
Technology Transfer, Internationalization and Firm Reputation throughout Business Incubation lifecycle

Dinis Caetano¹, Jorge Andraz¹, Miguel Amaral²

¹ *Faculdade de Economia, Universidade do Algarve and CEFAGE-UAlg*

² *Instituto Superior Técnico, Universidade de Lisboa, Departamento de Engenharia e Gestão*

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Abstract

This paper analyses the role played by business incubators (BIs) in developing and facilitating technology transfer, internationalization and reputation among tenant firms. We focus on the founders' perception, through the analysis of ten in-depth case studies of incubatees and graduated firms from IPN – a tech-based BI in Portugal.

A two-step research design was adopted. First, primary data was collected through documentary analysis, participant observation and focus group involving the incubator's CEO and staff members. Semi-structured face-to-face interviews were also carried out among the founders, considering their companies' specific stage of development: *incubatees*, *under acceleration*, and *graduates*. Second, a survey was sent to founders or CEOs of the sampled companies.

Results show how incubators facilitate university-industry linkages, providing: (i) an assessment of key technology transfer practices, internationalization and reputation gained at incubators across firms' life-cycle and, (ii) insight on how founders of incubated and graduated firms perceive the value of incubation.

Although results suggest a positive impact of incubation on internationalization and reputation for incubatees and firms under acceleration, there is no evidence of benefits from the technology transfer processes. The empirical analysis also stressed the need for new post-incubation follow-up mechanisms and promotion of narrow relationships among graduated companies – which has been a widely neglected topic by both academics and practitioners.

Keywords Business incubators, Technology transfer, Internationalization, Reputation, Incubated firms, Graduated firms

JEL Classification L26, M13, M21

¹ These authors are with the Faculdade de Economia, Universidade do Algarve, Edifício 9, Campus de Gambelas, 8005-139 Faro, Portugal. E-mail: dmccaetano@ualg.pt (D. Caetano); jandraz@ualg.pt (J. Andraz). This paper is financed by National Funds of the FCT – Portuguese Foundation for Science and Technology within the project “UID/ECO/04007/2019” (Dr. Jorge Andraz).

² Instituto Superior Técnico, Universidade de Lisboa, Departamento de Engenharia e Gestão, Av. Rovisco Pais, 1049-001 Lisbon, Portugal. E-mail: miguel.amaral@tecnico.ulisboa.pt (M. Amaral).

Corresponding author: Dinis Caetano, Faculdade de Economia, Universidade do Algarve, Edifício 9, Campus de Gambelas, 8005-139, Faro, Portugal. Tel.: +351 289 800 915. E-mail: dmccaetano@ualg.pt

1 Introduction

Business incubators (BIs) have been recognized as facilitators of innovation and entrepreneurship (Aerts et al. 2007) and economic growth (Phan et al. 2005). The literature reveals that researchers have used various theoretical approaches to study the business incubation process (Mian et al. 2016). One of the most popular is the resource-based view (RBV), conceptual perspective developed by several academics (Barney 1991; Wernerfelt 1984). In practice, BIs possess a wide range of resources and capabilities aimed at stimulating competitive advantage for their incubatees and contributing to mitigate the high mortality rate that characterizes these small firms in the early stages (Aernoudt 2004). Over 60% of new businesses survive in the first year of activity, but only about 10% of them survive in the first 10 years (Timmons 1990).

A review of the extant literature reveals that new and small firms face several constraints such as liability of smallness (Freeman et al. 1983) and liability of newness (Lechner et al. 2006; Stinchcombe 1965). Overall, these companies are not able to easily obtain the resources, knowledge and skills they need, so they benefit greatly from the support available in BIs. Bhabra-Remedios and Cornelius (2003) point out that BIs are institutions that help new firms to survive and grow during the different stages of development characterized by uncertainty.

The past five decades have witnessed the emergence of technology business incubators (TBIs) as a novel economic development approach to promote innovative entrepreneurship (Lamine et al. 2018; Mian 1997). Link and Siegel (2007) point out that these incubators have an important role in regional entrepreneurial ecosystems by promoting technology-based economic development and the improvement of the image of location. Within TBI models (according Lamine et al. 2018, most popular models include technology incubators, science parks, and accelerators), one important contribution is the university technology business incubators (UTBI), which have served as focal in attracting academic spinoffs and new technology-based firms (Mian 2013).

High-tech companies in specific technological sectors (e.g., biotechnology, health, materials, ICT and software) are key actors for the creation and transfer of new knowledge in society (Pérez and Sánchez 2003). In order to measure the performance of small and new technology-based firms, one should not only consider tangible indicators such as sales growth, employment generation (Mian 1997; Peña 2004), profits (Peña 2004) and

tangible innovation outputs (Hasanov et al. 2014) under penalty of underestimating firms' contribution. The traditional body of research on new technology-based firms focuses largely on direct organic growth and there are very few empirical studies that have analysed the role of incubators on the dynamics of technology transfer (e.g., Rubin et al. 2015), internationalization (e.g., Fiates et al. 2013) and reputation (e.g., Studdard 2006). Overall, these studies has a qualitative nature through an approach centred on tenants without consider graduated companies. Alternatively, Lasrado et al. (2016) point out that university incubated firms performance continually improves above and beyond the incubation period, i.e., the number of jobs and sales grew over time, but no observed any evidence to support soft measures assessment (e.g., internationalization, reputation). In the other hand, these authors have no satisfactorily addressed the problem of comparison among incubated and graduated firms.

The extensive literature on incubators has dealt with the incubation process, the quality of business support or BIs' impact, but little attention has been given to the needs of the incubated and graduated firms that face new challenges in global economy. Moreover, the literature reveals aspects that could be improved on incubatees' different life-cycle stages, especially, a need for post-incubation follow-up mechanisms which has been widely neglected (Hackett and Dilts 2004; Schwartz 2009). This gap is a major motivation for our research within technological incubator as the IPN.

