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Do different types of incubators produce different types of innovations?

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Abstract Incubators are heterogeneous but there is a lack of understanding of the variety of innovation involved. We use four archetypes of incubator discussed in the literature (basic research, university, economic development and private incubator) and analyze their generation of different types of innovation (product, technological process and organizational innovation) during a 4 years period (2005–2008). In a sample of 80 incubators, we find that incubatees in some types of incubators are more prone to generate product and technological process innovations than those hosted in other types.

Keywords Incubation · Types of innovation · Types of incubators · Innovation generation

JEL Classification M13 · O31 · O32

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1 Introduction

The economic development of a country is strongly influenced by its national innovation system (Freeman 1982; Nelson 1993; Intarakumnerd et al. 2002). A national innovation system is composed of R and D activities performed by universities, research institutes, government agencies, and government policies as well as the linkages among them (Nelson 1988, 1993; Carlsson et al. 2002). Incubators and science parks as an element part of the national innovation system have been increasing in importance during the last few years.

Literature on the study of incubators and science parks is divided into four areas (Phan et al. 2005): companies located in the incubators; studies that research incubators themselves; studies focusing systemically on the university, region or country; and those that study the entrepreneurs operating in the facilities. Our research focuses on the first two areas, incubatees and incubators, by analyzing innovation and type of incubation.

The literature on types of incubator is based on the premise that not all incubators are equal and that there are different types with significant differences. Incubation research has tended to treat the types of incubator in a homogeneous fashion, although some studies have recognized the different nature of incubators (Allen and McCluskey 1990; Aernoudt 2004; Grimaldi and Grandi 2005). In order to analyze incubation, a distinction needs to be made between types of incubators, as different incubators achieve different results (Aernoudt 2004). The literature has considered the differences in the organization, activities, services and objectives of incubator types (Aernoudt 2004). Although these issues are important, deeper understanding of the performance of different types of incubator can add much value (Siegel et al. 2003), especially for practitioners and policy makers. While some studies have focused on the *extent* of innovation across different types of incubator, the gap we address concerns the lack of studies on the relationship between the *nature* of innovation and the type of incubator. Specifically, our two research questions are: Which type of incubator firms performs better in terms of innovation? Is there a relationship between the type of incubator in which a firm is hosted and the type of innovation generated? Insights from these questions are key to providing practical insights concerning the development of more fine-grained roles for the innovating activities of incubators that are adapted to specific contexts.

We use the four prevalent archetypes of incubators described in the literature (Allen and McCluskey 1990; Aernoudt 2004; Grimaldi and Grandi 2005). We address a major problem associated with the use of very small samples in the existing literature (Mian 1996; Siegel et al. 2003) by analyzing a sample of 80 incubators. This is larger than the sample sizes in most of the literature on incubation (for exceptions see Allen and McCluskey 1990; Aerts et al. 2007; Hackett and Dilts 2008). We supplement our quantitative analysis with qualitative insights from examples of the different types of incubators.

We find that basic research incubators are more intense in the origination of innovation as they generate more product innovation than economic development and university incubators. Further, basic research indicators also generate more technological process innovations than economic development incubators. As expected, university incubators and economic development incubators are less product and technological process innovative. No differences were found in organizational innovation between incubators. The next section reviews the literature on types of incubator and types of innovation. Section 3 discusses the hypotheses we test. Section 4 discusses our research context by describing incubator types in Spain and explaining our method. Section 5 covers a presentation of the results. The final sections discuss the results and draw the main conclusions from our research.

2 Literature review: types of incubator and types of innovation

2.1 Types of incubator

An incubator is an entity providing small new ventures with resources (Allen and McCluskey 1990) that improve their chances of foundation and survival (Löfsten and Lindelöf 2002; Hackett and Dilts 2004; Dettwiler et al. 2006). The objective of the incubator is to both improve the probability of survival of the firms supported (Escorsa and Valls 1996; Schwartz 2009; Schwartz 2012) and accelerate their development (Smilor and Gill 1986; Mian 1996). The main elements of the incubator include the services provided: financing, goals and structure, resources and support and entrepreneurial spirit (Löfsten and Lindelöf 2002; Dettwiler et al. 2006; Patton et al. 2009). An incubator thus offers physical facilities and intensive intangible high value added assets such as management, legal services, networking, etc. (Smilor and Gill 1986; Totterman and Sten 2005; Hughes et al. 2007; Soetanto and Jack 2011). Different types of incubator can be distinguished based on the need to address different market failures (Aernoudt 2004).

