



Organisation for Economic Co-operation and Development

DSTI/CIIE(2018)13/FINAL

Unclassified

English - Or. English

14 May 2019

**DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INNOVATION
COMMITTEE ON INDUSTRY, INNOVATION AND ENTREPRENEURSHIP**

PUBLIC RESEARCH AND INNOVATIVE ENTREPRENEURSHIP

Preliminary cross-country evidence from micro-data

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JT03447431

OECD SCIENCE, TECHNOLOGY AND INDUSTRY WORKING PAPERS

This paper was approved and declassified by the Committee on Industry, Innovation and Entrepreneurship on 15/11/2018 and prepared for publication by the OECD Secretariat.

Note to Delegations:

This document is also available as
OECD Science Technology and Industry Policy Paper No. 2019/64

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PUBLIC RESEARCH AND INNOVATIVE ENTREPRENEURSHIP: PRELIMINARY CROSS-COUNTRY EVIDENCE FROM MICRO DATA

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ABSTRACT

This paper provides a first assessment of the degree to which public research contributes to innovative entrepreneurship, using data on start-ups and venture capital (VC). It looks at academic start-ups founded by recent undergraduates and doctorate students or researchers. It shows that academic start-ups represent 15% of all start-ups in the specific sample under scrutiny. Their share is higher in science-based technological fields such as biotechnology (23%). Across the majority of countries and technology fields, start-ups created by undergraduate students represent the highest share of all academic start-ups. As to their performance, start-ups founded by researchers are more likely to patent and those founded by students introduce innovations that are more radical compared to other start-ups. While start-ups founded by undergraduate students receive less VC funding and are less likely to exit via IPO or acquisition, those created by researchers are as successful as their non-academic counterparts.

Keywords: public research, innovative entrepreneurship, knowledge transfer, academic entrepreneurship, student entrepreneurship

JEL codes: L26, O30

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Executive Summary

While substantial resources are invested in public research funding with the explicit objective of fostering knowledge diffusion from public research institutions to innovative entrepreneurship, very little is known on the extent to which innovative start-ups build upon public research. This report provides a first assessment, using detailed micro data on innovative start-ups and venture capital (VC) deals. Public research institutions (RIs) – including higher education institutions and other public research institutions – can affect innovative entrepreneurship by offering new ideas and human capital needed for successful entrepreneurial ventures.

This work provides evidence on the relative importance of “academic start-ups” – defined as start-ups founded by recent undergraduates and doctorate students or researchers, and investigates how academic start-ups differ from similar start-ups. It provides initial answers to the following questions: compared to similar businesses, (i) Are academic start-ups more (or less) innovative?, (ii) Are they more (or less) successful?, and (iii) Are they more (or less) inclusive?

The evidence shows that academic start-ups account on average for 14% of all start-ups in the specific sample under scrutiny (15% among VC recipients). Their share is higher in science-based technological fields, e.g. they account for 23% of all start-ups in biotechnology and science and engineering (and 24% when sample is restricted to VC recipients). While in these specific fields most academic start-ups are founded by experienced researchers (55 and 40% respectively), across the majority of countries and technology fields start-ups created by undergraduate students account for the highest share of all academic start-ups (60%, and 54% when sample is restricted to VC recipients).

Academic start-ups identified in Crunchbase present some interesting differences from comparable non-academic counterparts in the following ways:

- Start-ups founded by researchers are more likely to patent and those founded by students introduce innovations that are more radical as defined by the extent to which a patent differs from other inventions it relies upon.
- While start-ups founded by PhD and undergraduate students are funded less often and with lower amounts, ventures founded by academic researchers are not significantly different from non-academic start-ups in terms of success indicators (VC deals and exit).
- Academic start-ups are more likely to be located within the same urban areas of the PRI they emanate from, which points to the importance of the spatial characteristics of knowledge spillovers.

1. Introduction

Successful innovations often introduced by high-growth start-ups are responsible for a disproportionate amount of job creation and productivity growth (Wong, Ho and Autio, 2005). Start-ups are more effective in exploiting new technologies and introducing radical innovations (Almeida and Kogut, 1997^[1]; Baumol, 2004^[2]; Zucker, Darby and Peng, 1998^[3]). Recent OECD work has also shown that a tiny share of young firms contribute disproportionately to job creation across OECD countries (Criscuolo, Gal and Menon, 2014^[4]; Calvino, Criscuolo and Menon, 2015^[5]). However, the enabling factors of innovative entrepreneurship are still being explored, and it is unclear for policymakers which levers can and should be activated. Streamlining the linkages between public research and start-up creation is one of them.

The primary objective of funding public research institutions is advancing and disseminating knowledge – which is important for the society as a whole and has wider benefits, well beyond its effects on fostering innovative entrepreneurship. However, innovative entrepreneurship is an important additional outcome, and it can be the most important vehicle through which public research outputs make it to the market.

Many countries have public programmes to explicitly encourage the creation and development of academic start-ups. However, the relative success of academic entrepreneurship – especially in the context of the current digital transformation – and the channels through which this arises are still being investigated. For instance, some observers argue that innovative entrepreneurship is today much less dependent on public research than was the case in the past.¹

This report provides a first assessment of the degree to which public research contributes to innovative entrepreneurship, measured using detailed venture capital data. Research institutions (RIs) – including higher education institutions and other public research institutes – contribute to innovative entrepreneurship by offering new ideas and human capital needed for successful entrepreneurial ventures. This adds to other indirect channels through which public research benefits innovative entrepreneurship and innovation including in particular the knowledge created and shared via publications and at conferences.

This report focuses on innovative start-ups (ISUs) created by recent university graduates, doctorate students, and researchers, leveraging on Crunchbase, a data source on start-ups and their founders increasingly used by academic researchers and investors and whose coverage is sufficiently exhaustive for OECD and BRICS countries in recent years (Dalle, den Besten and Menon, 2017^[6]). In our context, ISUs are understood as young firm listed in Crunchbase and thus actively looking for VC funding. ISUs created by founders belonging to the categories above are labelled “academic start-ups”. The paper explores the characteristics of academic ISUs as identified in Crunchbase and compares them to other similar ISUs. It provides initial answers to the following questions: (i) Are academic ISUs more innovative?, (ii) Are they more successful?, and (iii) Are they more inclusive?

Building on these definitions, the paper contributes to the existing literature in several ways. First, it provides new cross-country evidence on academic and student entrepreneurship. The latter phenomenon, in particular, has been very little studied so far (Ástebro, Bazzazian and Braguinsky, 2012^[7]). Second, differently from the extant literature, this paper specifically focus on the performance of academic ISUs once created and on the extent to which they contribute to inclusiveness. It also discusses several avenues for further research that can originate from this study.

The project is complementary to a number of other projects of the OECD Directorate for Science, Technology, and Innovation (DSTI). The OECD Committee for Scientific and Technological Policy (CSTP), with the contributions of the Working Party of National Experts on Science and Technology Indicators (NESTI) and the Working Group on Innovation and Technology Policy (TIP), have been developing a wealth of indicators and quantitative analyses to explore the linkages between public research and private innovation. Work on industry-science linkages is at the heart of TIP work for more than a decade; see for instance OECD (2013^[8]; 2003^[9]). The 2018-19 project focused on assessing the impacts of public research and mapping the policies in support of knowledge transfer (OECD, 2019^[10]; Guimon and Paunov, 2019^[11]; Borowiecki and Paunov, 2018^[12]; Borowiecki and Paunov, 2019^[13]; Paunov, Planes-Satorra and Moriguchi, 2017^[14]).

This report is exploratory and scoping work, given that the project will continue under the next Programme of Work and Budget (2019-20) of the CIIE, in close collaboration with the other OECD bodies mentioned above.

The main findings of the paper are the following. In Crunchbase, academic ISUs account on average for around 14-15% of all ISUs created between 2001 and 2016. Their share is higher in science-based technological fields, e.g. they account for 23-24% of all ISUs in biotechnology and science an engineering. While in these specific fields most academic start-ups are founded by experienced researchers (55 and 40% respectively), across the majority of countries and technology fields start-ups created by undergraduate students account for the highest share of all academic start-ups (60%, and 54% when sample is restricted to VC recipients).

Furthermore, the three different categories of academic start-ups present some interesting differences from their non-academic analogues. For instance, ISUs founded by researchers are more likely to patent and those founded by students introduce innovations that are more radical, radicalness being defined by the extent to which a patent differs from other inventions it relies upon . Conversely, ISUs founded by researchers are not significantly different from non-academic ISUs in terms of success indicators (VC deals and exit). ISUs founded by academic researchers actually appear to be slightly more successful than ISUs created by founders with a comparable education curriculum. This is also true when the whole team of founders is composed of academic researchers only, suggesting that academic ISUs are not critically hampered by a purported lack of management skills. Finally, in general academic ISUs are more likely to be located within the same urban areas of the RI they emanate from, which points to the importance of knowledge spillovers.

The paper is structured as follows. The second section illustrates the conceptual framework and the policy relevance of the topic, with reference to the relevant economic literature, and poses several questions to be investigated empirically. The third section describes the data and the methodology used in the empirical analysis. The fourth section reports and comments on the results.

