of their relation.

Theme 2: The Actors interacting with startup's in Open Innovation processes

As depicted in the section about "Networks", opening up the innovation process implies the involvement of startups in relationships with different typologies of actors. Scientists widely studied this phenomenon, and the following actors emerged from the literature analysis:

- Incubators;
- Large Corporations;
- Venture Capital firms;
- Higher education systems;
- Others.

Incubators

A (business) incubator is a company that helps new and startup companies to develop by providing services such as management training or office space. Incubators can be sponsored and managed by different organizations, and the literature on startups and open innovation focalized the analysis mainly on three typologies of incubator: technology incubator (Kaufmann & Schwartz 2008), industrial incubator (Clausen & Rasmussen 2011), and university incubator

(Rubin et al. 2015). Each of these papers focalized the analysis providing evidence on how to stimulate innovation processes all along the lifecycle of a startup, from the pre-seed stage until the commercialization stage.
Kaufmann and Schwartz (2008) revealed in their analysis the failure of a technology incubator in Israel in assisting entrepreneurs in forming a strong initial network, putting evidence on the importance of the networks in the development of (biotechnology) firms.
Rubin et al. (2015) highlighted the importance of a technology business incubator in stimulating the innovation process by creating a bridge between market failures of new ventures (due to the fact that they lack managerial experience and ability to raise capital at an early stage) and improving access to capital at a firms early stage. They conclude by opening two questions about the role of universities in the startups lifecycle: first, university play a modest role as a source of new ideas for incubators and incubatees, and secondly universities play an important role in the later stages of incubatees' new product development processes.
In the public co-sponsored industry incubator, Clausen and Rasmussen (2011) evidenced three different goals of the incubator as a vehicle of knowledge transfer from large firms to society: (1) stimulate innovation and entrepreneurship in the form of new ventures; (2) stimulate innovation in the mother companies; and (3) stimulate innovation more generally in society. Conclusion remarks underline the role of a publicly co-sponsored industry incubator as a programme to commercialize knowledge within corporations that suffer from structural inertia.
Finally, Rothschild and Darr (2005) examined the intermediation role of incubators under a new complex model of innovation, a cyclical model of innovation management, where knowledge and know-how flow back and forth, via social network, in feedbacks loops throughout the entire process of innovation.

Large corporations adopted different mechanisms like corporate venture capital, internal incubators, strategic alliances and joint ventures to collaborate with startups and new ventures or to create new spinoffs or spinouts. The growth and increasing viability of startup firms, and their attendant disruption, create a new imperative to develop more agile, rapid means for large companies to engage with the startup community. Anokhin et al. (2011) studied the strategies large corporations should adopt to maximize the trade-off between the number of ventures and the position they take in their syndication networks. Since most corporate investors require at least one non-voting observer seat on a new venture's board, the interaction that inevitably occurs in their meetings make the boardroom a de facto forum for information exchange. Weiblen and Chesbrough (2015) reported four different models that corporations can employ to engage with startups successfully, focalizing on two new models that appear to have their own strengths: outside-in and platform startup programs. Minshall et al. (2010) move their attention on the specific challenges small firms such as startups need to manage in a partnership with a larger firm that brings this into an asymmetric partnership. The challenges increase when one partner is a commercially inexperienced startup attempting to exploit a novel technology at a low level of readiness, and the other partner is a long established, complex organization with operations spread over multiple business areas and geographic locations. They ended up with a management guidebook-based approach for addressing startups and large firms towards beneficial partnerships.

Venture capital firms

Venture capital firms (VC) are typically structured as partnerships, the general partners of which serve as the managers of the firm and will serve as investment advisors to the venture capital funds raised. VC are recognized as disseminators of knowledge since it provides a network of relationships including financial, commercial or technology-based contacts. The

literature on startups and open innovation highlighted the role of VC as a vehicle able to transfer experience and knowledge between new firms and establish contacts with third parties.
Ferrary and Granovetter (2009) studied the success story of the Silicon Valley, and their analysis reported how the venture capitalists usually use to invest in the seed stage than in the pre-seed stage, when considering successful startups. In addition, they illustrate the role of the venture capital as a creator of potential specific interactions with other agents in the network that determine a particular dynamic of innovation.
Stromsten and Waluszewski (2012) reported the role of VC as investors in entrepreneurial firms perceived as having potential but also high risk. VCs' governance mechanisms, adherence to a tight time schedule, and eagerness to eliminate uncertainties can "get a better sense of the risks [...] set clear goals and timelines [...] communicate clearly [...] and think critically about financial and product market cycles".
Finally, Pinch and Sunley (2009) highlighted the role of VCs as disseminators of knowledge in the cluster of high-technology businesses that have spun off from research undertaken at the University of Southampton UK. The interest is in the ways in which the 'know-how' possessed by VCs is passed on to their investees: while entrepreneurs possess more detailed knowledge of their technologies and an in depth understanding of the strengths and weaknesses of their startups, VCs typically possess more knowledge about financing opportunities and business development strategies. Therefore, VC information may be valuable to new venture team managers because VCs bring a variety of experiences with them from earlier investments.

