



**Economic performance of Portuguese Academic
Spin Offs. Does human capital matter?**

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Master Thesis in Innovation Economics and Management

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2013

Short Bio

Fernando Ricardo Castro was born in Lisbon, Portugal, on the 31st of January 1981. In 2007, he received a degree in Engenharia informática at *Instituto Superior de Engenharia do Porto*. Although his studies were focus in a more technical area during this period, the interest for the innovation area took him to embrace this area. Therefore, he participated in the 1st edition of School of Entrepreneurs ANJE/ISEP (*Associação Nacional de Jovens Empresários / Instituto Superior de Engenharia do Porto*), in which there was incorporated sessions in classroom and outdoors, concerning on how to create and manage a company – from the business, marketing and financial plans to the bureaucratic steps.

The area of entrepreneurship and innovation has always captivated him, so he initiated his postgraduate formation in 2011 and is presently enrolled in the *Mestrado em Economia e Gestão da Inovação* at *Faculdade de Economia da Universidade do Porto* with the dissertation entitled “Economic performance of Portuguese Academic Spin Offs. Does human capital matter?”

Acknowledgements

Throughout this master, I had the privilege to be surrounded by people, whose contribution allowed me to accomplish one more step in my academic path.

Unquestionably, the contribution of my dissertation's advisor, Aurora Teixeira, was essential to conclude successfully this path. Her attentive guidance, encouragement, wisdom and persistence helped me throughout this journey. I am grateful for her availability, constructive criticism and unconditional support. I will remember her as a dedicated professional and an inspiring person.

My recognition goes to the teachers of the Master in Innovation Economics and Management, for their excellence in transmitting knowledge to their students.

My sincere gratitude to my dear friends and colleagues of *Faculdade de Economia da Universidade do Porto*, for providing me constructive comments and suggestions.

Furthermore, I also like to thank all the entrepreneurs of the Academic Spin Offs who kindly collaborated with their responses to the inquiry that constituted the empirical basis of the present dissertation.

I thank my parents and family for their support and encouragement through my life, helping me to advance at personal and professional level. My sister, for always staying by my side on this journey that we call life.

To my girlfriend, for her unconditional support and motivation.

Dedicated to the loving memory of my father.

Abstract

University or academic spin offs have emerged as important mechanisms of industrial regeneration. However, studies detailing the factors behind their performance are still at an embryonic stage. Most of extant literature on spin offs deals with factors affecting the emergency of these firms and not so much on what influences their economic outcomes. Moreover, the role of human capital as a potential booster of spin offs' economic performance has been neglected or analysed in a rather superficial way. This work aims at assessing the role of human capital for the performance of Portuguese spin offs in its different forms, including entrepreneurs' education levels and types, skills, experience and network capabilities.

Using a sample composed by 90 founders of 61 ASOs located in Portugal, associated to the University Technology Enterprise Network (UTEN), we found that among human capital dimensions, business expertise, most notably markets knowledge, was the one that affected the most on ASOs economic performance. Founders' formal education both level and types failed to significantly influence ASOs economic performance. The unemployment status of the founders (before ASOs creation), formal contacts with university, as well as the undertaken of R&D activities and internationalization emerged as critical positive determinants of ASOs economic performance. Although some support exists for the relevance of universities' research excellence to ASOs performance, a univocally result emerged regarding universities context: ASOs that resort to the services of Science Parks, Incubators and TTOs in exclusive, outperformed the remaining.

Keywords: Human Capital; Academic Spin Offs; Economic Performance

JEL-Codes: J24; O39; L25

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1 Introduction

Human capital has been for a long time considered a key factor of countries' economic growth (Lucas, 1988; Romer, 1990). Macro level studies have considered, in general, human capital as the quantity of formal education that each individual possess (Mincer, 1958; Schultz, 1960). This concept, however, encompasses not only formal education but a set of activities related to people that is likely to influence individual's future income. These activities include, formal education, training, on-the-job training, improving health care in general, and other types of informal education, which could improve the efficiency of individuals (Becker, 1962).

Although not so highly analysed, at the micro level, more specifically, at the level of the firms, human capital has also been identified as a lever of firms' economic performance (Davidsson and Honig, 2003; Shane and Khurana, 2003; Walter et al., 2006; Alvarez and Rodriguez, 2011). In this case, human capital might refer to the entrepreneurs' levels of formal education (Colombo and Grilli, 2009; Gimmon and Levie, 2010), training (Gimeno et al., 1997; Colombo and Grilli, 2010; Ganotakis, 2012), social networks (Davidsson and Honig, 2003; Shane and Khurana, 2003; Walter et al., 2006; Alvarez and Rodriguez, 2011), or average firms' human capital, which respect the level of education, training and experience of firms' collaborators (Teixeira, 2002).

Despite the voluminous literature on the relevance of human capital for firms performance taking either the entrepreneurs' (Colombo and Grilli, 2009; Gimmon and Levie, 2009; Ganotakis, 2012) or collaborators' human capital as isolated factors of performance, there is a scarcity of analyses on this regard that integrate both entrepreneurs' and collaborators' human capital as interacting explanatory factors. The majority of existing studies tends to focus on the influence of human capital for SMEs (Soriano and Castrogiovanni, 2012), large companies (Hitt et al., 2001), population in general (Davidsson and Honig, 2003; Alvarez and Rodriguez, 2011), or start-ups (Gimmon and Levie, 2010; Okamuro et al., 2011). There are still limited understanding on how the distinct dimensions of human capital influences the economic performance of Academic Spin Offs (ASOs) (O'Shea et al., 2005; Karlsson and Wigren, 2012). It is likely that, contrary to other types of firms, the relevance of entrepreneurs' human

capital on ASOs' performance involves dimensions (for instance, type of education, level of industrial related experience) often neglected by extant literature.

ASOs are now playing a major role in society, by transforming new scientific discoveries into business opportunities (Grandi and Grimaldi, 2005; O'Shea et al., 2005; Walter et al., 2006). A spin-off company can be defined as a new company that was established by transferring 'core technology' and founders of a parent organization. It is considered a mechanism for technology transfer because it is usually formed to commercialize a technology that was originated in a public Research and Development (R&D) laboratory, a university or a private company (Carayannis et al., 1998). A University Spin-Off (USO) or Academic Spin-Off (ASO) involves the transfer of a core technology from an academic institution into a new company, where the founding member(s) may include the academic inventor(s) (O'Shea et al., 2008).

Although several and interesting studies exist on ASOs, in their majority the focus is on the factors that propel its emergence, and not so much on its economic performance after its development. Some recent studies, analysing ASOs located in developed countries like Sweden and USA, investigate how legitimacy, social and human capital influence the university employees' start-up propensity (O'Shea et al., 2005; Karlsson and Wigren, 2012). For Portugal, some studies on ASOs were recently released but they focus on the general determinants of performance (Teixeira and Grande, 2013) or the determinants of the speed of internationalization of such firms (Teixeira and Coimbra, 2013). They do not assess, in detail, the impact of the distinct dimensions of the entrepreneurs' and firms' human capital on economic performance of these same firms.

This study aims at filling in this gap by investigating the impact of human capital, in its distinct dimensions, on the economic performance of ASOs. It contributes to the literature that analyses this type of companies by studying the determinants of their performance, focusing on their development process and not just on their emergency. Additionally, it contributes to the broader literature of the performance determinants of firms, specifying the distinct dimensions of entrepreneur's human capital.

For addressing the dissertation's goal, we resort to quantitative and causality methods on a sample of 90 founders of 61 ASOs out of a population of 116 Portuguese university spin offs created in the last 10 years associated to entities belonging to the University Technology Enterprise Network (UTEN).¹

The present dissertation is organized as follows: In Chapter 2, we review the relevant literature, specifying the main concepts and the key determinants of the economic performance of firms. The methodological considerations and the data used in the analysis are presented in Chapter 3. In Chapter 4, we present the empirical results and in Conclusions, we put forward the main results, limitations and policy implications of the findings.

¹ UTEN is a network of professional Technology Transfer Offices (TTOs) focused on the commercialization and internationalization of Portuguese Science and Technology.

2 A review of the literature

2.1 Main concepts: ASOs, human capital, and firm performance

In a context in which governments seek to promote knowledge-based activities, while reducing public expenditure, universities are seen as entities capable of supporting the creation of knowledge economies that generate large economic benefits (Sarkar, 2010; Wright et al., 2012). The universities were created with the goal of producing exclusive science and technology knowledge and qualified workers (O'Shea et al., 2005). However, their mission is expanding being presently important instruments of technological transfer and economic growth (Klofsten and Jones-Evans, 2000; Wright et al., 2012).

It is known that one of the mechanisms of knowledge transfer from University to the market is the creation of Academic Spin Offs (ASOs). These firms are created specifically with the objective to exploit technological knowledge originated within universities, being according to some authors, important contributors to economic growth and technological innovation (Grandi and Grimaldi, 2005; Wright et al., 2012).

The term spin-off is used in the literature as a new firm, usually founded by students, professors or researchers at a university, that develop a new technology, which was initially developed in a public laboratory R&D (Research and Development), a university or a private R&D organization (Carayannis et al., 1998; O'Shea et al., 2005). This technology is the main reason the University spin-offs are founded primarily, rather the presumption of competitive advantage concerning distribution, marketing or sales, in which usually the founders are engineers and scientists (Pérez and Sánchez, 2003). With the support of the university's business incubator (or another mechanism), it will develop a product or a business concept that will be explored commercially by a new venture. In several studies, Shane and his co-authors consider "university spin-offs" as start-ups exploiting university inventions but not necessarily founded by university employees (Shane and Stuart 2002; Di Gregorio and Shane 2003; Shane 2004).

Spin-offs represent one potential mechanism for technology transfer from the parent organization (Grandi and Grimaldi, 2005), as they progressively contribute to region's economic development (Etzkowitz, 2003; O'Shea et al., 2005).

The two most important sources of new technology-based firms are university spin-offs and corporate spin-offs. These two kinds of spin-offs are very alike, nevertheless, there are considerable differences: while a private firm usually retain the research inside the firm, the university often encourages the transfer of the results to be used outside the university (Pérez and Sánchez, 2003).

There are four principal actors/roles in the spin off process (Pérez and Sanchez, 2003):

- 1) The technology creator, who through the innovation development brings the technological innovation to the point at which the transfer of this technology can begin;
- 2) The entrepreneur(s) - who strives to create a new business that is focused on technology innovation, and commercialize the technology in a product or service that is sold in a market;
- 3) The parent organization, in which the R&D activities take place to create the technological innovation and which may provide such functions to the spin-off as assistance in patenting the innovation, technology licensing, etc.;
- 4) The venture investor, who provides the financial resources to establish the spin-off, and who may provide needed business management expertise.

Thus, the phenomenon of new businesses started by university employees stands as one activity clearly connecting university and business (Karlsson and Wigren, 2012). An ASO is characterized by a direct transfer of knowledge from the university to a new company, established by resources belonging to the academic world (Sarkar, 2010).

According to Pérez and Sánchez (2003), there are three types of ASOs: 1) Companies formed by university professors or researchers who wish to commercially exploit the results of research carried out by them in university; 2) Companies founded by university licensing to commercially exploit results of research developed in academia; 3) Businesses run by people outside the university who decide to explore commercially the results of academic research.

There are several factors that influence the success of (academic) spin-offs, including the educational title of the individual or the founding team, the cooperation among individuals for the start of the business (Karlsson and Wigren, 2012), and founders professional experiences in innovation prior to start-up (Okamuro et al., 2011). According to Okamuro et al. (2011), given that startups usually lack business

experience, the founders' human capital has an essential role in their growth and sustainability.

The term 'human capital' was originally developed by Jacob Mincer (Mincer, 1958), Theodore Schultz (Schultz, 1960) and Gary Becker (Becker, 1962). These authors considered the education in general (Mincer, 1958; Schultz, 1960) and training and other activities aimed at increasing individual's efficiency (Becker, 1962) as 'capital' - since it becomes a part of the person, it cannot be seen as an asset, which can be bought or sold, so it referred as 'human capital'.

The studies of these pioneers on human capital helped to rationalize the impact of this form of capital on individual earnings and wages. Specifically, the time spent in training/education represents a deferral of income to an individual (Mincer, 1958), explaining the difference of individual's incomes. As such, it represents an 'investment'. At a macroeconomic level, these differentials or returns on the investment in education (Schultz, 1960) are in a proportional relation to the increase of a country's income. Intangible resources like knowledge, as well as on-the-job training, improvement of general medical care and other type of informal information that improve person efficiency, were considered by Becker (1960) as human capital.

Human capital can be defined as "a stock of personal skills that economic agents have at their disposal" (Rauch et al. 2005, in Gimmon and Levie, 2010: 1215), encompassing an individual's education, experiences, and skills that help in the tasks of getting one's work done (Gimmon and Levie, 2010).

At the micro level, the importance of human capital has been recognized for a long time, and "the effective management of human capital, not physical capital, may be the ultimate determinant of organizational performance" (Youndt et al., 1996: 836). Indeed, as Karlsson and Wigren (2012) underline, organizations, in general, and firms, in specific, are founded by individuals with reputations, ideas, social networks, knowledge (tangible and intangible) and human capital, which impact significantly on their performance.

Organizational performance is composed by three specific dimensions: financial performance (Choi and Wang, 2009), economic performance (Richard et al., 2009), and international performance (Lee and Habte-Giorgis, 2004).

The financial performance of a firm represents the extent to which the market recognises the value added by the firms' assets (human and social capital, trust, network relations with stakeholders, etc.) (Choi and Wang, 2009). Often, this concept is measured by the discounted present value of future cash flows of a company (Richard et al., 2009). This calculation, as one piece, do not simply reflect a proficient evaluation of the company, since there are psychological and other influences, that affect the appraisal of future cash flows (Malkiel, 2003). Another important limitation of accounting measures of performance is that they put emphasis on the historic activity, depreciating the future performance of the company (Richard et al., 2009). The financial performance is also measured by the Tobin's q, the ratio of the market value of the company assets (the numerator is the market valuation, the going price in the market for existing assets) and the replacement cost of the company assets (the denominator is the reproduction cost or the price in the market for newly produced commodities) (Tobin and Brainard, 1977). It is possible to get an accurate estimate for the market evaluation of the company, by summing the values of the stocks and bonds that a firm has issued. However, it is more difficult to estimate the reproduction cost of its assets.

Economic performance includes innovation capabilities (Richard et al., 2009), productivity (Carmona et al., 2012) and the competitiveness of the company (Ruzzier et al., 2006). Innovation has long been recognized as an important driver of economic performance, since companies that have successful innovations, also demonstrate competitive advantages and increasing market value (Carmona et al., 2012). It is important to distinguish between innovation and invention, since both terms are often used synonymously. An invention must be understood as the creation of something capable of creating commercial value (Schumpeter, 1939), while innovation is the concretion of the invention, which is effectively creating value (Schumpeter, 1939). The studies of innovation draws on Schumpeter's theory of creative destruction, in which the fittest survives (the 'novel' entrepreneur) and the weakest are eliminated (the common entrepreneur) (Schumpeter, 1939). The entrepreneur is an individual who has an innovative character, accepts risks and make decisions in the design of new business and opportunities, with the objective of creating value (Schumpeter, 1939). Schumpeter assigns a fundamental role to the entrepreneurs, considering them as individuals who have the ability to implement innovations. Innovation is a fundamental instrument for

entrepreneurs, by which they exploit change as an opportunity for a different business or service, introducing new products, new markets, new methods of production and the creation of new businesses, these innovations will enable the company's competitiveness, survival and growth (Lee and Habte-Giorgis, 2004). Empirical research and surveys of companies demonstrated that innovation leads to new products and services, better quality, and lower prices (Carmona et al., 2012).

The internationalization is the expansion of economic activities beyond the border of countries (Ruzzier et al., 2006). One can conceive international performance of a firm by its commitment towards external business (Grande and Teixeira, 2011). Exporting is a crucial business activity, which is vital to the nation's economy, since it produce jobs, resulting in economic growth (Lee and Habte-Giorgis, 2004), being also vital to a company that intent to maintain a competitive advantage, either in the domestic or international market. According to Lee and Habte-Giorgis (2004), from the moment a company begins its internationalization through exporting, it benefits from economies of scale, which decrease the costs of manufacturing for both the intern and the international market, leveraging the competitiveness of the company. In order to maintain the competitive advantage of their competitors, it is crucial that a company has a diversification strategy in terms of geography or product, achieving economies of scale and scope, which have a positive impact on company performance (Lee and Habte-Giorgis, 2004).

Studies related to the organizational sociology and entrepreneurship (Richard et al., 2009) often uses survival of the firm as proxy for companies' economic performance. Indeed, survival and economic performance of the companies are intimately related (Baker and Kennedy, 2002).