2. Conceptual framework

2.1. Policy relevance

This work is relevant for policy for several different reasons. First, there is a lively debate on whether fostering academic entrepreneurship – both student entrepreneurship and entrepreneurship emanating from researchers - should receive more policy attention. Widening the evidence base in this area is useful and timely for policy making in particular in the European Union, in light of the debate on a possible “innovation paradox” of a dynamic public research sector confronted with an unsatisfactory business innovation performance. For instance, the delay with which European countries and Japan are attracting equity investments in artificial intelligence, compared to e.g. People’s Republic of China (hereafter “China”) and United States (OECD, 2018_[15]), could be a symptom of this innovation paradox. On the other hand, it might be that public research is at cause by insufficiently fostering innovative entrepreneurship. Assessing the magnitude of academic entrepreneurship can fruitfully inform this important debate.

A better understanding of the mechanisms through which public research affects innovative entrepreneurship may also be useful for policymaking. First, it may better inform the policies underlying the allocation of public research funds across areas and institutions, in the light of their impact on innovative entrepreneurship. Second, it may help address bottlenecks and inadequate innovation performance in some countries, regions, or technologies. Third, it may inform the design of entrepreneurship policies. Fourth, to the extent that knowledge spillovers may propagate beyond national boundaries, it may highlight market failures and the risk of sub-optimal underinvestment in public research provision, calling for supranational coordination and multilateral agreements.

Above and beyond the economic benefits of innovative entrepreneurship in terms of productivity, employment, and growth (Haltiwanger, 2012_[16]; Haltiwanger, Jarmin and Miranda, 2013_[17]; Calvino, Criscuolo and Menon, 2015_[5]; Criscuolo, Gal and Menon, 2014_[4]), innovative start-ups can play a disproportionately important role in meeting broader environmental and social objectives² e.g., start-ups may be more effective in exploiting new technologies and introducing radical innovations, which can help address some of the major policy challenges of our times (e.g., climate change, aging society).³

Innovative entrepreneurship can also promote inclusiveness, and this issue is also high in the policy agenda given growing concerns that economic inequality would undermine social cohesion. For instance, there is evidence that innovative entrepreneurship fosters social mobility in the United States (Aghion et al., 2018_[18]), while minority communities, particularly those of South/East Asian origin, have played increasingly important roles in US science and technology sectors (Stephan and Levin, 2001_[19]; Chellaraj, Maskus and Mattoo, 2008_[20]; Stuen, Mobarak and Maskus, 2012_[21]).

At the same time, the gender gap in entrepreneurship is striking and persistent. Across OECD and BRIICS countries, less than 15% of innovative start-ups list at least one woman in the founders’ team. Recent research focusing particularly on start-ups funding shows that companies with one or more women in the team of founders are less likely to have access to risk finance by 5 to 10% compared to men-only led start-ups. Furthermore, conditional on receiving funding, the total amount is lower by around 30% (Breschi, Lassébie and Menon, 2018_[22]).

Universities and public research institutions can be better placed to promote meritocracy and social mobility than other areas of the public and private sector because the outcomes are easily measurable, especially in scientific fields (e.g., through journal ranking and the impact factor of publications). Furthermore, universities have the explicit mission of promoting pluralism and diversity of views. Because of that, they can play an important role in fostering a more inclusive, diverse, and gender-balanced entrepreneurship. Conversely, the persistent gender gap in STEM (science, technology, engineering, and mathematics) disciplines in academia may be one factor hampering female entrepreneurship. The OECD's project on inclusive innovation has identified policy initiatives implementing "inclusive innovation policies" – a specific set of innovation policies that aim to boost the innovation capacities and opportunities of individuals and social groups that are underrepresented in innovation, research and entrepreneurship activities. Their goal is that all segments of society have opportunities to successfully participate in and benefit from innovation (here termed "social inclusiveness"): i) fostering the integration of disadvantaged groups in innovative activities and ii) addressing barriers to entrepreneurship encountered by disadvantaged groups (Planes-Satorra and Paunov, 2017^[23]; OECD, 2017^[24]).

The policy relevance of this analysis is also motivated by the fact that the funding to public research across OECD countries is substantial. For instance, the total budget of the European Union (EU) Horizon 2020 Research and Innovation programme is nearly €80 billion over a seven years period (2014 to 2020). This important investment, according to the programme description, "promises more breakthroughs, discoveries, and world-firsts by taking great ideas from the lab to the market". It is also explicitly mentioned that the programme should "make it easier for the public and private sectors to work together in delivering innovation".⁴ The situation is similar in the United States: the National Science Foundation (NSF) has an annual budget of USD 7.5 billion, and it is the funding source for approximately 24% of all federally supported basic research conducted by America's colleges and universities. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.⁵

Although these programmes typically target a broad, long-term education and research outcome, innovative entrepreneurship is considered one of the channels through which their effects are conveyed to society (Meyer, 2006^[25]; Shane, 2004^[26]; Acs, Audretsch and Lehmann, 2013^[27]; OECD, 2013^[8]). As Lööf and Broström (2006^[28]) put it, "even if universities in general are in the business of the creation and free dissemination of knowledge 'for its own sake' [...], it is naturally unsatisfactory if the largest sector for basic research in the society is not properly evaluated." Therefore, assessing the extent to which innovative entrepreneurship builds on academic research is one of the possible ways to evaluate their impact on society.

Many OECD member countries are also developing direct policy initiatives to support academic entrepreneurship. France, in particular, offers two interesting examples in this context: the status of "young academic firm" (*Jeune Entreprise Universitaire*), which entitles to tax credits and other benefits; and the "Deeptech Founders" programme, described in Box 1. Italy also offers favourable conditions to start-ups with a preponderant share of staff with master or PhD, within the policy framework for innovative entrepreneurship known as "Start-up Act" (Menon et al., 2018^[29]). In Greece, a new initiative was launched in 2016 aimed at providing equity capital to spin-offs: EquiFund invests public money in private sector led, market-driven venture capital and private equity funds that target Greek start-ups. The fund operates with three investment windows according to the maturity level of the business proposal: 1) the Innovation Window for the

earlier stages of commercialisation or research results; 2) the Early Stage Venture Capital Window for seed capital and start-ups; and 3) the Growth Window for expansion and growth of established SMEs. The UK Innovation and Commercialisation of University Research (ICURe) programme, launched as a pilot by Innovate UK in 2014 to support teams of academic researchers, offers training for project teams in developing appropriate commercialisation strategies for research and seed capital. More detail on these policy case studies and others have been gathered as part of the TIP Working Party's project on knowledge transfer (see DSTI/STP/TIP(2018)/11 for an initial overview).

Box 1. Deeptech Founders: the French policy initiative to foster academic entrepreneurship

France is experiencing difficulty in translating its world-class research into marketable innovation. BPI France, the French Public Investment Bank, and Hello Tomorrow, a non-profit organisation engaged in fostering innovation and start-ups in deep tech⁶, have recently announced a partnership to support researchers willing to bring their ideas to the market.

The consortium developed a four-month curriculum organized around 2 phases. The first phase consists in a theoretical training based on the experiences of other academic entrepreneurs. The second part is devoted to practical training and includes meetings with prospective funders and contractors. In both parts of the programme, successful scientific start-up founders and other industrial actors mentor the would-be entrepreneurs.

The goal of the programme is twofold. First, it is designed to help researchers find business opportunities for their technologies, and assess the viability of the project. Second, it aims to encourage them network with accomplished entrepreneurs from the academic world and potential future partners. The more general goal of the programme is to promote a more open mindset towards entrepreneurship among French researchers and to build bridges between academia and industry.

Sources: Vincent Fago, “Bpifrance et Hello Tomorrow forment des chercheurs à l’entrepreneuriat”, April 9th, 2018, *Le Monde*; Press release of BPI France on April 10th, 2018, available at <https://presse.bpifrance.fr/hello-tomorrow-lance-le-programme-deeptech-founders-en-partenariat-avec-bpifrance/>; <http://deeptechfounders.fr/> (visited on 7 September 2018).

2.3. Overview of the existing evidence

The literature relevant for the proposed analysis is organised around three main axes: the links between public research and private innovation in general; academic spin-offs; and inclusive entrepreneurship .

Linkages between public research and private sector innovation

A seminal paper by Jaffe (1989_[30]) finds a significant effect of university research on corporate patents, particularly in pharmaceutical and medical research, and in electronics, optics, and nuclear technology. University research appears to also have a further indirect effect on local innovation by fostering industrial R&D activity. Later studies – using firms’ product and process innovations, instead of patents, as a measure of innovative activity – confirmed Jaffe’s finding (Acs, Audretsch and Feldman, 1992_[31]; Feldman and Florida,

1994^[32]; Cowan and Zinovyeva, 2013^[33]).⁷ Several studies have shown the substantial decline in knowledge spillovers with distance, both for the specific case of RIs and more generally. For instance, Andersson, Quigley and Wilhelmsson (2009^[34]) exploit the decentralisation of post-secondary education implemented in Sweden over the 1990s and the 2000s and find that knowledge spillovers from university are substantial, but they decline rapidly; roughly half of the productivity gains from these investments are bounded within 5-8 km of the community in which they are made. Belenzon and Schankerman (2013^[35]) also find that citations to university patents decline sharply with distance.

