Linking science-based firms with performance factors: An integrative systematic review of the literature

Andrea Setti^{ID}

University of Pavia, Pavia, Italy

ARTICLE INFO

Article history:

Received 28 February 20

Received in revised form 08 March 20

Accepted 13 March 20

Keywords:

Science-Based Firms, Performances

Determinants, Systematic Literature

Review

JEL Classification:

O15, P36

ABSTRACT

Science-based firms (SBFs) are venture or corporation based on the development and commercialization of scientific discoveries that are exposed to the unique challenge to handle together business and science. Despite extensive efforts in the attempt to identify those factors that lead to the success of an SBFs the adoption of different definitions and names resulted in a lack of comprehensive picture on the determinants of SBFs' performances. With the objective to review the extant literature on SBFs' performances and to understand what are the most appropriate parameters to evaluate an SBF, a systematic literature review adopting a comprehensive definition of SBFs was performed. The review, adopting an integrative approach, identified 30 papers published in top journals whose research questions deal with the determinants of SBFs' performances. Findings showed that determinants widely used such as net income within profitability measures, do not fully reflect SBFs performances and innovation abilities should be further investigated. Moreover, preconceived factors such as location and size have low or no impact on SBFs which opens the debate for more investigation. Also, the review identifies a comprehensive and multi-level set of determinants which allows delineating a number of research questions to be addressed in future research.

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Introduction

In modern economies characterized by an intensive application of knowledge, academic research and science discoveries have a well-recognized value for technological change and economic growth (Cohen et al., 2002; Feldman et al., 2002). Before these scientific discoveries in the form of scientific knowledge reach the market in a form of new products and services, they need to be converted to marketable products. This process involves complex technology transfer activities involving many individuals in society which today represents one of the main challenges in knowledge-based economies (Fleming and Sorenson, 2004; Meyer-Krahmer and Schmoch, 1998). Among those activities, fostering innovation start-up creation is one of the most effective instruments for technology creation (Lumpkin and Ireland, 1988; Timmons and Spinelli, 2003; Hayton, 2005). Supporting the creation and development of such firms has become one of the main priority policies for several countries, especially for the European Union (European Commission, 2005).

One of the keys to success for these policies is the creation of successful Science-Based Firms (SBFs). SBFs have at the core of their objectives to create innovation from science, reflecting the ability of hosting economies to obtain a competitive advantage from scientific discoveries (Casper, 2007) and their ability to transfer knowledge from basic research to market (Autio and Yli-Renko, 1998; Fontes, 2005; Rasmussen et al., 2006; DiGregorio and Shane, 2003). Moreover, SBFs are the crucial link between industry and science (Debacker and Veugelers, 2005; Perez and Sanchez, 2003) and have the ability to create new jobs in high value sectors (e.g. Clarysse et al., 2005; Di Gregorio and Shane, 2003; O'Shea et al., 2008; Shane, 2004).

Literature reviews on this topic, which are relatively old, show an increasing number of studies facing issues of SBFs, but results are very fragmented (Djokovic and Souitaris, 2008; O'Shea et al., 2008; Rothaermel and Thursby, 2007). SBFs' topics in the literature are very broad. Studies on SBFs may look into impacts generated by SBFs at national level (e.g. Vincett, 2010; Wallmark, 1997) or at regional level (Smith and Ho, 2006; Chrisman et al., 2005; Garnsey and Heffernan, 2005; Berggren and Dahlstrand, 2009); links

* Corresponding author. ORCID ID: 0000-0001-5215-4042

between start-up conditions and performance (e.g. Clarysse et al., 2005, 2011; Colombo et al., 2010; Hayter, 2011; Rasmussen et al., 2011; Salvador, 2011). Studies may also comprise different individual levels of analysis, considering the dynamics of mainly scientists and academics (e.g. Bercovitz and Feldman, 2008; Fini et al., 2009; Toole and Czarnitzki, 2007; Grandi and Grimaldi, 2005; Gurdon and Samsom, 2010). Or studies may also look at institutions at University level (e.g. Moray and Clarysse, 2005; Heirman and Clarysse, 2007; Colombo et al., 2010; Grandi and Grimaldi, 2005). Despite their importance for knowledge-based societies, the academic literature fails to deliver clear and comprehensive results on how SBFs grow and what makes an SBF successful. To answer to the research gap, the present study will perform a literature review on the extant literature on SBFs' performances and will try to answer to the questions: "What are the key performance parameters to evaluate a SBFs? And "What makes an SBF successful?"

In following section is composed by the literature review in which the main characteristics of SBFs will be illustrated. This will be followed the research methodology detailing the procedure and protocols for data collection. Follows the section empirical data and analysis where a model built upon the results of the analysis is shown which supports the next section of findings and implications in which results and discussed and possible new research venues are presented. The paper closes with the conclusions with managerial implications and limitation of the study.

Literature Review

New science-based ventures have a higher probability to successfully commercialize radical innovations than incumbent firms, due to their smaller and leaner structure (Chesbrough and Rosenbloom, 2002; Danneels, 2004) and showing more commitment in the development and diffusion of technology (Thursby et al., 2001). In addition, SBFs are able to commercialize technologies that other firms fail to deliver to the market (Thursby et al., 2001), taking advantage from radical innovations, which are not attractive for incumbent firms (Markham et al., 2002).

Over the years, studies on SBFs outlined that these firms possess peculiar characteristics which differentiate them from any other companies (e.g. Mangematin et al., 2003, Mustar et al., 2006). SBFs usually are characterized by a higher level of market and technology uncertainty. This is related to the nature of research and development phases, which are often longer and more expensive. As an example, SBFs spend longer time to complete the prototyping phase (Pisano, 2006; Kazanjian, 1990) when compared to traditional firms; they foresee the intervention of large corporations that facilitate early growth (Colombo et al., 2010; Miozzo et al., 2016); in addition, they require a unique set of resources which are mainly dedicated to scientific research (Pavitt, 1984) whose outcome is, by nature, uncertain. The peculiar characteristics of these firms operating in different knowledge intensive industries, make their investigation even harder when compared to their counterparts, i.e. high-tech firms.

Due to their peculiar nature, literature has so far studied SBFs under different domains, i.e. research spin-offs and R&D department spin-offs (Mustar et al., 2006; Knockaert et al., 2011; Rasmussen et al., 2011) or under the lens of high-tech scientific sectors, such as biotechnology (e.g. Pisano, 2006, Zucker et al., 1998), pharmaceuticals (e.g. Gambardella, 1995) and semiconductors (e.g. Holbrook et al., 2003). These studies, to our knowledge, failed to adopt common sampling criteria, leaving selection open to interpretation and common sense of scholars.

These streams of research suffer from lack of taxonomical efforts, leading to a gap in the identification of a common definition. In this light, the seminal work of Pavitt (1984) on sectoral patterns based his taxonomy of SBFs that they have copious R&D investments concentrated on basic research activities in comparison to other firms. Lately, Autio (1997) studying the taxonomy of New Technology Based Firms (NTBFs) made the distinction between science-based NTBFs and engineering-based NTBFs, classifying the latter in firms which undertake applied research to innovate and identifying as science-based the firms that undertake basic research for the development of new technologies. A more recent work of Pisano on biotechnology firms introduced in 2006, defined Science Based Businesses as those businesses that attempt to advance science and seek a financial return from their application.

Despite their diffusion and recognized importance, it is still not clear how to develop and make successful a science-based venture. The last review on this topic is ascribable to the work of Mustar et al. (2006) which reviewing research-based firms' empirical works, the authors found limited examinations on firm performances and a taxonomy lightening differences in performances was still missing. Ten years after Mustar et al. (2006)'s review, it is still beyond comprehension what makes a SBF excel. As outlined by Pisano (2006, 2010) these firms are more capable to commercialize scientific innovation growing strongly in sales and attracting funding from the public and private market, but their cumulated profitability over years is still below zero. Other studies on SBFs provide empirical evidence that the majority of research spin-offs remain small (e.g. Mustar et al., 2006) and non-academic spin-offs have better performances than academic (e.g. Ensley and Hmieleski, 2005).

The fragmentation of the studies on performances and the lack of a common definition makes the argumentation underpinning performance factors of SBFs very much unclear. Efforts to understand why these firms have failed to succeed and what are the real factors enhancing the success of these ventures is needed in order to progress our understanding of these particular ventures. Without a clear comprehension of those factors enabling the growth and development, studies still rely on chance and luck in investigating them leaving the issues about SBF's success still open to debate.

To address the above mentioned issues, in the present study was adopted a definition that incorporates prior taxonomies and follows the guideline provided by Pisano (2006): “a SBF is a firm or entity that tries to advance science performing basic research activities and tries to obtain a financial return from the related scientific discoveries”. Thus, this definition incorporates the consideration of the use of ventures that apply the technical principles and requiring the application of scientific knowledge and technological skills to commercialize products. Adopting a comprehensive definition will be possible to make clarity in the field and extrapolate the core elements for these firms. Second were selected and systematically reviewed key contributions in the top journals of management, entrepreneurship, innovation and strategy in order to provide updated relevant evidences of SBFs’ performances.

Research and Methodology

The easiest way to synthesize data from the extant literature is through a narrative approach, summarizing a group of studies but without a real attempt to generalize them (Greenhalgh, 1997). As suggested by Tranfield et al. (2003), a systematic review of the literature (SLR) in management science provides the quality of the evidence synthesis which is nowadays demanded. The SLR takes its origin from the field of medical sciences, where poor judgement of the existent literature has caused many issues for both further advancements and in terms of misleading recommendations (Cook et al., 1997). The SLR is a method that allows researchers to produce synthesis of the findings in a systematic manner outlining the most relevant results and reorganizing them in a more comprehensible way (Peckham, 1991).

In contrast with traditional narrative reviews, systematic reviews adopt a replicable, scientific and transparent process which minimize the reviewer’s bias through the analysis of an exhaustive plethora of literature and provides detailed information about the decisions, procedures and conclusion of the author(s) (Cook et al., 1997). Such characteristics make the SLR a comprehensive and unbiased research which represents not only a preferred method in respect to traditional narrative literature review (eg. Greenhalgh, 1997), but also results to be the most valuable method to evaluate extensive literature. When systematic review analyzes quantitative data, the result is meta-analysis, when SLR reviews qualitative studies, the result is the so-called qualitative systematic review. Undertaking systematic reviews is nowadays considered as a fundamental scientific activity (Mulrow, 1994).

The purpose of this study it is to provide a consistent picture of what the literature has been done and provide evidences that allow us to comprehend how SBFs perform and what we can do to advance the understanding of this topic. For this reason, an integrative approach provides the advantage to include both methodologies, qualitative and quantitative, to reduce single-study weaknesses and to improve internal and external validity (Whittemore and Knafl 2005).