Higher education system

An open innovation ecosystem for startups is not complete without the role played by Higher Education System (HEI). HEI are an important source of knowledge, and as competitiveness became dependent on knowledge, ideas and creativity, HEIs became crucial for economic development.
Simões et al. (2012) analysed the role of HEI as an intermediary bridging the gap between producers and consumers of knowledge since they possess staff and various research units that can help venture startups and young entrepreneurs to identify opportunities, mobilize resources and create an organization. In their analyses realized in Portugal, a set of internal and external factors of HEIs that stood out as being able to influence venture creation within innovation networks are proposed. The most interesting one is the role of HEI as a "network actor" that incentives and energizes the diverse elements to integrate into an innovation network, that promotes knowledge sharing and that supports nascent entrepreneurs at the various stage of venture creation.
On the same advice are Minshall et al. (2007), where their study reported the case of the Cambridge Display Technology and the role played by University of Cambridge. As universities should develop the so called 'third mission' to supplement their traditional missions of research and teaching, the activities to be developed by universities includes faculty consultancy, licensing of university IP to established firms, building of spin-out ventures around university IP, and the support for the creation of student and faculty-led startup ventures.

Other actors

In the open innovation context, there exist actors other than the ones previously described that interact with startups but that currently receive less attention by the scientific literature as evidenced in this review. Autio (1997) underlined how *customers* can be an important source of technological know-how for new, technology-based firms (von Hippel 1986; von Hippel 1988; von Hippel & von Krogh 2003). The customer becomes increasingly involved in the transaction as a co-producer of value. *Communities* are another relevant actor to be considered

in the discussion as highlighted in Waguespack and Fleming (2009). In this case, endorsements from high-status third parties further serve as a form of free advertising, which, in turn, leads to relationships with additional high-status actors. Finally, Collinson and Gregson (2003) and Zhang and Li (2010) explore two similar organizations supporting innovation networks for new ventures creation. Both researches concluded examining the role of ties with service intermediaries and organizations established to promote new business startups in new venture innovation. This increases the opportunities for the required fusion of entrepreneurs' ideas, complementary technical and market knowledge, managerial knowledge and finance. Such organizations are helpful to integrate capabilities of new ventures to search, filter and integrate knowledge from a huge variety of sources.

Theme 3: Startups' Ecosystems and their impact on Open Innovation processes

Startups ecosystems are groups of organizations (including new ventures, universities, venture capitalists, public administrations and others) interacting to create and facilitate the success of startup companies. The term is sometimes used as synonymous of network. Here, however, we refer to Ecosystems as the overall milieu in which startups operate: this context includes actors to which startups are not necessarily linked through neither direct nor mediated relations if not in a very abstract sense. For example, public policies are undoubtedly an element of an Ecosystem, but it would be misleading to say that policymakers as such are part of a startup's network.

The financing system

One way in which other organizations create the right context for the creation and growth of new, technology-based firms is the facilitation of access to financing. In this respect banks, venture capitalists and governments are actors able to shape the Ecosystem. The presence of an active and efficient system of venture capital is often considered among the main reasons for success for a startups' ecosystem (Ferrary & Granovetter 2009). In a simulation-based study, Vitali and colleagues found that ecosystems, in which banks collaborate with startups, are characterized by lower mortality and higher productivity of new firms and, as a consequence, higher returns and lower risks for banks (Vitali et al. 2013). The surveyed literature suggests that public financing is important for startups, but presently public programs do not meet the financing needs of startups. In particular, according to Brown and Mason, the model of startup public programs are based upon (linked to universities, financed by venture capitalists, based on protected intellectual property) seems to be a stereotype not supported by empirical data (Brown & Mason 2014).

The knowledge creation and diffusion system

A second relevant aspect of a startup ecosystem is the presence of intellectual resources and the mechanisms of knowledge production and diffusion. Several organizations contribute in facilitating the creation of new knowledge and its transfer to and from startups. Venture Capitalists (Ferrary & Granovetter 2009), incubators (Clausen & Rasmussen 2011) and other boundary spanners (Lundberg 2013) transfer from startups to other actors (and vice versa) and translate it in the process. Venture capitalists and intermediaries also contribute on the efficiency of the ecosystem by selecting, mentoring and championing startup projects (Ferrary & Granovetter 2009). Also large corporations, through corporate venture capital programs, contribute to knowledge production and diffusion (Napp & Minshall 2011). Universities are often considered the main source of knowledge for new, technology-based firms. They provide knowledge about new technologies, but also on markets, legal and financial aspects even if seldom startuppers get their ideas form their academic environment (Rubin et al. 2015). According to Frenkel and colleagues, an ecosystem including diverse technologies encourages

the creation of startups (Frenkel et al. 2015). In order to effectively exchange knowledge, both formal and informal relations among the actors in the ecosystems are important (Padilla-Melendez et al. 2013).