More recently, the complex and circular interconnection between university research, tertiary education, and private innovation has been rationalized under the heading of “Knowledge Triangle”. The knowledge triangle is a policy framework that stresses the need for an integrated approach towards research, innovation and education policies, and attributes a central role to higher education institutions in fostering the integration of innovation, research and educational activities. The knowledge triangle concept draws attention on the reciprocity of the contributions of education, entrepreneurship, and research to each other.

Academic entrepreneurship

Academic entrepreneurship has been identified as an important channel for knowledge transfer between industry and science and received much increased policy attention. Spin-offs from research are the best-known form of academic entrepreneurship. Differently from a model whereby universities “transfer” knowledge to private companies, this model directly involves individuals studying or working in universities and other RIs in the creation of the start-up.

To date there is little research on how policy supports academic spin-offs, with the exception of work on the effects of the US Bayh-Dole Act⁸ and similar legislation implemented in other countries that mainly focus on ventures created by researchers. The majority of findings suggest that university IP ownership facilitated by the Bayh-Dole Act significantly fostered the commercialisation of research results, explaining the success of U.S. universities in commercializing inventions through entrepreneurship (Kenney and Patton, 2011^[36]; Rothaermel, Agung and Jiang, 2007^[37]; Shane, 2004^[26]; O’Shea, Chugh and Allen, 2007^[38]). According to the Association of University Technology Managers statistics (1998), around 12% of university-assigned inventions were transferred to the private sector through the creation of new firms in the 1990s. Aldridge and Audretsch (2011^[39]) analyse a sample of research grant by the National Cancer Institute between 1998 and 2002 in the US, to find that one quarter of patenting scientists have commercialized their research by starting a firm. In Norway, Hvide and Jones (2018^[40]) estimate that the end of the “professor’s privilege”, a shift of the ownership rights to commercialisation of research from researcher to university, led to a 50 percent decline in entrepreneurship and patenting rates by university researchers.

However, analyses of the characteristics of university spin-offs have focused on the process of spin-off creation, while the process of spin-off development and growth has been much less investigated (Mustar et al., 2006^[41]). The limited evidence to date points to an important role for science parks and incubators in supporting start-up development. For this reason among others, many university spin-offs are established in close proximity to the university (Breznitz, O’Shea and Allen, 2008^[42]; Shane, 2004^[26]).

However, academic spin-offs are only one of the several channels discussed in the relevant literature, with e.g. consultancy and contract research, joint research, or training being also

prominent (Agrawal and Henderson, 2002^[43]; Arundel and Geuna, 2004^[44]; D’Este and Patel, 2007^[45]). Other important channels of knowledge transfer are seminars, face-to-face interactions, and, especially, scientific publications (Bekkers and Bodas Freitas, 2008^[46]; Cassiman, Veugelers and Zuniga, 2008^[47]). Furthermore, the evidence presented above mainly concerns entrepreneurship emanating from researchers, and little is known about another type of academic start-up: student entrepreneurship.

Guimon and Paunov (2019^[11]) discuss policies implemented to support of academic spin-offs, including student entrepreneurship. These programmes support knowledge transfer by linking industry with frontier knowledge, targeting in particular graduate students at the transition stage of their careers, when they need to decide whether to work for industry or engage in an academic career. If student entrepreneurship works properly, new employment opportunities for the youth are created, supporting also inclusiveness. Indeed, entrepreneurial activity by university graduates is an important spin-off channel (OECD, 2013^[8]). For example, Åstebro, Bazzazian and Braguinsky (2012^[7]) find that that recent graduates are twice as likely as their faculty to create a business venture, and that these spin-offs are not of low quality. Similarly, an analysis of Academic Enterprise Europe Awards finalists shows that the largest group of awarded founders were doctoral students, while professors were less numerous (Hoefler, Magill and Santos, 2013^[48]).

Inclusive entrepreneurship

Entrepreneurship as a tool to promote more inclusive societies has been recently emphasized. A series of reports under the aegis of a joint OECD – European Commission project on inclusive entrepreneurship in Europe have examined the barriers faced to business creation and self-employment by people who are disadvantaged or under-represented in entrepreneurship activities – youth, seniors, the disabled, women, ethnic minorities, the unemployed and others – and the public policy actions that can promote and support these activities (see e.g. OECD – European Commission, 2014). The OECD project on inclusive innovation has also document a number of policy initiatives fostering entrepreneurship for inclusion as a way to promote more inclusive growth (Planes-Satorra and Paunov, 2017^[23]; Paunov, 2013^[49]).

There has been some success in reducing inequalities in educational attainment. Women are more likely than men to attain tertiary education: 50% of women aged 25-34 were tertiary educated on average across OECD countries in 2017 compared to 38% of men of the same age (OECD, 2018^[50]). The number of doctorates awarded to women has also grown faster than those awarded to men (OECD, 2015^[51]). However, the gender gap issue in STEM disciplines – which are particularly relevant for innovative entrepreneurship – is still sizeable and persistent. For instance, in the US women account for nearly half of employed college graduates age 25 and over, but for only about 25% of employed STEM degree holders and an even smaller share – just about 20% – of STEM degree holders working in STEM jobs (Beede et al., 2011^[52]). The situation in other OECD countries is very similar (OECD, 2015^[51]).

In the academic sector, important differences in the careers of men and women persist. Women faculty earn less, are promoted less frequently to senior academic ranks, and publish less frequently than their male counterparts (Bentley and Adamson, 2003^[53]). Women faculty members also patent less often than men (at about 40% of their rate) (Ding, 2006^[54]).

Regarding ethnic minorities, the pattern is also mixed: for instance, the figures reported by Bayer and Rouse (2016^[55]) for the US show that, while there has been a steady increase in

the percentage of bachelor's degrees awarded to minority students over the last two decades in all fields, the share of doctorate degrees has been roughly stagnant especially in STEM (science, technology, engineering, and mathematics) and economics fields.

Inclusiveness critically depends on opportunities for ethnic minorities and women to contribute to the economy including as entrepreneurs. Public research centres and universities can potentially offer important opportunities to discriminated groups and minorities. RIs can help achieve this objective by promoting a wider involvement of these groups in higher education, by supporting plurality and diversity of views, and by enhancing meritocracy both for students and researchers. RIs also typically have a strong international vocation, which in turn can help integrate foreign communities. Holding an advanced degree and tight linkages to universities can help reduce barriers to access to finance that might otherwise affect these groups (based on active or statistical discrimination). In a recent paper, Aghion et al. (2018_[18]) show that innovation, particularly by new entrants, is positively associated with social mobility (but less so in Metropolitan Statistical Areas with more intense lobbying activities). This work therefore suggests that innovative entrepreneurship can be an important driver of social mobility, especially at the top of the income distribution, through creative destruction. However, there are obvious limitations to what academic entrepreneurship can do given the still existing inequalities in access to education as outlined above across groups.

2.4. Research questions

Building on the evidence summarised above, the following taxonomy is proposed. A first channel is related to human capital. Individuals accumulate human capital in higher education institutes (HEIs) and research institutes (RIs) – either as students, researchers, or both – that can allow them to become successful entrepreneurs. A second channel is knowledge diffusion through various informal mechanisms. Researchers in HEIs and RIs disseminate their work through scientific publications, conferences and interactions with informal and serendipitous contacts that may be facilitated by geographic proximity of researchers and entrepreneurs. A third more formalised channel includes hired research contracts whereby entrepreneurs formulate a research collaboration with HEIs and RIs to investigate a specific research question. Licensing of patents and other IP of HEIs and RIs may also serve as inputs to entrepreneurial activities. HEIs and RIs increasingly engage in joint collaborations with the private sector, so-called “co-creation.”

This report focuses on the first channel of the taxonomy illustrated above, i.e., the human capital (or “people”) channel. In order to shed further light on the importance of academic spin-offs and based on the overview of the existing evidence, a number empirical questions are identified.

Q1: Do academic ISUs bring more and different innovations to the market?

Academic ISUs – either founded by students or researchers – are closer to academic research and are thus likely to exploit knowledge from scientific research better than other ISUs. In particular ISUs founded by researchers and, to a lesser extent, PhD students do not suffer from the well-known challenge of transmitting knowledge as academics are involved in the ISU.

Consequently, we may expect that ISUs founded by undergraduate or PhD students, or by researchers are more innovative, and the innovations they introduce are closer to research. The difference between academic and non-academic ISUs may be stronger for ISUs

founded by researchers and PhDs students than is the case of recent undergraduate students since the former bring more scientific expertise.

Q2: Are academic ISUs more successful than non-academic ISUs?