2.2 Main determinants of firms' performance: hypotheses to be tested

The group of factors that determine and influence the performance of ASOs is very wide, similarly to those affecting the other types of firms, namely SMEs. In general, these studies categorise the determinants of firms' performance in three main groups: entrepreneurs (Davidsson and Honig, 2003; Shane and Khurana, 2003; Walter et al., 2006; Alvarez and Rodriguez, 2011), firms (O'Shea et al., 2005; Colombo and Grilli

2009), and context (Colombo and Grilli 2009; Gimmon and Levie, 2010) related factors.

2.2.1 Entrepreneurs related determinants

Human capital related factors

Business opportunities depend on prior knowledge like information about technological or market developments, or market inefficiencies (Shane, 2000) that create opportunities for introducing new products, processes or strategies (Alvarez and Rodriguez, 2011). The capability to identify business opportunities is a cognitive task that allows some individuals, but not others, to discover entrepreneurial opportunities (Shane and Venkataraman, 2000). Entrepreneurial activity depends upon the interaction between the characteristics of opportunities and the characteristics of the people who exploit them (Casson, 2005). Thus, opportunities are objective, but the perception of opportunity is subjective (Casson, 2005). These opportunities do not appear in the absence of human action, rather are created through the efforts of individuals (Freeman, 1982).

Human capital theory proposes that education or training gives individuals greater cognitive capacity, making the workers more productive and efficient (Mincer, 1958; Schultz, 1960; Becker, 1962), and that companies have an economic incentive to invest in human capital, expecting to obtain higher future profits derived from higher levels of productivity with respect to wages paid (Becker, 1962). If (business) opportunities arise, individuals with more or higher human capital quality should identify them better than others with lower human capital should (Davidsson and Honig, 2003). Formal education is one component of human capital that may assist in the accumulation of explicit knowledge that may provide skills useful to entrepreneurs for creating business (Alvarez and Rodriguez, 2011). Nevertheless, human capital is not only made up of knowledge provided by formal education, it also includes knowledge acquired through experience and practical learning (Davidsson and Honig, 2003).

The technology that the new spin off will exploit and the characteristics of the founders are fundamental for the new company, since they represent, largely the whole purpose of the creation of the new firm. Prior research has indicated that the founder's human

capital tend to enhance the economic performance of the new spin off (Okamuro et al., 2011; Karlsson and Wigren, 2012).

Alvarez and Rodriguez (2011) studied the factors that influence the discovery of entrepreneurial opportunities, centring on human capital, social capital and gender, which they refer as being key factors for maximizing the discovery of entrepreneurial opportunities. They confirmed the influence of human capital on the discovery of opportunities, chiming with previous research (Shane, 2000; Davidsson and Honig, 2003), recognizing that formal education contributes to the accumulation of knowledge, which gives entrepreneurs useful skills for business creation (Alvarez and Rodriguez, 2011). Other dimensions, outside formal education, namely skills and experience, were also recognized as key factors in the discovery of entrepreneurial opportunities (Shane and Venkataraman, 2000; Alvarez and Rodriguez, 2011) and related to firm's performance (Ganotakis, 2012). Indeed, Gimmon (1997) found that both the level of education and the management experience were positively related to a firm's economic performance.

The literature is somewhat conflicting on the role of academic degrees in venture creation, survival and performance (Gimmon and Levie, 2010). There are various studies on the relationship between new venture performance and education levels, indicating that research focused individuals have a lower propensity to start business, thus a researcher is valued based on academic production, an entrepreneur is based on market results (Roberts, 1991; Karlsson and Wigren, 2012). Karlsson and Wigren (2012) studied how human capital influences the employee's start-up propensity in Sweden. These authors demonstrate that tacit knowledge, like being able to help a colleague to start a business, has a positive impact on the creation of start-ups. Additionally, the academic position of the individual had a negative correlation with business start-ups.

Also related with the start-up emergence, Roberts (1991) proposed an inverted U relationship between the flow of technology from an advanced research and development "source organization" into a newly founded firm, and education level. The author found that performance, measured in flow of technology transferred, increases up

to the Master's degree level and then drop at the PhD level. Assuming that factors that are behind emergence also matter for subsequent performance, we conjecture that:

Hypothesis 1: There is a non-linear relation between founders' formal education level and ASOs economic performance.

In order to build a successful company, it is fundamental to have the business knowledge, the knowledge of product development and production, as well as the market knowledge (Gimeno et al., 1997; Colombo and Grilli, 2010; Ganotakis, 2012). Business management expertise provides specific human capital of the aspects of business that are relevant to create a spinoff company, which includes skills like selling, finance, sales, technology, logistics, marketing and organization and communicating (Shane, 2003). The study conducted by Ganotakis (2012) measured human capital through the entrepreneurial founding team's formal education, defining it into general education, technical education, and business education. It realized that specific human capital of the entrepreneur, especially associated with business/managerial, sector-specific and commercial skills are the key factors to manage a firm, identify appropriate markets for the product/service, resulting in a significantly performance of a firm, however general education fail to significantly impact on performance.

In a recent study, Colombo and Grilli (2009) found a significant correlation between founders' number of years of economic or management education and firm growth, and a weaker effect of technology education. Earlier, Almus and Nerlinger (1999) found that new ventures having entrepreneurs with high engineering and technical skills showed higher levels of growth. Entrepreneurs with high advanced/specialized technological expertise are likely to possess knowledge generated by R&D and this knowledge can lead to exploit leading edge technologies and therefore introduce radically new and technologically complex, innovative products/services to a market (Ganotakis, 2012), augmenting the performance of a firm.

Thus, we posit that:

Hypothesis 2: The type of human capital of ASO' founder influence this latter economic performance.

*Hypothesis 2a: ASOs whose founders have **advanced/specialized technological expertise** are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 2b: ASOs whose founders have **complementary education in Business/ Administration** are more likely to have a better economic performance than the remaining ASOs.*

Start-ups are commonly small companies with scarce initial resources, where the human capital and complementary resources brought by their founders are the main competing advantages (Shane and Stuart 2002; Shane 2004).

Penrose (1959) founded the concept of a firm as a bundle of resources, providing a theory of effective management of firm's resources, productive opportunities, and diversification strategy. She suggests that firms develop advantages from market imperfections and firms create economic value due to the effective and innovative management of resources, so the heterogeneity of resources give each firm its unique character (Kor and Mahoney, 2004). From the concept of the resource-based view, firms gain and sustain competitive advantage by deploying valuable resources (Barney, 1986). The life cycle of the technology is frequently short which leads to product development being progressively more accelerated (Wu, 2007). Consequently, technological start-ups face volatile environments, in which competing technologies appear frequently, so the survival and performance is not assured.

The entrepreneur resources and abilities brought to the firm are crucial for the performance and include the core resources of the entrepreneur, such as: specialized knowledge (Amit and Schoemaker, 1993), financial capital (Brush et al., 1997) and managerial ability (Collis, 1991).

Therefore, we propose the following hypothesis:

Hypothesis 3: The type of resource the founder brings to the new venture influences this latter economic performance.

*Hypothesis 3a: ASOs whose founders have brought **capital** to the ASOs are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 3b: ASOs whose founders have brought **market knowledge** to the ASOs are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 3c: ASOs whose founders have brought **business contacts** to the ASOs are more likely to have a better economic performance than the remaining ASOs.*

The professional experience of the individual has a very important role on the firm founding (Haveman and Cohen, 1994) which influence the entrepreneur expectations concerning the new company. According to several studies, work experience (Gimmon and Levie, 2010; Soriano and Castrogiovanni, 2012), entrepreneurial expertise (Shane and Khurana, 2003), and previous knowledge in a particular industry (Shane, 2000; Okamuro et al., 2011) enhances the ability to discover and sustain entrepreneurial opportunities. This is related to the importance of market knowledge, defined as organized and structured information about the market, which includes the knowledge of a company upstream (suppliers) and downstream (customers) partners and competitors (Lee and Habte-Giorgis, 2004). Entrepreneurs who have previous industry experience will have a better knowledge of any underdeveloped technological and marketing opportunities in that specific sector that might provide a good potential for market exploitation (Shane, 2000).

Concerning specifically with ASOs, often the inventors of the new technology normally do not have industry experience, since their careers have been academic, connected to research or teaching (Karlsson and Wigren, 2012). Studies have shown that ASOs founded by a team that involves both the inventor and people with significant industry experience are likely to have better performance than other university spinoffs (Doutriaux and Barker, 1995). Thus, the spin offs will have a better performance if their management team incorporates individuals with industry experience (Walter et al., 2006).

We accordingly conjecture that:

Hypothesis 4: The professional experience and status of ASOs' founders influence ASOs economic performance.

*Hypothesis 4a: ASOs whose founders have **prior experience** are more likely to have a better economic performance than the remaining ASOs*

*Hypothesis 4b: ASOs whose founders had **prior experience in the same industry** of the new firm are more likely to have a better economic performance than the remaining ASOs*

*Hypothesis 4c: ASOs whose founders have **previous industry experience** are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 4d: ASOs whose founders have **previous University or R&D experience** are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 4e: ASOs whose founders have **previous experience in large or multinational firms** are more likely to have a better economic performance than the remaining ASOs*

*Hypothesis 4f: ASOs founders' **prior status employment situation** is likely to influence the economic performance of ASOs*

The Triple Helix argument suggests that the interaction involving university-industry-government is fundamental in leveraging innovation in knowledge-based society, in which the university is considered as the source of new knowledge and technology, the industry represents the source of production activities and the government the source of contractual relations (Etzkowitz, 2003).

Given that many companies base their activities in R&D and innovation only if they are supported by government funds (Zawislak and Dalmarco, 2010), the government stands as an important part of that tripod (universities-firms-government), essentially responsible for the laws, policies and funds that may regulate and enhance academic spin offs.

There are several major supports given by governmental agencies and other organizations to newly created firms, which can be considered a competitive advantage (Lee et al., 2001), leveraging the economic performance of the latter, not only from the national level top-down, but also from the local level bottom-up, often in collaboration with other organizations in civil society (Etzkowitz, 2003). Specifically, many governments have introduced an increasing range of policies encouraging the

involvement of universities in technology transfer (D'Este and Patel, 2007). By reducing the possibly risk effects that are common during the early stage of a start-up, increased levels of network capabilities protect the new ventures from environmental threats (Lee et al., 2001).

University–industry knowledge transfer refers to various interactions at different levels, involving the exchange of knowledge and technology between universities and firms (Freitas et al., 2013), which can be designated as the third mission of universities and are very mechanisms for generating technological spillovers (D'Este and Patel, 2007). The main purpose of university-industry relations is to complement companies' resources by producing high-qualified scientific knowledge (Zawislak and Dalmarco, 2010). These interactions include various types of equity or contract based relationships between universities and industry, interactions about the commercialization of intellectual property and employment interactions (Freitas et al., 2013). Nevertheless, there are empirical evidence that realizes that relationships like personnel mobility, informal contacts, consulting relationships and joint research projects, represent a very important role in the knowledge transfer between university and industry (D'Este and Patel, 2007; Cohen et al. 2002).

There are diverse studies focusing on the university– industry interactions (Rothaermel et al., 2007; D'Este and Iammarino, 2010), nevertheless, this studies focus on the institutional mode and few analyse the informal interactions (Freitas et al., 2013). It is presumed that most interactions with individual academics are informal, which are difficult to measure, if they are not explicitly formalized in personal contractual interactions.

The network relations of academic spin-offs' founders with University and Government, provide their companies a variety of resources, like market information, ideas, social support, venture funding, and financial resources, augmenting their performance (Walter et al., 2006). Network capability enables a firm to associate its own assets to those of other firms by building relationships, and is a mechanism for anticipating market opportunities (Pérez and Sánchez, 2003).

A study conducted by Shane and Stuart (2002), using data from 134 firms founded to exploit MIT-assigned inventions during the 1980-1996 period, focusing on the role of

founders' social capital and how do initial resource endowments affect the performance of new ventures, demonstrate that university spinoffs, with entrepreneurs having direct and indirect relationships with venture investors, are most likely to receive venture funding and are less likely to fail, concluding that the social capital of the firm's founders represents an important benefaction.

There is evidence of a positive and significant relationship between the social networks of the entrepreneurs and the potential for discovering opportunities for business creation (Alvarez and Rodriguez, 2011). This confirms the idea that individuals integrated in dense social networks are more willing to cooperate and have a higher degree of trust, therefore have a higher access to large amounts of information, which can result in the discover of new entrepreneurial opportunities (Davidsson and Honig, 2003; Shane and Khurana, 2003; Alvarez and Rodriguez, 2011).

Hirai et al. (2012) examined the effect of university spinoffs' external advice networks on their performance (measured by a factor analysis using the variables of sales volume, employment and competitive capabilities), by studying 79 Japanese university spinoffs, and found a significant positive relationship, in which, more nonredundancy in a university spinoff's external advice network is associated with superior venture performance.

Therefore, we propose that:

Hypothesis 5: The level and type of network capabilities of ASOs founders influence the firm's economic performance.

*Hypothesis 5a: ASOs whose founders, at the date of the establishment of the ASO, had **formal linkages** are more likely to have a better economic performance than the remaining ASOs*

*Hypothesis 5b: ASOs whose founders, at the date of the establishment of the ASO, had **formal linkages** to University, Industry or Government are more likely to have a better economic performance than the remaining ASOs.*

*Hypothesis 5c: ASOs whose founders, at the date of the establishment of the ASO, had **informal linkages**, to University, Industry or Government are more likely to have a better economic performance than the remaining ASOs.*

Other entrepreneurs related factors

Studies demonstrated that firms founded by a team have a better performance, in terms of growth than firms founded by a single person, as the potential individual's know-how deficits are compensated by other members of the founding team (Eisenhardt and Schoonhoven, 1990). An earlier study of Eisenhardt and Schoonhoven (1990), focused on the characteristics of the founding top-management team and involving a sample of 92 newly founded U.S. semiconductor firms in Silicon Valley, found that the combination of size, heterogeneity and joint experience of the founding top management team was significant correlated with firm growth. Therefore, we propose the following hypothesis:

Hypothesis 6: ASOs with higher number of founders are more likely to have better economic performance than the remaining ASOs.

The commitment of the entrepreneurs to the company indicates the amount of human resources devoted to the venture. Firms created by 'fake' entrepreneurs, that is, those who see the venture as a 'hobby', tend to have lower performance, than that created by full-time entrepreneurs (Doutriaux and Barker, 1995). Therefore, we propose the following hypothesis:

Hypothesis 7: ASOs whose founders are full-time committed to the ASOs are more likely to have a better economic performance than the remaining ASOs.

2.2.2 Firms' related determinants

Several factors related to firms' characteristics and resources are likely to influence the performance of a company (Shrader and Simon, 1997), most notably: the source of emergence of the spin off (Colombo and Grilli, 2010), export and innovation capabilities (Lee and Habte-Giorgis, 2004) and the company size (Lee and Habte-Giorgis, 2004).²

Since in ASOs the technology is rarely market-ready, the source of creation of the firm is crucial, because the knowledge surrounding the technology is needed to modify or

² Age and size of the firms are typically included as important determinants of firms' performance. In this work, we chose not to include such variables as ASOs are mainly very small and young firms. Instead, we included the size of the founding team and whether the firm exports or not which might be considered as 'instrumental' variables of size and age, respectively.

adapt the technology and associated products/services to meet customer requirements (Di Gregorio and Shane, 2003). Therefore, we propose the following hypothesis:

Hypothesis 8: ASOs whose source of creation of the company has a relation to firms are more likely to have a better economic performance than the remaining ASOs.

Innovation has been for long identified as a critical lever of firms' economic performance (Lee and Habte-Giorgis, 2004; O'Shea et al., 2008; Carmona et al., 2012) and involves for input related activities such as Research and Development (R&D) and measurable outputs such as patents and other intellectual property right mechanisms that have the potential for generating income and new products and services (Lee et al., 2001). This input and output bundle is often recognized as the firm's technological capabilities. Lee et al. (2001) define technological capabilities as a firm's competitive advantage, which include technological knowledge, namely patents, and production skills. These capabilities become even more central in technological start-ups (Shrader and Simon, 1997).

The technological capability, viewed as patents, is an important core competence for new ventures to gain market acceptance and accomplish long-term competitive advantages and performance, mostly as high-tech industries are progressively more innovated and competitive (Zahra et al., 2006). Indeed, according to a study conducted by Lee et al. (2001), focusing on 137 Korean startups, the authors found that the number of patents, utility models and designs that were registered to the Korean Patents, are proxies for firms' technological capabilities and were positive and statistically significant related to firms' performance (two years sales variation).