The most basic classification distinguishes between for-profit incubators (also known as public incubators) and those of a non-profit nature (Grimaldi and Grandi 2005; Becker and Gassman 2006a, b). The core of non-profit incubators is the provision of logistical services to reduce the costs of starting up (Grimaldi and Grandi 2005). For-profit incubators are professionally organized and achieve profits from the involvement in new ventures. This type is able to access a pool of internal knowledge such as technology, suppliers, customers and business development (Becker and Gassman 2006b), management expertise and assets such as finance (Grimaldi and Grandi 2005). Beyond this basic dichotomy, several authors have identified more elaborate classifications with close similarities (Hackett and Dilts 2004). Allen and McCluskey (1990) distinguished four types: for-profit property development, not for profit development corporation, academic and for profit seed capital. Aernoudt (2004) distinguishes five types of incubators: mixed, economic development, technology, social and basic research incubators. Grimaldi and Grandi (2005) divide business incubators into five categories: business innovation centers (BICs), university business incubators (UBIs), technology incubators, independent private incubators (IPIs) and corporate private incubators (CPIs). Becker and Gassmann (2006b) introduce a similar but more complex classification which distinguishes government (university, science park/technology, community), non-government (non-profit development), independent (holding, venture capital, virtual) and corporate (service providers and technology development). Finally, Von Zedtwitz and Grimaldi (2006) distinguish between economic business, university, independent, company internal and virtual incubator. Table 1 summarizes the main literature on types of incubators and variables used. The literature offers a broad consensus which can be distilled into four archetypes of incubators.

The raison d'être of the first type (economic development) is to reduce economic disparities (Aernoudt 2004) by maintaining a local/economic network (Von Zedtwitz and Grimaldi 2006). The BICs founded by the European Commission initiative in 1984 to provide space, infrastructure, communication facilities, visibility, etc. represent pioneering economic development incubators (Grimaldi and Grandi 2005). In 2008, 147 BICs were accredited in Europe (European Business and Innovation Centre Network 2009).

The second type is the university business incubator (UBIs) which operate as a tool created by entrepreneurial universities to support newly created technology firms (Mian 1994; Cooper et al. 2012; Guerrero et al. 2012). The two main categories of services offered by UBIs are the usual services provided by incubators such as rent reductions,

Table 1 Summary of authors, types of incubators and variables

Author	Types of incubator	Variables used
Allen and McCluskey (1990)	For profit property development Not for profit development corporation Academic For profit seed capital	Value added Primary objective Secondary objective
Aernoudt (2004)	Mixed Economic development Technology Social Basic research	Main philosophy Main objective Secondary Sectors involved
Grimaldi and Grandi (2005)	BICs (Regional development) University Technology Corporate Independent	Institutional mission Industrial sectors Location Origin of ideas Phase of intervention Incubation period Sources of revenue Services Management team
Becker and Gassman (2006a)	Mixed Economic development Technology Social, basic research	Mission and type of technology
Von Zedtwitz (2003)/ Von Zedtwitz and Grimaldi (2006)	Regional business University Virtual Independent Company internal	Vertical scope Segment scope Geographical focus Industry focus

access to capital and shared office space, as well as university related services such as laboratories, technology transfer services, and faculty acting consultants (Mian 1996, 1997). UBIs are non-profit incubators which are economically funded and created to promote academic entrepreneurship (Von Zedtwitz and Grimaldi 2006).

The third type is the basic research incubator (Aernoudt 2004) formed by companies within research institutions whose main field of endeavor is fundamental research. Aernoudt (2004) provides the example of a European-like MIT set up to research bits, atoms, neurons and genes. This type of incubator is built around research institutes created ad hoc or that are part of a sectoral concentration. Once the company is incubated, the resulting technology is licensed to commercial partners or is spun off as an autonomous entity.