The IPN is a non-profit private organization which promotes innovation and technology transfer between academia and industrial sector. Currently, IPN operates in business incubation and acceleration of technology-based companies. With a capacity for 50 companies, the IPN business incubator has an offer of resources available in three areas: (1) infrastructures; (2) specialized services; (3) networking. Recently, the IPN opened the first Business Accelerator in Portugal, able to host 20 technology-based companies, at more advanced stage of development that are already established in the market and are striving for faster growth and internationalization. Hereinafter, IPN Incubator is designated as the junction of the IPN' business incubator and accelerator.

The purpose of this study is to examine the practices of technology transfer, internationalization and reputation building within and beyond the incubation period from the perspective of incubated and graduated firms. Therefore, this study aims to fill a gap in relation to knowledge regarding the business incubation lifecycle, and may offer a better understanding of more accurate and realistic contributions of BIs to development

of technology-based firms through their actors' perception. The relevance of this approach can be underlined by the fact the incubators' evaluation by tenants is often neglected and/or not tackled in a formal/rigorous manner by BIs (Demirgil et al. 2011). The lack of evidence is even more noticeable in the different stages of firms' life-cycle. We expect that results of this study help to close this gap.

The paper is structured as follows: the next section reviews the literature related to our research. In section three, we describe our data sources and the methodology. Section four presents and analyses the results, and lastly, we present conclusions in the final section.

2 Literature review

2.1 Business incubation

Recently, technology business incubation mechanisms have established themselves as intermediary organizations between academy and industry, favouring the diffusion of innovations, the creation of spin-offs and the promotion of technology transfer processes, reducing barriers between universities and companies (Mian 2013; Muscio 2010). These incubators - known as TBIs - rely on technology transfer and on the promotion of qualified entrepreneurship in specialized industries, through the support of technology-based companies, often operating in global markets (Mian 2013).

TBIs have become strategic both in protecting innovations developed by researchers and in the transfer and commercialization of academic knowledge (O'Kane et al. 2015). Technology incubators are equipped with infrastructure and services suitable for starting up and growing companies that develop emerging technologies (Hansen et al. 2000), namely access to laboratories, advanced technology, equipment, technical and scientific support, including academic teachers, specialized students and libraries and facilitate the transfer and commercialization of technology through links with universities and R&D centers (Mian 2013; Phillips 2002). In the literature, the link to universities is recognized as a key feature for the success of any type of incubator (Hackett and Dilts 2004; Mian 1996). The existence of incubator-university links favours the creation of value both incubated and graduated firms (Phillips 2002).

The extensive literature on incubators reveals that three main dimensions of incubation can be identified: (1) infrastructure; (2) business support services and (3) access to

external networks and networking activities (Hackett and Dilts 2004; Peters et al. 2004). According Mian et al. (2016), the modern incubators providing their tenants with a mix of value-added services such as qualified infrastructure, business support services, networking, access to capital, consultants, and university resources.

In addition to the low-cost rental space, most incubators provide shared resources such as meeting and conference rooms, reception, administrative services or car park (EC 2002; McAdam and McAdam 2008). Some incubators, especially TBIs, also offer more specialized resources at the infrastructure level, such as laboratories and research equipment (Grimaldi and Grandi 2005).

The incubators often provide business support services, which include coaching (Bergek and Norrmann 2008; Hansen et al. 2000; Mian 1996; Peters et al. 2004), training (Aerts et al. 2007; Barrow 2001; Mian 1997), access to professional services through networks (Bøllingtoft and Uihøi 2005; Hackett and Dilts 2004), access to financial resources (Aerts et al. 2007), risk and seed capital (McAdam and McAdam 2008) and virtual support (Barrow 2001; Carayannis and von Zedtwitz 2005).

The networking opportunities through incubators allow new firms to obtain external resources, knowledge and reputation (Bruneel et al. 2012) and, overall, the creation of value among the incubated companies (Hughes et al. 2007). The opportunities for network sharing by incubators provide firms with preferential access to potential customers, suppliers, technology partners and investors (Hansen et al. 2000; Scillitoe and Chakrabarti 2010).

Stephens and Onofrei (2012) report the existence of three main phases in the business incubation process: (i) pre-incubation; (ii) during incubation; (iii) post-incubation (graduation). The stage at which more information gaps exist for the incubator is the post-incubation phase and it has been an under-researched topic (Schwartz 2009). Currently the literature on incubation is very focused on the survival and growth of the incubated firms but it is scarce on the connections of the BI with the graduated firms. Moreover, exit policies and post-incubation follow-up have not received much attention from incubators (Hackett and Dilts 2004). Many BI do not have follow-up mechanisms for graduated firms and fail to relate to these companies after leaving. Therefore, it is important to develop a value proposition that in practice reinforces the incubator's ties with these companies, making it possible to avail resources, knowledge and information

in favour of firms supported by incubator. On the other hand, incubators can be attractive to graduated firms, sharing networking and participating in joint projects with incubatees. Therefore, there are reciprocal opportunities and interests in incubator-graduated interaction mechanisms. This is a challenge for all BIs that, like IPN, face these problems.

The lack of evidence about the different stages of firms' life-cycle within and beyond the incubation process is recognised by researchers (Schwartz 2009). In this paper, the authors was motivated to fill a gap in relation to knowledge regarding the business incubation life-cycle. Thus, in order to face this gap, we conducted a pioneer study in tech-based BI in Portugal and will limit itself to Portuguese technology-based companies, incubated and graduated by IPN.

2.2 Technology transfer, internationalization and reputation through incubators - research questions

i. Technology transfer

The process of technology transfer is fundamental to the creation of value and economic growth, it has a strong connection to universities (Hayter and Rooksby 2016; Kalar and Antoncic 2015; Siegel et al. 2003), and it is favoured by the presence of an entrepreneurial ecosystem involving local conditions and qualified actors (Isenberg 2010). Technology transfer between universities and industry has driven technology-based innovations and business competitiveness in several countries (Bozeman et al. 2015, Siegel et al. 2003). The term 'technology transfer' is broad and not easily measurable (Agrawal 2001). Bremer (1999), defines technology transfer as the transfer of research results from universities to the commercial sector. There are various ways to transfer research from universities to society. While the traditional form is by publishing research results, the commercial forms are by licensing, patenting or spin-offs (Vinig and Lips 2015).