In addition, business R&D is essential to gain competitiveness in the market. Studies have shown that firms that invest on R&D tend to experience higher growth than firms that do not, since R&D is crucial for product and process innovation, contributing to the performance of firms that use innovation as a strategy (Lee and Habte-Giorgis, 2004). Since not all innovations are patentable, and that some firms have a lower propensity to patent, the R&D expenditure intensity can be used as an alternative to assess firm innovative dynamics (Yang et al., 2010). Therefore, we propose the following hypothesis:

Hypothesis 9: Innovative ASOs are more likely to have a better economic performance than the remaining ASOs.

Hypothesis 9a: ASOs that possess patents are more likely to have a better economic performance than the remaining ASOs.

Hypothesis 9b: ASOs that perform R&D activities are more likely to have a better economic performance than the remaining ASOs.

Exporting is likely to have a positive impact on firm's performance, since these latter can take advantage of a growing market abroad (Teixeira and Grande, 2013). However, few studies demonstrate the direct linkage between ASOs exporting and performance. Lee and Habte-Giorgis (2004) studying US manufacturing firms found a significant and positively influence of export activity on firm's economic performance. Therefore, we propose the following hypothesis:

Hypothesis 10: Exporting ASOs are more likely to have a better economic performance than the remaining ASOs

2.2.3 Contextual related determinants

Resources and capabilities may provide a university with advantages in technology transfer processes (O'Shea et al., 2005; Powers and McDougall, 2005). Gras et al. (2008) categorize five types of resources and capabilities related to universities: human capital (researchers), stock of (theoretical and applied – publications and patents) knowledge, policies and strategies, resources and capabilities of TTOs, and support measures provided by universities for new academic entrepreneurs and spin-offs.

Existing studies demonstrated that the size and nature of financial resources allocated to universities influence the performance of ASOs, suggesting that a greater proportion of industry-level funding is associated with higher levels of technology transfer (O'Shea et al., 2005).

There is evidence of a significant correlation between the quality of university researchers and spin-off performance (Zucker et al., 1998; O'Shea et al., 2005; Powers and McDougall, 2005). Powers and McDougall (2005), showed that human capital related with individuals from higher quality academic institutions create spinoff firms to

capture the rents generated by their intellectual capital, suggesting it may be easier for academics from top tier universities to assemble resources to create start-ups due to their increased credibility (DiGregorio and Shane, 2003). O'Shea et al. (2005) also found a significant correlation between the quality of university researchers and the spin-off activity. Other explanation from spinoff rate is that a higher quality ranking of a university's enhances the finance from investors, since it is believed that technologies created from higher quality universities are better than less eminent universities (DiGregorio and Shane, 2003). Albeit university patenting pool is no guarantee that a university developed technology will be transformed into a product/service and, ultimately, implemented in the market (Powers and McDougall, 2005), it represents nevertheless a safeguard for the potential future economic value. Whereas Powers and McDougall (2005) found that university patenting is not a prediction of spin-off's activity, O'Shea et al. (2005) uncovered a positive correlation between the number of universities patents and the spin-off activity. Additionally, some authors content that spin-off activity can be encouraged or inhibited according to the different policies and strategies universities have regarding technology transfer (Di Gregorio and Shane, 2003). The excellence of university's R&D centers is likely to reflect such idiosyncrasies. Therefore, we propose the following hypothesis:

Hypothesis 11: Host University characteristics and quality influence the economic performance of ASOs.

Hypothesis 11a: ASOs associated to higher scientific quality rating universities (higher certified scientific research and scientific publications) outperform the remaining ASOs.

Hypothesis 11b: ASOs that are associated to Universities with higher pool of advanced applied/commercialized knowledge (patents) are more likely to have a better economic performance than the remaining ASOs.

Hypothesis 11c: ASOs that are associated to Universities with higher proportion of research excellence are more likely to have a better economic performance than the remaining ASOs.

Incubators and other related science and technology infrastructures, in particular, science parks and TTOs, are viewed as a support environment for start-ups, which may include shared office space, a pool of shared support services to reduce overhead costs,

professional business support or advice and network provision, in which the professional business support is the more relevant function provided by the incubator (Bergek and Norrman, 2008). Thus, since most university technologies are embryonic, therefore, it is necessary to develop them until the point they can be put in the market, so the existence of incubators, science parks and TTOs can influence the spinoff activity and performance by providing an adequate environment for business development (DiGregorio and Shane, 2003). Although Di Gregorio and Shane (2003) and O’Shea et al. (2005) failed to uncover a significant effect of the presence of university-affiliated incubators/science parks/TTOs on start-up rates, we posit that:

Hypothesis 12: ASOs that resort to technology transfer support from TTOs and other science and technology infrastructures outperform the remaining ASOs.

Hypothesis 12a: ASOs that resort to Science Parks support outperform the remaining ASOs.

Hypothesis 12b: ASOs that resort to Incubators support outperform the remaining ASOs.

Hypothesis 12c: ASOs that resort to TTOs support outperform the remaining ASOs.

The ‘milieu innovateur’ corresponds to a set of formal and informal relationships that are established in delimited territorial space and involving the different economic and social agent’s, forms of production and even a specific culture (Camagni, 1991). Certain sectors tend to agglomerate spatially (Stuart and Sorenson, 2003), because firms’ environment has a role in the process of innovation, both in terms of static efficiency (i.e., increases the efficiency of technologies already in use), and in terms of dynamic efficiency (by reducing the uncertainty that characterizes the processes of innovation and imitation, favouring the development of collective learning processes) (Camagni, 1991). Then, since economic, legal and cultural environments influence businesses activity, the geographic location of the universities and the sector of activity are likely to influence the spinoff creation and performance (DiGregorio and Shane, 2003).

O’Shea et al. (2008) suggest that the knowledge infrastructure of a region is a key factor in spinoffs activity, and Maine et al. (2010) found significant evidence suggesting that

specialized cluster effects are associated with higher growth rates for young biotech firms. Therefore, we propose the following hypothesis:

Hypothesis 13: ASOs located in higher economic developed regions outperform the remaining ASOs.

Hypothesis 14: The sector of activity of the ASO is likely to influence its economic performance.

3 Methodological considerations

3.1 Target population

The empirical analysis undertaken in the present study aims to assess to what extent the distinct human capital dimensions of founders impact on ASOs' economic performance, controlling for other (firms and contextual related) factors that are likely to influence performance in the line exposed by Teixeira and Grande (2013).

Given that the University Technology Enterprise Network (UTEN) is the only source that in Portugal gathers information on the ASOs associated to each Portuguese public university, in this assessment, we consider as our target population these ASOs.

Data on the firms and context were gathered and provided by Aurora Teixeira and Marlene Grande who have been responsible within UTEN for several studies on ASOs (see Teixeira and Grande, 2013).³ The distribution of ASOs by Portuguese public universities is depicted in Table 1.

Regarding the entrepreneurs characteristics a new questionnaire was constructed and implemented by this dissertation's author through a direct email survey (between March and June 2013) to all founders of the 116 ASOs earlier surveyed by Aurora Teixeira and Marlene Grande.

This new founders' questionnaire was designed to contain extensive and detailed information on the human capital characteristics of each founder, such as the education, experience and social capital. In the end of the survey period, we managed to obtain responses from 61 firms (out of the 116 firms), representing 90 founders (out of 302), which correspond to response rates of respectively, 53% (in terms of number of firms) and 30% (in terms of number of founders).

³ The questionnaire implemented by these researchers is presented in Appendix 2.

Table 1: Distribution of the population of ASOs by TTO and University (reference year: 2013)

Associated University	UTEN partner associated to Technology Transfer	Target ASOs [Founders]	Respondent ASOs [Founders]	Effective Response rate ASOs [Founders]. in %	% of total response rate ASOs [Founders]
ISCTE	INDEG	1 [1]	1 [1]	100.0 [100.0]	1.6 [1.1]
U. Algarve/ U. Évora	CRIA	12 [22]	8 [12]	66.7 [54.5]	14.8 [15.6]
	Sines Tecnopólo	1 [2]	1 [2]	100.0 [100.0]	
U. Aveiro	UATEC	8 [30]	3 [3]	37.5 [10.0]	4.9 [3.3]
U. Beira Interior	Parkurbis	5 [8]	1 [1]	20.0 [12.5]	3.3 [2.2]
	UBI GAPPI	2 [6]	1 [1]	50.0 [16.7]	
U. Coimbra	IPN	6 [15]	2 [2]	33.3 [13.3]	6.6 [10.0]
	OTIC-UC	4 [16]	2 [7]	50.0 [43.8]	
U. Lisboa	IMM	2 [8]	1 [1]	50.0 [12.5]	1.6 [1.1]
U. Madeira	Gapi Madeira	1 [2]	1 [2]	100.0 [100.0]	1.6 [2.2]
U. Minho	Avepark	3 [6]	1 [1]	33.3 [16.7]	13.1 [11.1]
	Avepark and Spinpark	3 [14]	1 [1]	33.3 [7.1]	
	Avepark and TecMinho	1 [2]	1 [1]	100.0 [50.0]	
	Avepark, Spinpark and TecMinho	1 [1]	1 [1]	100.0 [100.0]	
	Spinpark and TecMinho	1 [3]	1 [3]	100.0 [100.0]	
	TecMinho	10 [30]	3 [3]	30.0 [10.0]	
U. Nova Lisboa	FCT-UNL	3 [6]	2 [3]	66.7 [50.0]	8.2 [6.7]
	FCT-UNL and Madan Parque	3 [10]	2 [2]	66.7 [20.0]	
	Madan Parque	7 [11]	1 [1]	14.3 [9.1]	
U. Porto	INESC Porto	6 [21]	4 [5]	66.7 [23.8]	37.7 [41.1]
	UPIN	2 [3]	2 [3]	100.0 [100.0]	
	UPTEC	25 [67]	15 [27]	60.0 [40.3]	
	UPTEC/UPIN	2 [6]	2 [2]	100.0 [33.3]	
U. Técnica Lisboa	Inovisa	2 [3]	1 [1]	50.0 [33.3]	6.6 [5.6]
	Taguspark	1 [1]	1 [1]	100.0 [100.0]	
	TT@IST	4 [8]	2 [3]	50.0 [37.5]	
Total		116 [302]	61 [90]	52.6 [29.8]	100.0 [100.0]

3.2 Description of the founders' questionnaire

The founders questionnaire has been organised in seven sections (see Appendix 1). Each question of the questionnaire enable us to obtain the proxies for the relevant variables, which then are used for testing the hypotheses put forward in Chapter 2.

The first section is constituted by the demographic characteristics of founders such as name, gender and time dedicated to the company by the founder.

The second section consists in all the level of education that the founder owns (less than high school; high school; bachelor; degree; master and PhD) and the respective area of education (sciences and health; exact sciences; social sciences; computer science; economic/ managerial and engineering).

The third section refers to the three most important complementary training obtained, choices were technological; business/ administration and human resources / behavioural / leadership. The fourth section involves the resources brought by each founder to the firm, at the date of its formation: capital; markets knowledge; technological; marketing and sales; business contacts; organizations management.

The fifth section explores the professional experience prior to the formation of the firm by sector (banking / insurance / consultancy; biotechnology; construction; electrical engineering; mining / metals and minerals; food industry; aircraft industry; automotive industry; footwear industry; pharmaceutical industry; maritime industry; mechanical industry; furniture; chemicals; health; information technology and communication; textiles and clothing; tourism) and type of organization (micro company (less than 10 workers); small company (between 10 to 49 workers); medium business (between 50 to 249); large business (more than 250 workers); multinational).

The sixth section explores the employment status at the time of the creation of the current company: unemployed; company owner (company exists; company bankrupt; company sold); employee; self-employ and student.

The seventh section studies the social capital of the founder, the relationship between social capital and university spinoffs' performance has not been studied properly (Hirai et al., 2012). The assumption we explore is that entrepreneurs' social capital contributes to new venture performance, defining two types of relationship at the date of the establishment of the ASO. First, we define formal linkages as if the founder had at least two contacts per year, including contracts, projects between organizations and the company. Second, we define informal linkage as if the founder had at least two contacts per year, including personal relationships and / or established through common interests with a more social character. We focused on the formal and informal relations with

University, Industry and Government. In addition, we detailed the specific type of industry (micro; small; medium; large; multinational) and type of Government (national; local; European) of both formal and informal relations.

3.3 Model's specification, main hypotheses to be tested and proxies for the relevant variables

Based on the literature review performed (see Chapter 2), the econometric specification to be estimated comprises three main groups of determinants: 1) those related to the founder(s) (formal level of education, area and complementary education, resources brought to the company at the date of its formation, previous experience and employment status at the time of the creation of the ASO, level and type of network capabilities, number of founders, and founders commitment to the ASO. 2) those related to the ASO (source of creation, innovation, internationalization) and 3) contextual factors (university characteristics, TTOs support, regional factors and sector of ASO). In algebraic terms, the general econometric specification that is used to test the hypotheses put forward stands as follows:

$$\begin{aligned}
 & \mathbf{Economic\ performance}_i = \hat{\beta}_0 + \\
 \mathbf{Entrepreneurs' related} & \left\{ \begin{aligned} & + \hat{\beta}_1 \mathit{Formal\ level\ of\ education} + \hat{\beta}_2 \mathit{Area\ of\ education} + \\ & + \hat{\beta}_3 \mathit{Resources\ brought\ to\ the\ company\ at\ the\ date\ of\ its\ formation} + \\ & + \hat{\beta}_4 \mathit{Previous\ experience\ and\ employment\ status} + \\ & + \hat{\beta}_5 \mathit{Level\ and\ type\ of\ network\ capabilities} + \hat{\beta}_6 \mathit{Number\ of\ founders} + \\ & + \hat{\beta}_7 \mathit{founders\ committed} + \end{aligned} \right. \\
 \mathbf{Firms' related determinants} & \left\{ \begin{aligned} & + \hat{\beta}_8 \mathit{Source\ of\ creation} + \hat{\beta}_9 \mathit{Innovation} + \hat{\beta}_{10} \mathit{Internationalization} + \\ & + \hat{\beta}_{11} \mathit{University} + \hat{\beta}_{12} \mathit{TTO} + \hat{\beta}_{13} \mathit{Region} + \hat{\beta}_{14} \mathit{Sector} + \hat{\epsilon}_i \end{aligned} \right. \\
 \mathbf{Contextual determinants} & \left\{ \begin{aligned} & + \hat{\beta}_{11} \mathit{University} + \hat{\beta}_{12} \mathit{TTO} + \hat{\beta}_{13} \mathit{Region} + \hat{\beta}_{14} \mathit{Sector} + \hat{\epsilon}_i \end{aligned} \right.
 \end{aligned}$$

Where, i is the subscript for each founder and e_i is the sample error term.

The proxies related to the determinants of economic performance (i.e., the model's independent variables) are described in the Table 2, together with the study's main hypotheses.

Table 2: Hypothesis and proxies for the independent variables

Determinant group		Hypothesis	Proxy for the independent variable	
Entrepreneurs' related determinants	Human capital	Education level <i>Hypothesis 1: There is a non-linear relation between founders' formal education level and ASOs economic performance.</i>	Master (dummy: yes:1; no:0)	
			PhD (dummy: yes:1; no:0)	
		Education type <i>Hypothesis 2: The type of human capital of ASO' founder influence this latter economic performance</i>	<i>H2a: Advanced/specialized technological expertise</i> Engineering degree (dummy: yes: 1; no: 0)	
			<i>H2b: Complementary education in Business/ Administration</i> Complementary Business/ Administration training (dummy: yes: 1; no: 0)	
		Resources <i>Hypothesis 3: The type of resource the founder brings to the new venture influences this latter economic performance.</i>	<i>H3a: Capital</i> Capital (dummy: yes:1; no:0)	
			<i>H3b: Market knowledge</i> Markets Knowledge (dummy: yes:1; no:0)	
			<i>H3c: Business contacts</i> Business Contacts (dummy: yes:1; no:0)	
		Professional experience <i>Hypothesis 4: The professional experience and status of ASOs' founders influence ASOs economic performance.</i>	<i>H4a: Prior experience</i> Professional experience (dummy: yes: 1; no: 0)	
			<i>H4b: Prior experience in the same industry</i> Same industry experience (dummy: yes: 1; no: 0)	
			<i>H4c: Previous industry experience</i> Professional experience in Industry (dummy: yes: 1; no: 0)	
			<i>H4d: Previous University or R&D experience</i> Professional experience in University or R&D (dummy: yes: 1; no: 0)	
			<i>H4e: Previous experience in large or Multinational</i>	Large (dummy: yes: 1; no: 0)
				Multinational (dummy: yes: 1; no: 0)
			<i>H4f: ASOs founders' prior status employment situation is likely to influence the economic performance of ASOs</i>	Self-employ or company other (dummy: yes: 1; no: 0)
Self-employ (dummy: yes: 1; no: 0)				
Unemployed (dummy: yes:1; no:0)				
	Employee (dummy: yes:1; no:0)			
	Is a company Owner (dummy: yes:1; no:0)			

(..)