Start-up success or failure is usually hard to observe. In Crunchbase as in other databases on ISUs and Venture Capital, there is little information on failures, and a few start-ups that are officially still operating might actually be “living dead”. Following the existing literature (Da Rin, Hellman and Puri, 2011^[56]; Da Rin, Hellman and Puri, 2011^[56]), successful start-ups are identified based on three different outcomes: i) the probability to receive funding; conditional on receiving funding, ii) the amount received, and iii) the probability to experience a successful exit via IPO or acquisition.

Some academic ISUs may be more successful with regards to access to venture Capital and exit events because they produce more or better innovations. Their strong links with universities and connections to research networks unavailable to non-academic start-ups may further help them build strong innovations. Furthermore, human capital accumulated in HEIs and RIs – either as students, researchers, or both – can allow academic founders to become more successful entrepreneurs than other entrepreneurs. The types of skills may vary from scientific knowledge, which are critical to entrepreneurial endeavours in such fields as biotechnology or chemistry, to other capabilities for entrepreneurs, such as project management skills acquired in a number of social science disciplines, and that can critically facilitate entrepreneurship.

At the same time, there are other skills that academic founders - both researchers, PhDs and recent graduates with no business experience - may lack. The secret behind business success consists not only in the presence of strong expertise but also in the right combination of skills and expertise. Some of the early failures in promoting academic entrepreneurship via TTOs can be partly explained by the limited expertise of HEIs in running business activities, including innovative academic enterprises (OECD, 2013). Furthermore, a recent work suggests that successful entrepreneurs are not young but middle-aged (Azoulay et al., 2018^[57]). This evidence implies that ISUs founded by undergraduate students may underperform, rather than outperform, other similar ISUs.

Consequently, we have no clear a priori regarding the success of academic ISUs compared to similar non-academic ISUs. The success depends on the distinctive contributions and the matching of academic skills acquired to entrepreneurial endeavours.

Q3: Are academic ISUs are more inclusive than other ISUs by providing more opportunities for ethnic minorities and women?

Stronger emphasis on meritocracy in universities and the higher share of women in tertiary degrees may support that academic ISUs, especially those founded by undergraduate and PhD students, are more inclusive towards women. Furthermore, university affiliation can act as a positive signal to outsiders, including funders, facilitating ISU funding and creation. However, the low number of female and minority students in STEM degrees, and the gender gap in career advancement for researchers in STEM fields, point to important challenges women and minorities face in universities. Therefore, it is unclear whether academic ISUs will be more inclusive than non-academic ISUs .

Q4: What reasons explain why academic ISUs differ from others?

There are two major factors why we may expect academic ISUs to differ in the nature of their innovation (Q1) and success (Q2). It may be because **they benefit from their university network** non-academic ISUs do not have. The geographic proximity of start-ups to the university of origin helps them build and maintain strong collaboration. It may also be **because they benefit from different skills** than non-academic ISUs. If the latter is the most relevant, then geographic proximity should not be a major determinant for start-ups success, all else equal.

3. Data and methodology

3.1. Data on innovative entrepreneurship

The data source on innovative start-ups and venture capital deals used in this report is Crunchbase (www.crunchbase.com), a commercial database on innovative companies maintained by Crunchbase Inc. The database was created in 2007 within the Techcrunch network, but its scope and coverage has increased significantly over the past few years. As reported by the Kaufmann Foundation, the database is increasingly used by the venture capital industry as “the premier data asset on the tech/startup world”. Dalle, den Besten and Menon (2017^[6]) present a detailed discussion of the database and its potential for economic, managerial, and policy-oriented research.

Crunchbase raw data are obtained through two main channels: a large investor network and community contributors. These data are processed by the Crunchbase analyst team with the support of artificial intelligence algorithms, in order to ensure accuracy and scan for anomalies. Additionally, algorithms continuously search the web and thousands of news publications for information to enrich profiles.

Compared to other commercial databases covering similar information and frequently used for economic research, Crunchbase has major advantages: it contains cross-linked information on companies, their funders, and their staff; it is partially crowd-sourced, which adds to the comprehensiveness and timeliness of the database; it is updated on a daily basis; and it is structured in an accessible way. The comprehensive information on the profile of founders and the timeliness of the data are two of the characteristics of Crunchbase that make it particularly valuable for policy analysis. The VC industry evolves very rapidly – for instance in the Crunchbase data China went from having almost no investment in artificial intelligence in 2015 to being the second biggest global player after the US in 2017 – therefore more traditional sources of data may fail to cover the main trends early enough.

Breschi, Lassébie and Menon (2018^[22]) discuss the coverage and representativeness of the database, compared to some benchmark data sources that are more commonly used in the literature. The general message of the benchmarking exercise is that the coverage of Crunchbase is at least as good as comparable data sources. In particular, the country-year comparison with aggregated sources on VC investments suggests that the coverage of Crunchbase is sufficiently exhaustive across OECD member countries and four large emerging economies (i.e. Brazil, China, India, and Russian Federation), with few exceptions.

As is common with commercial databases built for business intelligence rather than for statistical analysis, the findings may be misleading if its peculiarities are not properly taken into account. The database indeed suffers from a number of limitations. First, the historical dimension of the database is mainly limited to the snapshot of companies that have been active recently. Start-ups that failed and ceased operations are likely not to have left any trace in the database. Therefore, spurious ascending growth trends of deal number or investments may appear in the data. This calls for caution in the examination of trends over time. Second, the amount invested in the VC deal is not disclosed in around 20% of cases. Third, the classification of investors into different groups (e.g., corporate, government, etc.) is not always accurate, and requires considerable additional refinement and cross-validation

work. Fourth, it is important to carefully circumscribe the relevant sample in relation to the specific analysis to be undertaken. Not all companies reported in Crunchbase are start-ups (e.g. also several large and old corporations appear in the database, especially if they are acquirers of start-ups). Similarly, it is also important to properly define the geographical scope of the used data. In some circumstances, it may also be appropriate to limit the analysis to start-ups with at least one round of funding, in order to focus only on start-ups with a real business potential (as it is the case, for instance, of the identification of start-ups operating in artificial intelligence by OECD (2018_[15])). These and similar issues are discussed in depth in the previous OECD studies that make use of the database (Breschi, Lassébie and Menon, 2018_[22]; Dalle, den Besten and Menon, 2017_[6]).

To address these concerns, the sample used for the analyses presented in this work is restricted to young companies (created after 2001), located in OECD and BRICS countries (countries for which the coverage of the database is satisfactory). An innovative start-up (ISU) is thus defined as a young company actively looking for VC funding. While there exists no accepted definition of the term “start-up” in the literature, with some research strands considering as start-ups all new firms, including the majority of small businesses with limited growth ambitions, the venture-capital literature generally adopts a more targeted and narrow definition of start-ups, which corresponds to a venture-capital backed company with fast-growth ambitions.

A qualification is also important about the classification of companies into technological category groups. Companies typically list one or several technological category groups in which they operate (the median number is three in the sample used in this report), choosing from a list of 45. Aggregate statistics are based on fractional counts. These category groups have the advantage of providing a comprehensive mapping of the current technological landscape in which ISUs operate. However, they do not have any direct links to traditional sectoral classifications adopted by official statistics (e.g., NACE, NAICS, or ISIC). These latter classifications have proven to be of limited use for ISUs, as the large majority of them are classified in very few sectors (see e.g. Menon et al. (2018_[29]) for the case of Italy). Nevertheless, while all sectoral classifications are generally based on self-reported information by companies, in the case of Crunchbase the reported information might not be fully objective, as it might be influenced by self-promotion incentives, especially for start-ups that did not receive funding yet.

The database has been refined and expanded by OECD in a number of different dimensions. A particularly important addition consists in adding patent data from PATSTAT, based on an original approach that exploits information on both companies (patent applicants) and people (patent inventors) listed in the database in order to fine-tune the fuzzy matching (Tarasconi and Menon, 2017_[58]).

In addition, Breschi et al. (Forthcoming_[59]) further refined and expanded the database by developing a classification of public VC investors encompassing all OECD and BRICS countries. CIIE Delegates and national experts kindly contributed to this task by collaborating with the OECD in validating the list of public investors.

This work also uses indicators of patent quality developed by (Squicciarini, Dernis and Criscuolo, 2013_[60]). In particular, it uses two different measures: the citation to non-patent literature (NPL) share index and the radicalness index.

1. The *citation to NPL share index* is calculated as the number of NPL citations included in a patent normalized by the maximum number of NPL citations of patents belonging to the same year and technology cohort. This captures the

relative importance of NPL citations in a patent document vis-à-vis the other patents in its cohort. The NPL share index is further refined to reflect the propensity of a patent document to cite NPL relative to the whole prior art cited in that same document and thus takes values between zero and one. This is thus a proxy of the patent closeness to academic research.

2. The *radicalness index* measures the extent to which a patent differs from other inventions it relies upon. It is based on the idea that the more a patent cites previous patents in classes other than the ones it is in, the more the invention should be considered radical, as it builds upon paradigms that differ from the one to which it is applied. It is computed as the number of technology classes contained in the cited documents of a patent that differ from the technology classes of the patent itself, as a share of the total number of technology classes contained in the cited documents. It ranges between zero and one.