The fourth type of incubator is the private one which has two subcategories: corporate business incubator and independent private incubator (Grimaldi and Grandi 2005; Becker and Gassman 2006a, b; Von Zedtwidtz and Grimaldi 2006). Corporate business incubators are set up by large organizations to take advantage of the creation of new businesses. They act in the interest of their parent corporation and have access to the parent companies network and knowledge (Becker and Gassman 2006a). Becker and Gassmann (2006a) distinguished four types of private incubators taking into account their source and type of technology: fast-profit incubators, market incubators, leveraging incubators, and in-sourcing incubators. Applying the knowledge-based view of the firm, four modes of mainly

tacit knowledge were identified in respect to the different incubator types: (1) entrepreneurial knowledge, (2) organizational knowledge, (3) technological knowledge, and (4) complementary market knowledge. Independent private incubators (Grimaldi and Grandi 2005) are set up by independent institutions to help entrepreneurs create their own business. Developers typically invest their own money and engage in management activities once the business has been launched. Independent private incubators aim to gain quick profits from successful start-ups and are often part of a holding company or are sponsored by venture capitalists (Becker and Gassmann 2006b).

For the sake of completeness, other types of incubators can be identified: Network (Bollingtoft and Ulhoi 2005), Farming (Abetti 2004) or Virtual incubators (Von Zedtwitz 2003; Von Zedtwitz and Grimaldi 2006). These are driven by a bottom up approach where the ventures themselves develop and manage the incubator, or are focused on the specific needs of the entrepreneurial community rather than a particular industry. As these are generally small in number we exclude them from this study.

2.2 Types of innovation

Many types of innovation can be identified (Abernathy and Clark 1985; Kleinschmidt and Cooper 1991; Rothwell 1994; Ottum and Moore 1997; Adams et al. 1998; Tidd and Bessant 2009). The classification introduced by Schumpeter (1939) which distinguishes between product and process innovations is the most common and widely used (Abernathy and Utterback 1978; Kotabe and Murray 1990; Light 1998). The literature has incrementally evolved this classification.

Damanpour (1987) proposes a distinction between technological, administrative and ancillary innovations. Edquist et al. (2001) subdivides product innovation into product and service, while process innovation is subdivided into technological and organizational innovation. This classification was used by Damanpour et al. (2009). Walker (2006) produces a classification with three types of innovation which are product, process and ancillary. Walker (2008), in a service sector study, distinguishes among service, organizational process and ancillary. This classification subdivides organizational process innovation into marketization and organization innovation.

We adopt the classification used by Edquist et al. (2001) and Damanpour et al. (2009) as it is an advanced version of the literature on innovation types and one of the most widely used. A distinction can be made between product innovation that proceeds from a new good or quality of a good, and a process innovation that proceeds from a new way of producing the same goods (Archibugi et al. 1994). Process innovation directly affects the structure of the organization (Walker 2006). Unlike product innovation, process innovation indirectly affects the introduction of new products or services through a change in the production process (Damanpour et al. 1989; Damanpour and Gopalakrishnan 2001). Two types of process innovation can be identified (Damanpour et al. 1989; Damanpour et al. 2009): technological process and organizational innovations.

Technological process innovations are new elements related to the introduction of new equipment, tools or methods in the mechanical production, automation or computerization (Damanpour et al. 1989). Organizational process innovations consist of changes in structure, strategy or administrative processes (Damanpour 1987). The objective of this type of process innovation is to change the organizational structure, its degree of complexity, formalization and centralization. The results for this innovation could range from

the opening of a new market to the discovery of new supply sources or a different position within the sector.

3 Theoretical framework

3.1 Types of incubator and types of innovation

There is an extensive literature on the impact of science parks and incubators on company innovation with positive (Monck et al. 1988; Colombo and Delmastro 2002), negative (Westhead 1997) or inconclusive results (Udell 1990).

Studies that looking at performance by type of incubator have found differences in terms of occupancy rate and job generation by different types of incubators but no difference in survival rate (Allen and McCluskey 1990; Aernoudt 2004). But previous studies have not discussed the generation of the nature of innovation by different types of incubators.

Some types of incubators are more specialized than others. As basic research incubators are linked to technological centers or evolve from the formation of natural clusters, specialization is higher than in other types. Higher levels of specialization promote the adoption of technical innovations rather than administrative innovations (Damanpour 1987; Subramanian and Nilakanta 1996). Many basic research incubators are born from natural clusters and network relations are more intense than those in other types. These interfirm cooperations can improve the capacity to innovate (Cornish 1997; De Propis 2002). Based on these arguments, we derive the following hypothesis:

Hypothesis 1 Basic research incubators will generate more product innovations than other types of incubators.