Determinant group		Hypothesis	Proxy for the independent variable		
Entrepreneurs' related determinants	Human capital	Networks <i>Hypothesis 5: The level and type of network capabilities of ASOs founder influence the firm's economic performance</i>	<i>H5a: Formal linkages</i> Formal contacts (dummy: yes:1; no:0)		
			Formal contacts with University (dummy: yes:1; no:0)		
			Formal contacts with Industry (dummy: yes:1; no:0)		
			<i>H5b: Formal contacts with University, Industry and Government</i> Formal contacts with Government (dummy: yes:1; no:0)		
			Formal contacts with Industry - Multinational (dummy: yes:1; no:0)		
			Formal contacts with Government - National (dummy: yes:1; no:0)		
Other factors	Number of founders	<i>Hypothesis 6: ASOs with higher number of founders are more likely to have better economic performance than the remaining ASOs.</i>	Number of founders (in ln)		
			Full time equivalent of founder	<i>Hypothesis 7: ASOs whose founders are full-time committed to the ASOs are more likely to have a better economic performance than the remaining ASOs.</i>	Full time equivalent of the founder to the company (in ln)
Firms' related determinants	Source of creation	<i>Hypothesis 8: ASOs whose source of creation of the company has a relation to firms are more likely to have a better economic performance than the remaining ASOs.</i>	Source creation of the firm is external to the university (dummy: yes:1; no:0)		
	Innovation	<i>Hypothesis 9: Innovative ASOs are more likely to have a better economic performance than the remaining ASOs.</i>	<i>H9a: Patents</i> If the firm has patents between the year of 2008 - 2011 (dummy: yes:1; no:0)		
			<i>H9b: R&D</i> If the firm has R&D between the year of 2008 - 2011 (dummy: yes:1; no:0)		
Internationalization	<i>Hypothesis 10: Exporting ASOs are more likely to have a better economic performance than the remaining ASOs</i>	If the firm exports (dummy- 1:yes; 0:no)			

(..)

Determinant group	Hypothesis	Proxy for the independent variable	
University characteristics	<i>Hypothesis 11: Host University characteristics and quality influence the economic performance of ASOs.</i>	<i>H11a: Certified scientific research and scientific publications</i>	Scientific pool of knowledge (WOS publications per researcher) (2000-2007) (in ln)
		<i>H11b: Pool of advanced applied/commercialized knowledge (patents)</i>	International patent pool per 1000 researchers (2010) (in ln)
		<i>H11c: Research excellence</i>	Proportion of Research units classified with 'Excellent' or 'Very Good' by the FCT
University technology transfer office support	<i>Hypothesis 12: ASOs that resort to technology transfer support from TTOs and other science and technology infrastructures outperform the remaining ASOs.</i>	<i>H12a: Science park</i>	Science park (dummy: yes:1; no:0)
		<i>H12b: Incubator</i>	Incubator (dummy: yes:1; no:0)
		<i>H12c: TTO</i>	TTO (dummy: yes:1; no:0)
Contextual determinants	Region	<i>Hypothesis 13: ASOs located in higher economic developed regions outperform the remaining ASOs.</i>	Index of purchasing power per NUT III regions (in ln)
			Sector
Bio sector (1 when the ASO belongs to the bio sector)			
Micro sector (1 when the ASO belongs to the micro sector)			
Agri-food sector (1 when the ASO belongs to the agri-food sector)			
Consulting sector (1 when the ASO belongs to the Consulting sector)			

4 Empirical results

4.1. Descriptive results

In a similar way as Ganotakis (2012), economic performance is measured by annual sales per individual employed, including founders (in FTE). In 2011 a respondent ASOs had, on average, 20.4 thousand EUR of sales per capita, with some ASO presenting no sales at all, and the ASO with the highest sales per capita reaching 122.82 thousand EUR. This compares not very favorably with the situation of Portuguese SMEs. Indeed, the turnover per capita observed in an average SME in Portugal was around 89.6 thousand EUR (reference year 2009, Source: INE), which is much higher than the figure evidence by ASOs in our sample.

Looking at the percentiles of sales per capita, we find that ASOs that are below the percentile 50, the ‘Low performers’, registered sales per capita lower than 8.9 thousand EUR. ‘Medium performers’ had sales per capita between 8.9 and 34.7 thousand EUR (percentile 75) and ‘High performers’ (Upper percentile) registered sales per capita above 34.7 thousand EUR.

On average the team of founders of a Portuguese ASO includes approximately 3 individuals, with the time committed to the venture being quite high (78%) (Table 3). Analyzing the economic performance, it is disreputable that the time dedicated to the ASO is crucial, with 82.6% of founders with more than 65% of time dedicated in the high performance (c.f. Figure 1A). In addition, the founders with less than 20% of FTE are almost all concentrated in the low performance ASOs group.

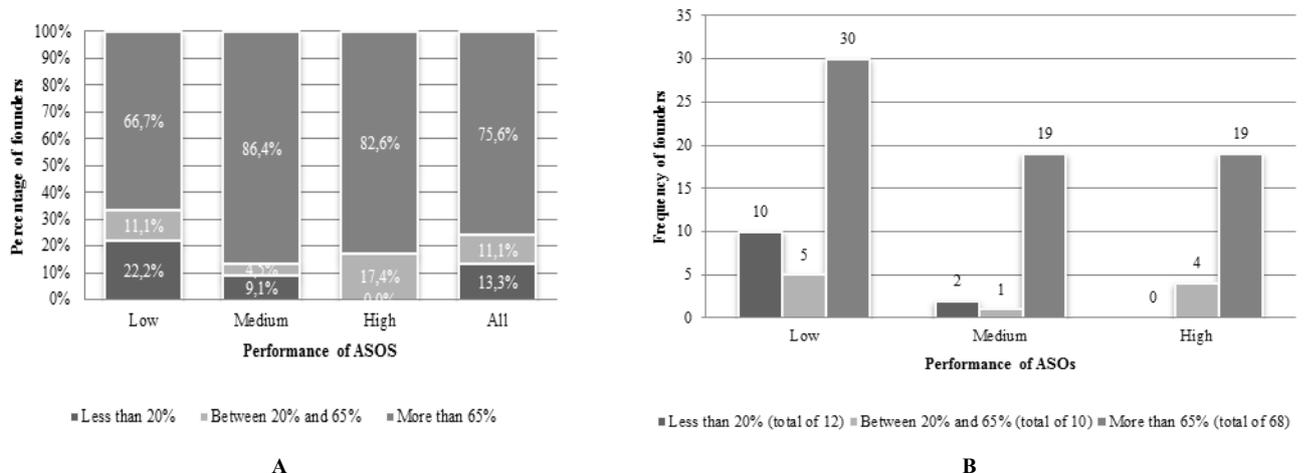


Figure 1- Distribution (%) and full time equivalent per group of ASOs performance

Note: The analysis involves 90 respondent founders of 61 ASOs. Performance is measured by sales per capita. Performance groups were obtained based on percentile distribution with ‘Low performance’ representing sales per capita lower than 8.9 thousand EUR; ‘Medium performance’ representing sales per capita between 8.9 and 34.7 thousand EUR; High performance representing sales per capita higher than 34.7 thousand EUR.

Source: Direct survey to ASOs founders – data was gathered between March and June 2013.

In several studies on ASOs it has been found that founders are academically high qualified (Colombo and Delmastro, 2002; Colombo and Piva, 2012; Karlsson and Wigren, 2012). Portuguese ASOs founders are also highly educated individuals with 27.8% having a master degree and about one third possessing a PhD. This is almost twice the proportion founded in start-ups in general (IAPMEI, 2007). Thus, in Portugal ASOs' founders are much more educated in formal terms than their start-ups counterparts (less than one quarter of these founders possess a university degree, with PhD account for only 0.6%).

Given that ASOs are, in general, technologically very demanding one would expect that founders tend to be individuals with high academic level and with technical education, who are able to exploit complex and innovative technologies into products. Relating economic performance with education, we observed that higher performance ASOs are associated with founders with lower education (mostly at the level of 1st and 2nd cycles). More specifically, 42.2% of founders with the level of education less or equal a university degree were the founders of high performance ASOs, against only 21.7% of the PhD founders. We can observe (cf. Figure 2B) that PhD founders, 17 out of 25 in total, are concentrated in the group of low performance ASOs.

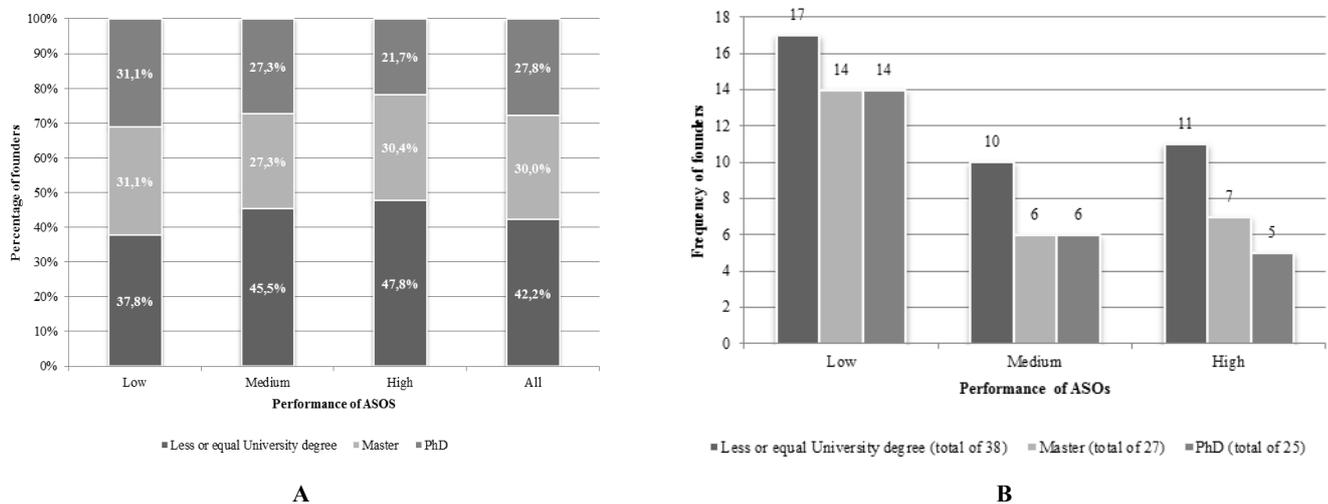


Figure 2- Distribution (%) and highest education per group of ASOs performance

Note: The analysis involves 90 respondent founders of 61 ASOs. Performance is measured by sales per capita. Performance groups were obtained based on percentile distribution with 'Low performance' representing sales per capita lower than 8.9 thousand EUR; 'Medium performance' representing sales per capita between 8.9 and 34.7 thousand EUR; 'High performance' representing sales per capita higher than 34.7 thousand EUR.

Source: Direct survey to ASOs founders – data was gathered between March and June 2013.

Almus and Nerlinger (1999) found that ASOs with entrepreneurs specialised in technical areas, such as engineering and science showed higher levels of growth (growth is measured as employment numbers, at least at two different points in time).

The majority of the respondent founders are graduated in Engineering (42.2%), with 15.6% being graduate in Computer Science. Only 11.1% had graduated in Economics or Management. Nevertheless, 36.7% of the founders did some kind of complementary courses on business related subjects. For technological complementary formal education, the corresponding figure is 28.9%. A relatively low share of founders (16.7%) has complementary education on human resources/behavioural/leadership issues. In line with the arguments by Colombo and Piva (2012), the ASOs founders possess a large amount of technical and scientific competencies.

Technological knowledge and capital are the most frequent resources brought by the founders to their ASOs, with 86% and 78% of the founders respectively, claiming to have brought such resources to the firm by the time of its establishment. Other resources brought by 42%/37%/32% of the founders are business contacts/ markets knowledge/organizations management. We can observe that marketing and sales are the less frequent resources brought by (18%) founders to the firm.

Entrepreneurs with experience in the same sector (i.e. gained in the same sector of the ASO prior to its foundation) tend to have a better understanding of the sector technology market and customer needs, providing a potential for market exploitation and ability to recognize opportunities, having a negative effect on failure and a positive effect on performance (Shane, 2000; Ganotakis, 2012). A large percentage of founders (81%) had generic previous professional, with 40% of the founders having previous experience in the same sector where the ASO operates, being this trait positively related with economic performance, since 60.9% of the entrepreneurs in high performance ASOs had prior experience in the same sector and 71.1% on the low performance ASOs did not had prior experience in the same sector (c.f. Figure 3A).

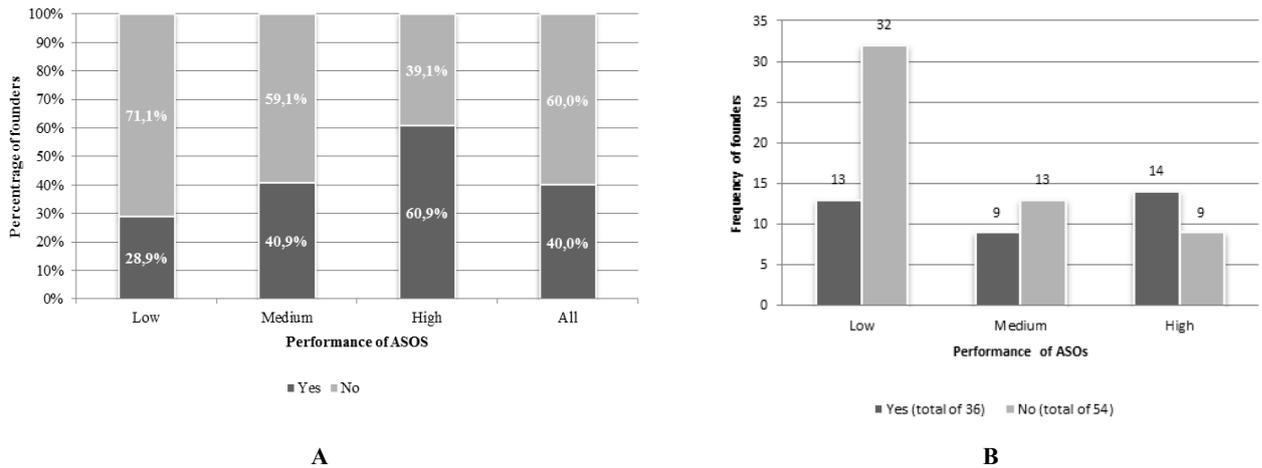


Figure 3- Distribution (%) and professional experience in same sector per group of ASOs performance

Note: The analysis involves 90 respondent founders of 61 ASOs. Performance is measured by sales per capita. Performance groups were obtained based on percentile distribution with 'Low performance' representing sales per capita lower than 8.9 thousand EUR; Medium performance' representing sales per capita between 8.9 and 34.7 thousand EUR; High performance representing sales per capita higher than 34.7 thousand EUR.

Source: Direct survey to ASOs founders – data was gathered between March and June 2013.

According to the study of Colombo and Piva (2012), on average, the founders of ASOs have greater experience with R&D, but exhibit less industry professional experience, both in technical and commercial functions. In term of sectors, 26% of the founders had previous experience in the ICT sector, 24% in the University or R&D sector and 11% in industry.

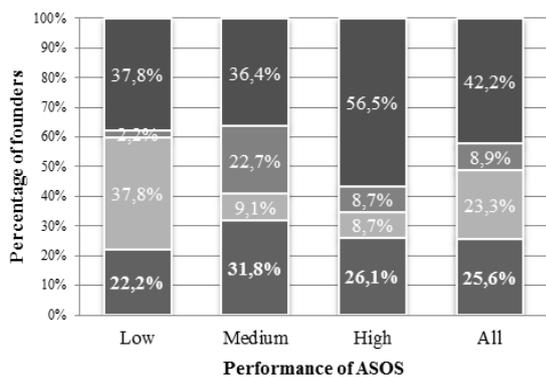
A quite balanced proportion of founders claimed to have past professional experience in firms from distinct sizes (39% in large, 24% in micro and 21% in small and medium firms).

In general, the term entrepreneurship induced by opportunity is when the entrepreneur creates a firm by response to an entrepreneurial opportunity (Lumpkin and Katz, 2009; GEM, 2010). By contrast, the entrepreneurship induced by necessity is when the entrepreneur is in absence of other income earning opportunity (i.e. dependent work) leading individuals to the creation of a firm, because they consider do not have better alternatives (Lumpkin and Katz, 2009; GEM, 2010).

