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ORIGINAL ARTICLE

The implications of entrepreneurship education on the careers of PhDs: evidence from the challenge-based learning approach

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ABSTRACT

We analysed the academic and business outcomes of 73 PhDs who attended an entrepreneurial education program, co-designed by two universities in collaboration with an international research center, in the last five years, and compared these results against 73 PhDs who did not attend the program. We based our analysis on a mix of quantitative and qualitative data regarding scientific and entrepreneurial achievements, as well as interviews with former program participants. Evidence from our analysis shows a positive effect of the entrepreneurial education program on the academic and business outcomes of PhDs.

Keywords: Entrepreneurship education; challenge-based learning; PhD's careers; start-ups; publications; H-index; third mission.

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INTRODUCTION

Scholars and practitioners have raised the question concerning what skills are needed for academic researchers to increase their ability to identify research topics with a higher potential impact. (Gould, 2015). The continued development of the university's Third Mission – which refers to the activities related to the transfer, exploitation and commercialisation of the results of academic research (Etzkowitz et al., 2000; Philpott et al., 2011) - has led to a revision of the classic academic skills of researchers and has required them to develop skills that allow them to have impacts with their research, to understand and solve problems with a long-term view, to exploit opportunities that arise on the market and apply the results of their research to these opportunities.

According to the literature (Muñoz et al., 2019; Rippa et al., 2020), entrepreneurship education programs are an opportunity for researchers to acquire knowledge and skills related to the business and entrepreneurial field. The literature suggests that these types of programs can provide academic researchers with the skills necessary to recognize and understand complex problems and market opportunities, enhance the value of their research findings, and communicate them (Barr et al., 2009).

In this framework, the European Union has pointed out the importance of focusing on entrepreneurship education, for both academics and non-academics, and, consequently, has underlined the need to a more diffused integration of entrepreneurship programs in higher education institutions (European Commission, 2008).

Building on this, several programs, designed specifically for researchers, have emerged. However, only a few studies have investigated the impacts of such courses on researchers. Moreover, these studies have mainly focused on changing in entrepreneurial mindset – e.g. entrepreneurial intention and self-efficacy – and on the skills acquired by PhD students during the programs, and have neglected the possible impacts on academic and non-academic performances (Duval-Couetil et al., 2020; Thursby et al., 2009). These studies have shown that one of the key elements allowing PhD students to learn business skills is learning together with people from different backgrounds, such as MBAs and JDs (Juris Doctors). On a parallel ground, previous studies show how academics can perceive entrepreneurial activities as a shift from their academic's duties to less critical activities (Kalar & Antoncic, 2015). This lack of engagement in entrepreneurial activities could have negative effects for the society, given the contribution of startups created from academic activities to regional development (Caree et al., 2014; Battaglia et al., 2020) and the higher research performances of academic entrepreneurs with respect to non-academic entrepreneurs (Fini et al., 2021). This call for a deeper understanding of the effects of entrepreneurship education on the academic performances of PhDs.

Yet, to the best of our knowledge, there is still no evidence on how these programs can affect the performances of the researchers who have taken part in them. More precisely, there is no evidence on how entrepreneurial education can enhance academic performances, pertaining to, for example, the number and quality of publications, or to business performances

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concerning, for example, the transfer of knowledge from research to the market through start-ups.

This research aims to fill this gap and take a first step toward understanding the effect of entrepreneurship programs on the career performance of academics. To do this, a mixed methodology has been used to measure the effect of entrepreneurial education programs on PhD's academic performance, such as number and quality of publications, and the transfer of knowledge from research to market, by analysing the number of created start-ups.

The research questions we aim to answer are:

R1: Do entrepreneurship education programs have an effect on the academic performance of researchers?

R2: Do entrepreneurship education programs affect the decision of researchers to create a start-up?

THEORETICAL BACKGROUND

In recent years, entrepreneurship programs targeting academic researchers have been gaining more and more momentum (McNabola & Coughlan, 2014). Scholars and practitioners alike have highlighted the relevance of entrepreneurship education for academics (Duval-Couetil & Wheadon, 2014).

The role of academic researchers is increasingly changing as it requires the academic and business competences to be combined in order to exploit the business opportunities which arise from the results of research, ease the technology transfer process and promote the Third Mission at the university level. (Miller et al., 2014). Bearing this in mind, one proposed solution has been to encourage the participation of researchers, as doctoral students and postdocs, in entrepreneurial education courses. These programs, if properly structured, allow researchers to acquire different skills from those accumulated in academia or during doctoral studies (Duval-Couetil et al., 2020).