In order to study the location of start-ups and linked universities, a particular effort has been made to obtain the geolocation of these entities. For universities, the procedure is detailed in Section 3.2.1. Regarding start-ups, obtaining their precise coordinates thanks to the Google Map API service is made particularly complicated by the existence of homonyms and by the fact that young firms, or those that are not active anymore (acquired or closed), are not always correctly referenced by Google. Therefore, the geolocation of start-ups relies on city, region, state, and country information contained in the database. Based on the coordinates of the city reported in the database, a Functional Urban Area (OECD, 2012_[61]) is attributed to each company. Firms that do not report city information – representing 25% of the main sample - are excluded for any analysis of distance between start-ups and universities.

3.1.1. Identification of academic start-ups

This report studies the links between start-ups and public research institutes. In the empirical analyses, start-ups are identified as being connected to academic institutions via their founders' education and past professional experiences. In addition to detailed information on companies, Crunchbase also contains the education and the employment history of listed individuals. Where possible, this information has been complemented and cross-validated with data taken from Tzabbar, Cirillo and Breschi (2018_[62]). While education and employment history is not available for the full sample of listed individuals, the data allow the analysis of the "curriculum vitae" of approximately 130 thousand people listed as founders or managers of more than 25 thousand start-ups. These textual data have been processed using machine learning algorithms to extract information that can be used in quantitative analyses. In particular, each education entry has been assigned a degree type and a subject field, and past professional experiences have been classified into a finite set of meaningful categories.

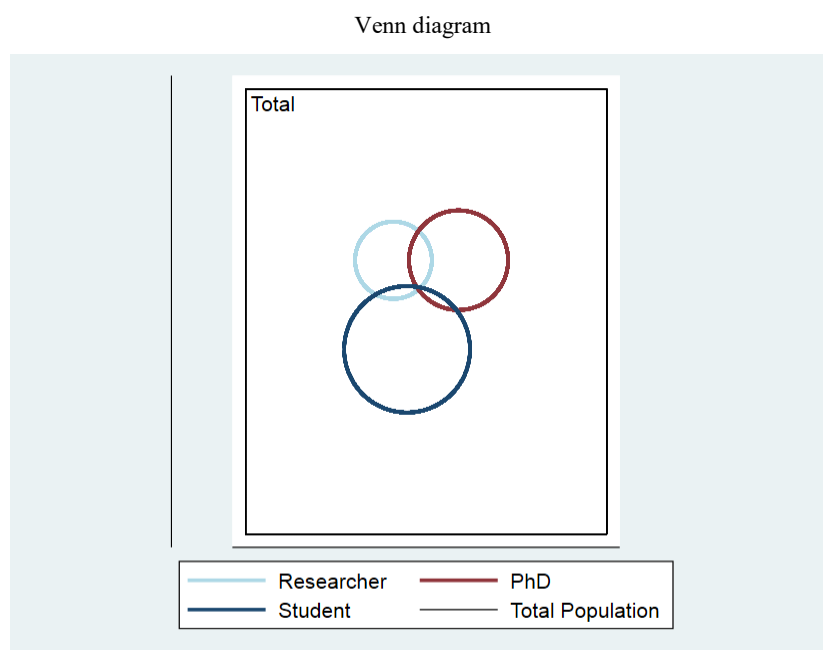
Three types of academic start-ups are considered: (1) An individual is defined as a *student founder* if she created a company within four years after the start of her undergraduate studies. We will compare those start-ups with those of founders who started their undergraduate studies more than four years earlier. (2) An individual is a *PhD founder* if she created a company within seven years after the start of her PhD. We will compare those start-ups with those of founders that hold a PhD they started more than seven years ago and founders holding no PhD. (3) Founders reporting at least one job experience as a 'post-doc', 'lecturer', 'professor', and similar job titles, who founded the company within three years after the end of their research experience, are classified as *researcher founders*. An

individual is defined as a ‘non-researcher’ founder if she has no professional experience in research in the past three years before founding her start-up, but reports experience in business activities before founding their start-up (i.e., listing at least one professional experience as an entrepreneur, as an engineer, or experience in management, finance, sales and marketing, computer science).

A number of caveats regarding the definitions of academic start-ups arise. First, regarding student founders, the definition may exclude student founders in countries where undergraduate studies may in some cases last longer than four years. This is to ensure the definition only covers student start-ups created immediately after graduation. The downside is that some student entrepreneurs are excluded.⁹ Second, researcher founders may retain strong links with university even after three years after the end of the last research experience, especially if they continue co-authoring research articles with former colleagues, or collaborating on joint projects. We expect, however, linkages to be weaker over time so that this measure captures well those founders with close ties to universities.

Figure 1 indicates the importance of academic start-ups in the total sample of young companies and the distribution by type of link (start-ups with at least one founder with experience in research, those with at least one PhD founder, and those with at least a student founder). The overlap shows that a small share of PhD start-ups also count a researcher in the team of founder. There is, however, almost no overlap between undergraduate student founders and other categories.

Figure 1. Definition of start-ups emanating from public research institutions



Note: The sample is limited to companies created after 2001, located in OECD or BRIICS countries, and having received at least one VC investment.

Source: Authors' elaborations on www.crunchbase.com

3.1.2. Definition of foreign minorities

A number of studies explore the role of inventors from an ethnic minority for innovation and knowledge diffusion (Freeman and Huang, 2015_[63]; Kerr, 2008_[64]; Kerr and Lincoln,

2010_[65]). These works typically rely on first and last names to identify ethnic communities. More specifically, they use a database from Melissa Data Corporation that lists names and their corresponding ethnicity. The data are particularly suited for the identification of Asian ethnicities, especially Chinese, Indian/Hindi, Japanese, Korean, Russian, and Vietnamese names; in comparison, the source is less useful for European names (Kerr, 2008_[66]). Although this approach has clear limitations and the resulting measure can be rather noisy – especially in small samples – a number of very important studies with policy relevant findings (e.g., a study the H-1B Visa Reforms in the United States by Kerr and Lincoln (2010_[65])) rely on this method, suggesting that substantial and useful information can be retrieved, with adequate care.

Therefore, a modified approach is implemented to identify founders from an ethnic minority in Crunchbase. This report uses the Global Name Recognition, a name search technology produced by IBM based upon information collected by the US immigration authorities in the first half of the 1990s.¹⁰ This technology gives, for each first and last name contained in Crunchbase, the frequency distribution of the name across all countries (i.e. the percentage of people with a given name in each country), and the percentile of the frequency distribution of all names in a country this name belongs to (a measure of rarity of a name in the country). Recent work using these data include Breschi, Lissoni, and Miguelez (2017_[67]).

A founder is defined as belonging to an ethnic minority if a) its first and last names belong to the first half of the distribution of names in their country of residence and b) the frequencies of first and last names in their country of residence across all countries are lower than 5%. The first criterion confirms that the names are relatively rare in the country, while the second ensures that they are less common in that country than in other countries.¹¹ An advantage of this method compared to methods used in previous work is that it does not require a precise identification of the ethnic origin of individuals but only whether they are likely to come from an ethnic minority group.

Based on this definition, 11% of start-ups in Crunchbase have been created by a founder from an ethnic minority (see Table 1). This classification was not cross-validated with other data sources and is therefore likely to suffer from measurement error (both “false negative” and “false positive”). As long as these errors are random, this will create an attenuation bias, i.e. driving regression coefficients toward zero. Further work may explore the issue more in depth, developing a more accurate definition of foreign entrepreneurship in selected countries, possibly following a similar approach to those recently proposed in a recent study for the United States (Bernstein et al., 2018_[68]).

Table 1. Summary statistics of main variables

	Number of observations	Mean	Standard deviation	Min	Max
Academic start-ups					
Academic ISU	20 281	0.14	0.35	0.00	1.00
One founder with research experience	30 101	0.02	0.15	0.00	1.00
One PhD founder	30 107	0.03	0.17	0.00	1.00
One student founder	30 540	0.08	0.27	0.00	1.00
Founders characteristics					
Number of founders	40 363	1.89	1.00	1.00	30.00
One founder holds a MBA	34 513	0.20	0.40	0.00	1.00
One founder holds a PhD	34 513	0.12	0.33	0.00	1.00
One woman	40 294	0.17	0.38	0.00	1.00
One founder from ethnic minority	14 414	0.11	0.31	0.00	1.00
Funding					

Funding dummy	40 363	0.57	0.50	0.00	1.00
Total funding (millions USD)	19 676	19.22	119.05	0.00	11 457
Exit	40 363	0.10	0.30	0.00	1.00
Patents					
Patent application dummy	40 363	0.14	0.34	0.00	1.00
Num. of patent applications	40 363	3.27	108.54	0.00	20 005
Non-Patent Literature citations	4 672	0.12	0.21	0.00	1.00
Radicalness	4 655	0.46	0.23	0.00	1.00

Note: The number of observations reported correspond to the biggest sample for which information is available on the given variable. The education background is available only for a subsample of founders, therefore education variables are typically defined for a smaller set of start-ups.

Source: Authors' elaborations on www.crunchbase.com and PATSTAT data.