The governance system

The capacity to facilitate startups' creation and growth is influenced by the (formal an informal) governance system regulating the ecosystem. In a study of startups ecosystems in China, Sharif and Tang observe that several governance models exist. Most of the ecosystems the authors considered were based on a top-down model in which large organizations like universities or governmental authorities regulated the interactions among the actors. However, bottom-up approaches, with the startups playing an active role are becoming more and more common (Sharif & Tang 2014). Indeed, in their study of university spin-offs, Minshall and colleagues found that spin-offs actively build and control networks of partners in the ecosystem (Minshall et al. 2007). Venture capitalists also play a role in the governance of the system, not only through mechanisms linked to their financing role, but also through informal relations (Ferrary & Granovetter 2009; Strömsten & Waluszewski 2012).

Summarizing the surveyed literature stresses the importance of three aspects, which influence the functioning and performance of an ecosystem: the financing system; the knowledge creation and diffusion system and the governance system. All three sub-systems are facilitated by the presence of networks of formal and informal relations among the actors.

Theme 4: The Entrepreneurial dimension in startups' Open Innovation processes

Stiglitz and Driffill (2000) defined "entrepreneur" the person who creates new businesses, brings new products to market, or develops new processes of production. This is just one among the thousands of definitions literature produced to describe the phenomena of entrepreneurship. Our review analysed articles focalized on the role of entrepreneurship for new venture creation in an open innovation arena. The entrepreneurial process in the open innovation era consists of distinctive activities such as the identification of opportunities, the mobilization of resources and the creation of an organization. Acquiring external scientific, technological and entrepreneurial knowledge is crucial for developing new combinations as well as for the success of entrepreneurial ventures. As this is the main aim, we categorize the literature reviewed into three categories: "*prior entrepreneurial experience*", "*entrepreneurial social capital*" and "*entrepreneurial policy*".

Prior entrepreneurial experience

Prior entrepreneurial experience is one component to explain entrepreneurial behaviours of new companies' entrepreneurs. Entrepreneurs launching new ventures often lack managerial experience. Kaufmann and Schwartz (2008) through a field research realized in the biotechnology sector, assumed that the entrepreneurs who turn into incubator are those with less business experience. Results confirmed this assumption in the way entrepreneurs who participated in a program incubator revealed a relative inferiority with respect to their management experience, managerial seniority with entrepreneurs who did not make use of the incubator. Simões et al. (2012) also revealed from their field research how spin-offs whose founding academic entrepreneurs participate in outside consulting arrangements with industry are more likely to commercialize their technology. On the same advice is Hayter (2013), who theorized how prior entrepreneurial experience positively influences the propensity if the nascent entrepreneur to create new firms. Moreover, previous experience in the sector has a significant and positive effect on nascent entrepreneurs' propensity to create firms.

Entrepreneurial social capital

Social capital is another interesting way to analyse the ability of nascent entrepreneurs to keep advantages from the open innovation opportunities. What happens is that the entrepreneur is not acting alone but together with others, and thereby the entrepreneurial activity is embedded in the network around the entrepreneur. This means the ability to manage the network as a result of the social capital embedded in the entrepreneur (or in the entrepreneurial team). Kaufmann and Schwartz (2008) assumed that entrepreneurs who come into incubators have a lower level of social capital. Results confirm this assumption and, later, Schott and Sedaghat (2014) go in depth analysing how entrepreneurial social capital influence the ability of new entrepreneurs to innovate. Results of the analysis revealed how networking in the private sphere has a negative, albeit small, effect, whereas substantial benefits for innovation are obtained by networking in the public sphere. In a field study in the open source sector (OSS), Gruber and Henkel (2006) reported how active participation in an open innovation process (OSS) gives firms visibility towards potential customers, helps to build a technical reputation, and allows them to overcome capacity limitations by recruiting outside development support.

Entrepreneurial policy

Finally, the "entrepreneurial policy" theme covered almost all the previously described aspects. If previous entrepreneurial experience and social capital are elements cited in the literature as crucial for new entrepreneurs, policies should be directed in order to improve these abilities. In this sense, Hayter (2013) evidenced how policies and programs designed to spur academic entrepreneurship should establish and strengthen managers, support services, potential customers, and a variety of innovation sources to improve commercialization and innovation. This is a critical task also highlighted in Brown and Mason (2014), where they denote how typically policy efforts are directed towards knowledge generation aspects, neglecting the crucial role of knowledge exploitation and networking aspects or "entrepreneurial ecosystem". Moreover, they also denounce how policy makers focus on high-tech firms "as a priority" when other sectors might pose better opportunities.