The integrative approach is commonly used in medicine studies to provide evidences regarding the accuracy and results of medical procedures, adding to the information coming from statistical inferences the data provided by patient’s observations. This allows reviewers to consider data but also contextual inferences provided by the context (Campbell, 1984). This approach, given to its nature, answers to the call for a broader observation of the findings providing sources from different angles. Due to the consolidated procedure on how to review the literature in medicine (Davies and Crombie, 1998), the present work follows both the guidelines provided by Cochrane Collaboration’s Cochrane Reviewers’ Handbook (Clarke and Oxamn, 2001) and the National Health Service Dissemination (2001).

Sample selection method

SBFs may assume different facets in academic researches, e.g. academic spin-offs, technology based firms, high-tech ventures, etc. making the identification of dedicated studies even harder than other topics. To overcome this issue, a preliminary study is necessary to identify the more appropriate key words to be included in the research string. To identify such terms, it was at first applied the string “science based firm” in Scopus database which provided a list of 34 papers representing a first repository of SBFs studies. Further was done an analysis of these studies in order to identify other key terms that these authors used in referring to this kind of firms in the form of origin of the firm (such as knowledge and technology) and new terms as nature of the firms (such as company and enterprise).

Applying the new key words to the string a continuous refinement of research results was possible to obtain a comprehensive list of the most relevant parameters regarding the origin and the nature of SBFs that combined together complete the research string for SBFs’ selection. A list of 22 items regarding the origin of the SBFs and a list of 18 terms to identify their nature was finally obtained as shown in Table 1.

In order too target only studies that attempt to advance the understanding of SBFs were not included terms referring to sector specific domains such as biotech, pharmaceuticals, chemical etc, but instead keywords referred to research streams such as academic entrepreneurship, knowledge management, innovation management were adopted.

Given the objective of this study to isolate performance evidences using both qualitative and quantitative approaches (that directly and indirectly address performances), general parameters were used in order to include a wider range of studies. The selected parameters for performance are: grow*, performance*, outcome*, success*.

The string was composed by combining origin factors indicating the main domain of the firm, such as academic, knowledge based, high tech etc. with nature of the firm key words representing the forms that firms can be identified, for example company, enterprise,

venture, spin off. The combination of origin and nature terms produced a list of 396 research terms (N. Origin x N. Nature x Perf.) that were furtherly combined with the four performance parameters. This allowed to obtain an extensive research query, including all combinations of terms regarding SBFs (see Table 1).

Table 1: Terms composition

Origin of the firm	Nature of the firm	Performances
Academic	company*	grow*
High tech	enterprise*	performance*
High-tech	entrepreneurial firm*	outcome*
Innovation*	firm*	success*
Knowledge based	new venture*	
Knowledge-based	spin off*	
New technology based	spin out*	
New technology-based	spin-off*	
Research	spin-out*	
Research based	startup*	
Research-based	start-up*	
Science	venture*	
Science based	business	
Science-based	spinoff*	
Scientist*	spinout*	
Scientist* based	startup*	
Scientist*-based	SME*	
Technology based	small and medium entrepreneurs*	
Technology-based		
University		
University based		
University-based		

To identify the relevant contributions and accomplish with the requirements for the validity and reliability of methodology (Tranfield et al., 2003), were considered only contributions rated at least 3 stars, according to the 2015 rankings of the Chartered Association of the Business Schools (ABS rank) in the field of innovation, management, entrepreneurship and strategy. From a preliminary study, an exception was made for the Journal of Technology Transfer, since emerged as a repository of relevant contributions for SBFs studies. To facilitate the selection of the papers, the query was applied in Scopus database, including all contributions up to the 31st December 2016. Additionally, a filter for “business” and “management” studies was applied, excluding all other fields from our search.

For the analysis of the findings, PRISMA (preferred reporting items for systematic reviews and meta analyses) sheme was adopted to organize, review and systematically report findings. PRISMA is a complex of procedures and guidelines for systematic reviews to help to ensure a transparent and complete reporting of the findings in a systematic manner (Liberati et al. 2009).

Sample selection analysis

Applying the query as described above in the database Scopus led to an initial list of 652 contributions in the field of management, innovation, entrepreneurship and strategy as shown in Table 2. We can observe that the journal of Small Business Economics, Journal of Technology Transfer, Research Policy, Technovation and Journal of Product Innovation Management are the journals with the most contributions with more than 50 articles each.

Analyzing titles, abstracts and introductions was possible to exclude papers regarding other thematic areas, and to exclude reviews, theoretical papers, and articles in press to comply with replicability parameters that a systematic literature review requires. Only articles reporting an empirical investigation and being officially published were selected. The screening process produced a list of 266 articles that were furtherly assessed for eligibility.

Table 2: List of journals

Journal	ABS Rank 2015	Initial count	Final count INCLUDED
Academy of Management Journal	4*	2	
Academy of Management Perspectives	3	2	
Academy of Management Review	4*		
Administrative Science Quarterly	4*		
British Journal of Management	4	5	1
Business and Society	3		
Business Ethics Quarterly	4		
California Management Review	3	4	
Entrepreneurship and Regional Development	3	21	1
Entrepreneurship: Theory and Practice	4	9	1
European Management Review	3	1	
Family Business Review	3		
Global Strategy Journal	3		
Harvard Business Review	3	13	
International Journal of Management Reviews	3	2	
International Small Business Journal	3	17	1
Journal of Business Ethics	3	49	
Journal of Business Research	3	37	2
Journal of Business Venturing	4	42	1
Journal of Management	4*	2	
Journal of Management Inquiry	3		
Journal of Management Studies	4	7	
Journal of Product Innovation Management	4	51	
Journal of Small Business Management	3	14	
Journal of Technology Transfer	2	85	2
Long Range Planning	3	10	2
MIT Sloan Management Review	3		
R and D Management	3	30	2
Research Policy	4	80	7
Small Business Economics	3	89	4
Strategic Entrepreneurship Journal	4	3	1
Strategic Management Journal	4*	12	1
Strategic Organization	3		
Technovation	3	65	4
Total		652	30

For the eligibility analysis, following the review protocol, a scrutiny of all the sample selection sections of each paper was performed in order to isolate only those studies which responded to the adopted definition previously provided: “a SBF is a firm or entity that tries to advance science performing basic research activities and tries to obtain a financial return from the related scientific discoveries”. According to the definition, are included only those studies which explicitly showed evidences of basic research activities to provide products or services. As example for exclusion were not included studies with samples of firms performing R&D activities but not related to scientific advancements or there was no evidence related to scientific progress (basic research connection).

Were also excluded studies relying on samples selected mainly on the basis of generic sector parameters (ICT, innovative, high-tech), samples of academic founded new ventures where was not possible to find scientific research (e.g. generic academic spin-offs); or service-based firms which are not science-related (excluding firms performing specific services for life-science industry), and manufacturing firms which do not perform science-based R&D activities.

The sample selection process excluded 224 articles which did not matched the selection criteria leading to an eligible sample of 42 papers. In Appendix 1 a comprehensive table including the selected studies is provided. In the column “Inclusion justification” is provided the rationale behind the choice of inclusion and in the column “Quotations from the paper” is reported the extraction of the text from which the justification is based. The last step for eligibility was text screening that led to a further exclusion of 12 contributions. In Figure 1 the PRISMA diagram shows the process that brought at the final list of 30 papers included in the study and then listed in in Appendix 2.

Fig. 1: PRISMA flow diagram

Description of the studies

A comprehensive list of the selected studies is provided in Appendix 2 in a chronological order. The ID is used as reference in tables and figures. In the table, information regarding sample and the methodology adopted by the different authors are provided. After the selection is possible to observe mainly two types of ventures. The first is represented by firms which are either new or dedicated ventures resulting from the spin-off or spin-out activity of a scientist's research, a research lab, a corporation, or an R&D project. The other is represented by incumbent corporations that try to develop scientific discoveries dedicating copious R&D investments on scientific research in order create new products or services (e.g. Pharmaceutical corporations, biotech, green-tech etc.).

From the list and also showed in Figure 2, papers focusing on SBFs and their performances are concentrated mainly in 14 journals. Most contributions are to be found in three main journals, *Research Policy* (7), *Small Business Economics* (4), and *Technovation* (4) where half of the empirical works are concentrated. The others are the *Journal of Business Research*, *Journal of Technology Transfer*, *Long Range Planning* and *R & D Management* with two contributions for each journal. The *British Journal of Management*, *Entrepreneurship and Regional Development*, *Entrepreneurship: Theory and Practice*, *International Small Business Journal*, *Journal of Business Venturing*, *Strategic Entrepreneurship Journal* and *Strategic Management Journal* standing comprehend one contribution.

Having a first look at the time in which data are collected in the selected articles, emerge that the booming of studies looking at the SBFs' performances phenomenon started in the 90s in conjunction with the booming of the Biotech industry. It is not surprising that biotech firms were frequently targeted as main source of sampling in understanding the performances of SBFs. Other typically targeted sectors were the life-science industry including pharmaceuticals and human health. Nanotechnology, defense and semi-conductors were also important sources for the understanding of the factors influencing SBFs' performances.

The geographical distribution of the selected articles was mainly concentrates in the European area, 25 studies out of 30 with a particular focus on the UK (4), France (4) Italy (3) and Belgium (3). Only five studies posit their attention on a sample concentrated in North America (4 in US and 1 Canada) and only 2 in Asia, 1 in Japan and 1 in Singapore¹.

¹ The sum is higher than 30 because two studies had more than one country of analysis.

Fig. 2: Journals and areas of selected articles

Thanks to the data retrieved in the columns Business entity and Industry, was possible to identify five main categories: “Academia”; “Technology-Based”; “Sector Specific”; “Research-Based”; and “Science-Based”. “Academia” refers to the stream of research that mostly targeted academic spin-offs and university spin-offs. In this category are included those studies that focused mainly on academic entrepreneurship and the new venture creation. The samples are represented by firms which foundation is based on scientific research conducted at an academic institution and founded or co-founded by researchers that had worked on the scientific findings at the academic institution in question, or by the university itself. Frequently scientists maintain their connections with the university to access to the academic network in order to overcome the lack of competences and to obtain resources.

The “Sector Specific” subject comprehends studies focused on the in-depth analysis of a single industry studies and especially verified for the Biotechnology industry. In “Technology based” stream, the division of New Technology-Based Firms dominate the scene. The samples are represented by a subpopulation of high-tech firms which most frequently are new ventures. Effectiveness of supporting programs for new high-tech ventures is in many cases the main issue of analysis. In the “Research-Based” domain the focus is on the development of founder(s)’ research. The main goal of these firms is the creation of new technologies undertaking basic scientific research. In the last category, “Science-based”, authors targeted directly the science-based industry including heterogeneous industry sectors stressing on the creation of new innovations with the application of scientific research.

