

Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy

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Abstract

Research-based spin-offs (RBSOs) have become an important aspect of the technology transfer process. Emanating from what is conventionally a non-commercial environment, RBSOs pose major challenges if they are to realise their potential to meet the objectives of their founders and the parent research organisations (PROs) from which they emerge. An important issue is to understand the heterogeneity of RBSOs. This paper reviews the literature on RBSO typologies to develop a taxonomy of RBSOs. We identify common themes in relation to these typologies in relation to (1) spin-off creation and (2) spin-off development. The dimensions that differentiate between firms are the type of resources, the business model and the institutional link. We identify gaps in current typologies in order to propose avenues for future conceptual and empirical research.

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1. Introduction

There is a growing interest among policymakers and academics in generating wealth from publicly-funded research. Research based spin-offs (RBSOs) have become an important aspect of the technology transfer process (DiGregorio and Shane, 2003; Wright et al.,

2004a,b). RBSOs involve the creation of ventures based on the formal and informal transfer of technology or knowledge generated by public research organisations (Smilor, 1990). This growth in spin-offs has become an international phenomenon (Clarysse et al., 2005) and has stimulated academic and policy debate regarding whether and how RBSOs create wealth (Lambert, 2003). The end result is that policymakers increasingly recognize the need to understand the heterogeneity of RBSOs and the context in which they occur.

Both new high technology ventures (NTBFs) generally and RBSOs face similar difficulties in establishing a market presence and in achieving sustainable returns.

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However, RBSOs also face two fundamentally different problems (Vohora et al., 2004). First, emanating from what is historically a non-commercial environment, RBSOs encounter specific obstacles and challenges since the university environment typically lacks commercial resources. A key concern is whether an institution has academic entrepreneurs with commercial skills to create viable ventures. Second, the venture's ability to develop commercially may be adversely impacted by conflicting objectives of key stakeholders such as the university, the academic entrepreneur, the venture's management team and suppliers of finance. For example, Clarysse et al. (2005) highlight the problems of conflicts between stakeholder objectives with regard to the type of ventures they wish to create and the resources they seek to commit. RBSOs thus pose major challenges if they are to realise their potential to meet the objectives of their founders and the parent research organisations (PROs) from which they emerge.

A key starting point in designing policies and strategies to address these challenges is the need to understand the nature of RBSOs. Traditional pioneering studies of new technology based ventures have identified typologies but have not separately identified RBSOs. For example, Jones-Evans (1995) develops a typology based on previous ownership backgrounds of entrepreneurs and Westhead and Storey (1995) distinguished new high tech ventures on and off science parks. Autio (1997) provides a typology based on science versus engineering based technology ventures in the context of the linkages with their environment. While there is growing recognition of the heterogeneity of high tech ventures, studies have tended to be unidimensional. For instance Mangematin et al. (2002) consider the heterogeneity of trajectories of biotechnology ventures in France in terms of whether their business models involve small, less research intensive projects targeting market niches or research intensive projects targeting broader market types. More recently, as will be shown in greater detail in Section 2, some researchers have started to focus on the specific case of RBSOs and various typologies have emerged, but they also take only a partial view of the RBSO phenomenon. There is, therefore, an important gap in our comprehensive understanding of the diversity of RBSOs.

This paper seeks to address this gap by providing a framework for understanding previous literature. Therefore, it synthesizes and extends existing studies to create a matrix as a tool to identify commonalities among the variety of typologies found in the spin-off literature in order to explain the diversity among RBSOs. We recognize that in order to understand the scope and the nature

of RBSOs there is a need to integrate the different conceptual traditions identified in previous studies. Hence, the paper synthesizes research from the perspectives of innovation, public policy, entrepreneurship, and strategy. Finally, this framework should help to guide future research and to provide policymakers and practitioners with a basis for designing and implementing strategies to facilitate successful spin-offs.

The paper is structured as follows. Section 2 outlines the scope of the literature relevant to this paper and attempts to provide a comprehensive theoretical view on differences among RBSOs. Section 3 discusses the methodology for identifying the relevant papers and maps the existing literature on RBSO typologies. Section 4 discusses the gaps in the literature and identifies opportunities for further research. Section 5 considers implications for practitioners and policymakers and limitations of the study.

2. Methodology and scope of the literature: towards a comprehensive theoretical view on differences between RBSOs

In order to derive a conceptual framework that would enable us to address diversity among RBSOs, we reviewed papers published since 1990 on NTBFs in general in order to identify the main streams of research explaining their diversity.

The decision to review the literature on NTBFs was based on the fact that RBSOs have only recently been specially scrutinized in the academic literature. In addition, RBSOs and NTBFs share several common characteristics. Thus, research on the factors driving variety among NTBFs in general could be relevant to understand RBSOs' characteristics and behaviour.

On the basis of this preliminary review a more precise selection of papers was made, based upon two criteria: we selected papers that either focused on RBSOs as a subpopulation of NTBFs or tried to explain the diversity among the NTBF population. Since the approach adopted in this paper is multi-disciplinary, we searched journals in entrepreneurship, public policy and regional issues, innovation and management for relevant articles. This search generated a list of over fifty publications on NTBFs. From a reading of the papers we identified three main theoretical research traditions. A first category of papers is embedded, explicitly or implicitly, in the resource based view of the firm (Barney et al., 2001; Brush et al., 2001). These papers mainly focus on the resources of the firm as a differentiator and a predictor of competitive advantage. Among these resource-based studies, some authors emphasise the differences in social

resources at start-up (Westhead and Storey, 1995; Shane and Stuart, 2002) as an explanatory factor, others focus mainly on the financial resources (Hellmann and Puri, 2000) or on the technological resources (Bower, 2003). Recently, Heirman and Clarysse (2004) and Druilhe and Garnsey (2004) have tried to offer a comprehensive view of different starting configurations including social, technological, financial and human resources. In line with its theoretical background, we label this group the resource-based perspective. A second category of papers is more atheoretical and descriptive in nature (Stankiewicz, 1994; Chiesa and Piccaluga, 2000; Mustar, 1997, 2002). Such studies describe the activities that are developed by NTBFs in general and RBSOs more specifically. Further, studies distinguish the sectors in which NTBFs are located and other key indicators that make these companies different from other start-ups. Because of their focus on sectoral differences, technological regime and product market combinations that generate growth, we label this the “business model perspective”. A third group of papers focuses on the relation which RBSOs have with their parent organisation. Most of the studies analyse how decisions made by the parent institute might influence the starting configuration and business model of the RBSO (Radosevich, 1995; Roberts and Malone, 1996; Carayannis et al., 1998; Steffensen et al., 2000; Meyer, 2003; Clarysse et al., 2005; Moray and Clarysse, 2005; Westhead and Storey, 1995; Lindelof and Lofsten, 2004; Link and Scott, 2004). Because of their focus on the link with the parent institute as a point of departure, we label this group the “institutional perspective”.

Each of the three aforementioned streams of research—the “resource based perspective”, “business model perspective” and “institutional perspective” is discussed in depth in the following paragraphs.

2.1. The resource based perspective

A number of scholars have examined the starting resource configurations of RBSOs, drawing on the resource-based view of the firm. In recent years, the resource-based theory, which attributes superior performance to organisational resources and capabilities has emerged as one of the most influential frameworks in strategic management research (Barney et al., 2001).