Several programs have been created in response to the call for more commitment to entrepreneurial education, especially in academia. In their 2009 paper, Barr et al. outlined the best practices gained after fourteen years of TEC, an entrepreneurship course designed for researchers and students in the Science, Technology, Engineering and Mathematics (STEM) fields and for MBAs. Barr and colleagues highlighted four points that are essential for the effectiveness of the program:

- **Reality**: the program should allow students to work on real problems and on technologies that actually exist, or are under development, so that they can develop a real company.
- **Intensive**: the program should reflect real world issues.
- **Interdisciplinary**: the teams should be composed of students with different backgrounds, e.g., STEM, Business, etc.
- **Iterative**: the program should teach students how to perform multiple iterations on the idea they are working on.

An interesting insight into the effects of entrepreneurship education programs on academic researchers is provided by the TI:GER program (Thursby et al., 2009). This program is based on the collaboration of PhD students, MBAs and JDs in order to bring the thesis topics of PhD students to the market. The program aims to train PhD Students, MBAs and JDs and create synergies between their different backgrounds to foster a career in innovation-related fields. From the questionnaires administered pre and post course, it was found that this course had a positive effect on the participants, helping to smooth out the differences in terms of skills related to the exploitation of a new technology. Moreover, in addition to improving researchers' skills, this program also had a positive effect on the entrepreneurial intention and self-efficacy of researchers (Duval-Couetil et al., 2020). However, the study on TI:GER program only focused on differences in skills and did not explain the mechanisms and synergies that can arise from possible cross-pollination between the various backgrounds and did not analyse the longer-term effect on the attendants career performance.

Building on this, this paper aims to understand whether entrepreneurship education programs could have an impact on the performance of the researchers who attend them. Moreover, the aim is also to understand whether this kind of program could improve the number and the quality of the publications of PhDs and their business performance concerning the creation of startups.

METHOD AND DATA

Data and Methodology

Data set includes 146 PhDs from Politecnico di Torino. 73 PhDs has attended a challenge-based entrepreneurial education program (treated sample) while the other 73 did not (control sample).

The course attended by the PhDs is called Innovation for Change (I4C), jointly developed by the Collège des Ingénieurs, CERN IdeaSquare and the Politecnico di Torino. I4C is a challenge-based entrepreneurial education program in which teams composed of MBAs and PhDs collaborate to create solutions (based on brand new technologies and with a societal and economic viewpoint) to real high social impact problems according to a long-term view, proposed by large companies and organizations. To solve the problems proposed, teams are invited to work for 20 weeks on a solution that could be implemented in 20 months, and which could have an impact on real world on 20 years. The objective of this structure is to help participants link present activities to long term global challenges that are outside the radar of most of for-profit start-ups.

We collected demographic data and information related to academic and business performance for each PhDs in the sample. The demographic data were collected from public sources available on Politecnico di Torino website while information on academic performance like the number of publications, the h-index and the number of founded start-ups were collected from Scopus and LinkedIn.

Using demographic data related to the PhDs who attended I4C, we create a control sample of PhDs who did not attend the program. The control sample was created pairing each PhDs who attended I4C with a PhD with similar demographic variables, to avoid significant differences from the treated sample. The demographic variables used to build the control sample were gender, doctoral cycle, doctoral field, master's degree earned and nationality (Italian vs Not-Italian). Possible differences between the two groups were tested using a t-test for each demographic variable. No significant differences were observed between the two samples.

The descriptive statistics concerning gender, doctoral field and nationality are shown in Tables 1 - 2. Females represent the 28,77% of the sample while Not-Italians represent the 21,92%. As expected, most students belong to the Engineering field while only a few belong to the Architecture field.

To answer our research questions, we perform econometric regression analyses. More precisely, we use both linear regressions (OLS) and negative binomial regression, to account for the discrete and non-negative nature of our dependent variables.

Finally, 9 interviews were conducted with former I4C participants to establish any further effects of the program and help us highlight the mechanisms affecting the PhDs' learning process and interpret the results of our quantitative analysis. The semi-structured interviews were focused on the following areas:

- Background and current employment of the PhDs
- Their experience in the program and with their team.
- Effects of the program on their career.