Theme 5: The role of financing and financing institutions

The most frequent type of financial support that have been found in the papers, selected for the theme "Financing" are the following: "*Venture capital (VC) and corporate venture capital (CVC)*"; "*Funding relationships between University and startups/spin-offs*"; "*Strategic partnership complementary to capital (market) financing*". Beyond the well-known economic meaning of VC and CVC, it is worth pointing out that the last two methods represent the most recurrent financing choices of funding open innovation in startups in order to overcome uncertain economic conditions. The selected papers have been clustered into the three sub-themes hinted above.

Venture capital (VC) and corporate venture capital (CVC)

As for the first sub-theme, Pinch and Sunley (2009) have studied the role of VC investors as supporting high-technology agglomerations. By means of an in-depth qualitative survey conducted in the UK, the authors found that VCs could have an important role in balancing differences between innovative technologies and commercial technologies. Indeed, abilities that are needed so that innovations are successful in the marketplace are different from the academic point of view about funding and prestige. Therefore, VC can actually support the commercialization of innovation. Moreover, the results suggest that the system of financial support for technology startups should be improved. In the same vein, Ferrary and Granovetter (2009) have tried to understand the role of funding agents, and among them the VCs, to support

creation and development of startups. By analysing the Silicon Valley innovation system through the complex network theory, the authors have highlighted that the complete system, which determines a particular dynamic of innovation activities, is supported by networks of VC agents. These establish specific positive interactions with other agents in the network (universities, large companies, laboratories) that are likely to create future innovation ventures. About the same sub-theme, a further study by Anokhin et al. (2011) has investigated the effectiveness for corporate venture capital (CVC) to participate in networks of large firms. Data for this study were collected using a data set of investment decisions made by 163 corporations over four years. The dataset has been analysed to verify the effect of network centrality and investment intensity on innovation performance. The analysis has suggested that corporations need to consider the trade-off between the number of ventures they support and their position in the networks. The best strategies appear to be those that support many ventures from outside the network centre or those that support few ventures but occupy a central network position. Continuing on the same sub-theme, Chesbrough (2012) has given empirical evidence to how a large corporation can build a community and how to establish a challenge to lead a number of new startups being funded not only by its own support, but also by VCs. Indeed, the author observes that VCs have a different conception of the market and might recognize opportunities that internal people may fail to catch. By describing the case study of General Electric Ecomagination Challenge, the author has analysed a best practice of a challenge that created processes and structures to make sure that at least some investments would pay off for the company. In regard to the same subject, Stromsten and Waluszewski (2012) have explored how VC ownership and governance influence the innovation process when relationships and networks are critical contextual factors. The authors have analysed the interface between innovation and corporate governance and in particular, how resources interact in industrial networks. The results revealed that the relationship between a VC and a startup company is embedded in a wider network and, therefore, needs deeper recognition. Moreover, it resulted that the governance of the VC spreads in the surrounding network and influences startups' possibilities to develop organizational and technical resource interfaces to critical counterparts such as suppliers and customers. Finally, Weiblen and Chesbrough (2015) have examined how large corporations from the technology industry can engage with startups and tap into their entrepreneurial innovation. The authors have showed that in addition to the two traditional methods of CVC and corporate incubators, there are other two new models of engaging with startups: inside-out platform startup programs and outside-in startup programs. In the former, startups are mere executors of the technology supplied by those corporations that want to enlarge their own markets. In the latter, the corporation acts as an incubator for the startups and fosters mutual learning, in the hope to earn more than if it depended only on its own assets.

Funding relationships between University and startups/spin-offs

The second sub-theme concerns "*Funding relationships between University and startups/spin-offs*". Wouters (2010) has hypothesized conditions under which value-based agreements on real options reasoning can be applicable. Two case studies are examined to provide empirical support for these hypotheses and helped to explain why value-based arrangements were found in the first case, but not in the second one. Indeed, the latter case, an R&D company in the nanotechnology field, founded in 1999 as a university spin-off, showed how there can be commercial uncertainty because very innovative technology hampers the development of customer value proposition. Moreover, Soetanto and van Geenhuizen (2015) have analysed the ability of the spin-offs in attracting funding for research and development and, in particular, how the relationships of academic spin-off firms with their parent university influence their ability to attract funding. By studying a sample of 100 academic spin-off from Netherlands and Norway, the authors found that the ability to attract funding has an association with having a

dense, strong, and complex network with university network. Moreover, they confirmed that maintaining a significantly strong relationship with the university might reduce the time and effort allocated for exploring external resources outside the university. Nevertheless, a relationship is beneficial as long as it is not too strong or not too complex.

