Does Exposure to University Research Matter?—Evidence from Europe

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Abstract

This paper addresses the behavior and performance of young companies established by entrepreneurs who have been previously exposed to academic research for a considerable amount of time. We use data from a large survey of young companies established in ten European countries and eighteen high-tech, low-tech and knowledge-intensive service sectors. While a fair amount of similarity exists in terms of business motivation and client focus, our findings reveal the group of firms founded by Ph.D. holders to exhibit extensive dependence on university graduates and post graduates as employees, higher reliance on venture capital funding, higher dependence on internal R&D and external scientific and research networks as sources of knowledge, better innovative performance especially in terms of new-to- the world products, increased awareness of intellectual property protection and, last but not least, better performance both in terms of both employment/sales growth and international sales. These we find as important—even though exploratory—indication of support for our basic premise that exposure of company founders to university research affects entrepreneurial incentives and behavior in ways that reflect higher levels of creation and use of scientific and technological knowledge and market niche specialization.

Keywords: university entrepreneurship, academic research, knowledge-based entrepreneurship, SMEs, young firms

1. Introduction

Academic entrepreneurship has been a long discussed topic among scholars. Since the end of World War II, the outstanding success achieved by the application of scientific knowledge to the development of military technologies led to an exponential increase of government funding for academic research, especially in the US (Franzoni and Lissoni 2009). A parallel process has been the transfer of university produced knowledge to the private sector especially during the last three decades along with a remarkable increase in new forms of entrepreneurship associated with new innovations (Franklin et al., 2001) usually taking the form of 'university spin offs'. The idea that knowledge stemming from research conducted on university campuses can be used to commercial applications, led Etzkowitz (1998) to coin the term entrepreneurial university describing the role that universities have been assuming in modern economic development activities. In this vein, research universities are

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becoming increasingly engaged in entrepreneurial activities that allow them to capitalize and commercialize academic knowledge, while at the same time they also embrace entrepreneurial culture in the main academic areas of education and research (D'Este et al., 2010).

This paper examines young companies established by entrepreneurs holding advanced post-graduate degrees (Ph.D.). It explores the formation of entrepreneurial ventures created by individuals who have been previously exposed to academic research for a considerable amount of time, at a bare minimum of three years, during the preparation of their Ph.D. thesis. This is a form of academic-related entrepreneurship—defined rather broadly—implemented by graduates with advanced education background. Recent research suggests that entrepreneurship in new independent firms represents a possible 'missing link' between publicly available knowledge and economic growth through the exploitation of this knowledge (Acs et al., 2008). By examining the attributes of firms founded by Ph.D. holders we seek to shed more light on whether university research outputs and acquired skills can be converted into 'dynamic entrepreneurship' which in turn may affect positively economic growth and social well-being.

To the best of our knowledge, existing empirical studies do not take into account entrepreneurial activities that have been initiated by university graduates after they have left the university. These people are only loosely connected to the university and are very difficult to identify in empirical studies. In addition, most universities do not keep records of the companies founded by graduates from their undergraduate, master or Ph.D. programmes (Wright et al., 2007). Taking into consideration that a) there is a significant increase in the number of Ph.D. holders worldwide during the last three decades (OECD, 2013) and b) that the additional supply of highly qualified human capital cannot be fully absorbed in existing businesses, the need for new entrepreneurial activity becomes more significant. Our study, using a rich European dataset, attempt to address this gap in the literature by providing empirical evidence on the structure and behavior of young companies established by entrepreneurs holding advanced (doctoral) degrees.

A founding team's characteristics be can be critical to a young firm's success and subsequent growth. Founders with a broader general knowledge base are presumed to have a better ability to effectively search their environment and identify new opportunities (e.g. Ucbasaran et al., 2008; Shepherd and DeTienne, 2005). At the same time, entrepreneurs with a high degree of human capital are capable to fruitfully exploit new opportunities. In particular, the cognitive base and the educational background of the founders is an important variable for the study of knowledge-intensive entrepreneurship in general and academic entrepreneurship in particular. In this study we adopt a broader definition of academic entrepreneurship and investigate whether new ventures founded by Ph.D. holders exhibit different characteristics and/or different behavior patterns compared to the rest of the firms established in the same period in Europe. More specifically, the paper explores the extent to which this form of academic-related entrepreneurship possesses different properties in terms of employees' human capital, formation factors and funding, knowledge sources, success factors and strategy as well as innovation and firm performance.