Resource-based scholars define resources rather broadly as all tangible and intangible assets semi-permanently tied to the firm. As a result, a variety of alternative resource classifications exist. For example, Grant (1991) classifies resources as: tangible, intangible and personnel-based resources. Tangible resources

include the financial capital and the physical assets of the firm such as: plant, equipment and stocks of raw materials. Intangible resources encompass assets such as reputation, brand image and product quality. Finally, personnel-based resources include technical know-how and other knowledge resources including organizational culture, employee training, loyalty, etc.

Barney (1991), on the other hand, classifies resources as: physical capital, human capital and organizational capital resources. According to his classification, physical capital resources include the physical technology used in the firm, a firm’s plant and equipment, its geography and its access to raw materials. Human capital resources, on the other hand, include the training, experience, judgment, intelligence, relationships, and insights of individual managers and workers in the firm. Finally, organizational capital resources include a firm’s formal reporting structure, its formal and informal planning, controlling and coordinating systems, as well as informal relationships among groups within a firm and between a firm and those in its environment. Most of these resource typologies are developed in the specific context of large, established firms.

For example, Lichtenstein and Brush (2001) acknowledge the lack of an appropriate resource typology for new ventures. These scholars reviewed the literature on small business growth in order to identify the resources, which may be important for new and small companies. They found that capital, organizational systems, management know-how, employees, owner’s expertise and reputation, technology, physical resources, leadership, organizational structure and culture or informal systems are the most relevant for new ventures. Further, Brush et al. (1997, 2001) categorized the resources of early stage ventures into six types: technological, human, social, financial, physical and organizational resources. Other researchers, who explore resource-based theory in new and/or small firms, adopt the same typology (e.g. Borch et al., 1999). In the context of this study on spin-offs, we build on previous work of Barney (1991) and Brush et al. (2001) and adopt four resource categories in the remainder of the paper: technological, social, human and financial resources. Each of these resource categories is described below.

The category ‘*technological resources*’ refers to the firm-specific products and technology (Borch et al., 1999). Spin-offs might vary in degree of innovativeness, scope of their technology, (perceived) quality or legitimacy of the firms’ R&D and position of the firm in the product-development cycle. The category ‘*human resources*’ refers to attributes of the founding team, the management team and the personnel of the company.

Usually, human resources are measured as: size of the founding team, background of the founders, professional management experience, and organizational size. Brush et al. (2001) define ‘social resources’ of a company as its industry and financial contacts. Others refer to these social resources as the network or the social capital of the company (e.g. Elfring and Hulsink, 2003; Lee et al., 2001; Nohria, 1992). Lee et al. (2001) make a distinction between ‘partnership-based linkages’ and ‘sponsorship-based linkages’. Westhead and Storey (1995) and Lindelof and Lofsten (2004) distinguish the network benefits of firms located on or off science parks. The ‘financial resources’ refer usually to the amount and type of financing of the firm. A distinction is made between capital, loans, subsidies, and reserved profits. Further, having personal funds, which can be invested in the very early start-up phase, can be an advantage for spin-offs. Therefore, it makes sense to split the variable ‘capital’, by two indices, namely the amount of external capital invested in the firm and the amount of personal funds (money invested by the entrepreneurs or their personal friends and family).

According to studies in this literature that have focused on human resources, the initial competencies of new ventures basically coincide with the competencies of the founders (see Cooper and Bruno, 1977). Therefore, they mainly link the diversity of spin-offs with the characteristics of their founders. Other studies have focused on financial and technical resources. An interesting aspect of the analysis of these taxonomies inspired by the resource-based view is the evolution in the investigation of financial aspects. For a long time, classifications of RBSOs based on this dimension have distinguished firms only according to the presence of venture or industrial capital (Mustar, 1997; Shane and Stuart, 2002; Heirman and Clarysse, 2004). Wright et al. (2004) recently took a step forward exploring the relations between the resource configuration of a spin-off and the presence of a risk capital provider. They argued that RBSOs created as a joint venture with an industrial partner will have different resources endowments/access to resources as a consequence of the different resource base of the capital provider they are linked to.

Less explored have been technical resources. Heirman and Clarysse (2004) examined the technical resources of RBSOs focusing on the stage of the technology development cycle and the scope and innovativeness of the firm’s technology. Hindle and Yencken (2004), studying the conditions of knowledge transfer between the PRO and the spin-off, considered different types of technology, that is patented technology versus technical knowledge without formal protection. Other types of

technical resources such as firms’ plants and equipment, distributing channels and access to raw materials have remained unexplored in the literature.

Whereas resources are assets, either owned or controlled by a firm, capabilities refer to the ability to exploit and combine resources through organizational routines in order to accomplish its targets (Amit and Schoemaker, 1993). Resource-based scholars have only recently begun to systematically explore the dynamics of the processes by which firms build their competencies and engage in strategic maneuvering within a given industry. Teece et al. (1997) state that dynamic capabilities reflect a firm’s ability to achieve new and innovative forms of competitive advantage. These encompass organizational and managerial processes (i.e. coordination/integration, learning and reconfiguration), specific asset positions (i.e. technological and financial assets, as well as assets connected to the reputation) and path dependencies (i.e. the firm’s history).

Vohora et al. (2004) describe how RBSOs go through a number of distinct phases in the development of resources and dynamic capabilities. They found that a RBSO has to overcome critical junctures at the intersection of each consecutive phase, which they label research, opportunity framing, pre-organization and re-orientation phase. It is only when they can overcome certain resource hurdles, that RBSOs are able to go from one phase to the other.

2.2. Business model perspective

A second stream of researchers has focused on the business models of NTBFs and RBSOs. This stream of research finds its roots in the management literature. Although consultants often refer to the ‘business model’ adopted by a start-up, the academic literature largely ignores it (Chesbrough and Rosenbloom, 2002; Zott and Amit, 2005). Chesbrough and Rosenbloom (2002) defines the business model as the articulation of the value proposition, the identification of the market segment, the position which is taken in the value chain and the estimated cost structure and profit margin. Bower (2003) is probably the first who explicitly referred to the business model of RBSOs as a subject of study. Druilhe and Garnsey (2004) more systematically analysed the different business models at start-up in a sample of RBSOs from the University of Cambridge. In the same vein, Heirman and Clarysse (2004) linked business model to growth in a sample of Belgian NTBFs. Studies within this perspective can be divided into three groups.

The first group focuses on activities undertaken. Stankiewicz’s (1994) pioneering study made a

distinction between RBSOs that are mainly *consultants*, those that are *product oriented* and, finally, those that have a *technology asset oriented mode*, which means that they basically develop technologies which are sold through licenses and partnerships. The latter group does not engage in market oriented activities. The conceptual distinction between service and product oriented RBSOs has been confirmed in various empirical studies. Chiesa and Piccaluga (2000) find in a sample of Italian RBSOs that about half of the RBSOs are service oriented and about half are product oriented. Mustar (2002) derives a typology that comprises five spin-off categories and is focused on the nature of the firms' output, that is whether it is for final customers or not and whether it is service, production or research oriented.¹ Pirnay et al. (2003) report similar prevalence rates of product oriented and service oriented RBSOs in a sample of Belgian spin-offs. Bower (2003) highlights the technology asset oriented mode as a dominant mode in the emerging phase of a new technology such as biotechnology in the late eighties or plant biotechnology in the early nineties. The aforementioned studies are typically atheoretical in nature and explorative in approach.