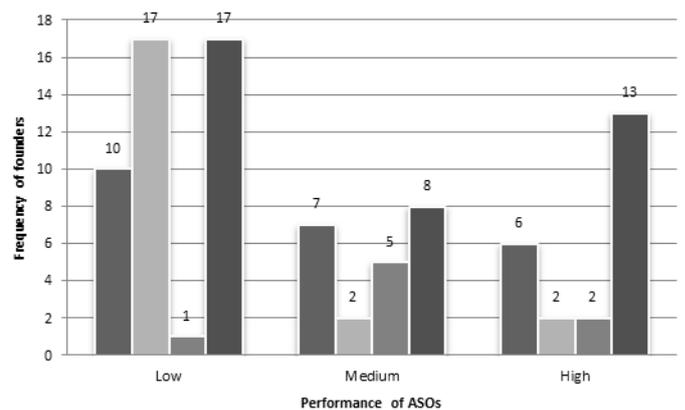
There is a positive correlation between the wealth of a country and entrepreneurial activity induced by opportunity (opportunity to increase revenue, acquiring independence, etc.), so low income countries will be characterized by necessity based entrepreneurs (Lumpkin and Katz, 2009). If a country has more entrepreneurship induced by opportunity, it implies that individuals have a greater freedom of choice to

choose to self-employment (GEM, 2010). Entrepreneurship induced by necessity is also associated with lower level of education and performance, against entrepreneurs induced by opportunity that may have greater performance (Lumpkin and Katz, 2009).

According to a study from IAPMEI in 2007, in Portugal, 34% of the entrepreneurs were previous self-employ or a company owner, 34% were workers, 3.3% were students and 12.8% were unemployed. In addition, in the GEM 2010 report, demonstrated that in Portugal, 38.2% of early-stage entrepreneurs have created a business motivated by opportunity and 31.1% were induced by necessity. In comparison with the GEM 2007 report, there was an increase of 8.4 percentage points in 2010 in the early-stage entrepreneurs motivated by necessity. Before starting the current business about one quarter of the founders of the ASOs, had already have a business (as self-employed or company owner with staff at service). A similar percentage did not have business experience at all, being student or research (scholarship holder). About 42% was employee with only 9% of the respondent founder being unemployed by the time they start the ASO. Concerning the performance of the ASOs, as we can see in Figure 4A, 37.8% of the founders of the low performance ASOs were students or had a scholarship, against 8.7% in the high performance ASOs, being the lack of professional experience a possible explanation for this excessive difference. In contrast, we can observe that 56.5% of the entrepreneurs in the high performance ASOs were (former) employees.



■ Self-Employ or CompanyOwner ■ Student or Scholarship
 ■ Unemployed ■ Worker



■ Self-Employed or CompanyOwner (total of 23) ■ Student or Scholarship (total of 21)
 ■ Unemployed (total of 8) ■ Worker (total of 38)

A **B**
Figure 4- Distribution (%) and employment status per group of ASOs

Note: The analysis involves 90 respondent founders of 61 ASOs. Performance is measured by sales per capita. Performance groups were obtained based on percentile distribution with 'Low performance' representing sales per capita lower than 8.9 thousand EUR; Medium performance' representing sales per capita between 8.9 and 34.7 thousand EUR; High performance representing sales per capita higher than 34.7 thousand EUR.

Source: Direct survey to ASOs founders – data was gathered between March and June 2013.

Table 3: Descriptive statistics for the dependent variable and entrepreneurs' related factors

		Mean	Min	Max	Correlation Coefficient ^(a)	Sig. (2-tailed)	
Dependent variable	0. Sales per capita (th. €)	20.4	0	122.8	-	-	
Human capital	Maximum level of formal education	1. Master	0.300	0	1	0.045	0.615
		2. PhD	0.278	0	1	-0.152	0.090*
	Type of formal education	3. Economic/ Managerial	0.111	0	1	0.000	1.000
		4. Engineering	0.422	0	1	0.147	0.102*
		5. Computer science	0.156	0	1	-0.186	0.038**
	Complementary education	6. Technological	0.289	0	1	0.005	0.957
		7. Business	0.367	0	1	0.008	0.926
		8. Human Resources / Behavioural / Leadership	0.167	0	1	-0.027	0.768
	Resources brought to the company at the date of its formation	9. Capital	0.778	0	1	-0.095	0.289
		10. Markets knowledge	0.367	0	1	0.229	0.011***
		11. Technological	0.856	0	1	0.031	0.728
		12. Marketing and sales	0.178	0	1	0.037	0.677
		13. Business contacts	0.422	0	1	0.118	0.189
	Previous Experience	14. Organizations Management	0.322	0	1	0.066	0.461
		15. Has professional experience	0.811	0	1	-0.017	0.847
		16. Same sector as ASO	0.400	0	1	0.233	0.010**
		17. Sector: ICT	0.267	0	1	0.223	0.013**
		18. Sector: University or R&D	0.244	0	1	-0.195	0.030**
		19. Sector: Industry	0.111	0	1	0.086	0.340
		20. Type organization: Micro	0.244	0	1	0.052	0.559
		21. Type organization: Small	0.211	0	1	0.089	0.320
		22. Type organization: Medium	0.211	0	1	-0.046	0.610
		23. Type organization: Large	0.389	0	1	0.123	0.173
	Employment status	24. Type organization: Multinational	0.0889	0	1	-0.029	0.747
		25. Self-employed or company owner	0.256	0	1	0.080	0.372
		26. Student or scholarship	0.233	0	1	-0.242	0.007***
		27. Unemployed	0.089	0	1	0.109	0.223
		28. Employee	0.422	0	1	0.073	0.414
	Social capital	29. Self-employed	0.144	0	1	0.010	0.908
		30. Company owner: company exists	0.078	0	1	0.043	0.631
		31. Network Capabilities	0.933	0	1	-0.101	0.263
		32. Formal contacts	0.867	0	1	0.024	0.787
		33. Informal contacts	0.833	0	1	-0.167	0.063*
		34. Formal contacts with University	0.744	0	1	-0.052	0.562
		35. Formal contacts with Industry	0.489	0	1	0.081	0.365
		36. Formal contacts with Government	0.167	0	1	-0.001	0.987

(..)

		Mean	Min	Max	Correlation Coefficient ^(a)	Sig. (2-tailed)	
Human capital	Social capital	37. Formal contacts with Industry: Large	0.211	0	1	-0.104	0.246
		38. Formal contacts with Industry: Multinational	0.122	0	1	0.065	0.466
		39. Formal contacts with Government: National	0.100	0	1	-0.065	0.471
		40. Informal contacts with University	0.722	0	1	-0.110	0.221
		42. Informal contacts with Industry	0.578	0	1	-0.063	0.480
		42. Informal contacts with Government	0.189	0	1	-0.148	0.100*
Other factors		43. Number of Founders (no.)	2.8	1	9	-0.127	0.114
		44. FTE (full time equivalent), in %	78.9	5	100	0.274	0.001***

Note: N=90; (***) (**) (*) statistically significant at (1%) (5%) (10%). Grey cells identify relative high correlation coefficients between independent variables and the dependent variable sales per capita; (a) We use Kendall-tau, which is a non-parametric correlation coefficient that can be used to assess and test correlations between non-interval scaled variables. Nevertheless, results do not differ substantially from those obtained with Pearson correlation coefficient.

Founders' social capital in terms of (formal and informal) business contacts is quite high, with more than 80% claiming that in the last year they established regular formal and informal contacts with the University, Industry, Government or other entities.⁴ Specifically about a half of the respondent said to had established formal contacts with the Industry, and 29% with Multinational firms. We observed that 87% of the founders had formal contacts and 83% had informal contacts. We found that 49% of the founders had *formal contacts with Industry*, 17% had *Formal contacts with Government* and 29% had *Informal contacts with Industry – Multinational*.

Relating in a bivariate way the economic performance of ASOs (sales per capita) with human capital related potential factors, we concluded, based on the estimates of the correlation coefficients, that ASOs whose founders devoted substantial amount of time to the ASO, are engineers, who brought market knowledge to the firm at the time of its genesis, possessed previous professional experience in the same sector that the ASO operate or in ICT, tend, on average, to be associated to better economic performance ASOs. In contrast, founders with an education background in computer science, whose previous professional experience was in the university and established high amount of informal contacts are associated to lower performance ASOs.

⁴ It is considered as formal contacts, if the founder has at least two contacts per year, including contracts and projects between organizations and the firm. Conversely, informal contacts occur, when the founder has at least two contacts per year with the organization, including personal relationships and/ or established through common interests, with a more social character.

Concerning firms' characteristics, 22% of the founders respect ASOs that were created outside the university (Table 4). Although a significant proportion of the founders (51%) are linked to ASOs that performed R&D activities in the period 2008-2011, a quite low percentage (14%) registered patents in the same period. Over forty per cent of founders are linked to ASOs that export. In 2009, Portugal had 348,552 micro, small and medium enterprises (SMEs). From these, 10% of total were exporting SMEs. Thus is important to mention that, although this number is very low, in terms of turnover represented 40.0% of the total SMEs activity in 2009 (INE, 2011). The turnover per capita observed into the total SME was around 89.8 thousand EUR and 39 thousand EUR below SMEs exporters.

On average, ASOs whose source of creation is external to the university, performs R&D activities and exports tend to outperform their remaining counterparts.

Table 4: Descriptive statistics for the firms' related factors

	Mean	Min	Max	Correlation Coefficient	Sig. (2-tailed)
45. Source creation of the firm: External to the university	0.222	0	1	0.177	0.049**
46. Has Patents in 2008 - 2011	0.144	0	1	-0.104	0.248
47. Performed R&D activities in 2008-2011	0.511	0	1	0.431	0.000***
48. Exporter	0.422	0	1	0.291	0.001***

Note: N=90; (***) (**) (*) statistically significant at (1%) (5%) (10%). Grey cells identify relative high correlation coefficients between independent variables and the dependent variable sales per capita. (a) We use Kendall-tau_b, which is a non-parametric correlation coefficient that can be used to assess and test correlations between non-interval scaled variables. Nevertheless, results do not differ substantially from those obtained with Pearson correlation coefficient.

Universities associated to the respondent founders have registered in 2010, 6 international patents per thousand researcher (c.f. Table 5). In terms of scientific production internationally diffused, the ASOs founders are associated to universities that produced, on average, 2.9 articles indexed in WOS/ISI per researcher in the period 2000-2007, and that possess 54% of their research centres classified as Very Good or Excellent by the Portuguese Foundation for Science and Technology (FCT).

Regarding the region characteristics, on average, the respondent founders are associated to ASOs located in relatively developed NUTs III regions (presenting a per capita purchasing power index 10 points above the national average). Approximately one quarter of the founders are associated to ASOs that benefited from TTOs or other S&T infrastructure support. Only this latter variable is statistically correlated with ASOs economic performance, reflecting that in bivariate terms, ASOs that resort to TTOs/S&T support perform relatively worse than the remaining.

Table 5: Descriptive statistics for the contextual' related factors

	Mean	Min	Max	Correlation Coefficient	Sig. (2-tailed)
49. University international patent pool (number of international registered patents per 1000 researchers), 2010	5.82	0.000	20.60	0.005	0.956
50. University Scientific pool of knowledge (publications indexed in WOS/ISI per researcher, 2000-2007)	2.90	.097	4.487	-0.063	0.435
51. Proportion of Research units with Very Good or Excellent by FCT	0.538	0.00	0.869	0.032	0.689
52. ASO resort to TTO/other S&T infrastructure support	0.244	0	1	-0.361	0.000***
53. Science park	0.167	0	1	0.193	0.032**
54. Incubator	0.411	0	1	0.172	0.056*
55. TTO	0.056	0	1	0.026	0.769
56. Per capita purchasing power index of the NUT III region where the firm is located (2009)	110.8	76.7	145.3	0.085	0.288
57. ICT sector	0.51	0	1	-0.020	0.822
58. Energy sector	0.13	0	1	0.229	0.011*
59. Bio sector	0.20	0	1	-0.296	0.001**
60. Micro sector	0.044	0	1	0.215	0.017*
61. Agri-food sector	0.067	0	1	-0.012	0.896
62. Consulting sector	0.044	0	1	0.045	0.614

Note: N=90; (***) (**) (*) statistically significant at (1%) (5%) (10%). Grey cells identify relative high correlation coefficients between independent variables and the dependent variable sales per capita. (a) We use Kendall-tau_b, which is a non-parametric correlation coefficient that can be used to assess and test correlations between non-interval scaled variables. Nevertheless, results do not differ substantially from those obtained with Pearson correlation coefficient.

4.2. Causality analysis: determinants of ASOs' economic performance

We estimated seven distinct models in accordance with the hypotheses specified. These models reveal a good quality of fit, with more than 60 per cent of the variance of firm's sales per capita explained by the variables included in the models. All the groups of determinants considered – entrepreneurs', firms or context – are relevant for explaining ASOs' economic performance.

Regarding human capital, we found that, for the sample considered, the founder's formal education level is not significant in any of the models (thus, *H1* is not corroborated). This is, nevertheless, in line with some extant studies (e.g., Roberts, 1991; Ganotakis, 2012; Karlsson and Wigren, 2012). In this vein, Roberts' (1991) and Ganotakis' (2012) content of an inverted U relationship between the formal education level and ASOs performance was not clear in our study. Such absence of statistical significance of the education level of ASOs founders might, to a large extent, be

explained by the fact that ASOs entrepreneurs are in their vast majority highly educated individuals.

Although Ganotakis (2012) and by Almus and Nerlinger (1999) have found that ASOs whose entrepreneurs had high engineering and technical skills showed higher levels of growth, in our analyses the type of human capital (proxied by engineering degrees and complementary business education) failed, in general, to significantly impact on ASOs economic performance. Thus, *H2* was not verified. In particular, complementary education in Business/ Administration (*H2b*), when significant, emerged negatively related to economic performance, which contrasts with the evidence found in Colombo and Grilli (2009).

The importance of managerial capabilities obtained through formal education is here somehow demystified, being instead underlined the relevance of other sources of business knowledge acquired, namely through experience, which are often neglected in comparison to formal business knowledge acquired through formal education. This type of informal managerial capabilities is reflected in our models by the market knowledge brought by the founder to the ASOs (*H3b*), which evidence a significant and positive relation to economic performance in all models (at 5% significant level).

Other resources brought by the founder, namely capital (*H3a*) or business contacts (*H3c*) failed to impact on ASOs performance.

Professional experience has been seen as a key factor for firms' performance (*H4*). In our case, and contrasting with extant studies (Shane, 2000; Okamuro et al., 2011; Ganotakis, 2012), the various proxies of professional experience, most notably the entrepreneurs' experience in the same sector (prior to the ASO's foundation), do not emerged as statistically significant. It might be that the experience effect is captured largely, as referred above, by the founder's past market knowledge and by founder's prior occupational status.

The evidence collected indicates that the prior employment status of the founder is relevant for explaining ASOs' economic performance. In particular, ASOs whose founders were previously to the ASO foundation, unemployed, compared to those that were employees, present, on average, higher economic performance (*H4i*). Thus, unemployment spells do not necessary 'condemn' individuals to necessity or unsuccessful business venturing. This is an interesting finding, which is in disagreement

with the commonly accepted idea that entrepreneurship induced by necessity is associated to low(er) performance new ventures as compared with those induced by opportunity (Lumpkin and Katz, 2009).

An important dimension of founders' human capital is their social networks. The estimations suggest that ASOs whose founders establish regular formal contacts with Universities managed to achieve higher economic performances, whereas those that establish regular formal contacts with national government evidence lower performance. Thus, the type of formal contacts established matters (*H5b*).

Regarding the other factors related to the entrepreneur, namely the size of the founders team (*H6*) and the founders' commitment to the ASO (*H7*), although the estimates are positive, none influence significantly on ASOs performance. This stand somehow at odds with the findings of Eisenhardt and Schoonhoven (1990), who found a significant positive correlation between size of the team and firm growth, and Doutriaux and Barker (1995), who suggest that firms created by part-time entrepreneurs had lower performance, than those created by full-time entrepreneurs.

Concerning the firms related determinants, our findings suggest that the source of creation of the firm does not influence performance (*H8*) as it was conveyed in the study by Colombo and Grilli (2010), but innovation capabilities (*H9a,b*) and internationalization propensity of ASOs significantly influence their economic performance. Specifically, evidence shows that ASOs that performed R&D activities in the period 2008-2011 or that by 2011 exported are more productive, which corroborates *H9b* and *H10*, and are in accordance with the literature (Lee and Habte-Giorgis, 2004; Teixeira and Grande, 2013). Further evidence suggests that ASOs that have patents in 2008-2011 reveal lower per capita sales (failing to validate *H9a*). This latter finding contrasts that of Lee et al.'s (2001), although this study measured firm performance by two years sales variation and not per capita sales. It might be that in the case of the Portuguese ASOs patents represent a cost and do not yet yield any return due to their recent application/registration.