The rest of the paper proceeds as follows: Section 2 provides a brief synthesis of the literature in search of a broader definition of academic entrepreneurship. Section 3 describes the dataset and section 4 presents the results of the empirical analysis and offers a discussion of the main findings. The paper ends with a section on conclusions.

2. In Search of a Broader Definition of Academic Entrepreneurship

A straightforward conceptualization of academic entrepreneur would suggest that he/she is "a university scientist, most often a professor, sometimes a PhD student or a post-doc researcher, who sets up a business company in order to commercialize the results of her research" (Franzoni and Lissoni, 2009). However, the abovementioned definition, although easily conceptualized, fails to take into full account the complexity of economic incentives that influence the behavior of academic scientists. In that vein, Franzoni and Lissoni acknowledge academic entrepreneurship as a multifaceted phenomenon that results from a much more complex set of strategies and incentives. They also suggest that academic research, in general, should rather be conceived as a 'scientific enterprise', in which career-motivated scientists act as research-oriented entrepreneurs, whose approach to commercial activities depends upon a broader career strategy (Franzoni and Lissoni, 2009).

When the term academic entrepreneurship was first introduced, it simply referred to an extension of business entrepreneurship to academia. However, its popularity increased through time and studies focused on this research can be integrated into three main categories representing the extensiveness of the definitions used: a) commercial approaches, b) knowledge transfer approaches, and c) value creation perspectives. The prevailing definitions of academic entrepreneurship originate from commercial approaches and center on the idea of for-profit business creation highlighting university spin-offs (Shane, 2004; Wright et al., 2009). A major drawback of commercial approaches is that they refer only to pure entrepreneurial intentions. In this way, they either exclude other means of profit making e.g. through knowledge transfer that the academia has at its disposal, or they disregard the fact that monetary value is just one type of value that can be generated through entrepreneurial action (Cantaragiu, 2012). However, the other two approaches of academic entrepreneurship broaden their scope and take these issues into consideration.

In particular, those scholars who choose to conceptualize academic entrepreneurship as a means of transferring knowledge from university to the market extend the definition of academic entrepreneurship so that it includes all types of contacts that academics may develop with business entities on the basis of monetary value creation both in the context of hard and soft academic entrepreneurial activities (Philpott et al., 2011). Hard activities produce more tangible entrepreneurial results and include patenting, licensing and spin-off formation, while softer activities may refer to knowledge transfer activities such as academic publishing, grant seeking and contract research which do not count as academic entrepreneurial examples under the strict commercial definition. In addition, value creation conceptualizations perceive entrepreneurship as a means of creating societal value without putting much emphasis on economic value (Botes, 2005; Kingma, 2011). In light of the above discussion, the main ideas which spun across the different abovementioned definitions can be integrated in order to arrive at a more complete and less vague conceptualization of academic entrepreneurship where individual or collective action is undertaken by academia members with the intention to transfer knowledge between the university and the external environment so as to generate economic and/or societal value (Cantaragiu, 2012).

Several scholars have attempted to broaden the concept of academic entrepreneurship. For example, Wright et al. (2007) in their study on academic entrepreneurship in Europe, focus not only on university spin-offs that build upon formal, codified knowledge embodied in patents but also include start-ups by faculty based in university which may

draw on their own IP or knowledge. They argue that they have broadened their perspective because in some institutional contexts intellectual property is not necessarily owned by the university and in this way they would miss a substantial part of reality. In a similar line of reasoning, Goel and Grimpe (2012) in their study of the differential forces driving academic entrepreneurship distinguish between research-driven academic entrepreneurship in which firm creation is a pure result of the scientist's drive to commercialize his research results created in the university, and general academic entrepreneurship in which firm creation is driven by factors (maybe chance, family connections, non-academic opportunity, due to someone else's research, etc.) other than the commercialization of the entrepreneur's own research results. However, as far as the role of individual academic entrepreneurs is concerned, while early work included a broad conceptualization of the academic entrepreneur (e.g. Doutriaux, 1998), more recent and influential scholarship put emphasis almost exclusively on the role of individual university faculty (Hayter et al., 2016) disregarding the fact that graduate students can have a catalytic impact on academic entrepreneurship (Boh et al., 2016; Lubynsky, 2012).