The second group of studies examine how technologies or knowledge can be transformed in commercial value. The transformation of technologies into commercial value can assume various forms. We identified four main approaches: infrastructure or platform companies, product companies, companies that move from product to platform, and prospector companies. Each is described in more detail below. First, infrastructure companies (Branscomb and Auerswald, 2001; Heirman and Clarysse, 2004; Druilhe and Garnsey, 2004) have an exit driven strategy, which is focused on seeking investor acceptance during most of their early growth path. Heirman and Clarysse (2004) show that most of these high growth RBSOs have increasingly negative cash flows and spend the largest chunk of their capital for technology development and platform building and not on business development, marketing or sales. Aggarwal and Bayus (2002) argue that the commercialisation of technology platforms takes on average over 14 years, which is much longer than the time horizon of most venture capital firms. This immediately shows the vulnerability of the platform model.

A second transformation approach, therefore, concerns ventures that offer goods and services that cus-

tomers quickly choose to buy and are thus able to grow their revenues at a faster rate in the early years (Chesbrough and Rosenbloom, 2002). These ventures are more likely to become profitable sooner, to consume less cash and to rapidly achieve a profitable liquidity event for their investors (Bhide, 1992). The long lead times to market as described by Aggarwal and Bayus (2002) might also be a major reason why some RBSOs start up as consulting companies in software or contract research start-ups in biotech (Bower, 2003). Usually, these quick revenues are needed to become more attractive as a company. In general, concrete business plans for smaller but focused markets/applications are found to be more successful than 'large scale/broad' product introductions (Moore, 1991; Golder and Tellis, 1996).

Heirman and Clarysse (2004) describe a third transformation approach involving those new technology based firms that start as a one product company and only later on develop a customer driven technology base. Usually, the founders of these companies have business experience and got interested in a close to market product, which the parent company does not support. The reasons for this might be various. Either the product does not fit in the mainstream strategy, the market size does not meet the minimum requirements for the parent company or the top management cannot be convinced. The founders leave the company with a marketable product and spend the first years after company start-up to commercialize the product. After a few years, they are quite familiar with the customer needs and develop new products for their established customer base. Doing so, they change their strategy from a one product company towards a multi-product one with several products that suit their customer basis. This model might also be consistent with the observations of Mustar (2002), Chiesa and Piccaluga (2000) and Degroof (2002) who report a high prevalence of product oriented RBSOs.

The fourth transformation approach is inspired by the work of Druilhe and Garnsey (2004) who base their typology on the interplay between the entrepreneur's prior knowledge and experience and the intensity of resource requirements and in line with Heirman and Clarysse (2004) and Degroof (2002). Interestingly, in contrast to the other studies, Druilhe and Garnsey (2004) adopt a dynamic perspective on how these interrelationships yield a business model and suggest that business models are altered as entrepreneurs improve their knowledge of resources and opportunities. This means that many RBSOs start up without a clear idea of how they will create value in the beginning, especially if these entrepreneurs are researchers or professors and are unfamiliar with the transformation approaches that are used

¹ Mustar (2002) also presents a typology focusing on the origin of the entrepreneurs and their relations with public sector research that was previously developed in Mustar (1997).

in the industry. They spend considerable time in searching for the right approach to value creation during the first years after start-up and can be considered as “prospectors”. Usually, they continue to develop the technology in the meanwhile and test various assumptions in the market place. Often pre-seed capital and incubation funds linked to universities provide a first investment in these companies to finance their search for a viable mechanisms to create value.

The third group of studies distinguishes NTBFs (and RBSOs as a subsample) based upon the *growth orientation* which these companies establish. In contrast with the US success stories as described in Saxenian (1994), Autio and Lumme (1998) conclude that most high tech start-ups in Finland do not grow at all. They argue that their results might have more external validity for the rest of Europe than the US studies. Also Wtterwulghé (1998) describes how Belgian and French NTBFs tend to be mostly one-man SMEs with a limited ambition to grow and without a clear commercial strategy. In an exploratory article, Tiler et al. (1993) reported that NTBFs start up in three different growth modes. The fast and slow growers as described above and, finally, the transitional growers. They might start up as consulting companies, R&D boutiques or niche players and eventually turn into high growth companies. The difference with the low growers is that the latter already have the *ambition to grow* at start-up, but for a variety of reasons they postpone exponential growth plans for a few years. Degroof (2002) builds on this analysis to explore the growth ambitions of 42 Belgian spin-offs at start-up. He also found these three different types.

2.3. The institutional perspective

The institutional perspective is based on the recognition that RBSOs are founded to exploit intellectual property emerging from science and are typically embedded in a parent organisation, although the nature of the embeddedness may vary. This parent organisation has its own culture, incentive systems, rules and procedures (Moray and Clarysse, 2005). Scholars, who study RBSOs from this perspective, are particularly interested in how the institutional context shapes the starting configuration and later development of the RBSO (Dacin, 1997). Studies may combine insights from institutional and neo-institutional theory (e.g. Boeker, 1989) with reference to resource dependency theory (Meyer, 2003) and even strategic management (Moray and Clarysse, 2005) to explain their findings.

Roberts (1991: 103–107) noted the variety of linkages between science-based entrepreneurial firms and MIT.

He questioned entrepreneurs about the link between the firm and the research organisation and, more specifically, about the importance of technology transferred to the new firm. The author asked respondents to rate the degree of dependence on source technologies: direct, partial and vague. Where technology is transferred directly, the company would not have been started without the formal transfer of Intellectual Property Rights (by means of a license agreements or transfer of a patent). “Partial” means that the company was founded based on the formal transfer of Intellectual Property rights; however, this know-how needed to be expanded with some other source of know-how (i.e. IP coming from another institute than the parent institute). The category “vague” represents those companies that are categorised as RBSUs by the parent institute for other reasons than formally transferred technology. Building on this pioneering work, the Association of University Technology Managers² adopted a more pragmatic approach labelling those companies which have received a formal transfer of technology “spin-offs”, while the other ones are start-ups. Formal means that there is some kind of license relation, be it equity based or not, with the parent organisation. Informal means that the relation is not institutionalised. Moray and Clarysse (2005) have found that the degree to which the technology is “formally” transferred from the parent organisation to the RBSO has both a direct impact on the starting resources of the RBSO and on the later growth path of this RBSO.

A number of scholars in this institutional tradition do not limit their analysis to the *institutional link*, but analyse how the *strategic choices* made by the parent institute might have a lasting effect on the RBSOs that are created (Boeker, 1989). In a pioneering study, Radosevich (1995) focuses on the inadequate incentive systems at universities to induce inventors to become involved in the commercialisation of their inventions. Instead of having a lasting effect, universities and public research institutes are still considered as a barrier. Steffensen et al. (2000) were probably the first to make a clear distinction between those RBSOs that result from an organised effort by the parent organisation and those that occurred spontaneously, sometimes even despite the university. In this study, they describe the efforts of research centres to provide facilities to new firms. Along the same line, Franklin et al. (2001) examine universities’ attitudes to using surrogate entrepreneurs in the development of spin-offs in order to compensate for the lack

² For a description see www.autm.org.

of entrepreneurial culture. Debackere (2000) indicated that universities can also have a positive and stimulating impact on the creation and growth of RBSOs. In an in-depth case study, he clearly describes how the University of Leuven created a separate organisation to foster RBSOs and support them in their early growth path. Lundqvist and Hellmark (2003) performed a similar study, describing the entrepreneurial university support system of Chalmers University in Sweden.

Building on the insights of previous studies, Mustar (2002), Meyer (2003) and Clarysse et al. (2005) suggested that the policy choices made by the parent institute might not only affect the number of spin-offs but also the “type” of spin-off. Clarysse et al. (2005) distinguish between three kinds of organisation modes at the level of the parent organisation: the low selective mode, which is oriented towards maximising the number of entrepreneurial ventures regardless of the start-up size and configuration; the supportive model which is oriented towards generating spin-offs as an alternative to licensing and tries to set up RBSOs with an average resource intensity; and the incubator model focused on RBSOs which are viewed as tradable assets.