3.2. Data on public research institutions

3.2.1. Disambiguation of public research institutions

The list of RIs reported in the source data is composed of RIs reported in founders' background information, RIs listed in Crunchbase, RIs entering the Leiden Ranking, and RIs appearing in a consolidated list of universities compiled by OECD¹².

This list of RIs reported in the source data is not standardised, which means that the same RI can be reported under a variety of slightly different names. In order to be able to use this information in the empirical analysis, a disambiguation procedure is necessary. This is performed in three steps. First, each unique entry is geolocated via the Google Map API service, in order to retrieve its geographic coordinates. Second, the similarity of each combination of RI names is quantified with a string-distance metric (the Jaro-Wrinkler). Finally, the pairs of RI names that show a combination of high location and string similarity are considered to be the same RI. In order to filter-out inexistent or irrelevant institutions, only RIs that are matched to an entry of the University Census database or the Leiden University Database are kept in the list. The output of the disambiguation is then checked manually, devoting particular attention to the biggest and top-ranked research institutions. The outcome of the procedure is a disambiguated RI list with a unique numeric identifier for each institution, which is linked to both the University Census and the Leiden Ranking.

3.2.2. Ranking of public research institutions

Ranking of public research institutions comes from the Centre for Science and Technology Studies (CWTS) Leiden Ranking 2016. This ranking is based exclusively on bibliographic data from the Web of Science database produced by Clarivate Analytics. The measure used in this report is the proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited. Some RIs are not included in the Leiden Ranking and they are thus excluded of any analysis using this ranking.

3.3. Descriptive evidence on start-ups

In the following, some general descriptive evidence of the database under investigation is presented. The graphs generally report simple averages across companies, aggregated by country or technology. In order to report statistics that are based on a sufficiently large number of observations and to ease visualisation, the sample is limited to companies located in the top 20 countries or operating in the top 20 technologies in terms of number

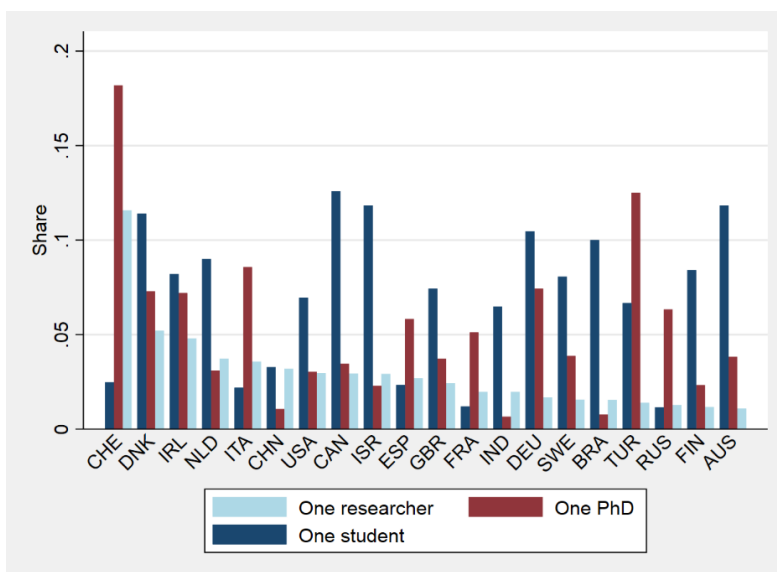
of observations. The sample is also limited to companies located in OECD and BRIICS countries, created after 2001 and having received at least one VC investment.

The graphs reporting average values across countries or technologies can partially reflect composition effects. For instance, the share of academic start-ups varies across countries, and this may affect the average value of other variables. In order to partial-out the potentially confounding effect of sample composition, Annex A reproduces the main graphs reported here using a simple econometric technique that calculates “robust” country and category averages via a linear regression model. These “robust” graphs indicate whether, keeping other variables such as country, technological field, and founding year, constant, each group is statistically different from the baseline group along the specific dimension under scrutiny. The interested reader can therefore cross-check the robustness of the core messages emerging from the descriptive analysis by comparing the simple graphs reported here with those derived from regression analysis in Annex A.¹³

Figure 2 reports the share of academic start-ups in Crunchbase by country and type, i.e., depending on whether at least one founder is an academic researcher, a PhD student, or an undergraduate student, respectively. Student ISUs account for the highest share of academic ISUs in most countries reported in the graph, with peaks over 10% in several countries. The share of ISUs founded by former researchers is much lower, at around 5% or less. This is consistent with evidence from the US showing that recent graduate students are twice as likely as professors to start a business within three years of graduation (Åstebro, Bazzazian and Braguinsky, 2012^[7]). ISUs founded by PhD students are more than 15% of the total in Switzerland, and around 7% in Denmark, Ireland, Germany, 9% in Italy, and 13% in Turkey.

Figure 3 illustrates the same indicator across technological fields. Biotechnology clearly stands out as the field with the highest incidence (14%) of ISUs founded by former researchers, while education, apps, and transportations are characterised by relatively high shares of student entrepreneurship. Figure 4 and Figure 5 further explore the relationship between professor- and student-founded ISUs by the means of scatter plot. Interestingly, the relationship between the two variables is rather weak and non-linear, especially across technologies. Some countries or technological fields characterised by high shares of ISUs founded by professors may show a relatively low incidence of student entrepreneurship, as it is the case of Switzerland (or of biotechnology). Conversely, in countries like Australia the share of ISUs created by students is very high while the share of ISUs created by researchers is much lower.

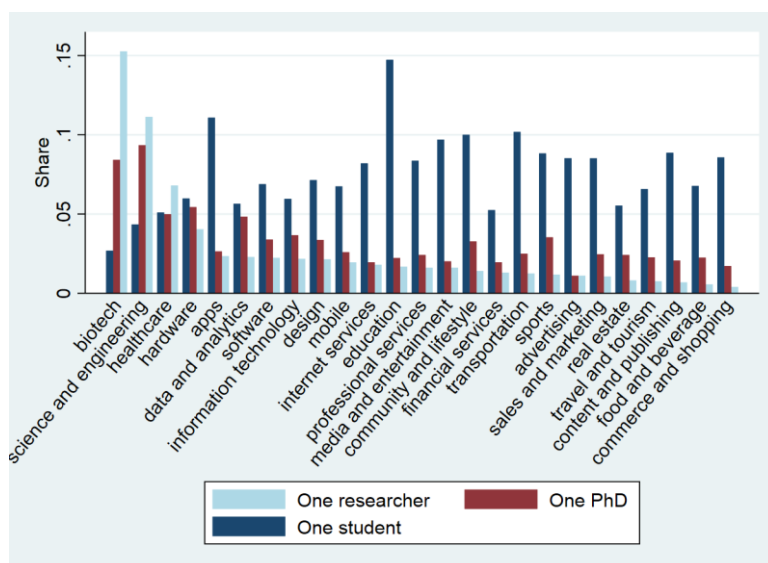
Figure 2. Share of academic start-ups in Crunchbase by country and type



Note: The sample is limited to companies created after 2001 and having received at least one VC investment. The graph is limited to top 20 countries in terms of number of start-ups.

Source: Authors' elaborations on www.crunchbase.com

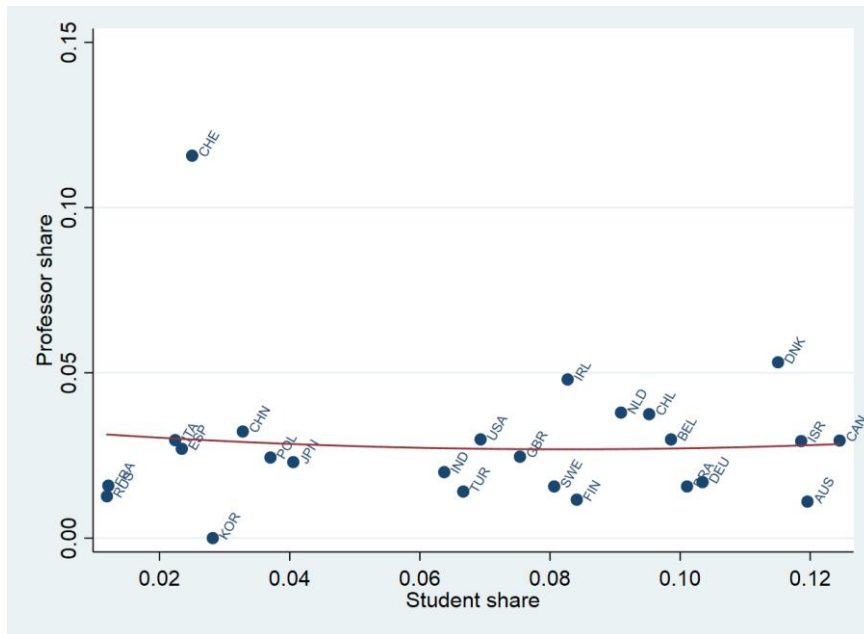
Figure 3. Share of academic start-ups in Crunchbase by technological field and type



Note: The sample is limited to companies created after 2001, located in OECD or BRICS countries, and having received at least one VC investment. The graph is limited to top 25 technologies in terms of number of start-ups.