A common feature of the abovementioned studies is that although they stress the role of the academic entrepreneur as initiator of knowledge transfer from the university towards the creation of a new venture they do not take into account those companies created on the basis of university knowledge but not by members of the academia. Thus, firms created by university graduates after they have left the university are excluded. These people are only loosely linked to the university and are very difficult to identify in empirical studies. Most universities do keep track of the companies founded by graduates from their undergraduate, master or Ph.D. programmes (Wright et al., 2007). However, even in the case that they do it is usually not clear whether the company's set up is based on knowledge developed and transferred in the university setting or whether it is based on knowledge accumulated by the graduate outside the university. Nevertheless, the number of firms created by graduates should not be underestimated as empirical evidence show that they might even outnumber spin-offs (Wright et al., 2007).

In the present study a wider perspective of academic entrepreneurship is adopted suggesting that agents who have been exposed to academic research for significant lengths of time can create high-potential entrepreneurial ventures. Moreover, it is assumed that these new endeavors do not essentially encapsulate scientific or research knowledge directly created and consequently transferred from university into the business setting. In this vein, these ventures can be founded by people with a strong scientific background and a prior formal relationship with the academia who do not necessarily exploit knowledge generated during their academic career. In particular, we hypothesize that Ph.D. holders can be involved in 'high-potential' entrepreneurial action or knowledge intensive entrepreneurship setting up firms which focus on the dynamic application of new knowledge.

It is widely accepted that the founder(s) characteristics serve as important resources to competitive advantage in the creation of new entrepreneurial ventures. In particular, the cognitive base and the educational background of the founders is considered as an important factor for innovation (Arvanitis and Stucki, 2012). Through formal education, people acquire skills helping to identify opportunities in the external environment (Shane, 2000). In addition, a higher education level may enhance the ability of founders to absorb new ideas and thus the ability to conceive innovative opportunities.

There has been a significant increase in the number of Ph.D. holders as a percentage of the population across all countries between 2000 and 2011 (OECD,

2013). Taking into consideration that the educational attainment and previous research exposure of founders may be strongly related to innovative entrepreneurship, these individuals constitute a pool of high-potential would-be entrepreneurs. In this paper we investigate whether new ventures founded by Ph.D. holders exhibit different characteristics and/or different behavioral patterns compared to the rest of the firms established in the same period in Europe. More specifically, we try to link prior academic research exposure to knowledge-intensive entrepreneurship (KIE).

Knowledge-intensive entrepreneurship can be considered a type of high-potential entrepreneurship. It indicates ventures the initiation or expansion of which is based on the dynamic application of new knowledge. Knowledge-intensive firms can play important roles in sectoral, local and national innovation systems by operating as problem-solvers, knowledge brokers, knowledge-intensive service providers, or specialized suppliers. Following Malerba and McKelvey (2016), we rely on a formal definition of knowledge-intensive entrepreneurship developed in the context of AEGIS[1], a large-scale, integrated, EU-funded research project. Here, KIE is associated with four basic characteristics: (a) new firms (ventures); b) new ventures that are innovative; c) new ventures engaging in activities that are knowledge-intensive; and d) new ventures that are not to be found solely in high-tech industries, but may well be active in lower technology industries.