An important dimension of the institutional link concerns the physical property-based contexts within which the link takes place. Many universities have established incubators and science parks as environments to facilitate the creation and development of RBSOs (Phan et al., 2005; Siegel and Phan, 2005). Critical issues concern what these property-based contexts offer besides (typically subsidised) physical space. Distinct differences among the physical and other resources offered may influence the types of RBSOs that can be sustained. Clarysse et al. (2005) note that the low selective mode offers office space and infrastructure within the university but very limited technical, financial or human capital resources; the supportive mode involves the setting up of limited incubator facilities, a pre-seed capital fund and a permanent staff in the technology transfer office to support these start-ups; the incubator model involves extensive incubator facilities and networks as well as financial and specialist human capital resources.

Westhead and Storey (1995), Ferguson and Olofsson (2004), Lindelof and Lofsten (2004) and Link and Scott (2004) examine the links with universities by firms located on or off science parks and offer insights into the differences between NTBFs and RBSOs according to the nature of these links. These studies suggest that the strength of the link is associated with the proximity and richness of the university research environment, R&D output and survival.

2.4. Summary

We can conclude that NTBFs and RBSOs in particular have been studied from three main theoretical perspectives: the RBV perspective, the business model perspective and the Institutional perspective. The RBV perspective has analysed the start-up configuration of NTBFs and RBSOs. The financial and human resources at start-up have particularly been subject of intensive study. Much less attention was paid to the technical resources and the social network of start-ups. Most studies have also focused on resources at a single point in time. We identified only one study which included dynamic capabilities as a subject. Second, the Business Model perspective has focused on what activities were carried out by NTBFs and RBSOs, the technological areas in which they were found, their product market choices and how they transformed knowledge into value creation. Again, most studies took a snapshot approach and provided a description at a single point in time. A dynamic view on how business models evolve, that is how choices in product market change over time, is largely absent from the literature, an exception being Druilhe and Garnsey (2004). Finally, we identified the institutional perspective in which the link between the parent institute and the RBSO is the main subject of study. In this stream, the choices made by the parent organisation are linked to the starting configuration, physical location, business model, technological regime and growth perspective of the RBSO. As in the two previous perspectives, studies are typically static in nature and focus upon the link at a single point in time although an exception is the study of the link between survival of science park firms and the link with universities by Westhead and Storey (1995).

In the next section, we select a limited number of papers that focus on typologies of RBSOs and map these papers on the three perspectives discussed above. The objective is to provide a synthesis of the existing insights about RBSOs and to analyse the gaps in these insights.

3. Mapping the literature on RBSOs’ typology

In this section, we develop a matrix of types of RBSOs based on an examination of the existing literature. The first part outlines the process of building the matrix while the second part describes its contents.

3.1. Methodology

As part of the process of identifying which papers should be selected we developed a number of dimensions

Table 1
Classification of Theoretical Papers

Paper	Theoretical approach	Spinoff/NTBF	Main findings
Nicolaou and Birley (2003)	Institutional; business model; resource endowment	Spin-offs	Endoinstitutional intradepartmental and interdepartmental networks, exoinstitutional networks, TT office and the presence of surrogate entrepreneurs feed into the idea evolution stage and generate different types of spin-offs
Pirnay et al. (2003)	Institutional; business model; resource endowment	Spin-offs	The status of individuals involved in the new business venturing process (researcher or student) and the nature of the knowledge transferred (codified or tacit) is used to develop a typology (4 types, 2 × 2 table)
Radosevich (1995)	Resource endowment	Spin-offs	Surrogate entrepreneurs may play an important role in transferring technology because of inadequate incentives and support mechanisms for scientists to change the focus of their activities if they work in universities
Stankiewicz (1994)	Business model	Spin-offs	Typology of spin-offs based on the main modes of activities in which the firms operate: (1) <i>consultancy and R&D contracting</i> (CC): exploit competence shortages and R&D environments, (2) <i>product oriented mode</i> (PO): organized around a well-developed product concept; (3) <i>technology asset oriented mode</i> (TA): concerned with the development of technologies commercialized through different types of alliances

This table presents a summary of each theoretical paper in terms of the theoretical perspective[s] adopted; whether the study referred to RBSOs only or a combination of RBSOs and NTBFs and the main findings.

by which we could classify the papers. This resulted in a population of 26 papers of which four were theory papers (Table 1) and the remainder empirical papers (Table 2). The dimensions were the nature of the theoretical background of the paper, the methodology employed, the sample size (if appropriate), the focus of the paper in terms of whether it only included spin-offs or whether NTBFs in general were also included and finally the geographic focus (where appropriate). These dimensions are summarised in Tables 1 and 2.

We then analysed the nature of the papers using the conceptual framework discussed above. The frequency of adoption in the papers of each of the three conceptual bases outlined above, that is resource endowment, business model and institutional link, and their detailed breakdown into specific aspects are presented in Table 3. The most frequently adopted conceptual perspective relates to the nature of the links between the RBSO and the institutional context from which it emerges (Table 3). Few studies, however, have considered the different institutional strategies involved in the development of spin-offs. Resource deployment in terms of transformation approaches and activities have formed the basis of a number of typologies, but consideration of the growth orientation of RBSOs has been little researched. While a substantial number of studies have developed typologies based on the different nature of human resource endowments, few have considered either the nature of financial resources or, surprisingly, the technological resources.

We then built up a matrix where the papers selected are positioned according to a critical analysis of their

contents and a subsequent classification along one or more dimensions. The objective of this exercise was to identify commonalities among the variety of typologies found in the literature and, especially, the variety of arguments that are put forward in these typologies to explain diversity among RBSOs.

Each paper was analysed by at least two authors, who produced a summary and proposed a positioning in the matrix. While for most papers the positioning was evident and unanimous, a decision concerning the classification of a few others was more difficult to reach, given their greater complexity. To obtain a final positioning, decisions were made on the following systematic basis.

Some papers have, as a clear goal, the production of a typology to explain the diversity of RBSOs. For others, the typology is the basis for a broader analysis or part of a process that leads to the development of a more general model of spin-off behaviour. For example, Hindle and Yencken (2004) propose a typology with four categories which is a step in the production of a wider model of RBSOs. For these cases, it was decided to focus only on the typology.