Only 12 of the 30 studies explicitly adopted a dominant theoretical framework. The theory that dominated the studies was the Penrosean resource-based view and the Teece, Pisano and Shuen’s (1997) dynamic capabilities. Among the authors that adopted resources-based view is possible to find Yagüe-Perales and March-Chordà (2012), Clarysse, Bruneel and Wright (2011), Miozzo and DiVito (2016), and Lubik and Garnsey (2016) which looked mainly on how resources can represent a source of superior performance. Studies on dynamic capabilities (Bruni and Verona, 2009; Alegre et al., 2011; Quintana-García and Benavides-Velasco, 2016) were concentrated on the different innovation capabilities of the firms.

Subramanian et al. (2016) adopted human capital and functional diversity theory, Knockaert et al. (2011) and Visintin and Pittino (2014) used principles from upper echelons theory and principles from knowledge-based theory, and upper echelons theory were used again by Knockaert et al. (2011). These theories were mainly adopted to explain the human resources and the top management team interactions with performances.

Looking at the methodologies and the research questions reported in Table 3 which were directly reported is explicitly indicated or rephrased according to the analysis of the text, a first distinction should be done between studies directly targeting the performances of SBFs in their research questions and studies that were included because reported performance findings during their research despite not directly addressing them. Their inclusion was given thanks to the query string that captured the word “success” and “performance” in the abstract, title and keywords. This was the case of two studies, the first is of Mangematin et al. (2003) in studying the dynamics of business models and the second is Nilsson (2001) which investigated the characteristics of Swedish biotechnology firms.

The research questions show a lack of maturity in facing SBFs’ performances, most of the themes were approached only once or twice with mixed methods and approaches. In fact, for example the topic of knowledge management was approached by Knockaert et al. (2011) that performed a qualitative and longitudinal analysis on the knowledge transfer of academic spin-offs and by Alegre et al. (2011), Yagüe-Perales and March-Chorda (2013) and Stephan (2014) that used a quantitative and cross sectional approach to explain the impact of the knowledge management on performances and on the knowledge management industry. From the methodology point of view, in fact, there is an equal separation between qualitative and quantitative approaches and between longitudinal and cross sectional analysis.

Table 3: Research questions of the selected articles

ID	Research questions (rephrased)
1	WHAT is the impact of strategic partnering on New Technology Based Firm-survival and growth in Belgium?
2	WHAT are the economic peculiarities characterizing the functioning of a research lab unit?
3	ARE public measures able to foster technical entrepreneurship?
4	WHAT pattern can be considered to describe the development process of NBEs? Are service and product/process development activities of NBEs geographically bounded within the regional environment?
5	HOW firms are established, positioned, financed? How they build and keep the competence within the Swedish biotechnology context?
6	ARE links with universities beneficial to the company's operations?
7	HOW business models are characterized in Biotech firms? WHAT are the dynamics?
8	WHAT are the impacts of support mechanisms on the development of start-up companies in a science-based environment?
9	WHY persistence does matter? WHAT are the mechanisms with which technological diversification contribute to the business expansion?
10	WHAT are the performances of Spin-offs generated in the Oxfordshire area?
11	WHAT are the effect of the technological application diversity, alliances, rent potential...? On the biotech firm's performances?
12	HOW dynamic capabilities influence the SBFs' value creation?
13	WHAT are Economic impact of Research-Based Academic Spin-off Companies? Are they convenient for the government?
14	HOW life-science firms perform in an Open Regional Innovation System?
15	WHAT is the propensity of acquire or being acquired of a Science-Based entrepreneurial firm?
16	HOW and WHY environmental dimensions and bundles of resources interact to create different growth paths?
17	HOW can knowledge be transferred and employed in SBEFs in order to enhance SBEF performance?
18	WHAT is the effect of Knowledge Management practices on firm's innovation performances?
19	WHAT are the differences in performances between biotechnology research spin-offs and non-biotechnology spin-off firms?
20	HOW do new small technology-based firms that collaborate with universities benefit from spillovers associated with resources of university scientists?
21	WHAT are the differences in performances between New Technology-Based Firms (NTBFs) and others in a knowledge intensive industry?
22	WHAT is the effect of Industrial partnerships on research spin-off's performances?
23	ARE public research spin-offs more innovative than comparable knowledge-intensive firms?
24	HOW entrepreneurial team demographic variables may create an appropriate balance between the scientific and business orientations, generating a positive impact on USO performance?
25	To WHAT extent does human capital (i.e., prior experience and knowledge) leverage the effect of bridging ties on the early growth of academic spin-offs?
26	HOW USOs' BMs evolve? HOW the interactions within and between their core BM components can ultimately result in sustainability and scalability?
27	HOW does fast growth of science-based firms occur? How is speed of early growth shaped by the institutional setting?
28	HOW firms use resources to realize market opportunities? How value creation is influenced by the wider value chain?
29	HOW gender diversity in top management teams (TMTs) and indicators of innovation capabilities can attract investment at the initial public offering (IPO) of research-based firms?
30	To WHAT extent diversity of educational levels among research scientists and engineers (RSEs) in the context of a firm's level of technological diversity influences innovation performance?

The most frequent research questions were posited for the analyses of the antecedents of SBFs' performances using mainly questions such as "what", e.g. what is the impact? what are? to what extent? reflecting the willingness to find a causal relationship between determinants and their effect. At the context level two were the studies that emphasized the role of the entrepreneurial context in which firms were established. Segers (1993) used technological partnership of small firms located in the Belgium area with incumbent

firms as antecedent to explain the impact on performances. Lawton-Smith and Ho (2006) instead measured the performances of the spin-offs generated in the Oxfordshire area taken in consideration the entrepreneurial environment in which there were formed.

At the firm level is possible to find more authors that tried to explain the factors which effect the performances posing the accent on the firm idiosyncratic nature. This is the case of George et al. (2002), Wang and Shapira (2012) and Scholten et al. (2015) that analyzed the themes of network effecting performances, followed by Alegre et al. (2011), Benghozi and Salvador (2014) and Subramanian et al. (2016), Suzuki and Kodama (2004), Bonardo et al., (2010) which respectively analyzed the themes of knowledge management, industrial partnerships, diversity, innovation capabilities and mergers and acquisitions as determinants success factors of the SBFs.

Durand et al. (2008), despite not being the only one that performed a single industry sample analysis (see e.g. Nilsson, 2001; George et al., 2002; and many others) were the only study posing a particular emphasis on the economic impact of choosing a particular strategy for a single industry, biotechnology, recognizing distinctive characteristics in respect to other industries. Yagüe-Perales and March-Chorda (2013) and Stephan (2014) used tested quantitatively the sector or subsector effect. Reitan (1997), Meyer (2003) and Vincett (2010), investigated the knowledge formation in the situation in which support mechanisms play a central role in the venture formation and performance.

The “how” and “why” questions were the most frequent questions that looked mostly into the way in which performances are formed at context and firm levels. Belussi et al. (2010) looked into the context of Regional Innovation Systems through the lens of open innovation, while Clarysse et al. (2011) used the interactions between environmental dimensions and resources to explain different conduct in different growth paths.

The other authors on the behavioral dimension, concentrated on the firm level looking into the functioning of the firm. Bruni and Verona (2009) focused on how dynamic capabilities influenced the valued creation, Knockaert et al. (2011) made an empirical analysis on how the knowledge is transferred to enhance SBFs performances; Visintin and Pittino (2014) looked into the variables of the entrepreneurial team to determine the right balance between scientific and business orientations; the management of resources was the focus of Lubik and Garnsey (2016) to generate a competitive advantage. Quintana-García and Benavides-Velasco (2016) verified how gender diversity in the top management team composition influence the success of an initial public offering of a SBF. It is notable to observe that no empirical works are focused on behavioral aspects formed at industry and support mechanisms levels. At the industry intersection, Yagüe-Perales and March-Chordà (2012) made a contribution arguing on dynamic capabilities between biotechnology research spin-offs and non-biotechnology spin-off firms.

Four main authors looked into the how SBFs evolve. Miozzo and DiVito (2016) from the growth point of view arguing about the speed of growth within the framework of the institutional setting. Pfirrmann (1999) within the context dimension, looked into how the environment effects the SBFs performances. Quéré, (1994) made an in-depth analysis on the scientists working in a business unit of an incumbent firm questioning on the evolution of the unit over the years and on its impact on the innovation capabilities of the organization. Evolution of business models and the interactions of their components were adopted by Ziaee Bigdeli et al. (2016) to explain the sustainability and scalability of the SBFs. Industry level analysis and support mechanisms were neglected in study of the evolution of SBFs.

Empirical data and Analysis

For the analysis of the findings, thanks to the integrative approach, both qualitative and quantitative sources of knowledge will be combined. In order to harmonize the analysis of the data and making comparisons possible, both factors influencing performances and factors being affected were reported with their reciprocal effect, with a plus sign indicating a positive impact, minus for negative and zero for no significant relationship. For the contributions adopting a quantitative approach with a testing of causal relationships were taken in consideration the dependent and independent variables tested, for the qualitative analysis the variables and relationships were deduced from the argumentation of the findings. A total number of 57 variables influencing SBFs performances and 51 variables being influenced emerged from the analysis of the 30 articles. In Table 4 variables influencing SBF's performances are grouped according four main groups of variables.

Firm-specific

The first determinant listed in the table is the financial resources which reflects the ability of the firm to obtain funds. Miozzo and DiVito (2016) and Nilsson (2001) outlined that respectively the early fundraising and the access to capital have a positive impact of firm's growth. The funds permit to the firm get access to a unique set of resources which are fundamental for the growth of the firm and in particular for the science-based firms which to advance science require costly and rare equipment or highly skilled personnel. To be noted Miozzo and DiVito (2016) concentrated only on the initial development of the firm, so the effect of the financial needs could be lower in the next stages of the firm's life.

Firm's experience could intuitively be related to performances, but in our studies the results and not so obvious and only few of them took in consideration these aspects. Results demonstrate that experience may not be related to the firm's success, in fact, prior entrepreneurial experiences of the firm was found not significant with the growth in terms of employment. Scientists play a key role

in the firm's activity, as we will observe later, but looking into their experience in research, the impact on early growth remain not significant (Scholten et al., 2015).

Different is the case of market experience. Bruni and Verona (2009) observed a positive effect on the success of SBFs' products. In their study on the pharmaceutical sector, they noticed that having a better comprehension of the market's characteristics and dynamics leads innovation decisions toward more attractive scientific discoveries for the market, resulting as a consequence, more successful.

Human capital was one of the most theme approached by authors of this topic, 9 out of 30 found evidence about the impact of human capital on performances. The results are not always consistent. First of all, we need to make a distinction between findings on the presence of scientists in the firm, studies analyzing both composition and characteristics of the top management team (TMT).