Economic development incubators are aimed at improving economic conditions in underdeveloped regional areas. Such areas are characterized by the dominance of Low and Medium Technology industries and less R and D intense companies. Economic development incubators typically provide physical assets and less intangible assets. Low and medium technology industries are more likely to engage in process innovation (Pavitt 1984; Heidenreich 2009; Tether and Tajar 2008). When technology becomes more mature the dominant design will drive companies to compete on process innovation and process integration (Utterback and Suarez 1993). Process innovation is also associated with the necessity to compete in cost sensitive markets (Roper and Hewitt-Dundas 2008). Hence, we derive the following hypothesis:

Hypothesis 2 Economic development incubators will generate more technological process innovations than other types of incubator.

Private incubators are entities which funnel the incubating efforts of larger companies involved in corporate venturing activities. Corporate ventures replicate characteristics of their parent companies. High levels of centralization and formalization that are typically more likely in larger organizations lead to administrative innovations (Subramanian and Nilakanta 1996). Also, organizational innovations are more likely to be generated by larger organizations than by smaller ones (Walker 2008). This leads to the following hypothesis:

Hypothesis 3 Private incubators will generate more organizational innovations than other types of incubators.

4 Data and analysis

4.1 Types of incubator in Spain

Legislation in Andalusia[1] regulates the main types of incubators in the Andalusian Innovation System. The Innovation Ministry has introduced a procedure under which both private and public incubators can be officially recognized. Equally, given the role played by the public sector in Europe, a larger number of public nature incubators are included in the Andalusian Innovation System. The types of incubator described in the Decree broadly match the four archetypes of incubator recognized by the literature described in the previous section. The Decree describes the objectives each type of incubator will accomplish within the regional innovation system but does not dictate the resources they will own or the type of innovation they will generate. We describe below the types of incubator as described by the Decree.

The *Basic Research incubator* is an incubator linked to a basic research center (Aernoudt 2004). The basic research center is an entity created with public funds whose aim is to develop fundamental research (Aernoudt 2004). The center is focused on a specific sector strategic for the region as it is typically created around a naturally formed cluster. The center includes an incubator to support the launch of startups born within the cluster. The incubator has more functions than the average incubator would have. A very important function is networking, under which the incubator may foster collaboration among companies within the incubator and hence connect new and established companies that may be located within the cluster or not. Basic research incubators are home to many technology ventures. Profiles of entrepreneurs in this type of incubator tend to be very knowledgeable and experienced people in the cluster sector with a very technical bias.

The *Economic development incubator* is an entity whose objective is to dynamize the economic development of the area of influence and to incubate SMEs that can convert into companies with a global projection (Von Zedtwitz and Grimaldi 2006). Economic development incubators aim is "to focus on the narrowness of economic development gaps" (Aernoudt 2004). Companies in this type of incubator are widespread in terms of sector, being service incubatees the most numerous type. Resources and capabilities developed by the incubator are very general in order to adapt to the open nature of the incubatees.

University incubators possess two particular attributes (Mian 1996), which are the typical incubator services (shared offices, services, rent breaks…), and access to university-related services (faculty consultants, technology transfer programs, employee education and training, library services…). The aim is to commercialize university technology (Allen and McCluskey 1990; Clarysse et al. 2005; Salvador 2011).

Private incubators in Andalusia are those incubators owned by companies with large operations which support ventures in order "to act as a knowledge hub of business building expertise where good ideas can be nurtured and from which knowledge is transferred to other units in the corporation" (Becker and Gassmann 2006a). We have not identified any private incubators whose primary objective is to sell proprietary services to tenants and create an investment opportunity as the secondary objective (Allen and McCluskey 1990).

An example of each type of incubator is summarized in Table 2.

[1] Andalusia is one of the largest regions in Spain in terms of GDP and population, and is situated in the South of Spain.