3. Data

The data used in the quantitative analysis originate in the AEGIS survey. The survey purported to identify the motives, characteristics and patterns in the creation and growth of knowledge-intensive young firms in high-tech manufacturing, low-tech manufacturing and knowledge intensive business services (KIBS). For the purpose of this study we delineated young firms as those founded between 2001 and 2007 i.e. firms that had been established for 10 years or less at the time of the survey and also had managed to exceed the critical three-year survival threshold. At the time of the survey, then, the sample firms were between 3 and 10 years old (average firm age 6.81 years) and were established in ten European countries: Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Portugal, Sweden, and UK. The countries were selected strategically in order to include the largest four economies and some of the medium and small economies in Europe belonging into different socioeconomic configurations (e.g. Nordic countries, southern European countries, eastern European countries).

The survey targeted 18 sectors spanning the categories high tech, medium high tech, medium low tech, low tech, and knowledge-intensive services (see Annex 1).

The initial population of companies was drawn from the Amadeus database, which contains comprehensive information on over 18 million companies across Europe. This was supplemented with companies from additional data sources, namely Kompass and Dun & Bradstreet, in order to reach the pre-selected targets of sample stratification per country and sector combination.

The population extracted from all available data sources included 202,286 newly established firms, with reported primary activity in the pre-selected sectors.

To ensure the criterion of firm newness the questionnaire screened out:

- Firms that were just new legal entities, i.e. companies that have resulted from some kind of legal transformation of already extant firms

1 EU funded research project "Advancing Knowledge-Intensive Entrepreneurship and Innovation for Economic Growth and Social Well-Being in Europe" (AEGIS), 7th Framework Programme for Research and Technological Development, European Commission

· Subsidiaries of existing firms and firms that had resulted from a merger, an acquisition or a joint venture

The average response rate to the questionnaire was 31.2%, however it varied from country to country ranging from 19.5% in the UK to 39.9% in Croatia.

Data were collected through telephone interviews with one of the firm's founders carried out by a professional company using a structured questionnaire. The survey was launched in September 2010 and was completed in March 2011. During this period a pilot test of the questionnaire was run for approximately a month and 80 pilot interviews were conducted in all ten countries. This trial phase assisted considerably in checking whether the questionnaire was understandable to the respondents in different countries, testing its length and in improving its clarity. A total of 4,004 complete questionnaires were obtained, with data on almost 300 variables. Table 1 summarizes the obtained completed questionnaires per country across three categories of sectors: high tech (high and medium-high-tech), low tech (medium-low- tech and low-tech), and KIBS[2].

Table 1. Firm distribution across country and sector group

Country	Sector groups			Total
	High-tech	Low-tech	KIBS	
Croatia	29	114	57	200
CzechRepublic	26	78	96	200
Denmark	35	69	226	330
France	59	189	322	570
Germany	67	161	329	557
Greece	22	177	132	331
Italy	63	287	230	580
Portugal	29	154	148	331
Sweden	37	90	207	334
United Kingdom	56	160	355	571
Total	423	1479	2102	4004

In this paper we isolate the subsample of these new entrepreneurial firms that count among their founders at least one doctorate (Ph.D.) degree holder. These are 323 companies spread across all ten European countries. Their distribution across major sector groupings is shown in Table 2, in comparison to the sectoral distribution of non-Ph.D. founder firms. Knowledge-intensive business services account for a disproportionately large share: more than two-thirds of the Ph.D.-founder firms compared to almost half of the rest.

Table 2. Subsample characteristics

Sector group	Ph.D. Founder		Non-Ph.D. Founder	
	count	%	count	%
High-tech	50	15.5%	373	10,1%
Low-tech	45	13.9%	1434	39,0%
KIBS	228	70.6%	1874	50.9%
Total	323	100%	3681	100%

The majority of firms in both subsamples are micro firms with up to 10 people. Micro firms account for 64% of the firms in the Ph.D.-founder subsample for 60% of the firms in the non-Ph.D. founder subsample.

4. Findings

Our basic premise is that exposure of company founders to university research affects entrepreneurial incentives and behavior in ways that reflect higher levels of creation and use of scientific and technological knowledge and market niche specialization. We look at the educational levels of employees, factors affecting firm formation, funding sources, factors to create and sustain competitive advantage, overall strategic direction, sources of knowledge, and innovativeness by two groups of new companies: those founded by at least one person holding a Ph.D. degree and the rest.