Scientists have proved to be crucial for the performance of the firm, Vincett (2010) in his study found positive strong relationship between physicists working in research-based spin-offs and their impact on the Canadian's economy. The presence of scientists seems to be crucial not only at firm level but also at country level. Yagüe-Perales and March-Chordà (2012), observed the presence of scientists as founders outlining that the presence of scientists provides a superior growth in terms of size and turnover but having them in the position of the founders has no effect on the international performance, through international patents, and no effect on the profitability of the firm. A reason could be related to the business capabilities which scientists frequently lack. Another logic could be related to the dichotomy between scientists' objective to advance science and the scientists' desire to advance their career, which is not consistent with profitability. Another reason could be connected to the long research period which is needed to complete and commercialize a new scientific discovery; probably longer time horizons should be used to better outline economic performances of these ventures.

The ownership of the firm at the top management team level are source of superior market performance. Bonardo et al. (2010) demonstrated that founders can exercise their power to grow through mergers and acquisitions. This can be true for founder-scientists due to the different orientation of scientists and academics which are more innovation and research oriented (Wright et al. 2007) looking for an improvement in their academic career and develop their academic interests rather than setting up a fast growing venture (Meyer 2003). The presence of business professionals in the board of directors enhance the attractiveness of venture capitalists and the IPO success making SBFs more successful in financial performances (Meyer, 2003).

Table 3: Variables groups

Dimension	Determinants	Growth			Financial			Economic			Innovation			Market			Internatio nalization			TOTAL			ID
		-	0	+	-	0	+	-	0	+	-	0	+	-	0	+	-	0	+	-	0	+	
Firm-specific	Financial Resources			2																-	-	2	5, 27
	Experience		1						1					1						-	1	2	12, 22, 25
	Human capital	1	2	1		1	2		1	1		2		1		1				1	5	7	2, 8, 13, 15, 19, 24, 27, 29, 30
	Innovation capabilities			2			2	1	1	1		2	5							1	3	1	4, 9, 11, 12, 17, 23, 27, 29, 30
	Knowledge Management											3								-	-	3	2, 18
	Profitability			1																-	-	1	15
	Sector		1						2											-	3	-	21, 22
	Size			1						2										-	-	3	15, 22
	Strategy	1		2						1										1	-	3	7, 21, 28
	Type of firm	1		1		1		2			1					1				1	3	3	22, 23, 19
Relationships	Affiliations	2		2		1	1				1			2						2	1	6	23; 16; 10; 15; 28; 20, 15
	Collaboration with scientists						1													-	-	1	20
	Industrial partnerships			3				1	1			3								1	1	6	5; 11; 28; 1; 14; 22;
	Networks			4	1	1	1				1			1						1	1	7	25; 5; 20; 28; 6
External actors	Incubation						1													-	-	1	8
	Supporting programs	1		1			1	1		1										2	-	3	3, 8;13
	TTO support			1			1													-	-	2	26
	Incumbents firms	1																		1	-	-	16
	Venture capital			1							1									-	-	2	16
Environment	Ecosystems			3																-	-	3	4, 22, 28
	Location							1			1									-	1	1	23
TOTAL																				1	1	6	
																				1	9	6	

Looking at the characteristics, no impact has attributable to the gender diversity in the top management team (Quintana-García and Benavides-Velasco, 2016) suggesting that gender issues in scientific ventures are not a concern. On the contrary the diversity of the TMTs in terms of education (Subramanian et al., 2016), functions (Miozzo and DiVito, 2016) and profiles, academic and non-academics (Visintin and Pittino, 2014), are positively related to innovation performance, early growth and growth in sales and employees. This is in line with the previously mentioned lack of capabilities showing that a heterogeneous group of mindsets perform better in different aspects in respect to a homogeneous group.

Together with human capital determinants, innovation capabilities are frequently studied in the literature (9 out of 30). As expected, higher innovation capabilities are associated with higher performances, as it is observable also in Table 4 where many positive relationships are shown. Advanced stage in technological development is related to a superior growth (Miozzo and DiVito, 2016; Pfirrmann, 1999), in fact, the speed to product or service from the R&D is positively associated to be more attractive in terms of shares disinvestments (Knockaert et al., 2011). Findings supported by Quintana-García and Benavides-Velasco (2016) which recognize how the value of the patents (number of citations), products on the market and number of products under development is directly related an IPO success.

SBFs core capabilities are related to scientific discoveries, in fact, persistent accumulation of knowledge was found positive related to innovation performances (Suzuki and Kodama, 2004). Applying these core capabilities in different fields SBFs are able to obtain economies of scope. Innovation capabilities are source of superior economic performances: Vincett (2010) in studying basic research activities, recognize that basic research in research-based firms is a strong benefit on the final outcome outlining that governmental investments on research-based spin-offs should target basic research providing superior returns and economic growth. Innovation output in SBFs, as we would have expected, is a direct result of the R&D intensity, the higher is the amount of efforts in the creating new innovations the higher is the innovativeness as a whole (Stephan, 2014, Bruni and Verona, 2009).

Among the innovation determinants it's a different story if we consider innovation's technological applications. Durand et al. (2008) in their study on rent generation and rent appropriation of research oriented or service oriented biotechnology firms, argued that in the case of different technological applications (technological diversity measured in number of applications) there is negative impact on return on sales of research oriented firms, arguing that not necessarily science and money go together. Instead, in line with the previous innovation determinant findings, technology diversity resulted positively related to innovation performances (Subramanian et al., 2016, Suzuki and Kodama, 2004). This indicate that if the firm is diversifying its R&D efforts in different fields results to be more innovative but less profitable.

Innovation performances result to be improved by knowledge management practices (Alegre et al., 2011), knowledge transfer within the firm and a conjunctive appraisal at research and strategic level of the firm. The transfer of knowledge within firm units, seems to have a strong positive effect on final innovation performances and help the firm itself to overcome different stages of product marketing. In fact, the lack of market information at research unit level due to the miscommunications between the strategic and R&D departments, is translated into minor innovation performance in different industrial applications (Quérel, 1994).

No impact of sector has been found in the selected studies. Sector has no impact on growth considered in sales and size (Yagüe-Perales and March-Chorda, 2013) and no impact on productivity and profitability performances (Yagüe-Perales and March-Chorda, 2013; Benghozi and Salvador, 2014).

Two authors mentioned findings on the size of the firm effecting performances. Bonardo et al. (2010) argues that growth by merger and acquisition and the ability to make profit is positively related to firm's size, which could be considered counterintuitive. Benghozi and Salvador (2014) also argued that size is positively related to added value but with low impact.

On the effect of strategy on SBFs' performance, three studies provided some evidences. The first by Yagüe-Perales and March-Chorda (2013) looking at the difference in strategies adoption, product oriented vs service oriented, found a positive relationship on cost per employee. Same effect on growth in employees and revenues. Another study related to the strategy is by Mangematin et al. (2003) which found that market oriented business models enhance firm growth and performance besides innovation oriented business models limit the growth of the firm. This is a representation of the actual debate on the science business and its major challenge: overcome the dichotomy between science progress and commercialization of the innovations. In the study of strategy and performances, particularly relevant are the investigation of Lubik and Garnsey (2016). They looked at how business models adaptation can be a source of value creation, recognizing the importance of the adaptation of the strategic posture within the embedded ecosystem.

Yagüe-Perales and March-Chorda (2012) found evidence that SBFs based on previous research has a better chance to obtain financial support from venture capitalists, being more attractive than their counterparts. Profitability in SBFs is not significantly related to spin-offs founded on previously research activities and it is not related to sector effect (Yagüe-Perales and March-Chorda, 2012, 2013), which is not directly effecting also the productivity (Yagüe-Perales and March-Chorda, 2013).

A contradicting result is represented by the negative influence for spin-offs based on previous research (Yagüe-Perales and March-Chorda, 2012). This could be explained by the lack of entrepreneurial capabilities of the scientist-founders or the lack of management

skills (see e.g. Mustar et al., 2008, Pisano, 2010). No significant results are related to the type of the firm, for example being an LTD or LLC or INC (Benghozi and Salvador, 2014).

Relationships

Several are the authors that made a contribution on the relationships variables of SBFs. These variables are represented by the relationships that ventures have with external entities such as university linkages, academic networks, technological partnerships or contracts with incumbent firms.

The affiliation determinant sees different authors involved. The first affiliation analyzed is the affiliation with universities and research institutes. These affiliations proved to be very effective during funds' collection making those SBFs with university affiliations more attractive to venture capitalists (Clarysse et al., 2011) and importantly university links are considered crucial in the SBF's growth (Lubik and Garnsey, 2016; Lawton Smith and Ho, 2006; George et al., 2002). A negative relationship is observed for the growth by acquisition which seems to be negatively related to the presence of the university as affiliate and the presence of venture capital (Bonardo et al., 2010). This is probably due to the conservative posture of the university which is more rigid toward expansion and slower in taking such growth venues. Findings also supports the evidence that the affiliation with the institute of origin in research-based spin-offs is beneficial in making radical innovations (Stephan, 2014).

Also collaborations with scientists affect positively the probabilities of obtaining funds due to their associated extended network (Wang and Shapira, 2012), supporting the previous findings that SBFs which have direct connections with the scientific and academic world perform better in terms of growth, financial resources and innovation.

Partnerships and in particular technological partnerships are the topics which received a considerable attention. Durant et al. (2008) in their study on French biotech firms, recognized that alliances with incumbent firms produce a beneficial effect on innovation performances generating more patents and articles but at the opposite but they have a negative impact on rent appropriation (ROS). These findings foster the argumentation on the real effect of big corporations and their collaboration with small ventures. Several evidences are found also on the growth of SBFs having industrial partnerships, finding a positive relationship between the two (Lubik and Garnsey, 2016; Nilsson, 2001; Segers, 1993). Intuitively, technological partnerships are positively linked with innovation (Segers, 1993) supporting the previous findings.

These findings foster the argumentation on the real effect of big corporations and their collaboration with small ventures. In a later study of Benghozi and Salvador (2014); in studying spin-offs with and with-out traditional industrial partnerships they found no significant effect in the relationships with other firms which are typically incumbents. They also suggest that, according to the studies of Steiner (2002, 2004) industrial partnerships should be contextualized and cannot be studied following the traditional approaches.

Networks have a positive impact of firm's performances. Meyer (2003) provides evidences that the firm's network helps in obtaining a successful IPO; Nilsson (2001) suggests that networks in academia in terms of links with researchers support the SBF's growth, which is line with the previous findings on the university and academic affiliations. Findings supported by Lubik and Garnsey (2016) considering networks in general and findings provided by Scholten et al. (2015) recognize that bridging ties is beneficial for the early growth new ventures obtaining more source of knowledge from different angles.

Relationships, as observed from our findings, represent a source of greater performances for SBFs which give them access to resources and capabilities that alone cannot reach. Firm growth has extensively recognized being related to the close collaborations with incumbent firms, universities and founder's networks.

External actors

Surprisingly on the incubation effect we only found the evidences provided by Meyer (2003) that looking into incubated firms, found that those businesses as part of incubators providing complementary services such as business consultancy or access to business network proved to be more effective during the launch of the initial public offering, enabling them to obtain funds easily.