In the last decades, TBIs have been consolidated as intermediary organizations between academia and industry whose main objective is to support the development of technology-based firms. These incubators are often located near universities, large industrial laboratories, innovation centers and science and technology parks with which they have formal links to obtain resources and promote the transfer and diffusion of new technologies to the market (Mian 2013).

The technology transfer from universities to business can be done through a number of mechanisms, but one of the most popular is the creation of spin-offs (Bercovitz and

Feldmann 2006), which directly contribute to regional economic development (Mian 1997). The close involvement of academic researchers in the process of technology transfer from academia to market is central for the success of spin-offs (Franklin et al. 2001) that benefit from the support of TBIs. Such support can be very relevant for the acquisition of technological maturity and business survival, either by incubating the spin-off or facilitating the acquisition of capital, access to networks and acquisition of training in management-related issues that make the difference in early stages and favour the introduction and development of new products in the market (Aerts et al. 2007).

Another technology transfer mechanism is the use of patents for the protection of intellectual property. According to the literature, the number of registered patents is one of the main innovation outputs of technology-based companies (Barbero et al. 2012; Hasanov et al. 2014). One of the objectives of TBIs is the management and patent protection developed by researchers and the transfer of these technologies to companies (Fitzgerald and Cunningham 2016; Muscio 2010).

Technology-based firms, especially spin-offs, transfer technology from their parent organizations (Pérez and Sánchez 2003). In order to overcome early-stage disadvantages, young companies must be more active in technology transfer than graduated firms, especially in the development of new products and services (as will be demonstrated in the empirical part of this study). To this end, firms should be able to benefit from the network of contacts and support of infrastructures and specialized services of the TBIs. Therefore, we propose the following first exploratory hypothesis:

Hypothesis 1. Technology-based firms are more dynamic in technology transfer during their early years in the incubator than during post-incubation phase.

ii. Internationalization

According to Keeble et al. (1998), internationalization of markets and exports are indicators often used in measuring business growth. Given that the incubator can contribute to the development of innovation by sharing resources and fostering knowledge agglomeration (Phan et al. 2005), it is expected that incubators contribute, even indirectly, to the internationalization of their companies (Engelman et al. 2015; Fiates et al. 2013). Engelman, Zen, and Fracasso (2015), in a study carried out with 115 companies housed in Brazilian technology incubators, show that incubation positively

affects the internationalization of companies and point out aspects that can be improved to expand the access of incubated companies to foreign markets.

In most cases, TBIs have a more extensive international contact network and participate in more transnational projects than traditional incubators, opening up opportunities for their companies to access global markets (Engelman et al. 2015). TBIs are more focused on technology-based companies, on the development of new products aimed, in general, at international markets (Mian 2013) and are better equipped with infrastructures, specialized equipment, and support for technology transfer and access to which non-technological incubators. This makes it easier for incubatees to close their first sale and enter the market (Ratinho 2011) through tradable goods and services and business expansion. Additionally, these incubators attract companies that operate in sectors with high growth potential and technological intensity such as biotechnology, ICT or software, which quickly overcome the weaknesses of early stages and record high turnover. In this way, incubators help incubated companies expand their business to other geographic areas in external markets, through business networks, innovation, trade missions, international contacts, etc. (Ratinho 2011).

In sum, the incubator is a "facilitator" by in a planned way, supporting its tenants' business process and favour the acceleration of their internationalization process, especially in early stages of the business. As technology-based firms often need to support internationalization in order to overcome their own early-stage gaps, start-ups should be more active in the internationalization process than graduated firms, resorting to TBI specialized support. As a consequence, we propose the following exploratory hypothesis:

Hypothesis 2. Technology-based firms are more dynamic in the process of internationalization during their early years in the incubator than during post-incubation phase.

iii. Reputation

Studies have found considerable evidence linking reputation to greater firm survival to incubated companies (Studdard 2006). Start-ups' reputation is positively associated with the business incubation process (Bruneel et al. 2012; Studdard 2006). In an empirical study involving 52 companies in incubators in the United States and Finland, Studdard (2006) concludes that firms interaction with the incubator's management team has a positive impact on the development of new products, technical skills, better reputation

and lower costs of sales to customers, but the most significant results point out that the greatest benefits obtained by the company, from its relationship with the incubator, is a perception of greater reputation. For new incubated firms faced with constraints of lack of experience and small size, the acquisition of reputation is one of the main challenges in the start-up phase. As companies often lack the internal resources to respond positively to these problems, they often rely on the support of the incubator and its management team. In this context, the networks available with the support of the incubator favour the acquisition of legitimacy by the incubated company through exchange relationships with other organizations (Bruneel et al. 2012) and the attainment of a reputation increasing the chances of survival (Studdard 2006). The connections and positive reputation enjoyed by most universities serve as important assets to UTBIs (Lasrado et al. 2016).

The new technology-based firms are characterized by constraints pointed out well-known problems of smallness and newness (Freeman et al. 1983; Lechner et al. 2006). On the other hand, reputation is recognized as one of the main assets of a firm (Studdard 2006). In order to overcome these disadvantages, firms in the early stages must be more active in gaining reputation than graduated companies. To do so, they should be able to benefit from incubator support in building business reputation. Therefore, we propose the following exploratory hypothesis:

Hypothesis 3. Technology-based firms are more dynamic in gaining reputation during their early years in the incubator than during post-incubation phase.

The lack of evidence throughout business incubation life cycle justified that our original hypotheses will seek to contribute for understanding of the role of TBIs in stimulating technology transfer, internationalization, and firm reputation for both incubated and graduated firms. The methodology are described in next section.

3. Methodology

In this research, a mixed qualitative-quantitative approach was adopted through the use of multiple case studies (Eisenhardt 1989; Yin 2017) based on data collected in the IPN. This TBI was selected due to its international prestige as demonstrated by the "Best Science Based Incubator" award it won in 2010, the year it was considered the best technology incubator in the world by the Technopoly Network and, as it is a successful case in the business incubation in Portugal (Marques 2014), being a self-sustaining and

economically viable incubator that promotes the technology transfer among the University of Coimbra and the companies (Caetano et al. 2019).