Strategic partnership complementary to capital (market) financing

Coming to the last sub-theme, "*Strategic partnership complementary to capital (market) financing"*, Minshall et al. (2010) have pointed out that an opportunity for the implementation of OI strategies can be generated by "asymmetric" partnerships, which can provide both startups and large firms with economic advantages. The study was conducted on the base of semi-structured interviews with representatives of large firms, startups, and investors in order to know the diverse challenges. Many approaches have been identified by both startups and large firms to meet asymmetric partnerships and firms have found to overcome many of the defined management challenges. As any approach has not received a complete approval, it has been recognized the need for a further in-depth analysis. Vitali et al. (2013) have aimed at analysing the relationship between smart growth and innovation to understand how identifying external funds for innovative entrepreneurs. The authors, following the agent-based computational economic approach, have assessed how internal and external financing impacts on overall economic growth and innovation adoption thus finding that collaborative companies have the highest positive impact on the economic system. Finally, Fujiwara (2013) has examined the difference between license-fee elements and has tried to determine the innovation valuation in strategic partnerships by using the real option perspective for the valuation of innovation partnership. The research was aimed at understanding if the adoption of strategic partnerships can be complementary to capital market financing. By making use of real option analysis, it has emerged that the main objective of the partnership is the establishment of a synergistic effect by different expertise partners in terms of cost efficiency, risk management capability, and favourite stage.

Theme 6: Performance of startups in an Open Innovation context

The analysis of the papers selected for the major theme "Performance" has allowed to group them into two sub-themes: innovation performance and organizational performance. Several authors have conceptualized the two expressions and from some of their attempted constructs we have extracted the few lines summarized here below.

Innovation performance is intended here as the relation existing between the definition of innovation and its application to the concept of performance, resulting in the quality and quantities of ideas and the efficiency and effectiveness of their implementation (Alegre et al. 2006). *Organization performance* is intended as the ability of the organization to achieve their goals by using resources in an efficient and effective manner (Lichtenthaler & Ernst 2008; Cohen & Levinthal 1990).

Innovation performance

As for the sub-theme *innovation performance*, Neyens et al. (2010) observed that alliances between startups and other firms to merge their complementary skills impact on incremental and radical innovation performance. The authors, by introducing a time dimension in the analysis of the alliance strategies (continuous or discontinuous) and assuming different partnership typology, demonstrated that results can vary markedly and have several implications on managerial practices in dependence of the variety of settings. They found that continuous alliances with competitors, university, and research institution affect radical innovation, while discontinuous alliance with suppliers, customers, and competitors affect incremental innovation. Also, the innovative performance is improved by a network centrality,

as Wang and Fang (2012) suggested in their research. On the other hand, they remarked that the cooperative network of a new venture evidenced a negative linear relationship with innovative performance. Again, results of their paper indicated that, in environmental uncertainty conditions, the positive relationships between the central position of a new venture and its innovative performance is heightened. Therefore, managers should be able to judge the industrial network critically, without counting on resources and information from relationships too much confidently.

Organization performance

The important role of managers in *organization performance* is underlined by Chaston and Scott (2012). Grounded on a robust theoretical and statistical base, the paper has examined the effects of entrepreneurial orientation and involvement in open innovation on the organizational performance of firms in Peru. The results have shown that there is a great accentuation on double loop learning among Peruvian organizations involved in open innovation. As for entrepreneurship practices, it seems that, in spite of some entrepreneurial behaviour, this concept is still not completely appropriate to the managerial activities in the emerging economies, and there is a need for developing research on management organizational processes. Equally important, in the paper by Hayter (2013), evaluations of the success of university technological spin-offs in terms of commercialization can be characterized as expressions of efficient organizational performance. He narrowed the focus on the so-called "credibility phase" (Vohora et al. 2004) of spin-offs development through and on the factors responsible for their organizational innovation performance toward commercialization. An accurate analysis highlighted several factors of ability and collaboration, related to entrepreneurship, university, firms themselves, and policy instruments. The assumption is that when a spin-off commercializes technology it does not only penetrate the knowledge filters, but it also signals its capability to contribute to economic development by means of the implementations of new ideas.

Theme 7: Knowledge stocks and flows in startups' Open Innovation processes

The analysis of papers selected for the theme "Knowledge" has allowed to cluster them into three sub-themes dealing with agents enabling assimilation of open innovation knowledge practices: knowledge transfer; knowledge-based entrepreneurship; knowledge incubators.
*Knowledgetransfer*means the interactivities of passing knowledge between two or more entities (Zander & Kogut 1995). *Knowledge-based entrepreneurship*is intended as the ability to discern or avail of an opportunity and act to fulfil an innovative knowledge practice or product. A *knowledge incubator* is an organization/agent that promotes the development of early stage ventures/startups through knowledge-based services.