Targeted R&D programs are representing both economic and financial success for a SBF (Vincett, 2010, Meyer, 2003). But looking at direct financial aids, Reitan (1997) argued that are important for the survival and foundation rate of SBFs, but influence negatively the level of the turnover and the employment rate. Despite R&D programs have proved to be very effective, the direct financial transfers as support policy resulted to be detrimental as suggested by Reitan (1997) which in line with Teece (1986) suggest that aids targeting complementary resources and capabilities are much more effective than direct financial transfers, because are more effective in establishing the underlying infrastructure.

Clarysse et al. (2011) looked into the growth of firms and the incumbent competitors of SBFs. For these firms the presence in their specific value chains of incumbent firms was observed as having a negative impact due to the massive complementary assets that these large firms possess. This support the actual debate on SBFs and NTBFs on the importance for small firms to rely on partnerships with incumbent firms which as previously observed are not necessarily translated in superior profits (or economic performance in general).

The presence of venture capitalists that provide capital for the firm are detrimental for the employment creation and innovation performance providing the resources needed to speed up the R&D process (Clarysse et al., 2011).

Ziaee Bigdeli et al. (2016) outlined from their case studies that the technology transfer office (TTO) providing a medium level support to these ventures provides a boost in terms of growth enabling them to learn about their technological capabilities and allowing them to adapt their business models. It was also found detrimental for the ensuring of seed funding. On the contrary a high level of support should not be implemented in order to avoid structural dependence from supporting institutions.

Environment

Evidences from the context are related to the ecosystem and the location of the firms. Regarding the former, Lubik and Garnsey (2016), in their argumentation of business models of advance material sector, underline the importance of the ecosystem in terms of access to resources, networks, collaborations which is translated in superior growth. Ecosystems are an effective vehicle of success which cannot be neglected in the conceptualization of SBFs' growth as supported by Pfirrmann (1999) which recognized that firm's environment is essential to fully comprehend the growth development patterns.

Concerning the location, Benghozi and Salvador (2014) in their study on Italian spin-offs recognized that for a spin-off being located in the north, south, center or islands does not affect the venture's value creation calling for a broader prospective for the analysis of the firm in their embedded ecosystems. Stephan (2014) identifies that variations in the location attributes explain the differences in innovation productivity between research spin-offs and others. The differences in location characteristics outlined by Stephan (2014) supports the evidences of the importance of context which SBFs are related.

Findings and Implications

With analysis of the selected articles many issues concerning the evaluation of SBFs' performances emerged opening the debate that should be addressed by further studies.

On the main concerns approaching a company is the role of the founder within the organization, which for SBFs is still not fully comprehended. No significant results are provided leaving this aspect of firm development basically undisclosed. More studies should be undertaken to understand these dynamics. Also the role of the ownership in the top management team influences significantly firm's performances. It is possible to argue that a dichotomy between founder(s) and stakeholder(s) objectives could be a source of explanation on the taxonomy of SBFs performances, questions such as "what are the objectives of the founders?", "What is the final goal of the scientists?", "How objectives impact on performances?" Should be answered.

It's clear the importance of scientists and how crucial they are for SBFs. We know that scientists working or being present in the company are crucial for the early growth but we don't know the real long term impact and dynamic. Evidence that a mixed top management team provides superior innovation performances but its impact and dynamic should be better studied. Sometimes, the gap between professional understanding and subjective knowledge in the TMT could cause a detrimental effect on the overall development plan and the success rate of a firm. Noteworthy, there are no studies regarding the direct relationship between market and product development plans and financial performances of SBFs. It is essential to study this relationships and factors affecting them (e.g., market need, market size, market barriers, competitive products, product price, and effectiveness) for SBFs including the specific areas such as pharmaceuticals, chemical industries, biotech, and medical devices firms.

Presence of business professionals: these firms mostly lack managerial expertise, studies on SBFs showed that presence of business professionals proved to be effective regarding superior performances. At what stages professionals are needed? Having long R&D processes, business skills are really required? Which business expertise is mostly needed? Various studies have proven that market knowledge significantly affects the success and growth of the firm. Paradoxically, there is no evidence regarding innovation capabilities and performance are found, highlighting the deficiency of market expertise regarding successful product development, advertisement, marketing strategies, and product management (Griffin et al., 2013).

Innovation together with human capital was one of the aspects more investigated by the selected sample. Innovation capabilities are among the most important determinants of the SBF's success. It is widely acknowledged that to compete, firms require to build up capabilities that generate both radical and incremental innovations (He and Wong, 2004; Katila and Ahuja, 2002; Rothaermel and Deeds, 2004). SBFs are compatible enough to receive financial resources if they potentially demonstrate their innovation capabilities including the presence of technical expertise and collaboration with prominent institutes and subject leaders but a more in-depth investigation of these capabilities should also be undertaken in relation with other internal and external aspects such as managerial capabilities, capability to attract funds, speed to market, speed to exit and so on.

As mentioned above, innovation capabilities are crucial for the performance, i.e., funds capital, IPO, M&A. This could be strictly related to their intrinsic nature. What is still unclear is: within SBFs, what is making them more innovative? There are few instances where the intensity and size of research affect the performance and growth of the firm. On the other hand, there are increase collaborations between academia and industry show that the mentality of SBFs is drawing a line between innovation centers and business unit. The saved cost of R&D infrastructure can be potentially used for further collaborations and developing influential

market plans. These collaborations help these firms to focus more on profit taking with less investment at the start-up level. Also, this can be useful when technological fields are involved in the invention where multiple collaborations with related firms could help in potentially managing superior resources for the R&D. For example, authors that performed structural dynamic monopoly model study to identify the expected benefits from R&D collaboration, found that partnerships with research organizations help in reducing the sunk costs of innovation and that a firm's probability of investing in innovation or R&D increases with the level of performance (Amoroso, 2014).

A variety of studies show a substantial heterogeneity in business models. Business models have typically been studied on service oriented or product oriented. It was observed that some SBFs have a sole activity of developing drugs, others have a mixed approach providing services and developing products, others they have strategies that involve the production of new molecules, and as output of research they provide services (such as laboratory analysis), they produce new devices and at the same time they are involved in the pure R&D activities. Future studies should consider business models as proxy of performance.

Moving toward external dimensions, affiliations with incubators, universities and research institutes has proved to be a source of additional resources and additional attractiveness for venture capitalists resulting in a superior growth and innovation performance. The context and the complexity of the relationships of the venture follow through the entire technological development but little still clarity should be done about the interactions of the firm within the context, what is the design of the context, what are the contextual factors that impact on performances and many other aspects are still to be better understood.

Ecosystems (business and entrepreneurial) are identified as an influential source of success and growth, but there is a lack of studies on the detailed investigation of this aspect. These ecosystems are a crucial role player in the performance outcome of SBFs, especially, different innovation capabilities. Based on these findings an approach considering broader dimensions such as ecosystem should be adopted to better clarify the SBFs performances. For example, the entrepreneurial ecosystem approach, seeing the entrepreneurship outcome. As a result, the interdependence between actors and factors in a particular region (Acs et al., 2017; Stam and Spigel, 2017) could be suitable for a better understanding. The questions are what are the differences and similarities between platform, user/open innovation, and ecosystem strategies? How these ecosystems comply with international collaborations and investments? How feasible for business units regarding incumbent transitions and hybrid businesses management?

Within universities, there are factors that determine the extent and the effectiveness of contribution to the SBF's. Such factors include; the central administration of the university, departments and their heads, existence and nature of research groups, scientists, and contributions from students. According to Siegel and Wright (2015), the correct collaboration between the Government, Academia and Companies greatly influence SBF's. What is the impact of these entities on SBFs' performances? How these relationships work?

There is no clear conceptual framework showing the relationship and the required actions for the SBFs to operate successfully in diverse macro external factors. Sometimes macro factors such as political and legal environment can deny a science-based firm a chance to operate, and mostly since the most of the operation principle of such firms are new, firms lack stands to claim their operation rights and a chance to grow, (Katz and Gartner, 2010). Therefore, there is need of studies and researches to be conducted to come up with solid definitions of macro factors about the operation of SBFs.

Conclusions

In this study, multiple studies have been reviewed using an integrative approach and isolated performance evidence that address directly and indirectly growth, outcome, and success of SBFs. Several studies concentrate on firm-specific dimensions succeeding in some situations to explain SBFs' performances and in some other cases finding contradicting results. In the investigation was outlined how the study of SBFs' performances are still widely understudied and lack of clear results and common directions for the understanding of these ventures.

The present work also provided several managerial implications. Looking at the development of technologies, a new science-based venture should be focused on the development of one core technology rather than try to develop many. Also having heterogeneous top management team with complementary knowledge and importantly the presence of business experts together with scientists. Looking at the business models, implementing services in support of the R&D financing could be the appropriate approach leading to profitability performances in the short run and make the science-based business even more attractive for investors. Given the heterogeneity and the lack of studies, these managerial suggestions are to be taken with precaution.

Some preconceived factors such as geographical locations, size, depth and extensiveness of research, the presence of scientists as a lead role player in SBFs are an important determinant of a performance measure for a SBF. This study reveals that either these factors have no significant relevance with economic performance or they have a very limited role in determining success and growth of the firm.

This study provides also evidence that policy makers should concentrate on designing ad hoc supporting programs which directly target only the special needs of these firms rather than direct financial transfers. Anyway, direct financial support is seen as positive but only at the initial stage of the venture formation. Afterward other needs such business consulting, access to specific resources such as human and technological are needed to continue the development of the venture. This paper also contributes to the

advancements in the characterization of SBFs adopting a holistic definition which could be adopted by further studies. Providing also a comprehensive set of subpopulations relying on academia, technology-based, sector, research, and science-based, should help authors in undertaking future studies on SBFs.

Some limitations have to be outlined, first of all, the analysis with an integrative approach of reviewing the literature is strongly characterized by judgment and interpretation that cannot be completely eliminated by the in advance established procedures, making the integrative analysis more sense-making rather than mechanical (Pawson, 2002). The results of the integrative analysis emphasize the central role of the reviewer(s) in the interpretation of the findings could bring to “a possible explanation” rather than providing one definite (e.g., Noblit and Hare, 1988). Another issue concerns the extreme contextualization of this approach (Fielding and Fielding, 2000) or the methods used in the qualitative analysis which are not entirely accepted by the academic community (e.g., Wolcott, 1990; Lincoln and Guba, 2005; Dellinger and Leech, 2007). Another limitation is related to the selection of the articles; the analysis has been conducted only on top management journals introducing the possibility to lose critical findings from empirical works in other journals.