Overall, IPN promotes technology transfer processes, especially through spin-offs and intellectual property protection (e.g., patents). The surrounding ecosystem has a strong potential for innovation and entrepreneurship, since the IPN's territory is characterized by agglomeration and specialization economies (e.g., health sciences, life sciences, ICT/software) that are the basis of the concept of entrepreneurial ecosystem (Mason and Brown 2014) and IPN facilitates the growth and the internationalization process of their companies (Caetano et al. 2019).

The research strategy was based on the combination of qualitative and quantitative methods in order to broaden the knowledge on the phenomenon of business incubation. The key units of analysis are the incubator and the selected companies (ten cases of technology-based firms from the IPN community are assessed). Thus, an exploratory-type multi-case approach was adopted (Yin 2017), a methodology used in similar analyses of business incubators (e.g., Bruneel et al. 2012; Grimaldi and Grandi 2005). The case study investigates recent events in which the boundaries between phenomenon and context are not clearly defined in order to understand and emphasize the real context in which the phenomenon occurs (Eisenhardt and Graebner 2007; Yin 2017). The main objective of case-based research is to achieve a deep understanding of unknown or undocumented phenomena, the actors involved, as well as their interactions (Woodside and Wilson 2003).

This study focuses on ten firms in different stages in business incubation life cycle. The data collection process was developed in two phases: a first one in a period of approximately seven months (from September 2015 to March 2016) through field work of a qualitative nature in order to understand the role of IPN in the incubation process and networking and the perception of the founders of the companies on these dimensions of analysis; a second phase over a period of approximately five months (from January to May 2017), where a questionnaire was used to obtain data about firms participation in networks and their evaluation about incubation process.

A combination of documentary analysis, direct observation, and focus group with IPN managers and semi-structured interviews (Berg 2001) was used to collect data for the first phase of the study. These techniques were combined with each other through

triangulation of data in order to integrate different perspectives of the phenomenon under study in a complementary perspective (Flick 2005). The triangulation of data sources allowed us to establish links between evidences from the techniques used, favouring a better understanding of the results obtained (Yin 2017).

The documentary analysis was based on sources of information, namely websites, reports, brochures and other archival documents. Direct observation was recorded through fieldwork which included ten visits to IPN with an average duration of two days each and personal interaction with the IPN community actors involving the incubator' CEO and six members, 30 founders of companies supported by IPN of which ten CEOs and top managers from analysed companies. A focus group session with five participants (CEO, management team and IPN technicians) was held for four hours to support the initial observations and preliminary discussions with the actors involved. The discussion in the focus group consisted of four topics of analysis: (1) importance of participating in an entrepreneurial ecosystem around local conditions; (2) technology transfer and internationalization processes; (3) provision of resources and services associated with incubation process; (4) business success stories.

The information collected in the focus group was relevant in that it allowed for the identification of the incubator's offer, its role in the technology transfer processes and internationalization and contributed to the design of the case study focused on companies and the perception of their founders. In addition, the IPN managers suggested companies with success stories within the IPN community that were candidates for the final sample. More specifically, cases of successful companies were analysed throughout business incubation life cycle. In order not to condition the participants, no concept of success was defined at the beginning of the session. From the diverse contributions of the participants and without having presented a formal definition of success, items such as technology transfer, internationalization and business growth were discussed and the group reached a consensus about what a successful IPN company is; namely: a company belonging to a high-tech or medium-tech sector, with links to universities, which develops new products and services, proceeds to intellectual property protection and has already begun the internationalization process.

Thus, ten companies were chosen based on the following criteria: technology transfer, participation in networks, internationalization, growth and development stage related to the incubation process. The first four criteria were proposed by the participants in the

focus group. The last criterion was defined by the researchers/authors and it was aimed to segment the companies for comparison among groups (graduated, under acceleration and incubated firms), since the measurement of incubation results benefits from the comparison of companies at different stages of the business process (Stephens and Onofrei 2012). In this context, the companies were divided into three groups: (i) three graduated outside IPN (G1, G2 and G3); (ii) three under acceleration at IPN Business Accelerator (A1, A2 and A3); and, (iii) four incubated at IPN (I1, I2, I3 and I4). The construction of the sample of cases was done according to the principle of intentional sampling considering the exploratory nature of the study (Coyne 1997).

The protocol designed for face-to-face, semi-structured interviews was based on an interview script consisting of the following topics: the company and the IPN, knowledge transfer, networking, and access to capital, markets and business growth. In all sampled companies it was possible to interview at least one of the founders, an essential element in the organizational memory that brings added value for case analysis. The interviews provided most of the specific examples of business linkages to each other and through the entrepreneurial ecosystem and each had an average duration of 50 minutes. At the end of each interview, entrepreneurs were invited to refer other questions and provide any other information they considered relevant. After the interviewees' authorization, the interviews were recorded in audio and transcribed for later data analysis.

In order to collect data for the second phase of the research that took place between January and May 2017, a quantitative approach was developed based on a questionnaire designed specifically to cover topics presented in line with literature suggestions (Bryman and Bell 2015; Fink 2003) and applied to company founders via electronic mail in order to collect data on the participation of companies in available networks and evaluation of the incubation process. The script of the questionnaire was structured in questions grouped into five groups: (I) identification of the company; (II) characterization of the entrepreneur; (III) general characterization of the company; (IV) business support networks; (V) evaluation of the incubation process. In the design of the questionnaire, we used mainly closed questions, seeking a balance between qualitative and quantitative questions. Since one of the focuses was the evaluation of networking and the incubation process, four of the questions were expressed on a five-category item scale (Likert scale), presented in an order that reflects an increasing degree of importance/concordance regarding the proposition presented. In order to improve the instrument, the first version

of the questionnaire was tested with three entrepreneurs, two of which were founders of incubated and under acceleration firms within IPN (different from the companies surveyed) and one founder of a graduated firm by another BI. Entrepreneurs' suggestions were welcomed and allowed some questions to be refined. This process was performed to ensure consistency (confirming whether the questions were precise and not ambiguous) and validity (covering the main topics of interest) to the research instrument. This questionnaire was answered by nine companies (only A1 did not answer).