Table 2 Comparison of Examples of Each Incubator Type

Characteristic	Basic research	Private	University	Economic development
Sector focus	Plastics	Energy	Biotech, ICT, environment and others	Very broad; 10 % technology
Date created	2003	1998	2003	1990
Number of staff	15	14	15	10
Number of start-ups hosted	10	7	73	32
Occupancy duration	2 years	Indefinite	2 years (extendable 2 more years)	3 years
Technology and market knowledge provided	Specialist events frequently organized to provide access to new technological knowledge involving external experts; coordination and attendance at international trade fairs; conducting of market research; close university ties to identify emerging technologies; access to incubator owned software and hardware	Specialist, leading technical knowledge from parent's R and D department and outsourcing to universities; no general business training as managers already experienced	General training for ventures in doing business; access to national trade fairs; market research not funded as too many sectors; access to university laboratory facilities	General knowledge on doing business and secondary source information; absence of attendance at trade fairs or coordination of interactions with universities
Managerial knowledge provided	Deep technical knowledge of plastics sector; incubator board comprises mix of public sector and private sector financial and sector expertise	Highly capable core company managers with sector experience; venture boards include internal and external members with deep sector experience	Equally from private and public sectors but little specialized knowledge on start-ups	Private sector SME and public sector experience but of limited relevance to start-ups

4.2 Sample

As discussed above, the Innovation Ministry created an official registry in early 2004 to record all the incubators operating in Andalusia whereby they can become accredited as an innovation agent. A total of one hundred and twenty incubators are included in the official registry.

The questionnaire was drafted during the autumn 2008. We piloted the questionnaire with managers of two public and one private registered incubator during November and December. Some minor modifications were included in the questionnaire to enable

incubator managers to better understand what was being asked. The questionnaire was not distributed to all one hundred and twenty incubators as some were rather young and did not have a sufficient number of years in operation to show valid results. The National Business Incubation Association (1990) reports that the occupancy ratio of incubators levels off at 70 % in the third year of operation. Hence, only incubators at least 4 years old were sent the questionnaire (Rice 2002). The questionnaires were thus sent to 98 incubators in early January 2009 via a software application operated by the Innovation Ministry.

The individuals responsible for providing information were incubators managers or another key informant in the incubator designated as possessing all the information requested in the survey (Kumar et al. 1993). A second round of contacts was carried out in early February. After these two rounds, we received a total of 90 responses. Such a high level of response was probably because the Regional Innovation Ministry backing the initiative is the primary funder of two-thirds of the incubators in our sample. Although there is a possibility that this link might lead to biased responses, we believe it is unlikely since the incubators are subject to heavy controls by the Ministry. First, incubators are financially audited on a yearly basis. Second, they are subject to closely followed performance objectives (number of new firms hosted, events organized, etc.). The provision of such information is obligatory for incubator managers and overstatement is difficult.

Some 10 questionnaires were incomplete, giving a final sample of 80 valid questionnaires. Out of the 80 questionnaires, 37, 21, 13 and 9 corresponded to basic research, university, economic development and private incubator type, respectively. The incubators were geographically dispersed and the sample included incubators resident in all of the Andalusian provinces. To help managers respond to the questionnaire, we used instructions on completion provided by the Spanish Institute of Statistics, and set-up a hotline under which questions were responded to by a representative of the Ministry.

Once the questionnaires had been completed, the Ministry organized meetings with the incubators in each of the provinces to check any qualitative issues arising from the process. No major issues worth reporting arose during the meetings.

4.3 Variables

Type of innovation Incubator managers were asked which type of innovation (innovation in product/service, innovation in technological process, organizational innovation) had been introduced by their incubatees in the three prior years (2005–2007). Our dependent variable is a dichotomous one indicating whether the incubator generated each of the three types of innovation (0) or not (1). A brief description of examples of each type of innovation was also requested to help us determine whether the selected type of innovation had actually been generated. Finally, the correspondence between the selected type of innovation and the example of innovation provided was checked by a team of two people and very few mistakes were found.

The scales used to measure product, technological process and organizational innovation were those used by Damanpour et al. (2009) and Walker (2006). Specifically, for product innovation we used the scale of Damanpour et al. (2009) and Walker (2006) as both are identical except that Damanpour et al. (2009) use theirs in a service innovation context. For technological process innovation we adopted the scale used by Walker (2006) which is a more elaborate scale than Damanpour et al.'s (2009). For organizational innovation we used the scale by Damanpour et al.'s (2009) as the scale is both simple and complete.