Knowledge transfer

As for the sub-theme "*Knowledge transfer*", the new, technology-based firms (NTBFs) have been analysed in terms of the systemic knowledge conversion process to which they are related (Autio 1997). The author views NTBFs from the resource-based perspective as bundles of technologic resources. The model elaborated in the study suggests that it is possible to identify niches for NTBFs not only in terms of technologic dynamics in the industry sector but also in term of functional relationship with the process by which generic scientific knowledge is transformed into basic technologies and application-specific technologic knowledge.
The role of venture capitalists (VCs) as indirect facilitators of knowledge for startups in the cluster of high-technology businesses has been investigated by Pinch and Sunley (2009).In contrast with the previous study on the Internet industry, the authors did not find a parallel evidence of cluster-based infrastructure disseminating technical knowledge in their study area

(Southampton, UK). Here, VCs were not involved in spreading technical knowledge, and there is little evidence that they supply specialist and tacit knowledge via strong relational partnerships. The authors' results suggest that institutional support from VC require a careful attention to the continuing effects of information asymmetry.
The capability of social capital of empowering knowledge transfer and exchange (KTE) is described by Padilla-Malendes et al. (2013), who have analysed these activities verifying between higher education institutions and spin-off (academic and non-academic), in order to convert knowledge into innovation within regional innovation systems. Individual and institutional/organizational relationships (formal and informal), organized in a sort of virtuous KTE cycle, appear to be particularly important for successful innovation and KTE activities addressed to SMEs.

Knowledge-based entrepreneurship

The second sub-theme concerns the "*Knowledge-based entrepreneurship*". The paper by Karlsson and Warda (2014) is an "invited paper" showing a selection of the various contributions from many authors to the Uddevalla Symposium (June 14-16, 2013), all supporting the relevance of the role of scientific, technological, and entrepreneurial knowledge based entrepreneurship to local, regional, and national development. Many researchers underline the role of institutional arrangements (formal and informal) and the structure and the efficiency of innovation networks, where many actors involved in innovative production foster the circulation and creation of new knowledge. The continuous evolution of the innovation networks, and in particular of knowledge-based entrepreneurship, has contributed to change the geography of entrepreneurship. The increasing agglomeration economies and the diffusion of the benefits of the associated external economies will become key factors for entrepreneurship in the twenty-first century.
In this vein, Hayter (2013) focused his attention on academic institutions. It is known that universities produce knowledge and human capital. Recently, universities started promoting spin-offs to generate new innovations and job/prosperity for regional economics. The purpose of the paper is the exploration of success factors. These are examined by means of the Knowledge Spillover Theory of Entrepreneurship that helps to find knowledge "filters". Findings revealed that spin-offs with access and strong external linkage to new technologies, knowledge, ideas, funding, and management are more likely to commercializing their technologies compared those that are without.

Knowledge incubators

Coming to the last sub-theme, "*Knowledge incubators*", Clausen & Rasmussen (2011) have helped develop open innovation policies to foster innovation and entrepreneurship. The work is based on an empirical study of an industry incubator with public and private funding. By this research, the authors have found out that the main task of industry incubators is that of preserving, retaining, and transferring valuable knowledge from large industrial firms to society. Their study has also revealed that the social benefits of such innovation intermediation activities may be far greater than their private value.
A further perspective on the same sub-theme is put forward by Rubin et al. (2015) who have found out that there is a lack of in-depth studies that examine both the different knowledge produced by incubators and the nature of knowledge flows between these knowledge agents and incubatees. They have shifted the focus in the existing incubator research from the incubator outcome to the processes and interrelationships within incubators. Findings revealed the existence of three types of "knowledge bearers": technological knowledge, market knowledge, and financial resource bearers. An incubator interrelationship model is presented,

based on the Horizontal Strategy theory applied to both countries study cases, helping incubatees to be more competitive and faster to market with their products and services.

Conclusion

This review of the literature represents the first attempt to organize the scientific knowledge related to the intersection between the startups and open innovation phenomena. By using an explicit method for the review (Pittaway et al. 2004) we selected a set of papers, which cover the whole knowledge domain object of this study. At the same time, any scholar interested in verifying or expanding our study has been given the means to do so. As a consequence, this study represents a solid first step in building a map of the state-of-the-art knowledge of the "startups in an open innovation context" phenomenon (Table 3).