Regarding the qualitative data analysis, the thematic content analysis technique was used in three main stages: (i) pre-analysis; (ii) exploitation of the material; and, (iii) data processing, inference and interpretation (Bardin 2010). In the analysis of the quantitative data, descriptive statistics techniques were used.

Overall, the cases were analysed in two moments: first, each case was analysed per se and the data were analysed according to their characteristics and individual context (within case); second, a comparison among cases was made, and the evidence was cross-checked and compared, interpreting their characteristics and differences in line of the literature as referred by some authors (Merriam 1998; Yin 2017).

A brief characterization of the cases is presented in Table 1. The mean incubation period is about five years, ranging from a minimum of three years to a maximum of seven years. This average period of incubation is higher than the international average (three years) and can be justified by the fact the majority of the firms are spin-offs, which in general face initial difficulties in the transfer and commercialization of technology. The sampled cases include three graduated companies (30%), three under acceleration (30%) and four incubated (40%), represented by G, A and I, respectively. Out of the total number of cases analysed, six are academic spin-offs and three are non-academic spin-offs. At the sector level, companies operate in seven different areas, with the ICT/software sector being the most expressive (with 45% of cases).

Table 1 Characterization of case study companies

Company	Incubation period	Sector	Spin-off type	No. of employees *
Graduated (G1)	2006-2011	Electronics & Instrumentation	Entrepreneurial	29
Graduated (G2)	2003-2007	Biotechnology	Academic	55
Graduated (G3)	1998-2003	ICT/Software	Academic	252
Under Acceleration (A1)	2009-2014	ICT/Software	Academic	43
Under Acceleration (A2)	2007-2014	ICT/Software	No	62
Under Acceleration (A3)	2008-2014	ICT/Software	Entrepreneurial	21
Incubated (I1)	Until 2013	New materials	Entrepreneurial	5
Incubated (I2)	Until 2014	Maritime Engineering	Academic	8
Incubated (I3)	Until 2010	Digital Media	Academic	15
Incubated (I4)	Until 2013	Health	Academic	6

Source: Own elaboration. * Number of employees: 2015 data

4 Case analysis and discussion

This study is focused on ten companies at different stages of development. First, we collected data from these companies and the IPN-Incubator through focus group session, semi-structured interviews, documentary analysis and direct observation (years 2015 and 2016). Finally, a questionnaire was used to obtain information, to better understand the incubation phenomenon, focusing on technology transfer, internationalization and reputation from the perspective of their founders (year 2017).

4.1 Technology transfer

The university-industry linkage is crucial for economic growth, technological intensity enhancement and business knowledge, and incubators are often designed to support technology-based firms (EC 2002). This is also the case of IPN, which promotes innovation and the transfer of technology, establishing the interface between the scientific and technological environment and the production sector.

Spin-offs are widely used to transfer knowledge from universities to industry or, alternatively, from large enterprises to SMEs. The case of IPN shows its effectiveness in setting up technology-based firms, especially spin-offs. According to Oakey (1995), the two main sources of new technology-based firms are higher education institutions (academic spin-offs) and well-established industrial enterprises (corporate spin-offs). Of the companies analysed, six are academic spin-offs (G2, G3, A1, I2, I3, I4), three corporate spin-offs (G1, A3, I1) and only one is not a spin-off (A2).

The results indicate that business spin-offs have developed faster than academics for a variety of reasons. First, because they take advantage of the accumulated experience, the network of contacts and the physical assets of the parent company, which is in agreement with the evidence reported by Smilor (1987). Secondly, because they manage to have mature technologies, innovative and marketable products in less time (e.g., company I1 made the first sale at the end of the first year of activity) given its strong market orientation. Third, they develop formal and informal relationships with the parent company (Roberts 1991). Finally, they become more international in their own right and have more financial resources of their own or of the parent company, not through venture capital funding. In contrast, academic spin-offs have longer patenting processes, although the relationship with the parent university greatly benefits the IPN's performance. The

results indicate that non-academic spin-offs tend to exploit innovations associated with market opportunities, whereas academic spin-offs initially focus on the innovative idea, playing a more important role in technology transfer (Pérez and Sánchez 2003) because they act as mediators between basic and applied research from which they originated, and a network of clients (Rothwell and Dodgson 1993). For academic spin-offs that during their early years are more polarized for technology than for the market, support from the IPN-Incubator is relevant to knowledge transfer and even more decisive when it comes to product companies in that technological maturity is a complex and time-consuming process. As one of the entrepreneurs said (I4):

“The incubation at IPN proved to be the right choice for a company with our technological profile, since this incubator presents all the necessary valences to start a business: linking to national and international scientific entities, specialized consulting and support to internationalization”.

Regarding the connection between founders and universities, most of the companies were created by members of the University of Coimbra (UC) as spin-out, demonstrating the very close involvement of academic researchers in the process of transferring technology to the market. As shown in Table 2, only A2 and I1 companies do not have entrepreneurs connected to this university. Of the four incubated companies, three of the founders are university professors and two of them (I2 and I4) have licensed patents. The academic experience of researchers/entrepreneurs is a relevant factor in the domain of the technology transfer process. Wu, Welch, and Huang (2015) argue that studies have shown that both the researchers' perception and their experiences explain the predisposition to engage in marketing activities. In this way, more experienced academics are generally more likely to engage in patenting activities because they have achieved a certain degree of safety in their university careers (Wu et al. 2015).