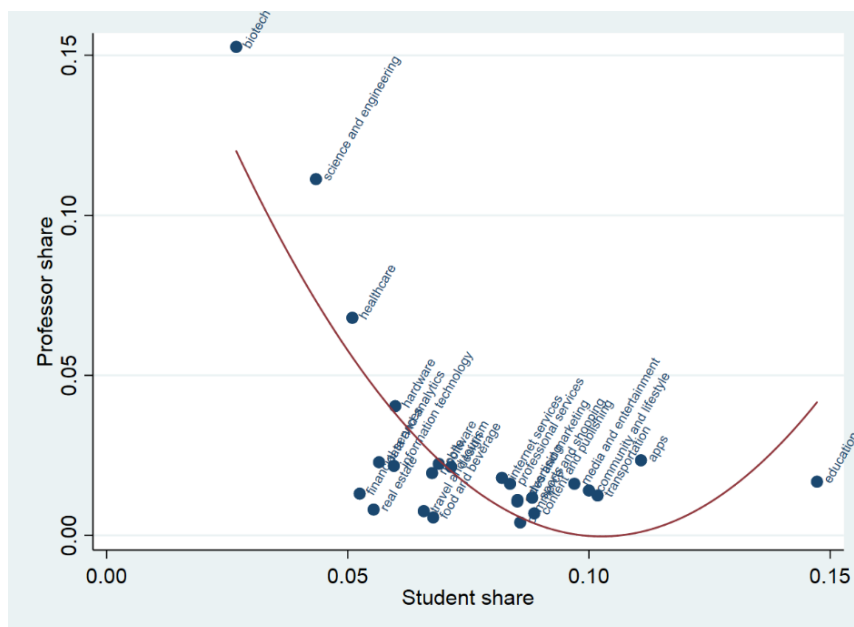
Source: Authors' elaborations on www.crunchbase.com

Figure 4. Professor-founded vs. student-founded start-ups in Crunchbase, by country



Note: The sample is limited to companies created after 2001, located in OECD or BRICS countries, and having received at least one VC investment. Graph limited to top 20 countries in terms of number of start-ups.
Source: Authors' elaborations on www.crunchbase.com

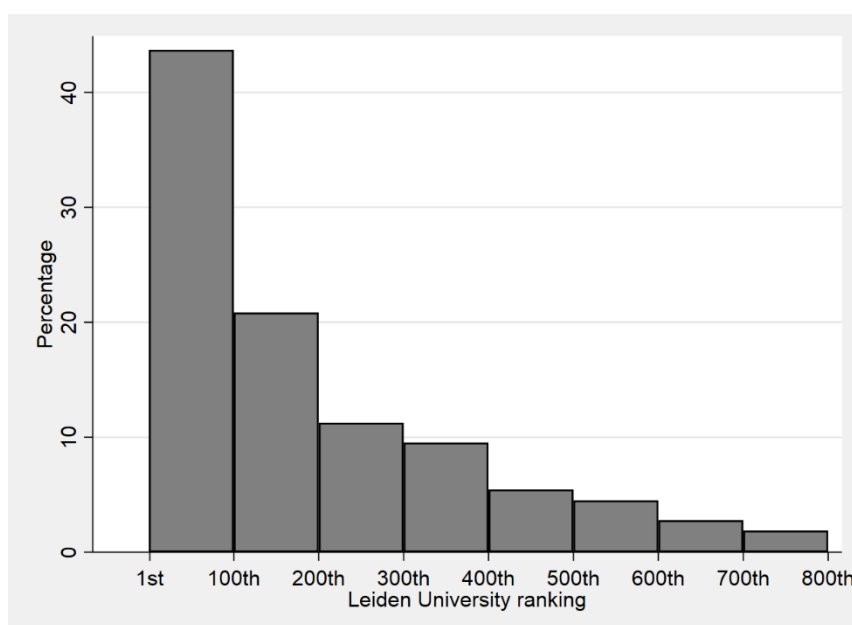
Figure 5. Professor-founded vs. student-founded start-ups in Crunchbase, by technological field



Note: The sample is limited to companies created after 2001, located in OECD or BRICS countries, and having received at least one VC investment. Graph limited to top 25 technologies in terms of number of start-ups.
Source: Authors' elaborations on www.crunchbase.com

As to the university origin of universities of academic founders, Figure 6 shows the histogram of academic founders by rank of alma mater university in the CWTS Leiden ranking. The ranking of universities is based on the proportion of a university's publications that belong to the top 10% most frequently cited. It is therefore independent of university size.¹⁴ Figure 6 indicates that academic founders mostly emanate from a set of frontier universities known as leaders in their field. Few universities account for a large percentage of academic founders. For instance, 45% of all OECD and BRIICS founders in the sample stem from the top 100 universities, and 14% from the top 10.

Figure 6. Share of academic founders by rank of alma mater universities



Note: The sample is restricted to founders for which the alma mater university is reported and can be linked to a university appearing in the Leiden ranking.

Source: Authors' elaborations on www.crunchbase.com and CWTS Leiden ranking.

4. Results

This section presents regression results to shed light on questions Q1 to Q4 listed in subsection 2.4. Regression analyses are meant to further uncover some interesting associations in the data, once other factors (including differences driven by country, technology, and cohort) are controlled for. It is worth stressing that the exercise is purely descriptive and causality cannot be inferred at this stage, although the richness of the micro-data can well serve this purpose in future work. In order to offer preliminary evidence on the question as to why academic SUs differ from non-academic ones (Q4) this section also presents preliminary analyses of the geographical distance between SUs and their alma mater RI.

4.1. Q1: Do academic ISUs bring more and different innovations to the market?

As pointed out in the previous section, the share of academic start-ups is higher for start-ups operating in science-based technology fields (Figure 3). This is especially striking for biotechnology, where 14% of start-ups receiving VC count at least one researcher founder.

Table 2 presents results of regression of different patent variables (patent indicator, patent number, and two measures of patent quality attributes, namely non-patent literature citations and radicalness)¹⁵ on a dummy variable identifying the different types of academic start-ups, controlling for total funding and technology, country, and founding year fixed effects. Results show that student ISUs are less likely to patent than non-student ISUs, but their patents are more radical, on average. ISUs founded by PhD students own patents that are closer to science, as they cite more frequently academic publications. ISUs founded by researchers, instead, are more likely to own patents, however their quality attributes are not significantly different from comparable ISUs.¹⁶

Table 2. Patenting activity by type of academic start-ups

	Patent dummy			Patents number			Non-Patent Literature citations			Radicalness		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
One student founder	-0.030***			41.03			-0.021			0.041*		
	-0.011			-36.79			-0.023			-0.022		
One PhD founder		0.029			0.088			0.043**			-0.027	
		-0.021			-4.442			-0.021			-0.021	
One founder with research experience			0.078***			3.116			0.004			0.011
			-0.021			-4.986			-0.020			-0.019
One founder holds a PhD or MBA			0.048***			4.209			0.025*			0.002
			-0.008			-3.153			-0.015			-0.011
Total amount (USD, log)	0.033***	0.036***	0.034***	10.56***	6.682***	6.718***	0.000	-0.000	0.000	-0.003	-0.004	-0.005
	-0.003	-0.003	-0.003	-3.87	-1.538	-1.504	-0.002	-0.002	-0.002	-0.004	-0.004	-0.004
Observations	9 682	9 127	8 586	1 957	1 984	1 928	1 682	1 718	1 674	1 676	1 712	1 669
R-squared	0.26	0.27	0.29	0.08	0.13	0.14	0.24	0.26	0.27	0.07	0.06	0.07
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Founding year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: * p<0.1, ** p<0.05, *** p<0.01. Robust clustered standard errors in parentheses. The sample is restricted to firms having received at least one VC investment. The sample of columns 1 to 3 is composed of all firms for which data is available. The sample of columns 4 to 12 is composed of firms having filed at least one patent application.

Source: Authors' elaborations on www.crunchbase.com and PATSTAT data.

4.2. Q2: Are academic ISUs more successful than non-academic ISUs?

Next, this section tests whether academic start-ups are more “successful” than their non-academic counterparts. Successful start-ups are identified based on three different outcomes: i) the probability to receive funding; conditional on receiving funding, ii) the amount received, and iii) the probability to experience a successful exit via IPO or acquisition.

Table 3 shows the difference in likelihood to get funding, total amount received, and likelihood of successful exit (IPO or acquisition), between academic ISUs and the comparison groups as described in subsection 2.1.1. The results show that, even controlling for country, technology, and cohort unobserved characteristics, ISUs founded by PhD or researchers are more likely to get funding by four to seven percentage points (compared to a baseline probability of 0.57, see Table 1). Conditional on receiving funding, the amount is slightly lower for PhD students’ ISUs. Conditional on the amount received, PhD students’ ISUs are also less likely to experience a successful exit – either an acquisition by a bigger company or an initial public offer (IPO) – by around two percentage point (compared to a baseline probability of 0.13).