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APPENDIX 1: Inclusion of the sample

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
1	Segers (1993)	J.-P. Strategic partnering between new technology based firms and large established firms in the biotechnology and micro-electronics industries in Belgium	<i>Small Business Economics</i>	From the description of the three business cases and the extent text is possible to observe the scientific research that they put in place to create new products.	<i>The case of Plant Genetic... ...PGS originates initially from academic incubators, i.e. the genetic engineering laboratories of the universities of Ghent and Leuven.... ...Corvas International, Inc.... ...The company intends to commercialize synthetic drugs for the improved treatment and prevention of major cardiovascular diseases... ... Micro-electronics... ...the regional government of Flanders (Belgium) therefore created Imec as part of a science and technology programme to promote research and applications of micro-electronics, in the fields of very large scale integration systems design methodologies, advanced semi-conductor processing and micro-electronics education and training.</i>
2	Quéré M. (1994)	Basic research inside the firm: Lessons from an in-depth case study	<i>Research Policy</i>	It is a study based on a business unit of a corporation, there is an evidence of basic research and the presence of scientists working on it.	<i>This case study concerns the Thomson-CSF basic research unit..... The reason for that change is the failure of the initial objective. Indeed, the number of new products or processes moving from basic research to industrial applications was, in fact, very limited.</i>
3	Reitan B. (1997)	Fostering technical entrepreneurship in research communities: Granting scholarships to would-be entrepreneurs	<i>Technovation</i>	The program targeted scientists and academics to promote the commercialization of research as a result from universities and research institutions. Evidence of science-based R&D.	<i>The scholarship programme was first announced in Spring 1982 by the Research Council of Norway. The programme has a twofold goal(Waagøetal.),1993a):</i> <i>1. to provide scientists and academics wishing to start an NTBF the necessary time, competence and money to assess whether the key conditions for launching the enterprise are present or not;</i> <i>2. to contribute to faster commercialization of R&D results from universities and research institutions through venture spin-offs.</i>
4	Pfarrmann (1999)	O. Neither soft nor hard - pattern of development of new technology based firms in biotechnology	<i>Technovation</i>	The sample includes new biotech firms as resulting spin offs from research laboratories, universities and industrial corporations. Evidence of science-based businesses.	<i>The aim of our analysis is to provide some insights into the development of biotechnology start-ups focusing on specific aspects of research and development (R&D), production and collaboration behavior... ...The majority of biotech company founders stems from research institutions, either from universities (23%) or from labs outside the university (54%) (see Appendix 2 and Fig. 3). Other sectors outside research, such as industry or the medical sector play a marginal role.</i>
x	Lee J. (2000)	Challenges of Korean technology-based ventures and governmental policies in the emergent-technology sector	<i>Technovation</i>	From the description of the firms the three cases are based on scientist applying research to produce innovation.	<i>3.1. Medison Co., Ltd</i> <i>Medison is one of the most successful VCs in Korea. It was spun off from the Korea Advanced Institute of Science and Technology (KAIST), the research-oriented graduate school of applied science. The founder, Min-Hwa Lee, with a Ph.D. in electronics engineering, and his six cofounders, were graduate students and technicians who were involved with a research project on ultrasonic scanner technology funded jointly by the government and a local medical equipment manufacturer..... (Continues)</i>

APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
5	Nilsson A. (2001)	Biotechnology Firms in Sweden	<i>Small Business Economics</i>	Biotechnology case studies, research-intensive or based on research discoveries. Strong evidence of science-based businesses.	<i>The core of this study is based on case studies of five biotechnology firms within these areas... ...The two most research-intensive firms in the case studies performed for this study were founded by researchers in academia... ...Two other firms in the case studies were built on discoveries bought from researchers in academia... ...The fifth firm in the case studies is a spin-off from the last firm mentioned. The founders wanted to focus and go deeper into a specific area and thus created a firm in order to realize their plans.</i>
6	George G., Zahra S.A., Wood Jr. D.R. (2002)	The effects of business-university alliances on innovative output and financial performance: A study of publicly traded biotechnology companies	<i>Journal of Business Venturing</i>	Biotechnology research based, from the description of the sample and the authors approach is ascribable to the case of SBFs with strong research-intensive R&D.	<i>This process yielded 147 publicly traded firms with a primary business focus in human gene therapy, diagnostics, and therapeutics.... ...To test the above hypotheses, data were collected from the biotechnology industry. This rapidly growing industry has a strong science-based basic research thrust that requires inputs from different streams of specialized knowledge (Hamilton, 1996).</i>
7	Mangematin V., Lemarié S., Boissin J.-P., Catherine D., Corolleur F., Coronini R., Trommetter M. (2003)	Development of SMEs and heterogeneity of trajectories: The case of biotechnology in France	<i>Research Policy</i>	The authors target biotechnology SMEs with a description with a strong presence of scientists involved in the R&D process.	<i>For analysing the factors stimulating firms' growth and determining business models based on their activities, a sample of 60 firms was selected amongst the 200 biotech firms in France (Lemarie and Mangematin, 2000).....Biotech SMEs are science-based. On average, R&D expenditures account for over 40% of the turnover. These SMEs obviously belong to a high-tech sector, where 76% of the founders have a scientific background and 14% are well-known scientists.</i>
8	Meyer M. (2003)	Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms	<i>R and D Management</i>	They target cases focalized in the exploitation of science based innovations.	<i>Our focus in this article is on support mechanisms and the impact they have on the development of start-up companies in a science-based environment. We will look here at four case histories drawn from a more comprehensive effort to explore corporate activities aiming to exploit novel science-based technologies (Meyer, 2000). The four cases looked at here were start-ups that originated in a university or public sector research environment.</i>
x	Heirman A., Clarysse B. (2004)	How and why do research-based start-ups differ at founding? A resource-based configurational perspective	<i>Journal of Technology Transfer</i>	Despite they started from a wide range database in high-tech sector, the authors refined the sample to select the research based start-ups making phone interviews.	<i>We found, however, that about half of the 27 RBSUs could also be identified by three other listings of high-tech companies: (1) The academic spin outs generated in Flanders between 1991 and 1997; (2) the portfolio of venture capitalists (VCs) investing in early stage technology firms; and (3) a database of SMEs requesting government support. These sources seem to be a more efficient way of identifying the population of interest. It is important to note that these sources are not mutually excluding cases. Obviously, some firms received venture capital, government subsidies and turn out to be a spin out. What makes our database unique is that we performed a phone survey to each company in these listings to discern if they are in effect an RBSU. Table I gives an overview of our sampling method.</i>

APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
9	Suzuki J., Kodama F. (2004)	Technological diversity of persistent innovators in Japan: Two case studies of large Japanese firms	<i>Research Policy</i>	Two large firms which apply science for product development.	<i>Canon and Takeda chemical industries.</i>
x	Powers J.B., McDougall P. (2005)	Policy orientation effects on performance with licensing to start-ups and small companies	<i>Research Policy</i>	They target research extensive and intensive universities and they evaluate the performance through the success of the spin offs which use licensed technologies from the university of origin. Science derivation.	<i>Our sample included 134 US research extensive and research intensive universities as defined by the Carnegie Classifications of US collegiate institutions and that were geographically spread across the contiguous United States. The universities included 92 public and 42 private institutions. The sample was identified based on data reported in the annual licensing surveys of the Association of University Technology Managers (AUTM, 2003) that were used primarily to derive the support and selectivity measures for this study.</i>
10	Lawton Smith H., Ho K. (2006)	Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies	<i>Research Policy</i>	It is shown that they have laboratories and they come from research centers of universities. There is a possible comparison between SBFs and other academic spin-offs.	<i>Further investigation up to the end of March 2005 reduced this number to 114, divided into spin-offs with university/laboratory IP (64 firms) and with founder affiliation (50)—academics, students and technicians.</i>
x	Kodama M. (2007)	Innovation and knowledge creation through leadership-based strategic community: Case study on high-tech company in Japan	<i>Technovation</i>	Big corporation which create new products with research and development with scientific research.	<i>NTT DoCoMo, Japan's largest mobile communication operator.</i>
11	Durand R., Bruyaka O., Mangematin V. (2008)	Do science and money go together? The case of the evelo biotech industry	<i>Strategic Management Journal</i>	They include all Biotech firms in France which are engaged in in biotech research which is extremely science-based.	<i>However, to study the dynamics of an entire national biotech industry, we build a dataset that includes all French firms involved in biotech... This effort represents the most extensive research ever conducted on the French biotechnological industry, and includes all firms that claim to be engaged in biotech research and that are thus classified in the census of biotech enterprises conducted regularly by the French research and technology ministry.</i>
12	Bruni D.S., Verona G. (2009)	Dynamic marketing capabilities in science-based firms: An exploratory investigation of the pharmaceutical industry	<i>British Journal of Management</i>	The sample relies on firms which are very development-based R&D intensive.	<i>The final sample is composed of two global R&D-oriented American players (USPharma-Alfa and USPharma-Beta), two global European firms, one more R&D oriented (EUPharma-Alfa and EUPharma-Beta), and two local European players (LocPharma-Alfa and LocPharma-Beta), less R&D oriented but still competing to introduce innovations they developed in-house (Table 1).</i>

APPENDIX 1. Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
13	Vincett (2010)	P.S. The economic impacts of academic spin-off companies, and their implications for public policy	<i>Research Policy</i>	They target research-based spin-offs.	<i>While all research builds on earlier international work, the immediate precursor of research-based academic spin-off companies ("RASOCs") is almost always research in their home country. Thus, the benefits accruing to that country would not have occurred absent that country's funding of AR. We specifically focus on Canadian AR in the "NSExm": the NSE excluding the medical and health sciences, but including life-sciences and engineering.</i>
14	Belussi F., Sammarra A., Sedita S.R. (2010)	Learning at the boundaries in an "Open regional innovation system": A focus on firms' innovation strategies in the Emilia Romagna life science industry	<i>Research Policy</i>	Life science firms very representative sample furthermore in the selection procedure they excluded those not involved in pure services making the sample eligible as science-based.	<i>The empirical context of this study is the life science industry in Emilia Romagna. Our definition of the sector includes the following specialisations: biomedical, biotechnology, pharmaceuticals and computer science industry applied to the medical fields. Therefore, our study does not focus only on dedicated biotech enterprises, including all firms active in the knowledge areas of the modern life science industry....During the sampling procedure we excluded firms involved only in assistance services, because they are not firms endowed with innovation and technological capabilities.</i>
15	Bonardo Paleari Vismara (2010)	D., S., S. The M&A dynamics of European science-based entrepreneurial firms	<i>Journal of Technology Transfer</i>	They target firms which are the result of the founder's research activities or firms resulted from the research activity of the universities affiliated. Firms with strong research-based foci.	<i>We identified as SBEFs those companies that had been developed by faculty members, based on their research, or companies created to development on research carried out in universities. Our definition of SBEFs was in keeping with the literature. However, in Sect. 5, we disaggregate the sample of SBEF firms with and without formal involvement of academics in the TMT...</i>
16	Clarysse B., Bruneel J., Wright M. (2011)	B., J., M. Explaining growth paths of young technology-based firms: Structuring resource portfolios in different competitive environments	<i>Strategic Entrepreneurship Journal</i>	R&D intensity firms, they are not all Science based, but within the sample it could be possible to isolate findings regarding science-based firms.	<i>We define 'young technology-based firms' as companies founded from 1991 to 2002, which develop and commercialize new product/services based on proprietary technology or skills...development of sorting technologies; development of prepress software solutions; development of a genomics technology platform; development of a nanobody technology platform; development of biometric verification technology platform, Development of a generic payments processing platform.</i>
17	Knockaert Ucbasaran Wright Clarysse (2011)	M., D., M., B. The relationship between knowledge transfer, top management team composition, and performance: The case of science-based entrepreneurial firms	<i>Entrepreneurship: Theory and Practice</i>	Firms are selected among the science based firms, in the table that describe the sample is possible to observe that they all had a research based creation of a new technology	<i>Today, IMEC is Europe's leading independent research center in the field of microelectronics, nanotechnology, enabling design methods, and technologies for ICT systems... ...and/or the leading professor of the research group at the PRI from which the venture's technology originated...</i>
18	Alegre Sengupta Lapiedra (2011)	J., K., R. Knowledge management and innovation performance in a high-tech SMEs industry	<i>International Small Business Journal</i>	They used all biotech firms very homogeneous. The paper analysis the knowledge development of these firms which are science based by nature given their formation and development of knowledge itself	<i>We test our hypotheses by conducting a survey in the context of a single industry: biotechnology companies in France... ...The target population of this study was narrowly defined to include a homogeneous set of firms.</i>

APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
x	Abramo G., D'Angelo C.A., Ferretti M., Parmentola A. (2012)	An individual-level assessment of the relationship between spin-off activities and research performance in universities	<i>R and D Management</i>	Spin-offs taking in consideration scientific research of their founders with affiliations.	<i>The survey identified 326 university spin-offs founded in Italy in the period under observation, from which were then excluded (1) those founded by scientists not holding a formal university faculty ; and (2) those where the founding members position all belonged to SDSs that are not included in science and engineering. The final dataset is composed of 284 spin-offs.</i>
19	Yagüe-Perales R.M., March-Chordà I. (2012)	Performance analysis of research spin-offs in the Spanish biotechnology industry	<i>Journal of Business Research</i>	In their sample selection they target only those firms which are science-based.	<i>The study focuses on dedicated biotechnology firms (DBFs), excluding purely pharmaceutical firms and those that operate in the biotechnology sector for exclusively commercial purposes. The dependent variable in this analysis is BIORESEARCHSPINOFF, a dummy that divides the sample into research spin-offs and other biotechnology firms....academic research carried out in universities or other academic research institutions of the same kind, and (b) the scientist who was the originator of the particular pre-foundation academic research is also the founder or one of the founders of the company.</i>
20	Wang J., Shapira P. (2012)	Partnering with universities: A good choice for nanotechnology start-up firms?	<i>Small Business Economics</i>	They target an extremely R&D and knowledge intensive segment such as nanotechnology. In the paper they also target scientists working in these firms in which they perform research.	<i>The nanotechnology sector is used as a case study in this paper due to its knowledge-intensive nature and close connections with university science research. Nanotechnology involves the manipulation of molecular-sized materials to create new products and processes with novel features due to nanoscale properties and is widely anticipated as a major driver of new technology-based business and economic growth over the next two decades (PCAST 2005; Lux Research 2006... ...We do not include firms that were previously established (based on other technologies) which have subsequently added or moved into nanotechnology research and production.</i>
x	Okamuro H., Nishimura J. (2013)	Impact of university intellectual property policy on the performance of university-industry research collaboration	<i>Journal of Technology Transfer</i>	They select firms according to sector from a research institute in Japan. This supposignly presume that are all firms based on previous research.	<i>Our empirical analyses are based on original survey data.⁷ After a pre-test with a smaller sample, we conducted a postal survey with a structured questionnaire in the summer of 2008 covering 9,882 Japanese firms with 20 or more employees in the fields of biotechnology, microelectronics, and software; we obtained 1,732 responses (a 17.5 % response rate). We selected these three technology fields to represent the major science- based industries in which UIC is especially important (Meyer-Krahmer and Schmoch 1998). Our sample firms were extracted from the company database of Tokyo Shoko Research (TSR), a major credit research institute in Japan, according to their own three- to four-digit level industry classification, and the directory of the Japan Bioindustry Association (JBA).</i>

APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
21	Yagüe-Perales R.M., March-Chorda I. (2013)	Performance analysis of NTBFs in knowledge-intensive industries: Evidence from the human health sector	<i>Journal of Business Research</i>	The sample relies on knowledge-intensive firms in three segments very science-based oriented. The stress also the R&D intensity which is very high (due to the science developments)	<i>An empirical analysis over a broad sample of firms located within the Valencia region and pertaining to three knowledge-intensive Human Health sectors: Biomedicine, Medical equipment and Bio-Agro Food, (all R&D-oriented Human Health sectors (R&D-HH)) follows from the desire to figure out distinctive features of the performance in NTBFs. These subsectors are the most intensive ones in terms of R&D activities.</i>
22	Benghozi P.-J., Salvador E. (2014)	Are traditional industrial partnerships so strategic for research spin-off development? Some evidence from the Italian case	<i>Entrepreneurship and Regional Development</i>	They target research spin offs founded by scientists, they built a database in a very thorough way in order to include only those ventures that were created for the development of new technologies from research activities.	<i>Considering that the usual definition of SO includes, in general, companies built out of R&D and is not only restricted to those participated by a university, we completed our first list with the Italian science park and incubator tenants list. Since science parks and incubators do not make any difference between SO and start-ups, we set up direct contacts (telephone and e-mail) with university staff as well as science park and incubator personnel. It gave us the possibility to filter the first list excluding firms not linked to the academic world. SO founders are scientists and not managers; therefore, differences might be expected in the way they run their company and in their performance, according to they call or not for complementary competencies and assets through TIP.</i>
x	Gauthier C., Genet C. (2014)	Nanotechnologies and Green Knowledge Creation: Paradox or Enhancer of Sustainable Solutions?	<i>Journal of Business Ethics</i>	Nanotechnology is a sector representative of science based firms. They also check for knowledge formation (through patents). In this case is representative of science based firms.	<i>To identify those firms involved in nanotechnology, we built a database of firms that have patented or published in nanotechnology, using a validated search strategy based on keywords (Mougotov and Kahane 2007) to extract patents from the EPO PatStat at the European Patent Office¹ (which collects data from 73 offices worldwide) and publications from the ISI/web of Science. We elicited 617,000 nanotechnology patent applications (from a total of over 65,000,000) between 1990 and 2009 (see Appendix 1 for details). We thus identified 14,845 firms involved in nanotechnology worldwide, of which 9,447 were patenting firms (2,716 both publishing and patenting; 6,731 only patenting) (Fig. 2), responsible between them for 323,918 nanotechnology patent applications over that period. To uncover economic and financial information about the nanofirms that create green knowledge, we then matched this database against ORBIS², a comprehensive global database that combines information on some 60 million companies, from.....</i>

APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
x	Lejpras (2014)	A. How innovative are spin-offs at later stages of development? Comparing innovativeness of established research spin-offs and otherwise created firms	<i>Small Business Economics</i>	The sample targets research spin-off with R&D activities.	<i>Moreover, companies provided information on how they were created, as: (1) a spin-off from a university, (2) a spin-off from a research institute, (3) a spin-off from another company, or (4) other type of firm foundation. In this study, we distinguish between the research spin-offs—that is, companies that spun off from a university or a research institute (hereinafter, spin-offs)—and firms created in other ways.</i>
23	Stephan (2014)	A. Are public research spin-offs more innovative?	<i>Small Business Economics</i>	The sample directly targets the research spin-offs, which are science based being concentrated on the advancement of science.	<i>Based on answers to one question regarding the origin of the company, I can differentiate between company and research spin-offs, and for the latter I can further distinguish between spin-offs that evolved out of a university setting and those that were created by a research institute (Pirnay et al. 2003).</i>
24	Visintin F., Pittino D. (2014)	Founding team composition and early performance of university-based spin-off companies	<i>Technovation</i>	Using the definition of Fini et al., 2011 and their definition fits with our definition: firm founded by previous scientific research....	<i>For the purpose of this research we adopted the definition of USO provided by Fini et al. (2011): a university spin-off is a company that has either the university among the founding shareholders or at least one academic (full, associate, assistant professor, PhD student, research fellow) among the founders. Two features distinguish therefore a USO in our perspective: the presence of at least one founder who was employed at the university at the time of start-up and the commercialization of a technology originally developed by academic research activity.</i>
25	Scholten V., Omta O., Kemp R., Elfring T. (2015)	Bridging ties and the role of research and start-up experience on the early growth of Dutch academic spin-offs	<i>Technovation</i>	The sample criteria was to include firms based on previous scientific researches and founded by their researchers	<i>To be included in the database, a potential spin-off had to be an autonomous company, based on scientific research conducted at an academic institution and founded or co-founded by researchers that had worked on the scientific findings at the academic institution in question.</i>
26	Ziaee Bigdeli A., Li F., Shi X. (2016)	Sustainability and scalability of university spinouts: A business model perspective	<i>R and D Management</i>	Three firms which are academic spin-offs representing a subsample of SBFs.	<i>USO_A: Founded in 2010 in partnership with the University and the United Kingdom's NHS Trust. The firm specializes in the design and development of Assistive Living Technologies and Services (ALTS), such as computer-based applications for assisted living purposes USO_B: Established in 2008 through a partnership between the NHS Foundation Trust and the University to focus on focusing on developing, validating, and delivering molecular diagnostics using the latest sequencing and genotyping technologies USO_C: Established in 2001 through the collaboration with the University TTO to focus on systems biology drug discovery through patented platforms</i>