Type of incubator As described in the previous sections, the four types of incubators mentioned in the Decree are consistent with some archetypes described by the literature

(Grimaldi and Grandi 2005; Von Zedtwitz and Grimaldi 2006). These four types of incubator are economic development, university, basic research and private incubator.

5 Methods and results

5.1 Method

Firstly, we used a non-parametric method (Chi square test) to examine the existence of differences in the type of innovation generated by affiliate companies hosted in each group of incubators. The test allowed us to confirm whether or not there are innovation type differences among the four types of incubators. Secondly, as the Chi square test does not provide information on between-incubator type differences, a parametric method (Tukey-HSD multiple comparison) was conducted to test between-incubator type differences on the type of innovation.

Table 3 contains descriptive statistics for our sample. The table shows the proportion and number of type of incubator respondents generating a type of innovation. For example, 17 out of 37 (45.9 %) of basic research incubators generated product innovation. Table 2 also shows the results of the Chi square test, confirming there are differences between the types of incubator by type of innovation.

Table 3 deals with our first research question as it displays which type of incubator performs better in terms of innovation. The table highlights how private incubators lead the generation of innovation, followed by basic research and university incubators. Private incubators predominate the generation of technological and organizational innovations, while basic research incubators predominate the generation of product innovation. Moreover, basic research and university incubators are the second most active in the categories they do not lead. Finally, economic development incubators are the worst performer in product and technological innovations, while university incubators are the worst performers in terms of organizational innovations.

Table 4 displays the results of the Tukey-HSD post hoc comparisons. Table 4 compares pairwise which of the four types of incubator perform better in the generation of each of the three types of innovation studied. For example, the first row of the table provides

Table 3 Type of innovation comparisons

Incubator	Product innovation		Technological process innovation		Organizational innovation	
	(%)	N	(%)	N	(%)	n
Basic research ($n = 37$)	45.9	17/37	48.7	18/37	37.9	14/37
University ($n = 21$)	14.3	3/21	33.3	7/21	28.6	6/21
Economic development ($n = 13$)	7.7	1/13	7.7	1/13	30.8	4/13
Private ($n = 9$)	22.2	2/9	55.6	5/9	55.6	5/9
Chi square (sig.)	10.48 (0.015*)		8.14 (0.043*)		2.19 (0.533)	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 4 Pairwise comparisons between different types of incubator and innovation type

Innovation type	Pairwise incubator types compared	Mean difference in innovation between incubator types	SE	Significance
Product innovation(1/0)	Basic research versus University	0.3166*	0.1183	0.044
	Basic research versus Ec./ reg. dev.	0.3825*	0.1396	0.037
	Basic research versus private	0.2372	0.1609	0.458
	University versus Ec./reg. dev.	0.0659	0.1528	0.973
	University versus private	−0.0794	0.1725	0.967
	Economic/regional development versus private	−0.1453	0.1877	0.866
Technological process innovation (1/0)	Basic research versus university	0.153	0.129	0.639
	Basic research versus Ec./Reg. Dev.	0.410*	0.153	0.044
	Basic research versus private	−0.069	0.176	0.979
	University versus Ec./Reg. Dev.	0.256	0.167	0.423
	University versus private	−0.222	0.189	0.643
	Economic/regional development versus private	−0.479	0.205	0.100
Organizational innovation (1/0)	Basic research versus university	0.093	0.133	0.898
	Basic research versus Ec./reg. dev.	0.071	0.157	0.969
	Basic research versus private	−0.177	0.181	0.761
	University versus Ec./reg. dev.	−0.022	0.172	0.999
	University versus private	−0.270	0.194	0.508
	Economic/regional development versus private	−0.248	0.211	0.644

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

information on the performance in the generation of product innovation by comparing basic research incubators with university incubators. Basic research incubator generates more product innovation than university incubator, as the mean difference (0.3166) is positive and the relationship is significant (sig = 0.044).

5.2 Results

Our results provide support for our second and main research question, as they confirm the existence of significant differences within archetypes concerning the type of innovation generated. Our results also show that some archetypes of incubator fare higher in all types of innovations. The findings in Table 3 support the idea that there are significant differences by type of incubator in respect of product innovation (significance = 0.015) and

technological process innovation (significance = 0.043) but not organizational innovation (significance = 0.533).