	Anokhin et al. (2011)	Autio (1997)	Baum et al. (2000)	Brown and Mason (2014)	Chaston and Scott (2012)	Chesbrough (2012)	Calusena and Rasmussenb (2011)	Collinson and Gregson (2003)	Ferray and Granovetter (2009)	Frenkelet al. (2015)	Fujiwara (2014)	Gruber and Henkel (2006)	Hayter (2013)	Hu et al. (2015)	Karlsson and Warda (2014)	Kaufmann and Scwartz (2008)	La Rocca and Senhota (2014)	Lundberg (2013)	Minshall et al. (2007)	Minshallet al. (2010)	Napp and Minshall (2011)	Neyens et al. (2010)	Nijkamp (2003)	Padilla-Melendez (2013)	Perez and Sanchez (2003)	Pinch and Sunley (2009)	Rotschild and Darr (2005)	Rubin et al. (2015)	Shan et al. (1994)	Sharif and Tang (2014)	Schott and Sedaghat (2014)	Simoes et al. (2012)	Soetanto and Van Geenhuizen (2015)	Stromsten and Waluszewski (2012)	Van Geenhuizen and Soetanto (2013)	Vitali et al. (2013)	Wang and Fang (2012)	Waguespackand Fleming (2009)	Weiblen and Chesborough (2015)	Wouters (2010)	Zhang and Li (2010)
The Role of Startups' network																																							
The role of structural aspects in startups' network			X														X	X				X	X								X	X	X		X				X
The role of qualitative aspect in startups' network						X										X								X				X	X	X		X							
The actors interacting with Startups in OI processes																																							
Incubators							X									X										X	X												
Large corporations	X					X													X																		X		
Higher education systems				X														X					X						X		X	X							
Venture capital firms				X					X																X								X							
Other actors	X							X																												X			X
Startups ecosystems and their impact on OI processes																																							
The financing systems				X					X																X							X			X				
The governance systems									X									X											X				X						
The knowledge creation and diffusion systems							X		X	X								X		X			X				X												
The entrepreneurial dimension in startups OI processes																																							
Prior entrepreneurial experience													X			X															X								
Entrepreneurial policy				X									X																										
Entrepreneurial social capital												X				X														X									
The role of financing and financing institutions																																							
Venture capital and corporate venture capital	X					X			X																X						X						X		
Funding relationships between university and startups/spinoffs																													X		X	X						X	
Strategic partnership complementary to capital (market) financing											X								X		X													X					
Performance of startups in an OI context																																							
Innovation performance			X								X											X						X								X			
Organizational performance					X								X																										
Knowledge stock and flows in startup OI processes																																							
Knowledge transfer		X																					X		X														
Knowledge-based entrepreneurship														X	X																								
Knowledge incubators							X																			X	X												

Table 3 – Synthesis of the reviewed literature

This study has implications both for future research and for managers and policy makers. The main implications of the study are described below.

Implication for research

The theme of this review is relatively new: most of the papers were published after 2009; several papers are based on qualitative studies with a theory building purpose. On the other hand, the interest of scholars is steadily growing, as shown by the analysis of the year of publication of the papers.

Directions for future research can be derived from the conducted analysis. Indeed, it appears that a refinement of the available knowledge is needed from a methodological, empirical and theoretical point of view.

From a methodological point of view, two observations need to be made:

1) Startups represent a temporary form of organization. Their very nature is provisional and dynamic. Longitudinal studies are needed to understand their role in open innovation processes. Indeed, some of the qualitative studies considered in this review adopted a longitudinal approach with interesting results. The implications of decisions or events in the early stages of a startup lifecycle for the results in later stages can be understood only through studies with a longitudinal design.

2) The theme of startups and open innovation is intrinsically multidisciplinary. Consequently, studies mixing methods, concepts and even theories from different disciplines are needed.

Both qualitative and quantitative studies are needed. Quantitative studies like path analysis could help clarify the impact of open innovation strategies on firm innovative behaviour and, ultimately, on organizational performance. Quantitative, longitudinal studies might help understanding the multiple interactions among variables that characterize the complex dynamics of startups in an open innovation context.

From an empirical point of view, it would be useful to investigate to what extent new firms adopt open innovation strategies during their startup phase. Indeed several empirical studies exist, but most of them are exploratory studies. With reference to several topics, results are not conclusive. In the literature surveyed in this study, the topic of startups' networks is probably the most investigated. However, results are ambiguous or even contradictory with respect to several aspects. For example, the variable "strength of ties" has complex effects on startups processes and performance and requires an in-depth analysis. While in some cases it seems to affect innovation performance positively, in others the effect is negative. As others have highlighted (Gulati 2007), it is vital that the nature and purpose of networks are further explored and understood, from a qualitative, besides quantitative, point of view.

Most of the surveyed studies focused on the impact of network structure and characteristics on the innovative performance of startups. Other aspects of performance have been less investigated. Future research should clarify the impact of networks and networking on aspects like firms survival, economic and financial performance. These aspects are more difficult to investigate. While innovation performance can be measured through an analysis of patents, firms survival and economic performance pose difficulties linked to the transient nature of startups. New firms can be acquired by large companies or run out of business. It is difficult to design studies that compare successful and unsuccessful startups. To be relevant, however, research needs to consider these cases. It is important to understand how open innovation can support the ability of startups to translate innovativeness into the market and financial success. Several studies analysed the factors affecting the innovativeness of new firms, but being innovative is not relevant if it does not contribute to its success.

A gap in the literature concerns the analysis of forms of innovation different from product innovation (e.g. process and organizational innovation). Process and organizational innovation

are more difficult to study. Again, this is partly due to the limited possibility to use documents available in organized databases, like in the case of patents for product innovation. However, the success of many startups cannot be understood if not by looking at the changes they introduced in their business models. Studies designed to collect original data through surveys or case studies should be used to investigate this specific issue.