The contextual determinants emerge as critical for ASOs economic performance, most notably the support existent in terms of technology transfer, the region's development level and the sector in which the ASOs operates.

Albeit Powers and McDougall (2005) found that there was a strong relation between faculty quality (measured by the total number of citations that each university received)

and ASOs performance (measured by the number of start-up created), our estimations failed to encounter a significant relation between university's pool of knowledge (i.e., WOS publications per researcher) and ASOs performance (rejecting *H11a*). In the same line of Powers and McDougall (2005), university's patent portfolio did not emerged as significantly related to ASOs performance (thus *H11b* is not corroborated). The only university's characteristics that revealed some influence on ASOs economic performance is research excellence, that is, the proportion of R&D centers that were classified by the government science evaluation body, FCT (*Fundação para a Ciência e Tecnologia*), as 'Very Good' or 'Excellent' (thus, *H11c* receives middle support).

Interestingly, the support received by ASOs in the technology transfer process, through University science parks (*H12a*), incubators (*H12b*) or TTOs (*H12c*) emerged as an important factor for ASOs economic performance. Thus, H12 receives strong support. Compared with the situation of combined science parks-incubators-TTOs support (or no support at all),⁵ those ASOs that claimed to resort in exclusivity to one of the technology transfer support mechanisms, present higher levels of sales per capita. Despite Di Gregorio and Shane's (2003) and O'Shea et al.'s (2005) findings suggested that the presence of a university incubator has no significant impact on start-up activity, our results clearly emphasise that these S&T infrastructures are critical for ASOs performance.

The development of the local industrial basis and existence of positive regional spillover effects implicitly incorporated in (NUTIII) region's per capita purchasing power, impact significantly on ASOs performance. The corroboration of *H13* evidences the importance of a strong regional basis for new business to survive and endure (Pfeifer and Sarlija, 2010).

Finally, our study suggests that the sector of activity does matter for the performance of ASOs (Gadenne, 1998), corroborating *H14*. Firms that operate in the Energy/Environment/ Sustainability, Consulting and Agri-food sectors present, on average, all the remaining factors being constant, higher productivity levels compared to those operating in the ICT/Software/ Digital Media sector. Contrarily, the Bio/ Pharma or Medical devices/ diagnostics, and Microelectronics/ Robotics sectors show no relation to ASOs performance.

⁵ Almost all the surveyed ASOs referred to have received some kind of support, in exclusive or in combination.

Table 6: Determinants of ASOs economic performance: Econometric models: estimation results

Determinant group	Hypothesis	Proxy for the independent variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 6		
Entrepreneurs' related determinants	Education level	<i>H1: Founders' formal education level</i>	Master	0.161	0.133	-0.004	0.140	0.173	0.040	0.037	
			PhD	0.178	0.130	0.243	0.288	0.551	0.162	0.133	
	Education type	<i>H2: Type of human capital</i>	<i>H2a: Advanced/specialized technological expertise</i>	Engineering degree	0.270	0.245	0.275	0.278	0.271	0.264	0.236
			<i>H2b: Complementary education in Business/Administration</i>	Complementary Business/Administration training	-0.567*	-0.508	-0.538*	-0.482	-0.409	-0.504	-0.474
	Resources	<i>H3: Resource the founder brings</i>	<i>H3a: Capital</i>	Capital	-0.059	-0.105	-0.074	-0.091	-0.101	-0.125	-0.155
			<i>H3b: Market knowledge</i>	Markets Knowledge	0.675**	0.716**	0.628*	0.723**	0.715**	0.695**	0.723**
			<i>H3c: Business contacts</i>	Business Contacts	-0.251	-0.219	-0.245	-0.305	-0.280	-0.300	-0.251
	Human capital	<i>H4:</i>	<i>H4a: Prior experience</i>	Professional experience	-	-	-0.009	-	-	-	-
			<i>H4b: Prior experience in the same industry</i>	Same industry experience	0.375	0.394	0.352	0.339	0.334	0.333	0.350
			<i>H4c: Previous industry experience</i>	Professional experience in Industry	-	-	0.444	-	-	-	-
			<i>H4d: Previous University or R&D experience</i>	Professional experience in University or R&D	-	-	-0.274	-	-	-	-
	Professional experience	<i>H4e: Professional experience and status.</i>	<i>H4e: Previous experience in large or Multinational</i>	Large	0.316	0.317	-	0.098	0.167	0.134	0.118
				Multinational	-	-	-0.672	-	-	-	-
			<i>Hypothesis 4f: ASOs founders' prior status employment situation is likely to influence the economic performance of ASOs</i>	Self-employ or company other	0.141	0.131	0.218	-	-	-	-
				Self-employed	-	-	-	0.675	0.762	0.779	0.790
				Unemployed	-	-	-	10.041*	0.926*	10.138**	10.127**
				Employee	-	-	-	0.330	0.262	0.362	0.359
	Is a company Owner: still exists	-	-	-	0.791	0.727	0.836	0.799			

(...)

Determinant group	Hypothesis	Proxy for the independent variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 6												
Entrepreneurs' related determinants	Human capital	Networks	H 5: Network capabilities	H5a: Formal linkages	Formal contacts	-	-	-	-	-0.334	-	-									
				Formal contacts with University	0.347	0.349	0.467	0.608*	0.782	0.743*	0.747*										
				H5b: Formal linkages with University; Industry; Government	Formal contacts with Industry	0.048	0.057	0.090	0.081	0.121	0.214	0.180									
				Formal contacts with Government	-0.006	0.005	-0.087	-0.166	0.516	-0.035	0.034										
				Formal contacts with Industry - Multinational	-	-	-	-	0.463	-	-										
				Formal contacts with Government - National	-	-	-	-	-10.161*	-	-										
	Other factors	Number of founders	H6: Size of founders' team	Number of founders (in ln)	0.385	0.369	0.354	0.272	0.198	0.323	0.292										
					Full time equivalent of founder	H7: Commitment	Full time equivalent of the founder to the company (in ln)	0.087	0.089	0.027	0.068	0.100	0.111	0.080							
								Source of creation	H8: Source of creation	Source creation of the firm is external to the university	-0.069	-0.131	0.021	-0.050	-0.188	-0.051	-0.101				
											Innovation	H9: Innovation	H9a: Patents	If the firm has patents between the year of 2008 - 2011	-0.905*	-0.856*	-0.824*	-0.792*	-0.674	-0.847*	-0.757
													H9b: R&D	If the firm has R&D between the year of 2008 - 2011	10.725***	10.750	10.606***	10.644***	10.650***	10.627***	10.637***
								Internationalization	H10: Exporter	If the firm exports	0.555**	0.499*	0.593	0.639**	0.708***	0.616**	0.579**				

(...)

Determinant group	Hypothesis	Proxy for the independent variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	
University characteristics	H11: Host University characteristics	H11a: Certified scientific research and scientific publications	Scientific pool of knowledge (WOS publications per researcher) (2000-2007) (in ln)	-	0.368	-	-	-	-	0.463
		H11b: Pool of advanced applied/commercialized knowledge (patents)	International patent pool per 1000 researchers (2010) (in ln)	-	-0.122	-	-	-	-	-0.079
		H11c: Research excellence	Proportion of Research units classified with 'Excellent' or 'Very Good' by the FCT	0.015	0.015	0.018*	0.015	0.011	0.012	0.011
Contextual determinants	University technology transfer office support	H12a: Science park	Science park	10.723***	10.793***	10.763***	10.711***	10.845***	10.527***	10.657***
		H12b: Incubator	Incubator	0.853***	0.821**	0.803**	0.864***	0.854***	0.738**	0.738**
		H12c: TTO	TTO	10.734***	10.627**	10.558**	10.643**	10.858***	10.316*	10.342*
Region	H13: Region	Index of purchasing power per NUT III regions (in ln)	10.510**	10.317*	10.574**	10.592**	10.705**	10.658**	10.450*	
Sector	H14: Sector of activity (Default: ICT)	Energy sector		20.069	20.098***	20.016***	10.957***	20.178***	10.943***	20.007***
		Bio sector		0.080	0.082	-0.104	-0.012	0.053	0.059	0.043
		Micro sector		0.575	0.682	0.934	0.550	0.201	0.599	0.718
		Agri-food sector		0.977*	0.931*	0.719	0.469	0.695	0.573	0.535
		Consulting sector		20.284***	20.281***	20.816***	10.942***	10.932***	10.753**	10.803**
Constant			-90.411	-80.783	-90.394	-100.003	-100.513	-100.156	-90.524	
Adjusted R2				0.632	0.626	0.627	0.641	0.649	0.628	0.620

Note: (***) (**) (*) statistically significant at (1%) (5%) (10%). Grey cells identify relative high correlation.

5. Conclusions

Academic entrepreneurship gained emphasis, essentially, in recent times for policy makers as well as for university leaders. Viewed as solution for an unstable economy and society, as a result of globalization (Wright et al., 2012), academic entrepreneurship is viewed as promoting increased employment and innovation (O’Shea et al., 2005).

The aim of this study was to extend our understanding of the determinants of Academic Spin Offs’ (ASOs) economic performance, considering three groups of determinants - entrepreneurs, firms and context -, focusing and reflecting on the several dimensions of founders’ human capital. The main research question was: “Does founders’ human capital matter for the economic performance of Portuguese ASOs?”.

In addressing this research question, we analysed a sample of 90 founders from 61 ASOs created in 1997 or later, located in Portugal, associated to entities that belong to the University Technology Enterprise Network (UTEN).

Specifically, we investigated the effect that general and specific human capital of the founders of the Portuguese ASOs have on the economic performance (measured by sales per capita) of those firms, as well as the combination of skills that need to exist in a founding team to potentiate high performance levels. The results of this analysis contribute to the existing literature in a number of ways.

The extant empirical studies on this topic primarily focus on ASOs start-up rate and survival, neglecting the post emergence factors that influence companies’ economic performance, namely the human capital of ASOs’ founders. This study addresses also the scarcity of research on how distinct dimensions of human capital influence the economic performance of ASOs (O’Shea et al., 2005; Karlsson and Wigren, 2012; Ganotakis, 2012), contributing with the theoretical debate on the existence of different types of founders’ human capital that are likely to influence companies performance.

An interesting finding of this study was that although high levels of education level and technical education had a positive impact these were statistically non-significant for ASOs performance. Moreover, the complementary business/ administration obtained by formal education, when significant was negative related to ASOs performance, which contrasts with the extant literature (e.g., Colombo and Grilli, 2009). Interestingly, other type of business expertise acquired, mostly by informal ways, most notably markets

knowledge, revealed more impact on the companies' performance than managerial capabilities acquired in formal education.

A thought-provoking result, contrary to the literature (e.g., Lumpkin and Katz, 2009) and anecdotal evidence emerged in our study: the ASOs' founders that were unemployed by the moment of ASO creation, were associated to higher economic performances when compared to those who presented other employment status (e.g., employees, self-employed, business owners).

Formal contacts with university, as well as the undertaken of R&D activities and internationalization emerged as critical determinants of ASOs economic performance. Moreover, universities' excellence research also contributes (albeit in a smaller extent) to ASOs performance. Our results further uncover the strong role represented by the university technology support infrastructures, most notably, Science Parks, Incubators and TTOs, for the performance of Portuguese ASOs, when these latter firms used each type of support in an exclusively way, rather than a combination of diverse supports. Finally, the fact that ASOs located in highly developed regions managed to present higher performances demonstrates the importance of the regional spillovers in the line of Pfeifer and Sarlija (2010).

Some of our results have important policy implications. For instance, being an exporting firm is significantly and positively related to economic performance. Thus, policies that permit the access to international business intelligence services and market prospect knowledge for sure will contribute to ASOs long term sustainability. This might be coupled with innovation policies directed toward more specialized incubating and technology transfer services by the university technology support infrastructures, most notably, Science Parks, Incubators and TTOs, anchored in the internationalization of ASOs.

The formal contacts with university, emerged as critical determinants of ASOs economic performance, therefore the intensification of the interactions and connections between the agents (universities, research centers, laboratories research and technological infrastructures) and ASOs, should contribute to the formation of a true innovation system, oriented towards competitiveness and sustainable learning. This might be achieved through active employment policies that foster formal human

resources immersion of TTOs/Science Parks/Incubators staff in business firms and temporary training periods of staff from the ASOs in these technological infrastructures.

As usual in empirical scientific research, the small size of the sample that we use undermine to assess adequately some of the dimensions of the founders' human capital. An in depth, qualitative account of founders' background would be also an important complement of the quantitative study undertook and would permit to uncover the mechanisms through which tacit knowledge, informal and social linkages interact among the team of founders and influence the ASOs performance. Such endeavour is likely to constitute an interesting and challenging path for future research.

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Appendix 1: Questionnaire 1 on founders' human capital dimensions

Capital humano dos fundadores das empresas portuguesas intensivas em conhecimento

Este inquérito é confidencial, será tratado em termos agregados e apenas será usado para efeitos de investigação no contexto da Faculdade de Economia da Universidade do Porto (FEP-UP). Por favor tente responder a todas as questões.

Nome Empresa:

Nome Fundador:

1. Características demográficas e tempo dedicado à empresa

Género	Idade	Tempo dedicado à empresa (FTE*)
Escolha um item.	anos	%

* FTE – Full Time Equivalent - equivalente a tempo completo.

2. Habilitações Literárias e respetiva área de formação

Indique por favor todas* as habilitações literárias que possui e a respetiva área de formação

Inferior ao Ensino Secundário	Ensino Secundário	Curso Profissional	Bacharelato	Licenciatura	Mestrado	Doutoramento
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Para habilitações de bacharelato ou superior, por favor indique a área			Escolha um item.	Escolha um item.	Escolha um item.	Escolha um item.

*Nota: Por exemplo, se tiver o doutoramento ou mestrado, por favor, indique também os outros graus que completou e a respetiva área de formação

3. Formação complementar

Se possui/realizou formação complementar, por favor indique as 3 formações mais relevantes

Formação complementar	Outra (pf especifique):
Escolha um item.	
Escolha um item.	
Escolha um item.	

4. Recursos

Indique por favor que recursos trouxe para a empresa à data da sua formação

Capital (\$)	Conhecimento ao nível dos mercados	Conhecimento técnico-tecnológico	Conhecimento especializado marketing e vendas	Contactos de negócio	Conhecimento especializado de gestão de organizações	Outro (pf especifique):
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

5. Experiência profissional

Experiência profissional prévia à formação da empresa por setor de atividade e tipo de empresa (no caso de ter trabalhado em mais do que 3 setores, pf indique os 3 onde trabalhou mais anos)

Sector	Outro Sector	Número de anos	Micro Empresa (<10 trab.)	Pequena Empresa (10 e 49 trab.)	Média Empresa (50 e 249 trab.)	Grande Empresa (>250 trab.)	Multinacional
Escolha um item.		anos	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Escolha um item.		anos	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Escolha um item.		anos	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Situação profissional à data da criação da atual empresa

Desempregado	Empregado conta doutrem	Proprietário de uma empresa com pessoas ao serviço	Empresário sem pessoas ao serviço/ Por conta própria	Estudante	Outra (pf especifique):
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Situação atual dessa empresa</i>					
		Ainda existe	Faliu	Foi vendida	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

7. Capital Social

Indique pf se à data da criação da empresa mantinha contactos regulares,* de natureza formal,** com alguma das seguintes entidades

Universidade	Indústria					Governo		
	Micro Empresa	Pequena Empresa	Média Empresa	Grande Empresa	Multinacional	Nacional	Local	Europeu
<input type="checkbox"/>								

* Pelo menos 2 contactos por ano; ** Inclui contratos, projetos entre organizações e a empresa.

Indique pf se à data da criação da empresa mantinha contactos regulares,* de natureza informal,*** com alguma das seguintes entidades

Universidade	Indústria					Governo		
	Micro Empresa	Pequena Empresa	Média Empresa	Grande Empresa	Multinacional	Nacional	Local	Europeu
<input type="checkbox"/>								

* Pelo menos 2 contactos por ano; *** Inclui relações pessoais e/ou estabelecidas através de interesses comuns, com carácter mais social.

Appendix 2: Questionnaire 2 on ASOs characteristics

Este inquérito é confidencial. será tratado em termos agregados e apenas será usado para efeitos de investigação no contexto da Faculdade de Economia da Universidade do Porto (FEP-UP). Por favor tente responder a todas as questões.