Finally, in some cases the difficulties in classification were related to the ambiguity of the indicators. A particular case concerned technology transfer that could be presented as an indicator of two dimensions: the 'Technological resources' dimension (when the technology transferred is regarded as resource for the new firm) and the 'Institutional link' dimension (when the focus is exclusively in the transfer process). This was the case, for instance, in the Upstill and Symington (2002) paper. The

Table 2
Classification of empirical papers

Paper	Theoretical perspective(s)	Method	Sample size	Spin-off/NTBF	Geographical scope	Main findings
Autio (1997)	Institutional; resource endowment	Questionnaire	130	NTBFs and spin-offs	UK, US and Finland	Develops a model which classifies technology-based firms into science-based firms and engineering-based firms
Autio and Yli-Renko (1998)	Institutional	Questionnaire	389	NTBFs and spin-offs	Finland	Discusses the roles and impacts of technology-based firms (NTBFs) in a small open economy by providing details on the changing population of NTBFs in Finland between 1986 and 1993
Autio and Lumme (1998)	Resource endowment	Questionnaire	392	NTBFs and spin-offs	Finland	Four innovator roles of NTBFs are analysed: application innovators, market innovators, technology innovators and paradigm innovators. Application innovators and technology innovators are the oldest and largest among the four groups of firms. The largest potential for growth can be found among market innovators and paradigm innovators
Carayannis et al. (1998)	Institutional; resource endowment	Case study	7	Spin-offs	US, Japan	The traditional definition of spin-offs is an over simplification that should be expanded to include other resource transfers
Clarysse et al. (2005)	Institutional; business model; resource endowment	Case study	43	Spin-offs	Europe	The spin-off process from RIs will be very different in environments where high-tech entrepreneurship is new and in environments with more developed high-tech entrepreneurship. Also there may be a mismatch between a university's tech transfer ambitions and their resources/capabilities
Druilhe and Garnsey (2004)	Business model; resource endowment	Archival and case study	109	Spin-offs	Cambridge, UK	Academic spin-offs do not go through a standard linear process of emergence. Rather any typology of spin-offs should be grounded in a dynamic view of the entrepreneurial process
Ferguson and Olofsson (2004)	Institutional	Questionnaire and longitudinal archival		NTBFs and spin-offs	Sweden	Science park firms interacting with local universities achieve higher levels of R&D than comparable non-science park firms
Fontes (2001)	Institutional; resource endowment	Case study	19	Spin-offs	Portugal	Any typology of spin-offs should integrate the type of knowledge being transferred, the stage of development of application, the type of entrepreneur and their relationship with PRO. Different spin-offs need different types of intervention
Fontes (2005)	Institutional; business model	Case study	18	Spin-offs	Portugal	Spin-offs differ in terms of how they transform or transfer knowledge to a market. The means by which they do this will affect their relationship with the PRO
Franklin et al. (2001)	Institutional; resource endowment	Questionnaire	57	Spin-offs	UK	Surrogate entrepreneurs are an important source of commercial knowledge and skills that may increase a spin-offs chances of success
Heirman and Clarysse (2004)	Institutional; business model; resource endowment	Questionnaire	102	NTBFs and spin-offs	Belgium	The development of spin-offs is dependent on their initial resource endowments how these resources interact with the institutional origin and market characteristics
Hindle and Yencken (2004)	Institutional; resource-endowment	Illustrative cases	N.A.	Spin-offs	Australia	A spin-off's relationship with its PRO is important in terms of whether or not there has been a formal transfer of IP or whether the knowledge transferred is only tacit in orientation

Table 2 (Continued)

Paper	Theoretical perspective(s)	Method	Sample size	Spin-off/NTBF	Geographical scope	Main findings
Lindelof and Lofsten (2004)	Institutional; resource endowment	Questionnaire	273	NTBFs and spin-offs	Sweden	Firms with stronger links and networks with universities have higher R&D and growth
Link and Scott (2004)	Institutional	Questionnaire		NTBFs and spin-offs	US	Richer university research environments associated with greater proportion of spin-offs on science parks
Mustar (1997)	Institutional; resource endowment	Questionnaire and case-studies	200	Spin-offs	France	Successful spin-offs require networks of many different players. To succeed, researcher-entrepreneurs need to be integrated into networks allowing interaction between a wide variety of actors (e.g. PRO, other enterprises, public agencies, technological programs, customers and finance companies)
Mustar (2002)	Institutional; business model	Questionnaire	122	Spin-offs	France	Public support mechanisms for spin-offs are becoming more important. Spin-offs are heterogeneous and should be classified according to resources (human capital or origin of entrepreneur—academic; student; outsider), institutional link (PRO, science park; external) and output type (type of product and customer)
Scholten et al. (2001)	Institutional; business model; resource endowment	Case-studies	2	Spin-offs	Netherlands	Spin-offs can be classified as being (a) <i>exploitative spin-off</i> : a firm addressing an established environment which is accustomed to the technology; or (b) <i>explorative spin-off</i> : a firm addressing a new environment that is not familiar with the new technologies, products or services. The distinction has important implications for spin-offs in terms of the extent to which the venture has to establish external relationships since that is the key element of analysis and subsequently their success
Shane and Stuart (2002)	Resource endowment	Questionnaire	134	Spin-offs	US	New ventures with founders having direct and indirect relationships with venture investors are most likely to receive venture funding and are less likely to fail. Receiving funding is the most important determinant of the likelihood of IPO. Social capital endowments impact fund-raising
Steffensen et al. (2000)	Institutional	Case-studies	6	Spin-offs	US	An important factor in the success of the spin-offs is the degree of support received. Planned spin-offs usually maintain a close relationship with the parent organization during and after the spin-off process
Upstill and Symington (2002)	Institutional	Case-study	1	Spin-offs	Australia	Offer a model for transfer of technology from public-funded research and an analysis of the way the “technology transfer portfolio” evolved over time in one institution. Three types of spin-offs are identified depending on the method of technology transfer adopted: (1) direct spin-offs: companies involving IP generated at a research organization and former staff of the parent organization; (2) indirect spin-offs: companies established by former staff of the parent organization to exploit its tacit knowledge; (3) technology transfer companies: companies based primarily on the intellectual property from the parent organization
Westhead and Storey (1995)	Resource endowment	Questionnaire	284	NTBFs and spin-offs	UK	Science park firms with link to a university have higher survival rate than science park firms without such links
Wright et al. (2004a,b)	Resource endowment	Case-studies	4	Spin-offs	UK	Creating a spin-off as a joint venture with an industrial partner may be an important mechanism for overcoming resource constraints faced by venture capital-backed spin-offs

This table presents a summary of each empirical paper in terms of the theoretical perspective[s] adopted; the empirical method, the sample size, whether the sample was RBSOs only or a combination of RBSOs and NTBFs, the geographical scope and the main findings. N.A.: non-available.

Table 3
Areas covered by papers reviewed

Perspective	Studies	Categories	Key elements (variables)
Institutional			
Strategy of PRO	Clarysse et al.; Pirnay et al.; Steffensen et al.; Moray and Clarysse	Degree of involvement Strategic options Type of support	Organised vs. spontaneous Who drove the process Organisation modes at parent level Objectives as stakeholder Resources assigned Selection criteria Forms of direct and indirect assistance Organised vs. spontaneous
Link and Nature	Autio; Autio and Yli-Renko; Carayannis; Clarysse et al.; Ferguson and Oloffson; Fontes (2001); Fontes (2005); Franklin et al.; Heirman and Clarysse; Hindle and Yencken; Lindelhof and Losten; Link and Scott; Mustar (1997); Mustar (2002); Nicolaou and Birley; Pirnay et al.; Scholten et al.; Steffensen et al.; Upstill et al.; Moray and Clarysse	Technology transfer Links after start-up Parent features	Mode of transfer (formal IP vs. non-formal transfer) Formal vs. informal Modes of links Research quality of parent Support structure (incentives; TTO quality) Environment (local norms of reward systems and IPR policies; role models)
Business model			
Activities	Clarysse et al.; Druilhe and Garnsey; Fontes (2005); Heirman and Clarysse; Mustar (2002); Pirnay et al.; Skankiewicz	Type of sector	Product vs. service Product vs. technology asset oriented Final vs. intermediate customers
Knowledge transformation approach	Clarysse et al.; Druihle and Garnsey; Heirman and Clarysse; Mustar (2002); Nicolaou and Birley; Pirnay et al.; Stankiewicz	Type of company	Approach to business (platform vs. product companies vs. companies moving from product to platform) Interaction between entrepreneur's knowledge and intensity of resource requirements Position in value chain Time to market
Growth orientation	Clarysse et al.; Heirman and Clarysse; Nicolaou and Birley; Scholten et al.	Company objective	Exploitative vs. explorative Ambition to grow or not
Resource endowment			
Sources of resources	Carayannis et al.; Clarysse et al.; Druilhe and Garnsey; Franklin, et al.; Hindle and Yencken; Wright, et al.	Financial Source of technology Source of human capital	Internal vs. external Type of external Internal vs. external Type of external PRO vs. external (surrogate entrepreneurs; hired managers)