2 See Annex 1 for an analytical list of sectors in the three sector groups.

4.1. Educational Level of Employees

A very first indication that firms founded by entrepreneurs exposed to university research are more knowledge intensive comes from the finding that in our sample across ten European countries and across eighteen sectors the vast majority of such firms (91%) employ university graduates with a mean number of 8 per firm compared to 63% of all other firms and a mean number of 5 such employees (university graduates)[3]. Breaking these numbers down per aggregate sector of activity, we observe sustained behavior across sectors with differences intensifying in low-tech sectors and KIBS (Table 3). Interestingly, differences increase when we look at employees with Ph.D. degrees (Table 4) where only a tiny 6% of non-Ph.D. founder firms employ a person with such a degree compared to more than three-fifths of the Ph.D. founder firms. These differences are consistent across all sector groups (Table 5).

Table 3. Firms employing people holding a university degree per sector group

Sector Group	Ph.D. Founders			Non-Ph.D. Founders		
	N	%	Mean number of university graduates per firm	N	%	Mean number of university graduates per firm
High-tech	44	88.0%	6.59	222	59.5%	5.85
Low-tech	39	86.7%	4.56	740	51.6%	3.35
KIBS	211	92.5%	9.16	1343	71.7%	6.15

Table 4. Firms employing people holding a Ph.D degree per subsample

Firm Type	Count of firms employing Ph.D. holders	% of firms employing Ph.D. holders	Mean number of Ph.D holders per firm
Ph.D Founders	226	70%	2.17
Non-Ph.D Founders	212	6%	1.84

Table 5. Firms employing people holding a Ph.D. degree per sector group

Sector Group	Ph.D.			Non-Ph.D.		
	N	%	Mean number of Ph.D. holders per firm	N	%	Mean number of Ph.D. holders per firm
High-tech	35	70.0%	2.23	25	6.7%	2.24
Low-tech	30	66.7%	1.73	57	4.0%	1.77
KIBS	161	70,6%	2,24	130	6,9%	1,79

4.2. Factors Affecting Firm Formation and Availability of Finance

The observed differences above in terms of university graduates' employment do not carry over to the factors affecting firm formation (Table 6). Similar factors lead to company formation across the two subsamples. Irrespective of the education achievement of their founders, firms are established in fields where founders have had significant prior experience and adequate market knowledge. Technical knowledge in this field, knowledge of the specific market, and networks established in prior career are

3 We would expect the differences to be even larger if the comparison population was firms founded strictly by non-university graduates.

quite important factors in setting up a company. T-tests across the two groups indicate that firms with Ph.D. founders exploit more effectively their technical and engineering knowledge in the field, while at the same time they appear to evaluate the identification and exploitation of opportunities related to changes in technologies or markets as more important factors for firm set up compared to their counterparts.

Such observations hint to a positive link between prior significant exposure to academic research and to fields of business activity that require it and a tendency to continue in the same trajectory in their newly established business. That is, a focus on more knowledge intensive market niches.

Table 6. Factors affecting firm formation

Factors	Ph.D. Founders (N=320)	Non-Ph.D. Founders (N=3658)	t-test (observed differences)
	Average rating	Average rating	
Work experience in the current activity field	4.34	4.31	0.317n.s.
Technical/engineering knowledge in the field	4.07	3.81	3.408***
Design knowledge	3.03	3.04	-0.198n.s
Knowledge of the market	3.98	4.06	-1.364n.s
Networks built during previous career	3.85	3.73	1.669n.s
Availability of finance	3.37	3.33	0.634n.s
Opportunities in a public procurement initiative	1.97	2.10	-1.779ns
Existence of a large enough customer	3.04	3.27	-2.804***
Opportunity deriving from technological change	3.23	2.95	3.349***
Opportunity deriving from a new market need	3.42	3.25	2.096**
Opportunity deriving from new regulations or institutional requirements	2.44	2.50	-0.636n.s.