x	Hayter (2016)	C.S.	Constraining entrepreneurial development: A knowledge-based view of social networks among academic entrepreneurs	Research Policy	Inclusion because it targets researchers that founded a start-up and surpassingly with what said in the introduction should be startup based on their research activities as a consequence SB.	"Academic entrepreneurs, defined here as university faculty who establish a spinoff company based on their research (Shane, 2004), play a particularly important role in the founding and development of university spinoffs."
ID	Authors		Title	Source	Inclusion justification	Quotations from the paper
x	Hayter (2016)	C.S.	A trajectory of early-stage spinoff success: the role of knowledge intermediaries within an entrepreneurial university ecosystem	Small Business Economics	They specify that are all spin offs based on technology developed after a research activity.	As noted, all spinoffs were established based on technologies derived from federally funded research
27	Miozzo DiVito (2016)	M., L.	Growing fast or slow?: Understanding the variety of paths and the speed of early growth of entrepreneurial science-based firms	Research Policy	The sample is mixed including also firms which produce services, and hybrid firms which produces services and make research. The majority are science based with applied research given the specialization of the sectors in which they operate. Is possible to derive findings regarding SBFs	The focus on the biotechnology segment of the pharmaceutical industry is representative of entrepreneurial science-based firms because these firms require extensive financial resources for an extended period of time to develop new products in emergent scientific and technological areas with high levels of uncertainty.
x	Miozzo DiVito Desyllas (2016)	M., L., P.	When do Acquirers Invest in the R&D Assets of Acquired Science-based Firms in Cross-border Acquisitions? The Role of Technology and Capabilities Similarity and Complementarity	Long Range Planning	They target biotech firms which are representative of SBFs.	We focus on the acquisitions of six biopharmaceutical firms in the Cambridge, Oxford, and Manchester areas in the UK. The biopharmaceutical industry is an ideal setting for our study for two reasons. First, our research question focuses on the effect of cross-border acquisitions on the continued investment and development of acquired technological assets of science-based firms. Biopharmaceutical firms operate upstream in the value chain or product-development trajectory, generate product- and firm- specific knowledge and represent the complexity of R&D in science-based businesses.
28	Lubik Garnsey (2016)	S., E.	Early Business Model Evolution in Science-based Ventures: The Case of Advanced Materials	Long Range Planning	The sample relies on three firms which apply R&D for scientific discoveries and their commercialization.	Case 1: Metalysis; Case 2: Nanomagnetism; Case 3: Apaclara
29	Quintana-García C., Benavides-Velasco (2016)	C.A.	Gender Diversity in Top Management Teams and Innovation Capabilities: The Initial Public Offerings of Biotechnology Firms	Long Range Planning	Dedicated biotechnology firms are firms with a scientific R&D.	The research setting of this paper is provided by dedicated biotechnology firms (DBFs) that completed an initial public offering in the United States, during 1983–2009... ..Biotechnology firms tend to be involved at the riskiest stage of the drug development process.
x	Soetanto D., Jack S. (2016)		The impact of Technovation university-based		Inclusion because they have included the condition of technology created at	We delineated the population of spinoffs from these universities based on the following criteria. First, the firms needed to satisfy the condition of

incubation support on the innovation strategy of academic spin-offs	the university impiyng a Science-Based R&D activity.	<i>commercialising knowledge and technology created at the university. Second, at least students, graduates or academic staff had to be actively involved in the firms. Further, the firms needed to satisfy the condition of receiving support from the in- cubators or university.</i>
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APPENDIX 1: Inclusion of the sample (*continues*)

ID	Authors	Title	Source	Inclusion justification	Quotations from the paper
30	Subramanian A.M., Choi Y.R., Lee S.-H., Hang C.-C. (2016)	Linking technological and educational level diversities to innovation performance	Journal of Technology Transfer	The article is focused on science based firms promoted by the government for the development of their technology.	<i>The Agency for Science, Technology, and Research (A*STAR) was established to be the nation's supplier of scientific, engineering, and technology talent to commercial enterprises by offering scholarships to individuals to enroll in science and engineering- based disciplines....</i>

Appendix 2: Studies data

ID	Reference	Business entity	Industry	Size of the sample	Country of analysis	Affiliation	Theoretical foundations	Qualitative	Quantitative	Longitudinal	Cross sectional	Period of analysis	N. of observations	Research Strategy	Data collection method	Type of analysis
1	Segers (1993)	New Technology Based Firms (NTBFs)	Biotechnology, pharmaceutical, semi-conductor	3	Belgium	n.d.	n.d.	1	0	1	0	inception up to 1993 (most recent 1983)	3	Case studies	n.d.	Analysis of qualitative data
2	Quére (1994)	Basic research unit	Defense electronics	1	France	no	n.d.	1	0	1	0	1972-1987	1	Case studies	n.d.	Analysis of qualitative data
3	Reitan (1997)	New Technology Based Firms (NTBFs)	n.d.	64	Norway	Yes	n.d.	1	1	0	1	1993	64	Survey	Questionnaires, interviews, archival data, reports	Quantitative: ratios analysis
4	Pfirmsmann (1999)	New Biotechnology Enterprises (NBEs)	Biotechnology	35	Germany	Yes, university associated firms	n.d.	0	1	0	1	1997	n.d.	Case studies	Questionnaires and interviews	Analysis of qualitative data
5	Nilsson (2001)	Biotechnology firms	Biotechnology	3	Sweden	Yes	n.d.	1	0	0	1	1998	3	Case studies	n.d.	analysis of qualitative data
6	George et al (2002)	Science Based Basic Research Firms	Biotechnology	147	US	No	n.d.	0	1	0	1	1998	2457	Case studies	Databases	MANCOVA analysis
7	Mangematin et al. (2003)	Research-intensive Small and Medium Enterprises (SMEs)	Biotechnology	60	France	n.d.	n.d.	1	0	0	1	2000	n.d.	Survey	Interviews	Analysis of qualitative data
8	Meyer (2003)	Research Based Ventures	Nano technologies	4	USA and EUROPE	Yes	n.d.	1	0	0	1	2003	4	Case studies	Interviews	Analysis of qualitative data
9	Suzuki & Kodama (2004)	Technology based firms	Pharmaceutical and Electronics	2	Japan	n.d.	n.d.	1	0	1	0	1925-1999	n.d.	Case studies	Databases	Patent cross class analysis
10	Lawton & Ho (2006)	Technology based spin-off companies	Miscellaneous	64	UK	Yes	n.d.	0	1	0	1	2004-2005	64	Case studies	Databases	Ratios analysis, turnover

																	analysis, basic statistics
1 1	Durand et al. (2008)	Biotechnology firms		Biotechnology	313	France	n.d.	n.d.	0	1	1	0	1994-2002	162 4	Case studie s	Databases	Random- effects negative binomial regressions; generalized least squares (GLS)
1 2	Bruni & Verona G. (2009)	Science Based Firms (SBFs)		Pharmaceutical	6	Europe	No	Dynamic Capabiliti es	1	0	0	1	2003-2005	31	Case studie s	Interviews	Qualitative data analysis

Appendix 2. Studies data (continued)

ID	Reference	Business entity	Industry	Size of the sample	Country of analysis	Affiliation	Theoretical foundations	Qualitative	Quantitative	Longitudinal	Cross	Period of analysis	N. of observations	Research Strategy	Data collection method	Type of analysis
13	Vincett P.S. (2010)	Research-Based Academic Spin-Offs Companies (RASCs)	Miscellaneous	n.d.	Canada	n.d.	n.d.	0	1	0	1	1998	n.d.	Case studies	Databases	Comparisons and estimators
14	Belussi et al. (2010)	Life science Firms	Life science industry: biomedical, biotechnology, pharmaceuticals and computer science industry applied to the medical fields.	78	Italy	n.d.	Regional Innovation System (Evolutionary theories of economic and technical change)	1	1	0	1	2005	78	Case studies	Semi-structured interviews	Qualitative data analysis; negative binomial regression.
15	Bonardo et al. (2010)	Science Based Entrepreneurial Firms (SBEFs)	Miscellaneous	131	Europe	Yes, university affiliations	n.d.	0	1	0	1	1995-2003	131	Case studies	Databases	Poisson regression; Cox proportional hazard regressions;
16	Clarysse et al. (2011)	Young Technology based firms	Miscellaneous	6	Belgium	n.d.	Resource Based View	1	0	1	0	2002-2008	409	Case studies	Interviews, press releases and press articles	Qualitative data analysis
17	Knockaert et al. (2011)	Science Based Entrepreneurial Firms (SBEFs)	Miscellaneous	9	Belgium	n.d.	Knowledge-based Theory; Upper Echelons Theory	1	0	1	0	2010 (year of publication -1)	n.d.	Case studies	Interviews	Qualitative data analysis
18	Alegre et al. (2011)	High-Tech SMEs	Biotechnology	132	France	n.d.	Dynamic Capabilities	0	1	0	1	2002	132	Survey	Questionnaires	Structural Equations Modelling (SEM)
19	Yagüe-Perales & March-Chordà (2012)	Research Spin-offs	Biotechnology	32	Spain	n.d.	Resource Based and Dynamic Capabilities	0	1	1	0	1998-2004	102	Case studies	Databases	Standard dichotomous regression analysis

20	Wang & Shapira (2012)	New Nanotechnology-based firm (NNBFs)	Nanotechnology	230	US	Yes	n.d.	0	1	1	0	1996-2005	1539	Case studies	Databases	Tobit model
21	Yagüe-Perales & March-Chorda (2013)	New Technology Based Firms (NTBFs)	Human Health	173	Valencia-Spain	n.d.	n.d.	0	1	0	1	2009	173	Case studies	Databases	Factor analysis and ANOVA analysis.
22	Benghozi & Salvador (2014)	Research Spin-offs	Miscellaneous	155	Italy	n.d.	n.d.	0	1	0	1	2007	155	Survey	Questionnaires	Regression

Appendix 2: Studies data (continued)

I D	Reference	Business entity	Industry	Size of the sample	Country of analysis	Affiliation	Theoretical foundations					Period of analysis	N. of obs erv ati ons	Resea rch Strat egy	Data collection method	Type of analysis
								Qualitative	Quantitative	Longitudinal	Cross sectional					
2 3	Stephan A. (2014)	Research Spin-offs	Miscellaneous	121	Germany	Yes	n.d.	0	1	0	1	2004	121	Case studies	Databases	Propensity score matching (PSM)
2 4	Visintin & Pittino (2014)	University spin-off	Miscellaneous	103	Italy	Yes	Upper Echelons	0	1	0	1	2000-2006	103	Case studies	Databases	Hierarchical regression method
2 5	Scholten et al. (2015)	Academic Spin-offs	Miscellaneous	70	The Netherlands	Yes, university	Social Network Structure	0	1	0	1	2013	70	Survey	Questionnaires	Hierarchical multiple regression OLS
2 6	Ziaee Bigdeli et al. (2016)	University spin-outs	Life science industry	3	UK	Yes	n.d.	1	0	0	1	2011-2013	n.d.	Case studies	Interviews	Qualitative analysis data
2 7	Miozzo & DiVito (2016)	Science Based Firms (SBFs)	Biotechnology	35	UK and Netherlands	n.d.	Resource Based View	1	0	1	0	2006-2014	74	Case studies	Interviews	Deductive and inductive
2 8	Lubik & Garnsey (2016)	University Spin-Outs	Advanced materials	3	UK	Yes	Resource based and Ecosystem Analysis	1	0	1	0	n.d.	n.d.	Case studies	Semi-structured interviews	Inductive analysis
2 9	Quintana-García & Benavides-Velasco (2016)	Dedicated Biotechnology Firms (DBFs)	Biotechnology	229	USA	n.d.	Dynamic Capabilities	0	1	1	0	1983–2009	229	Case studies	Database	Hierarchical regression analysis. We
3 0	Subramanian et al. (2016)	Research Scientists and Engineers (RSEs)	Biotechnology	366	Singapore	n.d.	Human Capital and Functional diversity	0	1	1	0	2004-2008	720	Case studies	Database	Negative binomial model in hierarchical piecewise panel regression analyses