Table 3 (Continued)

Perspective	Studies	Categories	Key elements (variables)
Technology	Autio; Heirman and Clarysse; Hindle and Yencken; Scholten et al.; Autio and Lumme	Technology base	Quality of R&D
		Nature of technology	Technological regime Technology developed by entrepreneurs or not Degree of innovativeness Stage of development
		Conditions of transfer	Scope of technology Conditions of knowledge transfer from parent
Human	Fontes (2001); Franklin et al.; Heirman and Clarysse; Hindle and Yencken; Pirnay et al.; Radosevich; Scholten et al.; Shane and Stuart	Origin of team	Type of organization
		Team quality	Founder position in PRO Scientific background and status Management competences Previous experience in area Previous entrepreneurial experience
		Team variety	Presence of surrogate Variety of backgrounds and work experience
Financial	Heirman and Clarysse; Mustar (1997); Wright et al.	Type Amount	Mode of funding Level of investment
Social (networks)	Autio; Lindelhof and Losten; Mustar (1997); Nicolaou and Birley; Scholten et al.; Shane and Stuart; Westhead and Storey; Wright et al.	Entrepreneurs personal links	Relationship with parent after-startup
		Firm-level relationships Strategies to access missing resources	Contacts with industry and finance PRO vs. corporate Type of strategy

This table summarizes the papers reviewed in terms of the perspectives identified. We show the studies that adopt each perspective, the categories within each perspective and the key elements of each (i.e., variables).

decision was to focus on the main goal of the typology and particularly on what the authors meant by technology transfer. As a result, this paper was positioned in the “Institutional link” dimension, since the authors focused not on the characteristics of the technology itself but on its origin and the way it is brought into the RBSO. So, the final matrix was not the result of a mechanistic classification process, but of a process of reflection that attempted to perceive the main orientation and objectives of the papers.

3.2. Description of the matrix

The final matrix is depicted in Fig. 1. The matrix is not an end in itself, but simply a tool to enable a critical reading of the literature. Indeed, our purpose lies in the identification of clusters of papers based on the matrix in

order to distinguish common categorisations of RBSOs’ diversity but also to identify possible gaps or ‘empty cells’ in this literature.

Prior to discussing the matrix, it is important to recognise that, as every tool, this one also has its limits. First, it allows us to map one or two-dimensional typologies but is less accurate in positioning the three (or more)-dimensional ones. Second, the dimensions of the matrix are not totally orthogonal. Although this means that the dimensions have a degree of ambiguity, we argue that only a flexible approach could grasp the literature in its complexity and accordingly much attention was paid to the positioning of ambiguous papers.

Before discussing the location of the different papers along the three dimensions it is important to uncover the rationale behind these papers. The analysis of the papers selected enabled us to identify two main rationales

		Institutional link	Business Model	Resources				
				Sources of resources	Technical resources	Human resources	Financial resources	Social resources
Institutional link		Steffensen et al (2000) Autio (1997)	Pirnay et al (2003) Mustar (2002)	Carayannis et al (1998)		Fontes (2001)		Nicolaou and Birley (2003)
Business Model			Stankiewicz (1994) Scholten et al (2001)	Clarysse et al (2003)	Fontes (2005)			
Resources		Sources of resources					Wright et al (2004)	
		Technical resources			Autio and Lumme (1998)			
		Human resources				Franklin et al (2001) Radosevich (1995)		
		Financial resources						Shane and Stuart (2002) Mustar (1997)
		Social resources						

Fig. 1. A matrix for the categorisation of RBSO.

Note: The matrix maps the different types of perspectives adopted by the studies reviewed. Along the diagonal are those studies that consider only one perspective. The other cells in the matrix map those studies that combine two perspectives. The elipses super-imposed on the matrix identify those studies that link two broad categories of perspective and which distinguish more than one kind of resource (e.g., Heirman and Clarysse combine the institutional and resource perspectives and also distinguish four types of resources).

behind the analysis of RBSOs. The first concerns examining spin-off creation as part of the process of the transfer of technology generated in a research organisation. These papers focus on the process of spin-off creation and therefore place particular emphasis on the relationship with the parent research organisation—i.e. on the institutional link. While this link can also be regarded as a source of resources (human, technological, financial) or be identified as influencing (through the parent’s strategic choices) the type of firm created, the process is basically addressed from the standpoint of the parent organisation. The second rationale concerns examining RBSOs as organisations. These papers focus on the process of development of the RBSO, addressing the opportunities identified and activities performed, or the resources needed and respective sources of resources (the parent being only one of these), or a combination of both. In this case, the emphasis is more clearly on the RBSO itself, with the parent being regarded as one source of resources among others and/or only indirectly influencing the initial conditions that shaped that company. Since these two rationales influence the choice of dimensions and thus the typologies developed, they will be used as a basis for the analysis of the paper location in the matrix.

3.2.1. RBSO creation

This first group of authors is concerned with the creation of RBSOs in terms of the type of inputs transferred to the new organisation and/or with the strategies adopted by the research organisation to spin-off new ventures (Carayannis et al., 1998; Fontes, 2001, 2005; Franklin et al., 2001; Hindle and Yencken, 2004; Mustar, 2002; Nicolaou and Birley, 2003; Pirnay et al., 2003; Radosevich, 1995; Steffensen et al., 2000; Upstill and Symington, 2002). Some authors simply categorise the spin-offs according to this transfer process (e.g. Steffensen et al., 2000). Other researchers are more concerned with understanding the impact of this process upon the type of firm created (e.g. Pirnay et al., 2003; Fontes, 2005). In some cases, attempts have been made to explain the heterogeneity of spin-off firms (e.g. Nicolaou and Birley, 2003; Clarysse et al., 2005; Mustar, 2002).

With respect to the typologies falling within this group, the following distinguishing features can be noted.

- The institutional link is always an underlying dimension, whether or not it is explicitly considered as such in the actual typologies.

- There are typologies that are unidimensional in the sense that they consider only the institutional link as a means to transfer people or technology. There are also typologies that introduce other dimensions either by also considering the inputs transferred as resources for the new firm or by considering the influence that these inputs have on the business model adopted by the RBSO (Fontes, 2001; Steffensen et al., 2000; Upstill and Symington, 2002).
- The parents' strategic choices are a separate aspect of the institutional link, influencing both what is transferred and the conditions under which such transfer takes place (Franklin et al., 2001; Radosevich, 1995).
- The inputs obtained from the parent may be considered as resources for the new firm but it is unusual for "resource endowments" to be explicitly included in the typologies (Carayannis et al., 1998; Nicolaou and Birley, 2003; Hindle and Yencken, 2004). These inputs are sometimes seen as having an impact upon the firm's ability to access further resources.³
- The inputs may have a lasting effect on the business model of the spin-off created, in terms of the nature of the opportunities exploited or the type of activities performed (Fontes, 2005; Mustar, 2002; Pirnay et al., 2003).
- Only one typology shows the interaction between the three dimensions (Clarysse et al., 2005): the institutional link is a source of resources and a facilitator of access to further resources; the new venture's resources emerge as a differentiating factor; the type of inputs transferred and the conditions under which they are transferred are considered as having an impact on the nature of opportunities exploited and the activities performed. The type of opportunity being exploited also influences the type of resources that are necessary for growth.