Table 1. Percentage of PhDs according to their gender and nationality

Variable	Treated sample (n)	Control sample (n)	Overall sample (n)	Overall sample (%)
Male	*52*	*52*	*104*	*71,23 %*
Female	*21*	*21*	*42*	*28,77 %*
Italian	*56*	*58*	*114*	*78,08%*
Not-Italian	*17*	*15*	*32*	*21,92%*

Table 2. Percentage of PhDs according to their doctoral field

Variable	Treated Sample (n)	Control sample (n)	Overall sample (n)	Overall sample (%)
Architecture. history and project	*4*	*4*	*8*	*5,48%*
Architectural and landscape heritage	*2*	*2*	*4*	*2,74%*
Energy	*8*	*8*	*16*	*10,96%*
Physics	*2*	*2*	*4*	*2,74%*
Management, production and design	*5*	*5*	*10*	*6,85%*
Aerospace engineering	*5*	*5*	*10*	*6,85%*
Environmental engineering	*1*	*1*	*2*	*1,37%*
Chemical engineering	*10*	*10*	*20*	*13,70%*
Civil engineering	*1*	*1*	*2*	*1,37%*
Electrical, electronics and communications	*14*	*14*	*28*	*19,18%*
Computer and control engineering	*8*	*8*	*16*	*10,96%*
Mechanical engineering	*8*	*8*	*16*	*10,96%*
Metrology	*1*	*1*	*2*	*1,37%*
Materials science and technology	*3*	*3*	*6*	*4,11%*
Urban and regional development	*1*	*1*	*2*	*1,37%*

Dependent variables

We performed regression analysis using three different dependent variables. The descriptive statistics of the dependent variables are shown in Table 3.

We used the number of publications and the h-index as dependent variables for the first research questions. Number of publications is a traditional proxy for scientific productivity (Toole & Czarnitzki, 2010). In the same vein, h-index is a frequently used proxy to assess both productivity and impact of scholars (Hirsch, 2005; Cimenler et al., 2014).

We used the number of start-ups founded by PhDs as dependent variable for the second research question. We choose number of startups as the creation of startups is one of the key mechanisms exploited by universities to transfer and commercialize the results of academic research (Colombelli, 2016; Ricci et al., 2019; Linton & Xu, 2021).

As for the treated group, number of publications and start-up created refers to the publications published, and the start-ups founded after attending I4C. As for the control group, data were collected from the year in which the pair attended I4C. To test possible differences in the number of publications and startup created before the program between the two groups we run a t-test on the means. We found no significant differences between the two sample with respect to these two variables. Finally, H-index refers to the h-index of the PhDs at the time of the data collection, both for the treated and control group. Fig. 1, Fig. 2 and Fig. 3 show the distribution of the number of publications, the h-index and the number of start-ups created for the two groups.

Table 3. Dependent variables

Variable	Mean	Variance	Min	Max
Number of publications	*3.192*	*15.300*	*0*	*27*
H-index	*2.116*	*4.12*	*0*	*8*
Number of start-ups founded	*0.034*	*0.033*	*0*	*1*

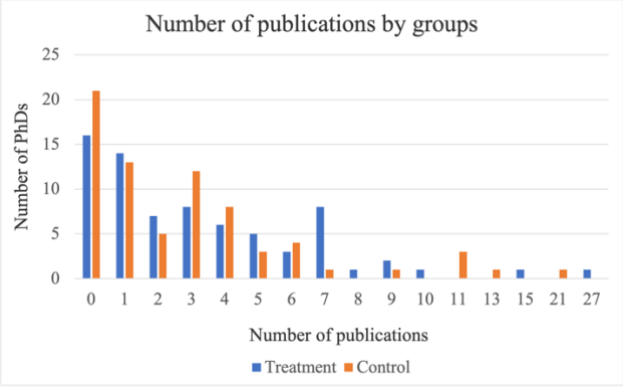

Fig. 1. Number of publications distribution for the two groups.

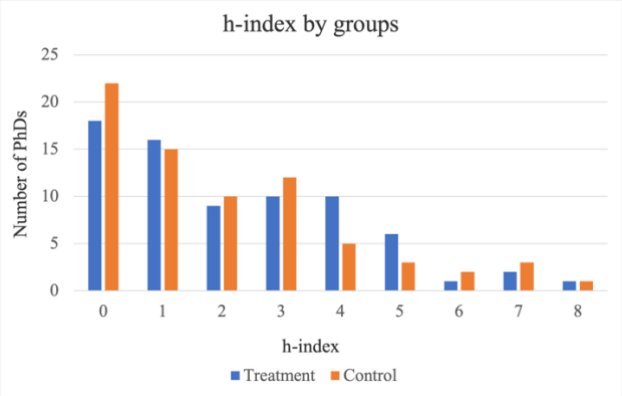

Fig. 2. H-index distributions for the two groups.