Nome empresa: _____

A. Descrição da Empresa

1. Fonte da emergência da empresa - o que deu origem à empresa? (pode escolher mais do que uma opção)

Estudantes Professores/Investigadores de uma faculdade/universidade/Instituto/Centro Empresa

Outra (pf especifique): _____

2. Fase atual de desenvolvimento:

Ideia Prova do conceito, i.e., protótipo Protótipo a funcionar em ambiente real

Produto/serviço pronto a ser comercializado

3. Focus em termos de internacionalização:

Nacional/local Europeu Mundial/global

4. Mercado-alvo:

mercado de nicho* mercado de nicho temporário** mercado *mainstream****

* Mercado de pequena dimensão baseado numa aplicação para um grupo de clientes específico ou reduzido; ** A primeira aplicação está destinada a um grupo de clientes específico, mas com a intenção explícita de desenvolver novas oportunidades e penetrar em novos segmentos de mercado; *** Grandes mercados fornecidos por outras empresas, maiores e com mais experiência.

B. Mecanismos de apoio

5. De qual(is) dos seguintes meios de apoio à empresa associados ao Sistema Científico e Tecnológico (SC&T) usufrui/usufruiu no decorrer da sua atividade

Parque Ciência e Tecnologia Gabinete Apoio à Atividade Intelectual Incubadora

Outro (pf especificar): _____

6. Importância dos mecanismos de apoio associados ao Sistema Científico e Tecnológico (SC&T) (1: nenhuma ... 5: muito elevada)

	1	2	3	4	5
1. Acesso a infraestruturas de conhecimento (e.g., bibliotecas) e competências especializadas (peritos)	<input type="checkbox"/>				
2. Contacto com um meio criativo	<input type="checkbox"/>				
3. Acesso a mão-de-obra qualificada (estudantes)	<input type="checkbox"/>				
4. Apoio no recrutamento de recursos externos	<input type="checkbox"/>				
5. Poder aceder a sócios potenciais com qualificações de negócio	<input type="checkbox"/>				
6. Competição/prémios de planos de negócio	<input type="checkbox"/>				
7. Mentoring e aconselhamento de negócios	<input type="checkbox"/>				
8. Acesso a redes formais e informais de negócios, ao nível nacional e internacional (investidores institucionais, empresas e organizações de consultoria)	<input type="checkbox"/>				
9. Aconselhamento no acesso aos subsídios públicos	<input type="checkbox"/>				
10. Apoio financeiro tal como acesso a capital de risco e <i>Business angels</i>	<input type="checkbox"/>				
11. Participação no capital social do <i>spin-off</i>	<input type="checkbox"/>				
12. Apoio na prospeção de oportunidades tecnológicas	<input type="checkbox"/>				
13. Avaliação da propriedade intelectual	<input type="checkbox"/>				

7. Principais obstáculos à criação e desenvolvimento da sua empresa, em particular, e de empresas intensivas em conhecimento, em geral

(1: obstáculo nada relevante... 5: obstáculo muito relevante)

	1	2	3	4	5
1. Fracas/ténues relações Universidade-Indústria	<input type="checkbox"/>				
2. Rigidez do mercado de trabalho	<input type="checkbox"/>				
3. Escassez de instituições financeiras	<input type="checkbox"/>				
4. O mercado de capital de risco ser ainda muito embrionário	<input type="checkbox"/>				
5. Políticas e estratégias de transferência tecnológicas confusas e pouco integradas	<input type="checkbox"/>				
6. Fracas capacidades das Universidades portuguesas para o desenvolvimento de aplicações comerciais (enfoque na investigação desinteressada e visando apenas a publicação)	<input type="checkbox"/>				
7. Obstáculos relacionados com o mercado (falta de conhecimentos dos promotores de marketing, competências de vendas e de clientes)	<input type="checkbox"/>				
8. Obstáculos financeiros (cash flow, investimento em capital, investimento em I&D)	<input type="checkbox"/>				
9. Obstáculos de gestão (incapacidade de lidar com a incerteza)	<input type="checkbox"/>				
10. Obstáculos governamentais como regulações e burocracia	<input type="checkbox"/>				
11. Obstáculos físicos (instalações, infraestruturas e distância aos fornecedores, mercados)	<input type="checkbox"/>				
12. Obstáculos na obtenção de aconselhamento a nível das fontes/meios de financeiro	<input type="checkbox"/>				
13. Obstáculos na obtenção de aconselhamento a nível dos mercados mais adequados/promissores para a atividade da empresa	<input type="checkbox"/>				
14. Obstáculos na obtenção de aconselhamento a nível operacional (como gerir e sustentar um negócio/empresa)	<input type="checkbox"/>				

C. Dados da empresa

8. Ano em que a empresa foi estabelecida/iniciou faturação/iniciou exportação

	2005	2006	2007	2008	2009	2010	2011	2012	Outro (pf indicar)
Ano em que a empresa foi oficialmente estabelecida	<input type="checkbox"/>	_____							
Ano em que a empresa iniciou a sua faturação/vendas	<input type="checkbox"/>	_____							
No caso que não tenha faturação, em que ano prevê ter	<input type="checkbox"/>	_____							
Ano em que a empresa iniciou as suas exportações	<input type="checkbox"/>	_____							
No caso em que não tenha exportações, em que ano prevê ter	<input type="checkbox"/>	_____							
Ano em que a empresa implementou a sua 1ª subsidiária no exterior	<input type="checkbox"/>	_____							
No caso que não tenha implementado a sua 1ª subsidiária no exterior, em que ano o prevê fazer	<input type="checkbox"/>	_____							

9. Volume negócios e patentes

	Efetivo				Previsto	
	2008	2009	2010	2011	2012	2013
Volume de negócios (em milhares de €)						
Valor (em milhares de €) das atividades de Investigação e Desenvolvimento (I&D)						
Número de patentes						
Valor anual dos rendimentos de licenças de patentes/royalties que a empresa recebe						

10. Capital humano da empresa

	Número	Tempo médio de trabalho ao serviço da empresa em % total trabalho (FTE*)
Fundador(es)		%
Colaboradores		%

* FTE – Full Time Equivalent equivalente a tempo completo - Um FTE de 1,0 ou 100% significa que o colaborador/fundador é um trabalhador de tempo integral, enquanto que um FTE de 0,5 ou 50% sinaliza que o colaborador participa das atividades da empresa somente em meio período.

Alguns dos sócios fundadores já tinha experiência prévia na indústria? Sim Não

Alguns dos sócios fundadores tem uma licenciatura ou formação avançada/especializada em:

Economia/ Gestão Direito Engenharia

Table A1: Correlation Coefficients of independent variables

Entrepreneurs' characteristics		1.	2.	3.	4.	5.	6.	7.	8.	9.	1.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.				
Maximum level of formal education	1. Master	1	-0.406***	0.231**	0.128	0.120	-0.257**	0.156	-0.098	0.175*	-0.096	0.062	0.140	-0.069	0.171	0.130	0.010	0.154	-0.090	0.077	0.079	-0.042	0.018	-0.124	-0.034				
	2. PhD		1	-0.140	-0.078	-0.129	0.097	-0.214**	0.055	0.152	-0.009	0.114	-0.223**	0.073	-0.268**	-0.081	0.000	-0.262**	0.340***	0.175*	-0.180*	-0.138	-0.138	0.269**	-0.107				
Type of formal education	3. Economic/ Managerial			1	-0.087	-0.054	0.009	0.024	0.032	0.189*	0.318***	-0.056	0.298***	-0.016	0.437***	0.171	-0.072	0.107	-0.201*	0.213**	0.128	0.250**	0.164	-0.064	0.014				
	4. Engineering				1	-0.305***	0.150	0.096	0.161	0.186*	0.003	0.095	0.014	0.044	-0.060	0.010	0.129	0.197*	-0.015	0.056	-0.120	0.164	0.109	0.149	0.049				
	5. Computer science					1	-0.274***	0.055	-0.027	-0.139	-0.136	0.089	0.041	-0.243**	-0.034	-0.028	-0.100	0.157	0.113	-0.054	-0.101	0.003	-0.072	-0.028	0.189*				
Complementary education	6. Technological						1	0.176*	0.373***	0.046	0.125	0.053	0.088	0.299***	0.033	0.182*	0.180*	-0.052	-0.077	0.165	0.037	0.151	0.031	0.196*	-0.027				
	7. Business							1	0.402***	-0.259**	0.091	-0.015	0.249**	-0.230**	0.067	0.249**	0.179*	0.167	-0.004	0.318***	0.050	0.171	0.058	0.102	0.167				
	8. Human Resources / Behavioural / L.								1	-0.048	0.155	0.014	0.026	-0.141	0.074	0.063	0.000	0.000	0.092	0.126	-0.185*	0.207	0.061	0.071	-0.035				
Resources brought to the company at the date of its formation	9. Capital									1	0.074	-0.068	0.039	0.132	0.254**	-0.053	0.109	-0.040	0.055	-0.066	-0.007	0.015	0.080	0.043	-0.115				
	10. Markets knowledge										1	-0.015	0.189*	0.377***	0.265**	-0.045	0.132	0.010	-0.111	0.245**	-0.111	0.171	0.058	0.102	0.167				
	11. Technological											1	-0.222**	0.159	-0.258**	-0.118	0.077	0.033	-0.060	0.045	-0.208	-0.097	-0.097	0.068	0.128				
	12. Marketing and sales													1	0.014	0.550***	0.150	0.095	0.180*	-0.129	0.113	0.344***	0.116	-0.027	-0.073	0.365***			
	13. Business contacts															1	0.036	-0.047	0.266**	-0.058	-0.120	-0.016	-0.015	-0.056	-0.001	0.149	-0.030		
	14. Organizations Management																	1	0.090	0.019	0.176*	-0.171	-0.017	0.161	0.051	0.109	-0.062	0.119	
Previous Experience	15. Has professional experience																		1	0.220**	0.163	0.274***	0.171	0.274***	0.250**	0.250**	0.269**	0.051	
	16. Same sector as ASO																				1	0.585***	-0.201*	0.072	0.063	0.133	0.133	0.233**	0.064
	17. Sector: ICT																					1	-0.226**	-0.133	0.066	0.242**	0.119	0.189*	0.077
	18. Sector: University or R&D																						1	0.046	-0.203*	-0.168	0.023	0.130	-0.178*
	19. Sector: Industry																							1	0.210**	0.250**	-0.010	0.081	0.014
	20. Organization: Micro																								1	-0.041	0.086	-0.082	0.004
	21. Organization: Small																									1	0.133	0.034	0.125
	22. Organization: Medium																										1	-0.022	-0.066
	23. Organization: Large																											1	0.071
	24. Organization: Multinational																												1

(..)

Entrepreneurs' characteristics		25.	26.	270	28.	29.	30.	31.	30.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.
Maximum level of formal education	1. Master	0.117	0.040	-0.034	-0.118	0.076	0.081	-0.019	0.114	0.033	0.050	0.136	0.033	-0.042	0.126	-0.057	0.027	0.020	-0.130	0.003	0.228**	0.000	0.007	0.010	0.079
	2. PhD	-0.306***	-0.049	-0.107	0.374***	-0.184*	-0.180*	0.166	0.170	0.011	0.306***	-0.061	0.055	0.044	-0.156	0.207*	0.052	-0.022	0.208	0.204**	-0.336***	-0.272**	0.169	-0.039	-0.078
Type of formal education	3. Economic/ Managerial	0.117	-0.195*	0.014	0.056	0.156	-0.103	-0.189*	-0.173	-0.032	-0.117	0.008	0.032	-0.183*	-0.024	0.000	-0.175*	-0.056	-0.080	-0.077	0.052	0.066	0.056	-0.008	0.056
	4. Engineering	0.221**	-0.152	-0.030	-0.048	0.161	0.088	0.048	0.137	0.020	-0.015	0.244**	0.101	0.054	0.299***	0.165	0.028	0.093	0.047	-0.045	0.043	0.084	0.097	0.116	-0.048
	5. Computer science	-0.181*	0.343***	-0.134	-0.057	-0.176*	-0.125	-0.008	0.078	0.027	0.181*	0.071	-0.192*	0.154	0.121	-0.143	0.061	0.119	-0.129	-0.085	0.193**	-0.008	-0.002	-0.071	0.006
Complementary education	6. Technological	0.189*	-0.236**	-0.113	0.100	0.157	0.089	-0.026	0.106	0.022	0.036	0.308***	0.110	0.271**	0.062	0.114	0.122	0.197*	0.319***	-0.026	-0.062	0.131	0.017	0.035	-0.197*
	7. Business	0.083	-0.038	-0.076	0.003	0.015	0.037	-0.166	-0.109	-0.093	-0.083	0.086	-0.093	0.002	0.068	-0.023	-0.043	0.044	-0.190*	-0.024	0.006	0.314***	0.212**	0.283***	-0.137
	8. Human Resources / Behavioural / L.	0.148	0.035	-0.140	-0.080	0.155	-0.019	0.000	0.088	0.200*	0.057	0.159	0.040	-0.012	0.015	0.050	0.144	0.201*	0.013	0.079	0.102	-0.024	0.240**	0.199*	-0.262**
Resources brought to the company at the date of its formation	9. Capital	0.129	-0.147	-0.115	0.078	-0.008	0.155	0.071	0.183*	0.120*	0.177	0.095	0.239**	0.146	0.036	0.178*	0.027	0.084	0.258**	0.064	0.007	-0.164	-0.084	-0.202*	0.024
	10. Markets knowledge	0.136	-0.202*	0.005	0.050	0.081	-0.049	-0.259**	-0.109	-0.093	-0.030	0.040	0.155	-0.055	-0.002	0.208	-0.094	-0.003	0.045	-0.296***	0.157	0.259**	0.081	0.283***	0.050
	11. Technological	-0.122	0.077	0.128	-0.033	-0.011	-0.235**	0.017	0.118	-0.099	0.194*	-0.041	-0.155	-0.020	-0.040	-0.074	0.169	-0.031	-0.125	-0.131	0.075	0.068	0.079	0.104	-0.033
	12. Marketing and sales	0.261**	-0.188*	-0.145	0.014	0.140	0.082	-0.109	-0.160	-0.026	-0.194*	0.243**	0.026	0.258**	0.359***	0.039	-0.296***	0.221**	-0.002	-0.142	0.098	0.450***	-0.026	-0.010	0.132
	13. Business contacts	0.015	-0.206*	-0.030	0.180*	-0.031	0.088	-0.042	0.137	0.020	0.140	0.154	0.161	0.164	0.024	0.165	-0.022	0.093	0.277***	-0.115	-0.016	0.138	-0.095	0.071	0.089
	14. Organizations Management	0.359***	-0.212**	-0.132	-0.060	0.190*	0.244**	-0.102	-0.079	0.117	-0.141	0.277***	0.330***	0.226**	0.178*	0.246**	-0.156	0.204*	0.214**	-0.120	0.077	0.261**	0.122	0.104	0.085
Previous Experience And status	15. Has professional experience	0.153	-0.405***	0.051	0.183*	0.037	0.140	-0.015	-0.022	0.013	-0.022	0.245**	-0.013	0.180*	0.093	-0.123	0.018	0.105	0.088	-0.001	-0.131	0.190*	0.198*	0.096	-0.047
	16. Same sector as ASO	0.094	-0.236**	-0.016	0.129	0.052	0.017	-0.055	0.053	-0.122	0.010	0.200*	-0.122	0.078	-0.028	-0.121	-0.101	0.055	-0.046	0.004	0.027	0.327***	-0.077	0.209**	0.174*
	17. Sector: ICT	0.165	-0.095	-0.100	-0.007	0.181*	-0.081	-0.141	-0.059	-0.135	-0.108	0.214**	-0.202*	-0.004	0.082	-0.201*	-0.131	-0.044	-0.227**	-0.056	0.197**	0.342***	-0.033	0.238**	0.197*
	18. Sector: University or R&D	-0.215**	0.175*	-0.087	0.090	-0.087	-0.165	0.152	0.147	0.185*	0.274***	-0.143	-0.046	0.023	0.025	0.069	0.180*	0.015	0.056	-0.009	-0.143	-0.180*	0.281***	-0.064	-0.015
	19. Sector: Industry	0.117	-0.195*	-0.110	0.127	-0.045	0.161	-0.047	0.035	-0.032	0.126	0.149	0.032	-0.096	-0.024	0.118	-0.018	0.159	0.010	0.000	-0.060	-0.019	0.257**	0.204*	0.056
	20. Organization: Micro	0.319***	-0.192*	0.004	-0.120	0.134	0.317***	0.048	-0.081	0.046	-0.082	0.013	0.162	0.023	-0.054	0.069	0.006	0.067	0.122	0.048	0.013	-0.055	-0.087	-0.116	0.090
	21. Organization: Small	0.321***	-0.221**	-0.162	-0.001	0.097	0.155	-0.189*	-0.117	-0.134	-0.259**	0.202*	-0.012	-0.134	0.056	-0.082	-0.226**	0.111	-0.041	-0.041	0.141	0.247**	-0.058	0.343***	-0.001
	22. Organization: Medium	0.196*	-0.092	0.030	-0.111	0.252**	-0.049	0.029	-0.037	-0.061	-0.134	0.148	-0.012	-0.001	-0.027	0.009	-0.044	-0.054	0.029	-0.084	-0.059	0.116	-0.135	-0.093	-0.001
	23. Organization: Large	0.055	-0.332***	-0.089	0.287***	0.061	0.109	0.030	0.112	-0.010	0.154	0.269**	0.071	0.202*	0.050	0.114	0.037	0.220**	0.139	-0.011	-0.085	0.067	0.191*	0.142	0.010
	24. Organization: Multinational	0.086	-0.080	0.040	-0.030	0.205*	-0.091	-0.230**	-0.107	-0.175*	-0.175*	0.085	-0.035	0.030	0.241**	0.026	-0.155	0.030	-0.051	-0.093	-0.003	0.209**	-0.128	-0.007	0.049

(..)