As shown in Table 4, with respect to product innovation, major differences are found between basic research incubators and university incubators (significance = 0.044) and between basic research incubators and economic development incubator (significance = 0.037), providing support for Hypothesis 1. Concerning technological process innovation, differences are found between basic research incubators and economic development incubators (significance = 0.044). These findings are not consistent with Hypothesis 2 as technological process innovations are not produced mainly by economic development incubators, as we predicted, but by basic research incubators.

No significant differences are found in the generation of organizational innovations and hypothesis 3 is not supported. Notwithstanding the fact the relatively large size of our overall sample, it may be that hypothesis 3 is not supported because our sample of private incubators is small at only nine. However, although the results are not significant, the findings show how private incubators excel among the other archetypes in originating organizational innovations.

6 Discussion

One of the main purposes of an incubation infrastructure is to originate innovation. Such a process is conducted through relations between ventures and other organizations and institutions (Bayona et al. 2002). The departure point for our research was a concern with how different types of incubators are associated with different types of innovation. We find that innovation output at incubators differs in terms of both type and quantity. In terms of type, different incubator archetypes produce different types of innovation. Specifically, basic research incubators are the ones producing more product and technological innovations. Private incubators generate more organizational innovations. In terms of quantity, basic research incubators and private incubators score higher in generating all types of innovation. Basic research and private incubators are able to originate a higher number of innovations than university or regional development incubators. Consistent with the literature that suggests that firms emphasizing collaboration and operating in clusters are more likely to be innovative (Rothwell 1991; Baptista and Swann 1998; Oakey 2007), basic research and private incubators are, by nature, the archetypes most effective in fostering external relationships.

The illustrative examples summarized in Table 2 highlight differences in the strategies and knowledge resources provided by each type of incubator that facilitate these different types of innovation. The most innovative incubator types, basic and private incubators, follow a focus strategy and the least innovative types, university and economic development incubators, follow a specialized one. Hence, our findings help shed some light on the debate about whether incubator specialization or diversification in incubator strategies generates greater performance (McAdam and McAdam 2008; Sammarra and Biggiero 2008). Both the basic research and the private incubators host fewer start-ups than the other two types of incubator, enabling them to focus resources in-depth rather than spreading resource thinly across a large number of ventures. Our interviews with managers of these incubators demonstrate differences in the technological, market and managerial knowledge associated with these strategies (Sammarra and Biggiero 2008).

With respect to accessing technological and market knowledge for incubates, the basic research incubator has an extensive and deep involvement in organizing specific events

focused on the plastics sector, involving external experts and with an international exposure, as well as conducting market research. The basic research incubator also has close university ties with three national/regional universities, aimed at identifying technology to be exploited by incubatees and potential new innovations to jointly work on. Further, this incubator owns specialist software and hardware for the use of incubatees. The private incubator also provides access to leading technology and commercial market knowledge through the parent company as well as working closely with universities. In contrast, the university incubator while providing access to university laboratory facilities provides little specialized support for technology or market commercialization. General training is offered for the ventures covering lean startup, obtaining R and D funding, other sources of financing, patent registration, etc., but market research has not been funded for a specific sector as the incubatees operate in a wide range of sectors and access to only national trade fairs is provided. The economic development sector provides even less specialist support, partly because of the broad scope of sectors covered. The incubator provides non specialized training and advice on payroll, tax compliance, funding alternatives, innovation development, etc. but no access to trade fairs.

The incubators also vary considerably in the depth of the managerial knowledge provided by the incubators. The basic research incubator's human capital involves managers with deep technical knowledge of the plastics sector and an incubator board comprising a mix of public sector and private sector financial and sector expertise. The private incubator also provides specialized managerial knowledge through highly capable managers from the company's core activity with hands on managerial experience in the energy sector. Many have been linked from inception to the opportunity development providing insights or as part of the R and D team. The venture boards are a mix of internal and external board members with extensive experience in the energy sector. In contrast, the managerial knowledge of the university incubator is not specialized. About half of the employees have worked in the public sector and half in the private sector but the incubator manager's major experience is in the public sector and mainly as incubator manager. Managerial knowledge in the economic development incubator comes primarily from personnel experienced in small/medium size companies or in the public sector but very few have specialized sector knowledge useful to startups hosted.