Table 2 Spin-out source, technology and intellectual property (2014-2017)

Company	Spin-out Source	Technology Development Status	New Products and Services	Intellectual Property Protection
G1	Informatics engineer from New University of Lisbon and mechanics engineer from University of Coimbra (spin-off from European Space Agency)	Established	Product (1), Services (2)	Patent (1); Trademark (2)
G2	PhD students from University of Coimbra	Established	Product (1)	Patent (4); Trademark (1)
G3	Three PhD students from University of Coimbra	Established	Product (2), Services (6)	Secrecy; Trademark (30)
A1	Two professors/researchers from University of Coimbra	Established	n/a	Trademark (1)
A2	Founder with professional technical courses (spin-off from MedicineOne, Ltd.)	Established	Product (1)	Trademark (1)
A3	Founder with a degree in economics and other with a master's degree in psychology from University of Coimbra (spin-off from Cnotinfor, Ltd.)	Established	Product (1)	Copyright; Trademark (3)
I1	Informatics engineer from New University of Lisbon, (spin-off from Active Space Technologies, S.A.)	Established	Product (3) Services (2)	Patent (1)
I2	Full Professor and researchers from University of Coimbra	Established and Prototype	Product (1)	Patent (1); Trademark (1)
I3	Full Professor, researcher and PhD students from University of Coimbra	Established	Product (4) Services (20)	Trademark (1)
I4	Full Professor, researcher and PhD student from University of Coimbra	Early commercialization	Product (3)	Patent (1); Trademark (1)

Source: Own elaboration.

At the level of technological development, 90% of the cases have already established and commercialized technologies (see Table 2). One of these companies has a product resulting from established technology and proceeds to the development of a prototype (I2). Another company is in the initial phase of commercialization of complex technological products (I4), facing a demanding production processes and a slow process of entering the market. These technology-oriented academic spin-off firms are at risk of

developing sophisticated technological products that are not market oriented and therefore have a greater chance of market failure (Roberts 1990).

To market entry, the entrepreneurial approach varies according to the technological problems to be face by the companies. On the other hand, fast commercialization of technology depend to respective sector of activity. Companies that do not belong to the ICT/software sector – e.g., product-based companies – when developing products subject to registration and patent protection face more barriers to entry due to the long technological maturity that mediates between the design and testing of prototypes and the commercialization of technological products.

In what concerns to innovation – as measured by the launch of new products/services –, the results show that 40% of cases introduced more than one new or significantly improved product or service over the period considered (see Table 2). Incubated firms proved to be more innovative, with I3 launching more products and services (24) due to the nature of its activity focused on digital media with platforms for end consumers in the tourism area.

With regard to intellectual property protection, the results suggest that graduated firms are the ones that most use these specialized services through three types of instruments: patent, trademark and trade secret (see Table 2). Thus, between 2014 and 2017, IPN companies registered 8 patents (half of them from G2) and 41 registered brands (of which G3 stands at 30).

Out of the 10 companies analysed, five have at least one registered patent (50%) and nine have one or more registered marks (90%). One company uses copyright (A3) and another company uses the trade secret due to security issues inherent in the marketing of its products (G3). In absolute terms, G2 is the one that has the most patents registered (four) as a result of the high technological intensity of its products and the need to protect the knowledge through this instrument while G3 is the one with the most registered trademarks due to being a company software development.

Some of the cases analysed use the services of IPN to support the protection of intellectual property, especially through the registration of trademarks and patents. Among the main barriers in the knowledge transfer process, respondents have stressed the time-to-maturity of (more time-consuming) product-based technology, the need to patent the knowledge (greater complexity) and the high legal costs of registering and protecting a patent at the

national and international level over a number of years. One of the entrepreneurs (I4) expressed this as follows:

"From a technology developed in UC we wrote peer reviewed scientific articles, we tested prototypes and decided to protect the knowledge produced through a patent called basically permeabilization of biological membranes through high frequency ultrasound produced by ultrathin films. We are very ambitious and we have decided to protect this in 30 countries by means of a patent in the main international markets, and our patent has already cost about € 200,000."

Another of the barriers identified is the complex process of drafting patents, which in most cases, requires very specialized support. As far as patenting and licensing of technology are concerned, while graduated firms are autonomous, other companies do not rely exclusively on the IPN support, but simultaneously use the IPN services and subcontract specialized external companies (e.g., I2 and I4). For these companies, outsourcing the writing of the patent is frequent and makes the process more agile and efficient. One of the entrepreneurs (I2) expressed this in the following way:

"For patenting process of new product that we intend to commercialize in next year, we have contract simultaneously with IPN and specialized external company to supporting the intellectual property protection and we benefit from this complementarity."

In contrast, G1 and G2 companies are directly involved in the patenting process by hiring outside companies for this purpose and assume the costs of patenting the technology without IPN' support services. A similar situation occurs in incubated firm I1 whose entrepreneur mentioned:

"As we are a spin-off of the G1 Company, we benefited from the support of the parent company in the patenting process through our own means, without IPN's specialized services."

"Product" companies rely more on patent registration to protect their technology rights. In contrast, service companies such as those operating in the ICT/software development sector protect intellectual property primarily through the use of trademarks (registration of brands), since it is not necessary to use patents in the European market for this purpose. As one entrepreneur said (A2):

"We have developed software for the clinical area for several years and our strategy of protecting intellectual property is based on the trademark of one of our products, a registration we made in Portugal, some European countries and in Brazil. As it is not necessary to patent

software in Europe we do not resort to patenting our software, which is evolutionary because subject to frequent improved versions."

4.2 Internationalization

In this case study, the approach to internationalization of companies follows two paths: (i) the first of a qualitative nature based on interviews with its founders and (ii) the second quantitative one, based on the 2017 survey.

The entrepreneurs emphasized that the IPN-Incubator was perceived as particularly valuable for incubated and under acceleration firms, facilitating the access to international markets during the first years of activity, which is in accordance with, for example, Engelman et al. (2015) in a study carried out on 115 companies housed in Brazilian technological incubators. According to an entrepreneur (A2) the support of IPN was decisive since the beginning of activity:

"In the first year of incubation at IPN, we have had sales in the international markets. The internal market is very conditioned and small, in the technology area it is good to test products but we need scalable markets. The internationalization process is complex, takes time and requires persistent work. As of 2011 we started to grow, in 2014 exports accounted for about 50% of turnover and currently about 80%. For the internationalization of the company, IPN support at the level of infrastructures and networks was decisive."