Entrepreneurs' characteristics		49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.
Maximum level of formal education	1. Master	-0.077	0.093	0.004	0.023	0.033	-0.005	-0.053	0.143	0.010	-0.043	-0.085	0.212**	-0.078	0.094
	2. PhD	0.053	0.185**	0.150	0.224**	-0.277***	-0.115	-0.150	0.039	-0.237**	-0.097	0.434***	-0.013	0.033	-0.134
Type of formal education	3. Economic/ Managerial	-0.066	-0.024	-0.101	0.128	0.032	-0.080	0.069	0.059	-0.008	-0.139	0.088	0.095	0.047	-0.076
	4. Engineering	0.076	0.048	0.113	-0.120	0.101	-0.028	-0.207	0.031	-0.019	0.128	-0.146	0.034	0.042	0.034
	5. Computer science	0.096	0.033	-0.090	0.327***	-0.027	-0.172	0.164	0.053	0.297***	-0.168	-0.138	0.056	-0.115	-0.093
Complementary education	6. Technological	0.164*	0.072	0.102	0.094	-0.022	-0.034	-0.048	0.160*	-0.112	-0.106	0.172	-0.019	0.124	-0.019
	7. Business	0.376***	-0.008	0.136	-0.057	0.155	0.020	-0.185*	0.084	-0.086	-0.027	0.138	-0.052	-0.018	0.060
	8. Human Resources / Behavioural / L.	0.402***	-0.073	0.173*	-0.116	-0.040	0.172	-0.108	-0.006	-0.040	0.000	0.149	-0.096	0.000	-0.096
Resources brought to the company at the date of its formation	9. Capital	-0.145	0.222**	-0.086	-0.007	-0.120	-0.042	-0.220**	0.128	0.012	0.052	0.000	-0.014	-0.071	-0.014
	10. Markets knowledge	0.103	-0.182*	-0.098	-0.111	0.031	-0.120	0.017	0.035	-0.040	-0.027	-0.092	0.060	0.074	0.172
	11. Technological	0.002	-0.101	-0.034	0.087	-0.240**	0.086	0.100	-0.013	-0.275***	0.068	0.126	0.089	0.110	0.089
	12. Marketing and sales	0.065	0.084	-0.055	0.006	0.260**	-0.093	-0.113	0.061	0.048	-0.097	-0.087	0.041	-0.008	0.182*
	13. Business contacts	-0.012	-0.117	-0.074	-0.067	-0.020	-0.166	0.087	0.037	-0.064	0.062	0.022	0.034	-0.048	0.034
	14. Organizations Management	-0.089	0.037	-0.059	-0.005	0.074	-0.045	0.040	0.065	0.104	-0.131	-0.107	0.082	0.102	-0.033
Previous Experience and status	15. Has professional experience	0.120	-0.053	0.017	0.076	0.063	0.057	-0.131	0.057	-0.131	-0.145	0.099	0.104	0.129	0.104
	16. Same sector as ASO	0.115	-0.033	-0.016	-0.148	0.304***	-0.037	-0.099	-0.068	0.073	-0.120	-0.011	0.044	-0.036	0.044
	17. Sector: ICT	0.025	-0.028	-0.068	-0.168	0.472***	-0.044	-0.037	-0.097	0.389***	-0.163	-0.239**	0.114	-0.161	-0.130
	18. Sector: University or R&D	0.136	0.001	0.193**	0.098	-0.185*	-0.002	-0.138	0.065	-0.168	0.005	0.233**	0.128	-0.048	-0.123
	19. Sector: Industry	0.203**	0.000	0.088	0.128	-0.063	-0.080	-0.086	0.084	-0.220**	-0.139	0.354***	-0.076	0.189*	-0.076
	20. Organization: Micro	-0.121	0.039	-0.187**	-0.143	0.092	0.208**	-0.138	-0.024	-0.168	0.005	0.039	0.003	0.159	0.128
	21. Organization: Small	0.210**	-0.007	0.000	0.023	0.280***	-0.156	-0.007	0.066	0.179*	-0.043	-0.054	0.021	-0.138	-0.112
	22. Organization: Medium	-0.041	-0.101	-0.130	0.023	0.061	0.010	-0.007	0.000	0.070	0.037	-0.054	-0.112	0.080	-0.112
	23. Organization: Large	0.203**	0.176*	0.219**	-0.029	0.010	0.121	-0.193*	0.205**	-0.041	-0.179*	0.114	0.270**	-0.030	-0.061
	24. Organization: Multinational	0.056	0.042	-0.122	0.095	0.070	-0.182*	-0.076	0.058	-0.007	-0.123	-0.059	-0.067	-0.083	0.501***

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	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	
Entrepreneurs' characteristics																					
25. Self-employed or company owner	1	-0.323***	-0.183*	-0.501***	0.701***	0.496***	-0.048	0.080	0.125	-0.182*	0.344***	0.285***	0.071	0.015	0.144	0.022	0.243**	0.303***	0.108	0.120	
26. Student or scholarship		1	-0.172	-0.472***	-0.227**	-0.160	0.042	0.139	0.035	0.263**	-0.329***	-0.176*	-0.157	-0.126	-0.096	0.108	-0.220**	-0.199*	0.043	0.155	
27. Unemployed			1	-0.267**	-0.128	-0.091	0.083	-0.222**	0.035	-0.175*	-0.227**	-0.035	-0.162	-0.117	-0.104	0.107	-0.049	-0.151	-0.064	0.098	
28. Employee				1	-0.351***	-0.248**	-0.042	-0.062	-0.161	0.037	0.109	-0.080	0.164	0.162	0.015	-0.173	0.002	-0.010	-0.095	-0.295***	
29. Self-employed					1	-0.119	-0.144	-0.025	0.014	-0.267**	0.167	0.155	-0.135	-0.057	0.074	-0.027	0.095	0.205*	0.150	0.118	
30. Company owner: Company exists						1	0.078	0.114	0.130	-0.020	0.214**	0.315***	0.256**	0.018	0.180*	0.087	0.164	0.284***	0.099	-0.044	
Previous Experience and status																					
31. Network Capabilities							1	0.681***	0.359***	0.456***	0.261**	0.120	0.138	0.100	0.089	0.232**	0.222**	0.129	0.050	-0.181*	
32. Formal contacts								1	0.175*	0.669***	0.384***	0.175*	0.203*	0.146	0.131	0.195*	0.128	0.189*	0.089	-0.020	
33. Informal contacts									1	0.353***	0.080	0.040	0.158	0.076	0.050	0.721***	0.523***	0.216**	0.205**	-0.037	
34. Formal contacts with University										1	0.063	0.125	0.116	-0.015	0.195*	0.433***	0.170	0.218**	0.073	-0.088	
35. Formal contacts with Industry											1	0.278***	0.529***	0.382***	0.267**	0.011	0.521***	0.437***	-0.024	0.021	
36. Formal contacts with Government												1	0.207	0.015	0.745***	0.011	0.201*	0.698***	-0.028	-0.123	
Networks																					
37. Formal contacts with Industry -Large													1	0.555***	0.191*	0.078	0.387***	0.446***	0.001	-0.163*	
38. Formal contacts with Industry - Multinational														1	-0.011	-0.072	0.250**	-0.007	-0.040	0.036	
39. Formal contacts with Government - National															1	0.124	0.210**	0.596***	-0.076	-0.165*	
40. Informal contacts with University																1	0.273***	0.236**	0.253***	0.028	
41. Informal contacts with Industry																	1	0.413***	0.048	0.050	
42. Informal contacts with Government																		1	0.148	-0.236**	
Other factors																					
43. Number of Founders (no.)																				1	-0.103
44. FTE (full time equivalent). in %																					1

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Entrepreneurs' characteristics		45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.
Previous Experience and status	25. Self-employed or company owner	0.054	-0.023	0.012	-0.037	0.041	0.047	-0.019	-0.037	0.080	0.080	-0.031	0.007	0.063	-0.005	-0.038	-0.126	0.048	-0.003
	26. Student or scholarship	-0.232**	-0.002	-0.196*	0.007	-0.029	-0.040	0.036	-0.008	-0.176*	0.073	0.096	-0.198**	0.119	0.093	-0.013	-0.119	-0.147	-0.119
	27. Unemployed	-0.073	-0.128	-0.085	-0.188*	-0.092	-0.179*	-0.185**	-0.087	-0.035	0.056	0.095	-0.140	-0.163	0.107	-0.156	-0.067	0.230**	0.312***
	28. Employee	0.192*	0.097	0.206*	0.135	0.041	0.096	0.092	0.090	0.101	-0.166	-0.109	0.244***	-0.064	-0.137	0.135	0.252**	-0.048	-0.075
	29. Self-employed	0.008	-0.079	-0.104	-0.095	0.034	0.044	0.083	-0.013	0.071	0.042	0.038	-0.045	0.149	-0.068	-0.047	-0.089	-0.110	0.065
	30. Company owner: Company exists	-0.055	-0.001	0.035	0.004	0.009	0.080	-0.096	-0.069	-0.019	0.095	-0.070	0.040	-0.048	0.008	-0.041	-0.063	0.255**	-0.063
Networks	31. Network Capabilities	0.036	0.110	-0.083	-0.042	-0.065	0.015	0.088	0.152	-0.239**	0.133	0.065	-0.087	-0.172	0.105	0.134	0.058	0.071	-0.159
	32. Formal contacts	-0.105	0.161	0.009	0.071	0.001	0.133	0.169*	0.147	-0.263**	0.062	0.095	0.029	-0.057	-0.038	0.114	0.085	-0.026	-0.074
	33. Informal contacts	-0.191*	0.099	-0.139	-0.040	0.097	-0.008	0.025	0.116	-0.200*	-0.050	-0.152	0.054	-0.139	0.088	0.149	0.096	0.120	-0.338***
	34. Formal contacts with University	-0.238**	0.241**	-0.063	0.037	-0.062	0.045	0.105	0.215**	-0.422***	0.127	0.031	-0.042	-0.216**	0.080	0.229**	0.126	0.054	-0.244**
	35. Formal contacts with Industry	0.279***	0.104	0.245**	0.019	0.229**	0.184	0.105	0.168	0.099	-0.094	-0.140	0.095	0.156	-0.187*	0.011	0.005	0.006	-0.103
	36. Formal contacts with Government	-0.096	0.155	0.020	-0.020	-0.042	-0.028	0.069	0.023	-0.200*	0.111	-0.108	-0.003	-0.159	0.088	0.000	0.048	0.120	0.048
	37. Formal contacts with Industry -Large	0.247**	0.020	-0.093	-0.056	0.107	0.102	-0.100	0.213**	-0.012	-0.045	-0.125	0.199**	0.016	-0.123	0.014	0.153	0.080	-0.112
	380. Formal contacts with Industry - Multinational	0.290***	-0.153	0.026	-0.044	0.141	0.139	-0.048	0.103	0.015	-0.105	-0.091	0.217**	0.026	-0.047	-0.102	0.249**	-0.100	0.084
	39. Formal contacts with Government - National	-0.089	0.179*	-0.044	0.015	-0.026	-0.072	-0.053	0.155	-0.149	-0.053	-0.081	0.019	-0.267**	0.196*	0.111	-0.072	0.208**	-0.072
	40. Informal contacts with University	-0.265**	0.043	-0.110	-0.022	0.035	0.030	-0.064	0.237**	-0.322***	0.014	-0.066	0.066	-0.210**	0.097	0.186*	0.013	0.166	-0.227**
40. Informal contacts with Industry	0.132	-0.033	0.019	0.002	0.185*	0.078	0.034	0.067	-0.040	-0.017	-0.284***	0.120	0.019	-0.062	0.034	0.075	0.048	-0.143	
42. Informal contacts with Government	-0.121	0.044	-0.096	-0.125	0.028	0.050	0.003	0.254**	-0.216**	-0.057	-0.117	-0.006	-0.153	0.061	0.185*	-0.104	0.099	-0.104	
Other factors	43. Number of Founders (no.)	-0.283***	-0.131	-0.211**	-0.084	0.027	0.180**	-0.019	0.053	-0.073	0.056	-0.120	-0.074	0.068	0.010	0.159*	-0.135	-0.185*	-0.131
	44. FTE (full time equivalent). in %	0.003	-0.092	0.125	0.086	0.067	0.085	0.041	-0.229**	0.176*	0.107	0.098	0.078	0.227**	-0.029	-0.292***	0.078	-0.132	0.146

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Firms' characteristics		45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.
Source of creation	45. Source creation of the firm: External to the university	1	-0.068	0.309***	0.138	0.059	-0.069	-0.014	-0.055	0.335***	-0.121	-0.013	0.033	0.202*	-0.052	-0.200*	0.014	-0.036	0.014
	46. Has Patents in 2008 - 2011		1	0.275***	-0.095	0.178*	-0.006	0.354***	0.060*	-0.184	0.171	-0.100	-0.059	-0.230**	-0.161	0.348***	0.065	0.144	-0.089
Innovation	47. Performed R&D activities in 2008-2011			1	0.071	0.357***	0.027	0.279***	-0.323***	0.139	0.094	-0.151	0.077	0.111	-0.074	-0.067	0.211**	-0.095	-0.113
	48. Exporter				1	-0.233**	0.011	-0.051	-0.225**	0.161	0.109	-0.109	0.041	0.071	0.128	-0.146	0.143	-0.048	-0.184*
University characteristics	49. University international patent pool 2010 (number of international registered patents per 1000 researchers)					1	-0.066	0.357***	-0.067	0.112	-0.060	-0.277***	0.189**	0.034	-0.125	0.165*	-0.050	-0.117	-0.005
	50. University Scientific pool of knowledge (publications indexed in WOS/ISI per researcher, 2000-2007)						1	0.342***	0.166*	-0.187**	0.021	-0.166*	0.300***	0.126	-0.299***	0.162*	0.019	-0.101	-0.022
	51. Proportion of Research units with Very Good or Excellent by FCT							1	-0.079	-0.074	0.134	-0.166*	0.199**	0.051	-0.223**	0.188**	0.067	-0.072	-0.103
Contextual characteristics																			
University technology transfer office support	52. ASO resort to TTO/other S&T infrastructure support								1	-0.254**	-0.475***	0.426***	0.196**	-0.064	-0.223**	0.297***	-0.123	0.159	-0.123
	53. Science Park									1	-0.374***	-0.108	-0.009	0.437***	-0.175*	-0.224**	-0.096	-0.120	-0.096
	54. Incubator										1	-0.203*	-0.146	-0.222**	0.204*	-0.079	0.258**	0.048	0.039
	55. TTo											1	-0.107	0.140	-0.095	-0.121	-0.052	0.130	-0.052
Region	56. Per capita purchasing power index of the NUT III region where the firm is located (2009)												1	-0.001	-0.176*	0.104	0.189**	-0.074	-0.009
Sector	57. ICT sector													1	-0.401***	-0.511***	-0.221**	-0.273***	-0.221**
	58. Energy sector														1	-0.196*	-0.085	-0.105	-0.085
	59. Bio sector															1	-0.108	-0.134	-0.108
	60. Micro sector																1	-0.058	-0.047
	61. Agri-food sector																	1	-0.058
	62. Consulting sector																		

Note: N=90; (***) (**) (*) statistically significant at (1%) (5%) (10%). Grey cells identify relative high correlation coefficients between independent variables. (a) We use Kendall-tau_b, which is a non-parametric correlation coefficient that can be used to assess and test correlations between non-interval scaled variables. Nevertheless, results do not differ substantially from those obtained with Pearson correlation coefficient.