Therefore, in the typologies focusing on the process of RBSO creation, the institutional link is a prominent dimension that enables differentiation between firms according to the type of inputs transferred from the parent and the conditions under which they are transferred. Some typologies also highlight the interaction between the institutional link and its influence on the behaviour of RBSOs through the dimensions of their resource endowments—and the business models they adopt.

³ For example particular initial resource configurations, close involvement of the parent, formal IP transfer may be important to access finance.

3.2.2. RBSO development

A second group of authors focus more directly on the process of development of RBSOs and the factors that influence it, being less concerned with their status relative to the parent research organisation (Druilhe and Garnsey, 2004; Heirman and Clarysse, 2004; Mustar, 1997; Scholten et al., 2001; Stankiewicz, 1994; Shane and Stuart, 2002; Wright et al., 2004a,b). Therefore, the typologies devised by these authors place greater emphasis on the "resource endowment" and "business model" dimensions, without explicit reference to the parent link as an influence upon each of them. Alternatively, they consider the parent as just one source of influence, among others. Several of these authors attempt to devise explanatory models for heterogeneity amongst RBSOs.

Concerning the typologies falling within this group, we identify the following situations.

- The focus is on the "resource endowment" dimension, that is the resources available to the firm (Mustar, 1997; Shane and Stuart, 2002; Wright et al., 2004a,b). These authors either address a range of resources or explore a particular one. In some cases they also address the impact of the availability of one type of resource upon access to others. While the parent link is not mentioned as an independent dimension it may emerge as an indirect factor: for instance parent decisions concerning the access to technology, the type of actors involved (e.g. academic or surrogate entrepreneurs), or its level of involvement, may in fact be behind the ability to access some type of resources.
- The focus is on the nature of opportunities identified and the activities performed to exploit them—i.e. the focus is on the business model dimension (Mustar, 2002; Stankiewicz, 1994; Scholten et al., 2001). Once again, while the parent link is not an explicit dimension in the actual typologies, it may still underlie them: e.g. in Stankiewicz (1994) the opportunities discussed are induced by the nature of knowledge transferred from the PRO; in Scholten et al. (2001) they generate different requirements in terms of parent support.
- More complex typologies combine both dimensions (Druilhe and Garnsey, 2004; Heirman and Clarysse, 2004), either assuming that the resource requirements are contingent on the opportunities being exploited, or that the nature of opportunities is associated with the type of resources that are possessed by the firms. The focus is on resource *deployment* and on how different strategies at this level can lead to differences in firms'

development. Druilhe and Garnsey (2004) argue for the co-evolution of opportunities and resources over time. In the Heirman and Clarysse (2004) typology there is also an explicit reference to the link to the parent as a dimension: as a source of initial resources it has an impact on resource configuration. Thus, these authors in fact combine the three dimensions.

Therefore, in the typologies derived from the “RBSOs as organizations” rationale, the dimensions that differentiate between firms are “resource endowment” and “business model”, alone or combined. The institutional link is usually kept in the background (as an implicit rather than explicit influence), when it is considered at all.

4. Discussion

4.1. Gaps in the taxonomies

It is apparent from the matrix that existing taxonomies focus only on certain specific aspects of the three categories and ignore other important topics. We now review the typologies based on institutional links, business model, and resource endowment to highlight the aspects neglected in literature.

Studies that examine how parent organisations facilitate spin-off creation and development focus their attention on direct support mechanisms ignoring indirect ones. PROs can support their spin-offs in at least two indirect ways. First, through the use of stages and contractual arrangements aimed at sharing the cost of qualified personnel between the RBSO and the parent organisation, this latter can contribute to lowering the personnel costs of the former thus reducing its financial needs. Second, the reputation of the research organisation may signal the quality of the new venture to both investors and potential partners, thus reducing the extent of ex-ante information asymmetries. This may help the RBSO to obtain access to external financing and to technological and commercial resources possessed by other firms.⁴ This signalling effect may also be important in the labour market, making it easier for the RBSO to recruit high quality personnel. The parent institution can also be a source of network links that are key in reducing the costs of the search for partners, thus favouring establishment

of alliances (Nicolaou and Birley, 2003; Scholten et al., 2001).

As to the typologies of RBSOs based on business model, most studies categorise RBSOs according to the activities performed by the firm and some studies focus on the characteristics of the market. However, other strategic aspects have so far been largely under-researched. The neglected aspects which deserve attention are many: for example, the degree of vertical integration and outsourcing decisions as they influence the structure of the value chain; or cost leadership and international expansion strategies because they impact on the organisation of the spin-off.

Most typologies drawing on the resource-based view of the firm examine the starting resource configurations of RBSOs, with particular emphasis on firms’ competencies. Those studies that examine human resources, have tended to link spin-off diversity with founder characteristics. Other studies have focused on financial and technical resources. However, it is only recently that classifications of RBSOs based on distinctions in the nature of financial resources have been developed to explore the relations between the resource configuration of a spin-off and the resource base of the capital provider they are linked to (see Wright et al., 2004a,b). In fact, there is little understanding of what types of business ventures are more likely to involve industrial partners and which are more likely to involve venture capitalists. There also is little understanding of the heterogeneity of industrial and venture capital partners (national versus multinational firms, experienced versus non experienced firms, etc.) or of whether the timing of their involvement in the development of RBSOs is different.

There has been some examination of the technical resources of RBSOs focusing on the stage of the technology development cycle and the scope and innovativeness of the firm’s technology. The conditions of knowledge transfer between the PRO and the spin-off and different types of technology have also been examined. There is a need to explore other types of technical resources such as firms’ plants and equipment, distribution channels and access to raw materials.

Research appears to have moved from an exclusive focus on the process of firm creation (as in the “RBSOs as instruments of technology transfer” rationale) to greater attention to firm development (as in the “RBSOs as organisations” rationale). This has led researchers to begin addressing aspects that had been neglected. However, there remains limited incorporation into typologies of the different resource requirements, business models and institutional linkages required as RBSOs evolve through their different phases of development.

⁴ The signalling effect is a kind of indirect support. ROs may also support their spin-offs in finding financing and other resources by actively working to create occasions of contacts and links with potential investors or partners.

4.2. Opportunities for future research

Our discussion leads to the identification of a number of relevant areas that have not been addressed and which open up opportunities for further research.

First, studies examining the resources of spin-offs mainly classify RBSOs according to the resources present in the firm at a given time. The survival and growth of a new venture, however, depends on the fit between the resource endowment of the firm and the resources necessary for its development, in the context of the strategy and business model it has adopted. These differ according to the characteristics of the economic and technological environment. It would, therefore, be useful to shift the focus from the analysis of existing resources to the investigation of the resource gaps and the strategies adopted by firms to acquire the lacking resources. The first steps in this direction have been made by Wright et al. (2004) who model the critical junctures in the growth of spin-offs developed by Vohora et al. (2004). While exploring the commercialisation of university owned intellectual property, they look at RBSOs' resource gaps and highlight that joint ventures may be an effective means for a spin-off to overcome resource constraints. In our view, however, as every industry has its own distinctive resources, analysis of the resource gaps of RBSOs operating in different sectors should start from the identification of the resources relevant for each industry. Then different RBSOs could be classified according to the degree of development of the distinctive resources of the sector they belong to. For example, the resources required by firms in biotechnology may be quite distinct from those relating to software, and the timescale and phases over which these resources may be required may also be very different.