In the analysed cases, the incubated firms are the most benefit from IPN support in the internationalization process, even in relation to under acceleration firms that have growth targets in the global markets. These supports are offered by IPN through soft-land networks, allowing access to global markets and contacts, favouring the establishment of partnerships in projects involving an international component for their companies, facilitating the identification and development of channels that allow the positioning of the products of the companies through these business partners. The role of IPN in this area is also recognized by graduated firms. For example, as was described by one interviewee (G2):

"IPN was contributed to the internationalization of our company and favour business growth. The actions and services provided by the incubator positively affected the company's internationalization strategy, based on a wide network of contacts, allowed to expand our activity to markets into European countries."

For other companies, the access to international markets was based more on business connections than on the IPN support. As one of the entrepreneurs mentioned (I1):

"Our company as a spin-off from another company is export-oriented with direct sales in the international markets (50% of the EU, 50% outside the EU) using the parent company's network of contacts."

In terms of geographic markets for goods or services sold, eight companies were present in international markets in 2015. In that year, two incubated firms had no exports (I2 and I4), and one of them had the first international sale in 2016 (I2). By the end of 2017, the company I4 had no records of international sales, and it was still looking for potential clients, partners and representations for the entry of its products in the international markets.

One of the barriers identified in the process of internationalization is recruitment of partners and professionals in foreign market. As a businessman of one of the companies participating in the acceleration program (A3) said:

"In terms of international sales, the crucial obstacle that we face is to reach the right people quickly, especially when we do not have a local network." Here IPN's support was important on the internationalization of firm, facilitating our entry into demanding markets of great size and high competitiveness, such as Germany, Brazil and the United States of America through a wide range contacts and a set of diversified services devoted to fostering internationalization (e.g., networking, consultancy, and business missions)."

The internationalization process presents some difficulties for the new companies, one of which is the degree of qualification and trust of human resources abroad. As one of the entrepreneurs said (A2):

"Human resources are critical in the process of internationalization. When we enter an external market, trustworthy people are needed who are capable of dealing with that market, have the capacity for adaptation, integration and at the same time defend the interests of our company. Sometimes it's a difficult balance."

The internationalization of firms is one of the main objectives of IPN and is one of the most important indicators of value creation and business growth. The openness through participation in innovation and business networks, the entry into new geographic markets and the establishment of new subsidiaries in other countries by the studied companies demonstrate the importance of increasing tradable goods and services to speed up

business growth. The exports and geographic markets of goods and services sold by the company are one of the main economic indicators.

In summary, despite the difficulty of establishing a relationship between the IPN-Incubator support and the results obtained by the companies in terms of internationalization, it is recognized that incubated and under acceleration firms benefit from the installation in physical infrastructures of IPN (Incubator and Business Accelerator) and the use of specialized services and networks available through the IPN support. The interviewees emphasized that without this technical support and training of companies and entrepreneurs, the results would not be so promising and did not open up so many perspectives of growth to the companies.

Our findings suggest that graduated firms have a completely autonomous market approach and are not dependent on the IPN for the pursuit of their strategic objectives.

4.3 Reputation

One of the main reasons given by the interviewees to choose the IPN as the host institution for their companies is the importance of the incubator support for corporate reputation. In addition, the IPN ecosystem provides many advantages for these companies, especially in their early stages of development. As one entrepreneur said (I3):

"The sustainable ecosystem that IPN creates with partners is the greatest benefit for our firm, the most valuable support for the survival and entrepreneurial growth and for building the reputation in the market, so necessary in the early years of activity."

In the same sense, another entrepreneur (I4) stated:

"IPN makes it easier to solve business problems and its credibility in the entrepreneurial ecosystem is very good, which is reflected in our company's reputation gains. We expect to benefit from incubation at IPN for our affirmation in the market."

Some interviewees highlight the importance of the network of contacts of the IPN and its management team for survival and business reputation. One of the entrepreneurs said (A2):

"One of the best indicators of the impact of IPN is the low mortality rate that characterizes the companies that choose to be incubated in relation to those that choose the other way, and this has benefits to the reputation of companies supported by IPN."

As mentioned by an entrepreneur from another company (A2):

"The relationship with IPN has favoured the building of a reputation throughout our incubation process, and the IPN's networking and the stability and competence of incubator management have contributed to this."

4.4 Impact of incubation process on technology transfer, internationalization and reputation

The assessment of technology transfer, internationalization and reputation as a result of the incubation process was measured by the degree of agreement in the companies' view regarding six items under the 2017 survey (Table 3).

Table 3 Impact of the incubation process on technology transfer, internationalization and reputation – 2017

Concordance with propositions ...	Graduates (G)	Under Acceleration (A)	Incubatees (I)	Mean (A and I)	Aggregate Mean
Introduction and development of new products in the market	2.0	3.0	3.0	3.0	2.7
Increase in technological intensity	2.3	2.5	2.8	2.7	2.6
Enrichment of own technological knowledge	2.3	3.0	2.8	2.9	2.7
Patent licensing for IP protection	2.7	2.0	1.8	1.9	2.1
Internationalization of the firm	3.0	3.0	3.8	3.5	3.3
Increasing the firm's reputation in the market	2.3	4.0	3.5	3.7	3.2

Source: Own elaboration from the 2017 survey (9 firms).

Note: The degree of concordance of the impact of the incubation process was evaluated using a five-step Likert scale from 1 (not agree anything) to 5 (totally agree).

Overall, the companies do not recognize the influence of the incubation/graduation process in which they participate in technology transfer (average value below 3.0), with a different situation in relation to internationalization and reputation of companies (average value over 3.0).

Regarding the impact of the incubation process on technology transfer, in average aggregate terms, it is noted that the support of the IPN-Incubator was not decisive for the companies' innovation activities, especially for technology licensing. When the cases according to the stage of development were analysed, the results suggest that incubated and under acceleration firms do not derive significant benefits from the IPN Incubator's performance in relation to the introduction and development of new products in the market, increased technological intensity, enrichment of own knowledge technology and patent licensing of graduated firms.