*** denote statistical significance at p<1%, n.s: no significant differences observed

Table 7. Funding sources

Funding sources	Ph.D. Founders		Non-Ph.D. Founders	
	Count of firms using a specific source (N=315)	% of firms	Count of firms using a specific source (N=3605)	% of firms
Own financial resources	287	91%	3303	92%
Family member	29	9%	337	9%
Previous employer	14	4%	78	2%
Venture capital	35	11%	142	4%
Bank	60	19%	1018	28%
National government or local authorities	31	10%	250	7%
EU funds	9	3%	103	3%
Other sources	27	9%	150	4%

Table 8. Average percentage of funding

Funding sources	Ph.D. Founders	Non-Ph.D. Founders
	Average % funding	Average % of funding
Own financial resources	76.99	79.49
Family member	34.10	43.27
Previous employer	45.36	43.94
Venture capital	61.11	40.73
Bank	45.13	51.98
National government or local authorities	32.48	34.36
EU funds	27.78	34.51
Other sources	62.11	57.08

Similar observations could be made for funding sources. The two subsamples seem to behave quite similarly with the exception of greater support of new firms with Ph.D. founders by venture capital (Table 7). The difference between the two subsamples was basically compensated by a relatively larger support of firms with no Ph.D. founders by banks (implying lower risk). For those firms receiving it, venture capital funding accounted for a very significant share of funding (Table 8).

4.3. Success factors and strategy

The ranking of critical factors for creating and sustaining competitive advantage indicates that in both cases market focus and offering novel products or services dominate. For companies with non-Ph.D. holders in their founding team it appears that the capability to offer products at low cost is a more significant success factor. For companies with Ph.D. founders R&D activities, networking activities and relationships with other firms or universities take

Table 9. Factors for creating and sustaining competitive advantage

Success factors	Ph.D. Founders	Non-Ph.D. Founders	t-test
	Average rating (N=323)	Average rating (N=3521)	
Capability to offer novel products/services	3.76	3.68	1.287n.s.
Capacity to adapt the products/services to the specific needs of different customers/market niches	4.23	4.22	0.087n.s.
Capability to offer expected products/services at low cost	3.00	3.29	-4.201***
R&D activities	3.59	2.88	8.593***
Establishment of alliances/partnerships with other firms	3.26	2.92	4.407***
Capability to offer high quality product/services at premium price	3.89	3.72	2.597**
Networking with scientific research organizations	3.00	2.18	10.325***
Marketing and promotion activities	3.22	3.23	-0.035n.s

***, ** denote statistical significance at p<1%, and p<5% respectively, n.s: no significant differences observed

Table 10. Main strategy

	Ph.D. Founders (N=323)		Non-Ph.D. Founders (N=3681)	
	Count of firms	% of firms	Count of firms	% of firms
Offer standardized products and services at low cost	31	9.6%	608	16.5%
Offer unique products and services	199	61.6%	2148	58.4%
Exploit opportunities in new market niches	93	28.8%	925	25.1%

up higher importance (Table 9). Marketing and promotion activities seem to be equally important for both groups.

Main company strategy is to offer unique products and services followed by the exploitation of new market niches at some distance. Offering standardized products at low cost appears to be the least popular option for both groups. However, the percentage of firms with non-Ph.D. founders implementing the latter strategy is significantly higher compared to that of firms with Ph.D holders.

4.4. Sources of Knowledge

Clients are clearly the most important source of knowledge for indentifying business opportunities in both business groups. However, companies with Ph.D. founders assign relatively lesser role to suppliers and higher importance to internal sources of knowledge including R&D and know-how. Other external sources of knowledge such as universities and research laboratories are reported of moderate importance in both cases. However, they appear to be ranked higher by firms with Ph.D. founders. Participation in nationally or EU-funded research projects appears to be limited across the two groups. Nevertheless, these knowledge sources appear more significant for companies with Ph.D. holders in their founding team.

These findings suggest that although both groups rely mainly on external knowledge sources related to industry (clients and competitors) to explore new technological and market opportunities, firms with Ph.D. founders appear to rely more on in-house R&D activities and external knowledge sources related to science and research activities for this purpose. This may be argued to indicate a more prominent capability both in generating new knowledge and in absorbing scientific knowledge through participation in collaborative activities. Most interestingly, suppliers appear to be more important knowledge source for companies with non-Ph.D. founders suggesting that these firms try to balance their lack of internally generated knowledge with knowledge seeking activities related to industry actors.