Second, existing typologies are cross sectional in nature and hence lack a dynamic aspect. In other words, most classifications have been designed to analyse spin-offs at a given point in time so they focus on static categories and overlook the dynamic processes underlying firms' emergence and growth. As firms evolve, their resources will change and they may develop a different business model; the relation with the parent organisation may also change in intensity and nature. This issue was identified by Vohora et al. (2004) who include a reorientation phase where the firm re-evaluates its basic business model and changes it accordingly. In all cases examined by Vohora et al. (2004) the business model was radically changed from the model outlined at the conception of the business. Hence, for a better understanding of the heterogeneity of RBSOs, we should examine how firms develop iteratively over time in terms of their

resource endowment, strategy and link with the PRO. One exception here is the paper by Druilhe and Garnsey (2004), who identified the importance of the evolutionary perspective and proposed a typology grounded in a dynamic view of the entrepreneurial process. They start from an initial taxonomy based on the interplay between the entrepreneur's prior knowledge and experience and the intensity of resource requirements. They revise this typology considering that business models are altered as entrepreneurs improve their knowledge of resources and opportunities. Another exception is Scholten et al. (2001) who consider how the parent organization influences the successes of its spin-off through exploiting its own social network during the various stages of emergence and growth of the spin-off.

These studies are a useful departure point for future research. An opportunity exists for new research to develop a dynamic view of other aspects of RBSOs' development that have not yet been analysed (e.g. social ties). All of these aspects can then be gathered in a unique typology which can be used to identify the position of a firm over the different phases of its life. Nevertheless, trying to design a single taxonomy able to follow spin-offs' evolution would be complex, and inherently problematic. Different phases of a venture's development may be characterised by different distinctive resources, institutional links and business models. A unique typology may not allow these differences to emerge so it would be necessary to define a more complex classification adding a fourth category: the phase of firm evolution.

Third, a little examined topic is the impact on firm performances of differences in the resource endowment, institutional links, and business model of RBSOs. Some authors have recognised that different types of RBSOs have different growth rates and/or survival probabilities but the diverse performances have generally been linked to the characteristics of the social capital of firms. The first attempt to connect features of the firm and performances was made by Mustar (1997). He classified spin-offs depending on their cooperation arrangements with other public and/or private bodies and highlighted the relation between the breadth of the social network and the growth trajectory and attrition rate. Also, Nicolaou and Birley (2003) recognised that different embeddedness of academics in a network of what they term exoinstitutional (i.e., outside the institution) and endoinstitutional (i.e., within the institution) ties may be associated with different growth trajectories and different evolutionary patterns. The characteristics of the social network a spin-off belongs to are not the only determinants of its performances. The spin-off's resource configuration and strategy can also influence its

growth rate. To date, no study has linked these categories and performances. Hence, a new challenge for future research is to build a taxonomy able to highlight the differences in the performances of RBSOs with diverse characteristics.

A fourth and even more interesting step forward will be to analyse which combinations of the diverse categories are more effective in generating viable RBSOs. As an example, suppose that the absence of initial financial constraints has a positive impact on the growth of RBSOs. If founders are rich enough to satisfy the financing needs of the venture internally, the start-up is not financially constrained. Hence, we can argue that a specific characteristic of human resources, that is the personal wealth of the entrepreneurial team, is associated with positive performances. Suppose now that the parent organisation of a RBSO is supporting it so that its financing needs are satisfied. In this second situation, whether entrepreneurs are wealthy or not does not make a big difference. This example shows that the influence on performance of a specific category in the matrix (i.e. in this example human resources) varies depending on other categories (i.e. the degree of support of the RO, one of the aspects of the institutional links category), which means there is a combined effect.

A fifth dimension concerns the property-based contexts within which the creation and development of RBSOs takes place. We have noted that differences in the physical and other resources offered may influence the types of RBSOs that can be sustained. An interesting research question is whether the match between type of property-based context and type of RBSO is fixed. For example, to what extent are incubators and science parks able to learn from experience and enhance their capabilities to develop RBSOs? In particular, what knowledge acquisition and assimilation capabilities (potential absorptive capacities) (Zahra and George, 2002) are possessed by the managers of science parks and incubators?

Lastly, the nature of institutional links requires further analysis especially at the systemic level as opposed to the PRO level. For instance, there is a need to consider the influence of different regimes relating to the ownership of IP as between the researcher and the parent organisation. This point suggests a need for international studies that examine different institutional regimes. For example, in Sweden in contrast to the US and the UK, IP rests with the academic researcher rather than with the parent organisation. To what extent do these differences affect the resources and strategy of spin-offs? Do differences in institutional links emerge that affect the nature of spin-offs that develop?

5. Conclusions

In this paper, we have attempted to map the literature on RBSOs through the development of a matrix aimed at identifying general dimensions of the typologies of RBSOs. The analysis enabled us to identify and integrate into a coherent framework, the set of variables or combination of variables that were found by the various authors to differentiate between RBSOs. This provides a first step towards understanding the variety among these firms. Additionally, it enabled a distinction to be drawn between research that focused on the process of spin-off creation and research that focused on the process of spin-off development, and to uncover a gradual move from an almost exclusive emphasis on the former to a greater interest in the second, with implications for the type of issues that need to be addressed by RBSO scholars.

By mapping the existing literature on to the matrix we have been able to identify gaps in the existing taxonomies and potential opportunities for future research. In this section, we conclude by outlining implications for policy makers and practitioners and comment on the limitations of our work.

5.1. *Implications for policymakers and practitioners*

Our analysis has a number of implications for policymakers and practitioners. First, our analysis emphasises the importance of understanding the heterogeneity of spin-offs and that this heterogeneity relates to a number of dimensions. This has implications for the design and implementation of strategies to develop spin-offs by research-based organisations such as universities. The development of strategies to aid spin-offs should be tailored to the specific needs of the spin-off and the institution from which they emerge. The matrix, in effect, provides clear dimensions along which policy makers and practitioners can shape their thinking about RBSOs. There is obviously a tension between the need to provide public policy and the needs of individual spin-offs and their parent organizations. The dimensions of the matrix will hopefully enable a better understanding of the complexity of RBSOs and thus help design better targeted public policy measures.

Second, our analysis indicates the need to distinguish between the creation and the development of different types of spin-offs in the design and implementation of spin-off strategies. This distinction is important as it suggests that practitioners may need to differentiate their approaches between the two areas rather than assuming that the development of a spin-off simply requires the continuation of activities, resources, business models,

etc., utilised during the creation phase. Vohora et al. (2004) provide evidence of the importance of focusing on development as well as the creation of spin-offs. In all cases they studied, the spin-offs underwent a re-orientation phase where the fundamental business model of the company changed. Therefore, by only examining the creation of a company we may arrive at a false impression of what the company may become.

Third, in relation to the development of different types of spin-offs, important policy implications relate to the role of the property-based science park and incubator contexts in which support occurs. Our analysis identifies the different institutional linkages and resources associated with different types of incubators and science parks. In addition to providing physical resources, policy may need to focus carefully on introducing the appropriate linkages and resources required to create and develop different types of RBSOs.

5.2. Limitations

The analysis in this paper is limited by the set of papers that have attempted to delineate typologies of spin-offs. While this is a reflection that the area is an emerging one, we have shown that the papers available do provide the basis for defining a broad conceptual framework. We hope that the synthesis we have made, along with the critical dimensions we have identified, will provide a sound foundation for future work.

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