An analysis of the responses of each company shows that only three companies are aware of the positive impact of incubation for the introduction of new products (A3, I3 and I4) and two companies have the same perception for the increase in technological intensity and enrichment of self-knowledge (A3 and I4, G2 and A3, respectively). On the other hand, the sampled companies do not consider the IPN support in patent licensing for intellectual property protection to be significant. One of the barriers identified in the process of technology transfer is the patent writing process that is often outsourced. Thus, the results do not confirm the evidence gathered in the semi-structured interviews in which several companies highlighted the importance of the IPN support in technology transfer mechanisms, especially in the protection of intellectual property. In average, the companies in the early stages do not significantly value the impact of incubation on patent licensing, manifesting a more unfavourable perception of this mechanism of technology transfer than that of graduated firms, which does not support the paper's first hypothesis.

Regarding the impact of incubation on the internationalization process, in average aggregate terms, the companies agree (moderately) that the IPN-Incubator favours its internationalization through the access to global markets (see Table 3). According to Engelman et al. (2015), incubation positively affects the internationalization of companies. The results suggest that the incubated firms with the most difficult access to new markets benefit most from the IPN. This evidence supports our second exploratory hypothesis. Of the analysed cases, three of these companies (I1, I2 and I4) acknowledge the positive impact of the internationalization process. The graduated firms are internationalized by their own means and do not benefit from the IPN support and networks.

In average, concerning the impact of incubation on the construction of corporate reputation, the companies (moderately) agree that the IPN-Incubator favours the acquisition of reputation as one of the main intangible assets that companies seek to obtain especially in the first years of activity (Bruneel et al. 2012). In this topic, the results suggest that incubated and under acceleration firms benefit most from the IPN (see Table 3). This evidence supports our third exploratory hypothesis and it is in line with the findings of an empirical study conducted by Studdard (2006), involving 52 companies in incubators from the United States of America and Finland, which stress that the interaction of new companies with incubator management has a positive impact on companies, resulting in a perception of greater business reputation. Hence, incubator support increases the probabilities of survival and contributes positively to reduce the risk of early-stage corporate mortality (Shepherd et al. 2000).

Among the analysed cases, five of these companies (A2, A3, I2, I3 and I4) acknowledge the positive impact of the incubation process on reputation acquisition, one of companies' main assets (Studdard 2006). Graduated firms building reputation by their own means and do not recognize a reputation increase in the market as a result of the incubation/graduation process in which they participate. Over the years they become less willing to cooperate with the IPN-Incubator not benefiting from its support to increase reputation (the exception is G2).

Among the graduated firms, the results indicate a significant difference between G2 and the other two companies. While G2 benefits from its own technological know-how and recognizes the importance of IPN support for reputation, G1 and G3 do not take innovation and reputation gains from the IPN community ownership. In the first case it is confirmed the high involvement of G2 in the activities developed by the IPN-Incubator and the withdrawal of benefits from this interaction. In other cases, G1 and G3 are very innovative and mature technologies, independent and are further away from the IPN. In contrast, in what concerns to internationalization the G1 is the company that benefits most from the IPN networks and contacts.

Among the companies at early stages, the ones that benefit most from the incubation process in which they participate are I2, I3 and I4 and A3, respectively, in terms of internationalization and gains in reputation.

5 Conclusion

The results demonstrate that although the IPN supports all companies, regardless of their stage of development, that support is more robust and directed at incubatees and companies under acceleration. After a strong interaction in the early stages, the flow of support to technology transfer, internationalization, and reputation attainment decreases at a later stage. Our dataset suggests that academic spin-offs are more vulnerable than corporate spin-offs in the early years. Therefore, the IPN support is relevant to transfer technology from university to this type of spin-offs and, indirectly, to their customers through complex technology-based products. In this type of companies, the incubator management should develop a differentiated strategy taking into account the specificity of these companies. Therefore, a case-by-case approach cannot be neglected.

The use of intellectual property protection increases after the first years of activity, particularly through the use of patent protection and trademark registration but, at the same time, the relationships between these companies and the IPN have diminished. In sum, the set of analysed firms does not recognize the influence of the incubation/graduation process in which they participate in technology transfer. The TBIs should reinforce the endowment and training of specialized personnel to improve the offer of intellectual property protection services. If companies recognize the quality of these specialized services and realize that their needs are met, they do not will use external consultants or spend resources internalizing those skills.

Companies were very active in the process of internationalization and reputation building in the first years of activity with the support of the incubator, benefiting from competitive advantages in accessing to international markets and obtaining legitimacy. In contrast, graduated companies have reduced their relationships with the business incubator over time, have taken an autonomous approach to the market and pursued their strategic objectives and organic growth by their own means. Thus, there is no evidence that the IPN support favours graduates' growth. Over the years these companies built their own reputation from internal competencies. Therefore, they do not derive benefits from incubator support that could contribute to increase the company's reputation in the market. The incubator's notoriety, and the growth and reputation of graduated firms are favoured by networking and improved incubator-business interactions.

Finally, awareness needs to be increased about the life after incubation. The investment of the modern business incubators in post-incubation follow-up mechanisms must be reinforced in order to increase its impact on graduated firms, through the critical role played by their stakeholders in promoting a win-win strategy with gains for all the actors involved. Thus, incubators must promote strong and extensive networking, improve business communication, increase visibility and broaden their value proposition adjusted to the needs of companies and promoting richer interactions among incubated and graduated firms, encouraging them to participate in partnership' projects with the sponsorship of incubator. To increase the flow of technology transfer, it is important to reinforce the linkages to the entire regional network of innovation and entrepreneurial ecosystem.

This study has several limitations. The first limitation concerns to the fact that the analysis is specific to cases of Portuguese companies, supported by one specific BI. Although these results help understanding companies' perception of the incubation process over different life-cycle stages, they should not be generalized or extrapolated directly to other geographic contexts (due to potential concerns on external validity). Further studies are needed in other technological incubators worldwide, in order to build on the conclusions presented in this paper. Second, complementary approaches such as, for example, large samples of companies from many different TBIs can be considered in future research.

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