Open Innovation seems to have spread mostly in a limited number of industries like the pharmaceutical one. However, the dynamics of new, technology-based companies change from industry to industry. Future research should consider the link between startups and open innovation within different industries. Variability in the relations between investigated variables can be expected when the industrial context changes.

Even though the role of Ecosystems has been the object of several studies, the obtained results seem to be not conclusive. Most studies are of a qualitative nature and stress the complexity of the obtained result. In part, this is due to the actual complexity of the phenomenon under investigation (and therefore qualitative studies seem to be the proper approach), but it also seems that this area of research needs a refinement in terms of research constructs. Ecosystem dynamics and configuration could be a fruitful line of research. Like, for example, in the study by Sharif and Tang (2014), it would be interesting to define possible configurations of an ecosystem and studying their impact on the diffusion of knowledge and trust and, ultimately, on firm performance. Results could be useful for both private investors and entrepreneurs looking for the right context for their enterprise and for public decision makers trying to attract resources. What seems also to be missing is research on the role of local or regional government agencies as players in the open innovation ecosystem. Not only configuration at the national level, but also at the regional and local level should be considered in future studies.

With reference to the actors involved in open innovation processes of startups, several studies investigate the role of venture capitalists, universities or incubators. In an open innovation context, an important role is played by communities of customers or other categories of individuals. It is expected that these networks play a key role in the dynamics of startups as well. However, virtually no paper on this topic has been found in this review. Future research should investigate the processes, which characterize the interactions between startups and communities of external individuals.

Startups are powerful engines of knowledge creation. Several studies consider the problem of transferring knowledge *to* startups. A few consider the problem for large corporations of absorbing knowledge *from* startups. An interesting area of research is how other actors, as universities or large corporations and the society in general, can benefit from the knowledge generated by startups. Also in the case of unsuccessful startups, knowledge is generated which can be of value for other organizations, institutions or individuals.

In conclusion, it needs to be observed that several studies adopt the point of view of large corporations or institutions. It seems that the interest of researchers has focused on cases in which at least one large organization was involved. The point of view of small companies has been neglected. More research would be needed on open innovation from the point of view of startups as the decision maker as well as on horizontal networks, in which SMEs play the key role. The impact of startups strategic and organizational choices on their survival and success is an obvious but under-investigated issue.

Further effort is needed from the point of view of conceptual refinement. There is still confusion on what it is exactly meant by both “startup company and open innovation”. Both terms describe very complex and heterogeneous phenomena. Taxonomies of these phenomena are needed as well as empirical studies aimed at understanding the differences and similarities between different forms of startups within different forms of open innovation contexts.

Implication for practice

Based on the scope of this literature review, four main types of actors can support new entrepreneurs in opening up the innovation process all along the startup lifecycle: incubators, ventures capitalists, large corporations and universities. Being able to manage the relations with these actors is a necessary competence for startuppers. Therefore, "networking" should be part of all the education programs for entrepreneurs. However, a more in-depth analysis of mechanisms and best practices for managing these relations is required.

There is general agreement on the central role of financial support in sustaining technological innovation. Allocating capital to startups to implement new processes and to commercialize new technologies in open innovation activities can be fulfilled by various upholders. VC/CVC support the commercialization of startups' innovations. In particular, it appears that there is a growing interest of large companies to work with startups with the goal of creating new opportunities, in addition to aiming at product commercialization. The literature provides directions for VC firms and large corporations to interact with startups. Less clear is how startups can manage the power unbalance between themselves and VC and large corporations.

Relationships with universities are able to provide access to financial support and knowledge. Managers of startup companies should be able to profit from the interactions with research institutions throughout their lifecycle.

Alliances, collaboration and relations in general, can positively affect new firms' performance. However, the positive results on innovation performance are heightened only by a central position in the network and in environmental uncertainty conditions. Too strong relationships risk having a negative effect on the innovative performance of startup companies. As a consequence, startuppers should balance their portfolio of relationships accordingly.

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APPENDIX 1

Exclusion criteria

No.	Criteria	Reason for exclusion
1	Pre-2003	Contributions on Open Innovation started after the publication of Chesbrough's book in 2003
2	Entrepreneurial orientation	Entrepreneurship is not intended as the creation of new firms, but as an individual's or an organization's disposition
3	Technology or plant startup	Startup is not intended as a new venture, but as the initial phase in the use of a new technology or in the operation of a new plant
4	Entrepreneurs and Open Innovation in old firms	Excludes many papers focusing on the role of the entrepreneur in enterprises which are not new firms

Inclusion criteria

No.	Criteria	Reason for inclusion
1	Theoretical papers	Provide the working assumptions to be used in the report
2	Qualitative and quantitative empirical studies	Capture all empirical evidence
3	Any study which focuses on Startups and considers Open Innovation at least as an aspect of the study	Focus on new technological ventures creation and open innovation as a context.
4	Any study which focuses on Open Innovation and considers Startups at least as an aspect of the study	Focus on innovation processes. Consider Startup as actors in an innovation network.