Table 11. Sources of knowledge

Sources	Ph.D. Founders	Non-Ph.D.Founders	t-test
	Average rating	Average rating	
Clients or customers	4.40	4.41	-0.223n.s.
Suppliers	2.82	3.41	-7.639***
Competitors	3.22	3.28	-0.858n.s.
Public research institutes	2.45	2.07	5.000***
Universities	2.67	2.07	7.546***
External commercial labs/R&D firms/technical institutes	2.22	2.02	2.868***
In-house (know-how, R&D laboratories in your firm)	3.84	3.22	7.925***
Trade fairs, conferences and exhibitions	3.08	2.94	1.895n.s.
Scientific journals and other trade or technical publications	3.21	2.84	4.896***
Participation in nationally funded research programmes	2.27	1.86	5.140***
Participation in EU funded research programmes	2.11	1.85	3.293***

*** denote statistical significance at p<1%, n.s: no significant differences observed

4.5. Innovation

Three quarters of the firms with Ph.D. founders reported to have introduced new or significantly improved goods or services in the last three years compared to two-thirds of the remaining (Table 12). This was consistent across sector group, with firms in high-tech sectors leading firms in low-tech sectors followed closely by KIBS. It is important to note that innovating firms with Ph.D. founders outperform their counterparts in terms of introducing new-to-the market and especially new-to-the world innovations indicating capability to introduce more radical product innovations.

Table 12. Introduction of innovations

		Firm type			
		Ph.D. founders		Non-Ph.D. founders	
		# of firms	% of firms	# of firms	% of firms
Radicalness of Innovation	No Innovation	82	25%	1374	37%
	New-to-firm	49	15%	825	22%
	New-to-market	102	32%	1002	27%
	New-to-world	90	28%	480	13%
Total		323	100%	3681	100%

The firms in our sample generally use more informal (secrecy) or semi-informal (confidentiality agreements, trademarks) than formal (patents and trademarks) methods of intellectual property protection. Informal protection methods are often much simpler and faster to introduce than formal protection methods, and can be maintained with limited resources, which is very important especially for newly established firms. Formal protection methods require major financial and human resources if they are to be exploited thoroughly in business. Nonetheless, firms with Ph.D. founders use all methods of intellectual property protection more extensively than the rest (Table 13).

Table 13. Intellectual property protection

Methods	Firm type	
	Ph.D. founders	Non-Ph.D. founders
	% of firms	% of firms
Patents	31.5%	15.0%
Trademarks	49.8%	40.2%
Copyrights	34.9%	26.7%
Confidentiality agreements	79.7%	52.2%
Secrecy	58.5%	38.5%
Lead-time advantages on competitors	59.8%	53.1%
Complexity of design	57.7%	44.5%

It is also worth noting that companies founded by Ph.D. holders also reported higher innovative inputs in terms of R&D expenses compared to the second group. Results suggest that there is a statistically significant difference in terms of the percentage of turnover spent on R&D activities during the last three years.

4.6. Firm performance

Growth in firm size provides one measure of performance over time. Firm growth can be measured in terms of inputs (e.g. employees), value (e.g. assets) or outputs (e.g. sales revenues) (Delmar, 1997; Weinzinmer et al. 1998; (Colombo et al., 2010). We measure growth in terms of employees and sales. In addition we measured firm performance as the percentage of sales obtained in international markets during the last three years. Internationalization exposes young firms to multiple and diverse exogenous (e.g., competitive conditions) and endogenous stimuli (e.g., resource demand) (Sapienza et al., 2006). It reflects the degree of young firms' success in pursuing opportunities beyond domestic markets. Table 14 suggests that firms with Ph.D. founders outperform firms with non-Ph.D. founders in all performance measures used.