Our findings have implications for entrepreneurs, incubator managers, venture capitalists and policy makers. Entrepreneurs should be aware of the degree of specialization that innovation offers to incubators. The literature has already described the clientele effect under which entrepreneurs are attracted by the supply of services incubators offer (Von Zedtwitz and Grimaldi 2006; Barbero et al. 2012). According to this approach, the profile of services offered by an incubator will attract particular types of entrepreneur. However, the clientele effect is more than the attraction of entrepreneurs based on services offered. Services offered lead to a set of resources and capabilities the incubator develops, as we have just observed. This set of resources and capabilities provides both a specialization for the incubator and a specific positioning which attracts entrepreneurs. Positioning has been described at length as being based on few specific features and not all features are equally attractive. The type of innovation in which an incubator specializes has a strong potential to position an incubator as this is one of the most important features entrepreneurs are likely to seek when choosing an incubator type. Our research provides suggestions to entrepreneurs as to the type of incubator they should join based on the type of innovation in which they are engaged.

Second, incubator managers should also be aware of the strong positioning they are adopting when they decide on the type of innovation on which the incubator will specialize

since this will become the key attribute to attract the entrepreneur. The literature has traditionally described which strategies best fit the different types of innovation (Utterback and Abernathy 1975; Calantone et al. 1988) and how these types of innovation should be managed (Lim et al. 2006). Managers at basic research incubators should continue to specialize in product and technological process innovations through the development of the specific resources and capabilities required, as illustrated by the support provided by the examples in Table 2, as well as expanding the networks to facilitate their generation. Managers leading private incubators may be able to build upon their comparative advantage in generating technological process and organizational innovations, and consider whether they should buy-in product innovation skills. University incubator managers may consider building upon their comparative advantage in product and technological process innovations. As university incubators are not strong at producing organizational innovations, perhaps because the innovations they deal with are very early stage, they may consider accessing organizational innovation skills at a late stage in venture development, through any of the available types of knowledge acquisition processes (Huber 1991). This may require the introduction of mechanisms to develop networking and boundary spanning between university incubators and potential commercial partners (Melkers and Xiao 2012), as well as the participation of universities and their incubators in regional development organizations that can help in coordinating access to such networks (Goldstein and Glaser 2012). This process may also involve investment to build up the 'brand' credibility of the university incubator with outside commercial actors so that they become actively willing to become involved as they can expect to find attractive innovations and spin-offs (Salvador 2011).

Third, the surge in the number of venture capital firms during the last decade has expanded their active search for deal flow. One of their ways to seek projects is by contacting and building links with incubators (Wright et al. 2006). Increased competition has forced them to specialize. Our findings indicate that funds specializing in products or services should spend time exploring incubators offering the best match for their strategic focus. Finally, our findings have implications for policymakers. If the role of incubation is the generation of innovations (Westhead 1997), policymakers should undertake a cost benefit analysis of the types of incubators supported by public money. Our study highlights how not all archetypes perform at generating innovations. Those incubator archetypes meeting the objective should be allocated more resources. Those archetypes less conductive of innovation should see reduced resources allocated.

Our research has a number of limitations. Our sample is one of the largest in the existing literature but, reflecting the nature of incubators in Europe, is dominated by publicly funded incubators. Future research could aim to focus more on privately funded incubators and examine differences between public and private incubation. Further, additional studies are warranted that analyze the conditions and processes under which particular types of incubator and their activities assist ventures in improving their innovation process.

7 Conclusions

Incubation plays an important role in innovation but prior research has provided only limited insight into the heterogeneity of the process. On one hand, prior studies on incubation have treated innovation uniformly, whereas there are different types of innovation, the distinction of which is essential to understanding the adoption of innovation. On the other hand, the nature of incubators has also been treated uniformly by many research

studies, whereas there is a very relevant typology of incubators that needs to be taken into account. The gap in the literature that we address is the need to understand the match between types of innovation and incubator archetypes. Such a match will allow incubator managers and policymakers to improve the efficiency of their incubation initiatives and to benefit entrepreneurs and their ventures. We have found that there are more than subtle differences in the type of innovation emanating from each type of incubator.

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