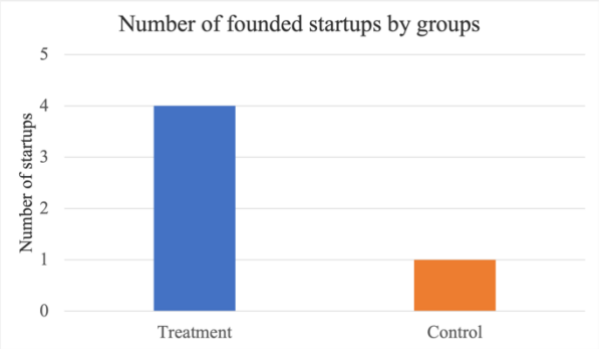

Fig. 3. Number of startups created in the two groups

Independent and control variables

Participation in the I4C course was used as key independent variable in the regression analyses. Moreover, we introduced control variables for doctoral fields and whether a PhD is an academic with a tenure-track position, without a tenure-track position or is no more working as a university researcher (Fini et al., 2021)

These control variables were used to avoid confounding effects related to any differences in the number of publications between the field of research and incentives in publications and creating start-ups among academics and non-academics. Moreover, we introduce year of enrolment in I4C as an additional variable, in order to control for different time spans for publishing and founding a start-up.

Table 4 shows how the variables were measured and defined.

Table 4. Independent and control variables

Variable	Description	Value
I4C	*The PhD researcher has taken part in I4C*	*1 if he/she has taken part in I4C, 0 otherwise*
Academic without tenure-track position	*The PhD is an academic without a tenure-track position*	*1 if he/she is still an academic without a tenure-track position, 0 otherwise*
Academic with tenure-track position	*The PhD researcher is an academic with tenure-track position*	*1 if he/she is still an academic with a tenure-track position, 0 otherwise*
Is no more an academic	*The PhD is no more a university researcher*	*1 if he/she is no more a university researcher, 0 otherwise*
Year of enrolment in I4C	*Year of enrolment in I4C*	*Year in which he/she has attended I4C*
Doctoral Field i	*Field of research i*	*1 if the PhD works in research field i, 0 otherwise*

RESULTS

Results of the regression analyses are shown in Table 5. The results show a positive effect of the program on the performance of the PhDs.

More precisely, as shown from column (1) to (4), participation in I4C has a positive and significant effect ($p<10\%$) on the number of publications and h-index.

This result reveals a positive correlation between entrepreneurship programs and the academic performance of the PhDs who attended the course. The results in columns (5) and (6) show that the program had a positive effect on number of start-up created by participants, although these results are not significant.

To better understand how the entrepreneurship program affect PhD's performances, we analysed the evidence that emerged from the interviews. The main results are:

1. The PhDs underwent a cross-pollination with the MBA approach to innovation.
2. PhDs achieved a greater ability to frame and solve complex problems.
3. PhDs increased their ability to present their research.

An interesting insight that has arisen from points (1) and (2) is related to the cross-pollination between MBAs and PhDs. During the I4C program emerged the cognitive distance between these two figures, especially in the way they face and solve complex problems. An example of this can be found in an excerpt taken from one of the interviews.

> "You could see a very different approach to problems. I saw them [MBA students] taking a much more practical approach, whereas the other PhDs and I were more anchored in the feasibility of things. Maybe it's a kind of mindset, but I saw them as being much more involved in the idea. Having a good idea and then maybe working on it later on to make it feasible, whereas the other guys and myself had the opposite approach, which was to have a feasible idea and then improve it. … The approach I had at the time was fine, but if we are talking about innovation, not incremental innovation, we need an approach like theirs, which was really ahead."

Concerning point 3, the course seems to have improved communication skills, as can be seen from an excerpt from the interviews.