Table 14. Firm performance

Firm performance	Firm type	N	Mean	t-test (observed differences)
% Sales in International market	Ph.D. founders	323	26.04	6.466***
	Non-Ph.D. founders	3681	13.43	
Avrg. Growth Sales (quartile)	Ph.D. founders	301	5.77	2.966***
	Non-Ph.D. founders	3361	5.25	
Avrg. Growth Employment (quartile)	Ph.D. founders	306	2.29	2.589**
	Non-Ph.D. founders	3391	2.08	

***, ** denote statistical significance at p<1%, and p<5% respectively

5. Concluding Remarks

As the world economy is experiencing an unusual stage of stagnation and uncertainties, entrepreneurship and innovation are increasingly regarded as critical drivers of sustainable development. In addition, in an ever changing global environment where acculturation is fast, more attention to changing mindsets and open entrepreneurial spirit might be a prerequisite for successful individual careers, innovative performance of firms and sustainable development of nations (Vuong and Napier, 2015).

This explorative paper used a rich European dataset to take an initial look at the structure and behavior of young companies established by entrepreneurs holding advanced (doctoral) degrees. In this respect, the paper explores the formation and relative performance of new entrepreneurial ventures created by persons who have been previously exposed to academic research for a considerable amount of time. We suggest that this can be considered as a form of broadly defined academic-related entrepreneurship. We hypothesized that Ph.D. holders can be involved in "high-potential" entrepreneurial activity setting up firms focusing on the dynamic application of new knowledge. Our interest in this form of "high-potential entrepreneurship" stems from the fact that in the knowledge intensive economy this type of entrepreneurial activity matters more than ever before for economic development (Autio and Acs,

2007; Henrekson and Johansson, 2010) as it provides a link between the production of new technological knowledge and its consequent commercialization (Delmar and Wennberg, 2010). Moreover, to the best of our knowledge, empirical evidence on entrepreneurial ventures founded by Ph.D. degree holders is practically non-existent.

The paper uses data from a large-scale survey undertaken in ten European countries which reached over 4000 young, small firms established during 2001-2007 in a set of manufacturing sectors and knowledge-intensive services. About one-tenth of this population has been established by entrepreneurs holding doctoral degrees.

Our findings suggest that young European companies whose founders have been exposed to academic research indicate, on the aggregate, a fair degree of similarity in behavior to those whose founders have not had the same exposure. Important similarities between the two groups of companies include: 1) Market focus and offering novel products or services are the critical factors for creating and sustaining competitive advantage; 2) Main company strategy is to offer unique products and services followed at some distance by exploiting new market niches; 3) Clients are the most important source of knowledge.

In addition, however, our results reveal that the former group of firms (Ph.D. founders) exhibits extensive dependence on university graduates and post graduates as employees, higher reliance on venture capital funding, higher dependence on internal R&D and external scientific and research networks as sources of knowledge, better innovative performance especially in terms of new-to- the world products, increased awareness of intellectual property protection and, last but not least, better performance both in terms of both employment/sales growth and international sales.

These results are suggestive rather than conclusive as they are obtained through simple tabulations and t-tests rather than extensive econometric analysis. Nonetheless, we believe that they are indicative of important differences in behavior and performance of companies founded by people with significant prior exposure to academic research.

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Annex 1

Table I. Industry coverage in the AEGIS survey

Selected Sectors	NACE rev. 1.1 code
High-technology manufacturing sectors	
Aerospace	35.3
Computers and office machinery	30
Radio-television and communication equipment	32
Manufacture of medical, precision & optical instruments (scientific instruments)	33
Pharmaceuticals	24.4
Medium to high technology manufacturing sectors	
Manufacture of electrical machinery & apparatus	31
Manufacture of machinery and equipment	29
Chemical industry (excl pharma)	24 (excl. 24.4)
Low-technology manufacturing sectors	
Paper and printing	21, 22
Textile and clothing	17, 18, 19
Food, beverages and tobacco	15+16
Medium to low manufacturing sectors	
Basic metals	27
Fabricated metal products	28
KIBS sectors	
Telecommunications	64.2
Computer and related activities	72
Research and experimental development	73
Other business services activities	74.1, 74.2, 74.3, 74.4, 74.5, 74.8*