> "The communication part gave me a lot, including things I took home for academic research. In the academic world, you usually don't pay much attention on communication: you usually do the presentation; the data are available, you present them and that's it, and in the meanwhile everybody has fallen asleep. Instead, the way things are presented acquires a certain importance because, even though the information is very technical, you have to transmit it. Now, when I make a presentation it's not like before; students and researchers are too focused on the results and not in the way they are presented. However, now I suffer from a form of paranoia. … It's no longer two slides, but I want to make it clear why the thing I'm publishing is relevant."

Tab. 5. Regression analysis on the performance

Dependent Variable	Number of Publications		h-index		Startup Created	
Variable	(1) OLS	(2) Negative Binomial	(3) OLS	(4) Negative Binomial	(5) OLS	(6) Negative Binomial
I4C	*0. 913*** (0.002)*	*0.344*** (0.000)*	*0.255* (0.084)*	*0.123* (0.068)*	*0.041 (0.103)*	*1.390 (0.256)*
Academic without tenure	*1.036 (0.452)*	*0.326 (0.191)*	*0. 210 (0.702)*	*0.092 (0.580)*	*-0.0289 (0.676)*	*-0.195 (0.917)*
Academic with tenure	*-0.722 (0.636)*	*-0.161 (0.559)*	*-1.269 (0.136)*	*-0.437 (0.131)*	*-0.078 (0.242)*	*-18.600*** (0.000)*
Constant	*3.204 (0.104)*	*-13.662*** (0.000)*	*2.532*** (0.001)*	*-14.177*** (0.000)*	*0.0777 (0.386)*	*-3.288 (0.509)*
Observations	*146*	*146*	*146*	*146*	*146*	*146*
R-squared	*0.417*	-	*0.545*	-	*0.139*	
Dummies for the Doctoral Field	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Dummies for year of enrolment in I4C	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Clustered Errors	*I4C Doctoral Field*	*I4C Doctoral Field*	*I4C Doctoral Field*	*I4C Doctoral Field*	*I4C Doctoral Field*	*I4C Doctoral Field*

*Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1. Baseline: Is no more an academic*

DISCUSSION AND CONCLUSIONS

Our results offer to policymakers and researchers in universities new knowledge helpful to improve, grow and spread this type of programs. The regression analyses showed that the entrepreneurial courses led researchers to perform better than those who did not participate in the course. The impact on academic performance appears to be twofold, an increase in the number of publications and in their quality. The most interesting result is related to the positive impact of these courses on the h-index of the researchers.

Such an increase in the quality of publications could be related to a better understanding of their field of research, the potential of the obtained results and also to the way in which they are presented. In addition to the academic skills of the researcher, this higher quality of productions could be related to the business skills learned during the course and the cross-pollination with students who have a business background. Furthermore, these are important implications for universities and policymaker, to foster this kind of programs and to enhance engagement through entrepreneurial activities among academics.

On the other hand, regression analysis also shows that the course had a positive but not significant effect on the number of start-ups created by researchers who took part in it. This result should be interpreted with care given the size of the selected sample and the number of start-ups founded in the sample.

Moreover, the interviews with former participants revealed several insights into the effects of the program on researchers. Results reveal that the cross-pollination between PhDs and MBAs shifts the way researchers approach complex problems. This could imply a change in the working approach of researchers, moving from an approach related more to product development to one focused more on understanding the problem that has to be addressed. Such an approach could therefore lead researchers to focus first on the general understanding of the problem, rather than focusing immediately on a solution, thus limiting the possible opportunities of a research area. This is another important implication for universities and policymaker in order to create and promote more structured and impactful entrepreneurship educational program for researchers.

This work is not without limitations. Indeed, it has not taken into account any possible self-selection effects within the sample. A possible self-selection of researchers toward entrepreneurship issues could contaminate the effects obtained from the regression analyses, especially those related to the number of founded start-ups. Moreover, data do not allow to account for start-ups stage of development or outcomes. This is an interesting avenue for future research.

This work is intended as a starting point for future research on the link between researchers' performance and entrepreneurship courses. The evidence obtained from this study shows that this type of program has a positive effect on the researchers' performance. Future research could extend this work by using a larger database or studying entrepreneurship programs involving even PhD from non-technical fields, to test other sources of cross-pollination. Moreover, future research could analyse the effect of entrepreneurship education by relying on other academic performance, such as number of grants achieved. Finally, in order to limit possible self-selection issues, future studies could measure the characteristic traits of entrepreneurs in order to build a sample that would limit such effects.

Despite its limitations, this work aims to be a point of reflection for policymakers and universities on whether to improve and foster challenge-based programs in entrepreneurship for PhD students.

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