Conversely, companies created by student founders are less likely to get funding than comparable non-academic start-ups, by eight percentage points. However, this latter result may partially depend on the possibly higher propensity of students to register and thus appear in the database, for a given level of start-up quality.¹⁷ However, the lower success rate of student ISUs is also confirmed by the regression of VC amount, which is limited to VC recipient only: if they receive funding, they get a substantially lower amount. Similarly, they are also less likely to experience a successful exit.

Table 3. Probability and amount of funding by type of academic start-up

	Funding dummy			Total amount (USD, log)			Exit dummy		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
One student founder	-0.08*** (0.012)			-1.00*** (0.0694)			-0.019** (0.00930)		
One PhD founder		0.068*** (0.014)			-0.19* (0.108)			-0.025** (0.0122)	
One founder with research experience			0.036** (0.017)			0.220 (0.162)			0.036 (0.0253)
One founder holds a PhD or MBA			0.090*** (0.009)			0.377*** (0.06)			0.013 (0.009)
Total amount (USD, log)							0.008*** (0.003)	0.009*** (0.003)	0.009** (0.004)
Constant	0.565*** (0.065)	0.551*** (0.07)	0.518*** (0.070)	17.21*** (0.283)	17.23*** (0.299)	17.38*** (0.289)	0.223*** (0.074)	0.224*** (0.076)	0.212** (0.096)
Observations	17 577	16 086	15 015	9 682	9 127	8 586	9 682	9 127	8 586
R-squared	0.06	0.06	0.06	0.27	0.25	0.27	0.14	0.14	0.14
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Founding year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: * p<0.1, ** p<0.05, *** p<0.01. Robust clustered standard errors in parentheses. The sample of columns 1 to 3 is composed of all firms for which data is available. The sample of columns 4 to 9 is composed of firms having received funding.

Source: Authors' elaborations on www.crunchbase.com

Table 4 looks more closely at start-ups with founders having experience in research, and analyses how the composition of the founding team correlates with funding and exit. Indeed, columns 3, 6, and 9 from Table 4 do not distinguish between companies created by teams composed by researchers only from those created by a team of founders with different professional backgrounds (research and business experience). For this new set of regressions, the number of founders is controlled for, as it is correlated both with start-up success in terms of VC funding and exit and with the probability to have founders from a diverse background. Column 1 presents evidence that teams of founders composed of researchers only are more likely to get funding than ISUs with a mixed team of founders and non-academic ISUs, while the amount of funding is not statistically different across the three groups (column 2). However, companies founded by a mixed team are more likely to experience a successful exit. These results indicate that, while companies originating from researchers do not lack skills necessary to get access to funding and grow, they seem to have different exit objectives.

Table 4. Comparison of start-ups founded by academic only vs start-ups founded by mixed team

Benchmark excluded category: all founders have experience in business only

	Funding dummy	Total amount (USD, log)	Exit dummy
	(1)	(2)	(3)
Founders have experience in business and research	0.015 (0.025)	0.202 (0.159)	0.061** (0.028)
All founders have experience in research	0.058** (0.0225)	0.092 (0.210)	-0.016 (0.032)
One founder holds a PhD or MBA	0.067*** (0.008)	0.318*** (0.058)	0.010 (0.009)
2 founders	0.160*** (0.013)	0.245*** (0.053)	0.020** (0.009)
3 founders	0.226*** (0.015)	0.514*** (0.067)	0.031*** (0.011)
4+ founders	0.238*** (0.017)	0.880*** (0.079)	0.041*** (0.012)
Total amount (USD, log)			0.008** (0.004)
Constant	0.421*** (0.071)	17.20*** (0.293)	0.219** (0.095)
Observations	15 002	8 575	8 575
R-squared	0.10	0.28	0.14
Country FE	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes
Founding year FE	Yes	Yes	Yes

Note: * p<0.1, ** p<0.05, *** p<0.01. Robust clustered standard errors in parentheses. The sample of columns 1 is composed of all firms for which data is available. The sample of columns 2 and 3 is composed of firms having received funding.

Source: Authors' elaborations on www.crunchbase.com

4.3. Q3: Are academic ISUs more inclusive than other ISUs by providing more opportunities for ethnic minorities and women?

Table 5 reports results on academic start-ups and their inclusiveness. Column 1 shows that ISUs created by undergraduate students are less likely to include a woman in the founding team by two percentage points (compared to a baseline probability of 0.18; column 2-3). On the contrary, PhD students' and researchers' ISUs are more likely to include a woman in the founding team by around the same magnitude, although the coefficient for researchers is not statistically significant (columns 2 and 3). Furthermore, all types of academic ISUs do not seem to be more inclusive regarding ethnic minorities (column 4-6).

Regarding the performance of start-ups led by disadvantaged groups, recent OECD work (Breschi, Lassébie and Menon, 2018^[22]) shows that in general start-ups including women in the team of founders are less likely to receive venture capital funding than start-ups with male founders only by 5-10%. When they receive funding, they receive lower amounts. Unreported regression results suggest that the penalty associated to the presence of a female founder is not different for the different types of academic start-ups and their non-academic counterparts.

Table 5. The different types of academic start-ups and inclusiveness

	One female founder			One founder from an ethnic minority		
	(1)	(2)	(3)	(4)	(5)	(6)
One student founder	-0.022**			-0.018		
	(0.011)			(0.012)		
One PhD founder		0.021*			0.007	
		(0.013)			(0.018)	
One founder with research experience			0.0271			0.045
			(0.0171)			(0.028)
One founder holds a PhD or MBA			0.0255***			0.01
			(0.00801)			(0.011)
Constant	0.057*	0.066*	0.0598	0.095*	0.124*	0.159**
	(0.034)	(0.037)	(0.0383)	(0.056)	(0.066)	(0.068)
Observations	17 560	16 070	15 000	6 082	5 466	5 000
R-squared	0.03	0.04	0.037	0.12	0.12	0.12
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes	Yes	Yes	Yes
Founding year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: * p<0.1, ** p<0.05, *** p<0.01. Robust clustered standard errors in parentheses.

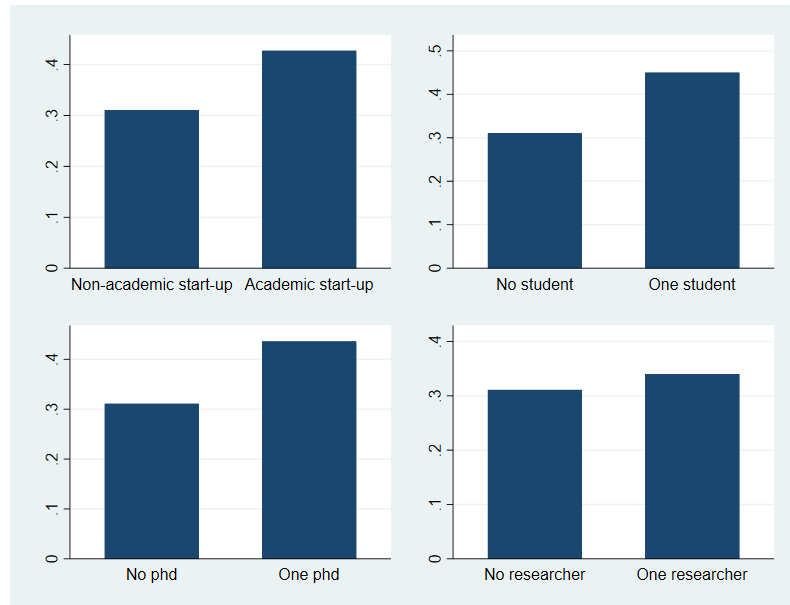
Source: Authors' elaborations on www.crunchbase.com.

4.4. Q4: Network/Collaboration Concentration vs. Skills

Academic ISUs may differ from non-academic ISUs for various reasons (Q4). First, they may benefit from knowledge spillovers from their academic network. They may also benefit from better skills of their founders than non-academic ISUs. While these two hypotheses are not competing, and both mechanisms can be at play, it is interesting to assess the importance of each channel. The graphs below shed some light on the collaboration mechanism. To the extent that knowledge spillovers reduce sharply with distance (Andersson, Quigley and Wilhelmsson, 2009^[34]; Belenzon and Schankerman, 2013^[35]), if knowledge spillovers and collaboration with universities matter to explain the success of academic ISUs, they are likely to locate closer to research centres than their non-academic counterparts. It is possible to identify, for each start-up, whether it is located in the same city (more precisely in the same Functional Urban Area - FUA) than the alma mater university of its founder(s). Figure 7 shows that academic start-ups are more likely to be located in the Functional Urban Area of their alma mater RI than non-academic start-ups. However, this is also due to the fact that non-academic start-ups are created by founders having started their university degree a longer time ago than academic start-ups, and therefore the former are more likely to change city than the latter.

Figure 7. Co-location of start-ups and alma mater RI

Proportion of firms located in the same Functional Urban Area as the alma mater RI of a founder



Note: Sample restricted to firms that report information on city and that can be geo-located in a Functional Urban Area or a region, and linked to a university that can be geo-located in in a Functional Urban Area or a region.

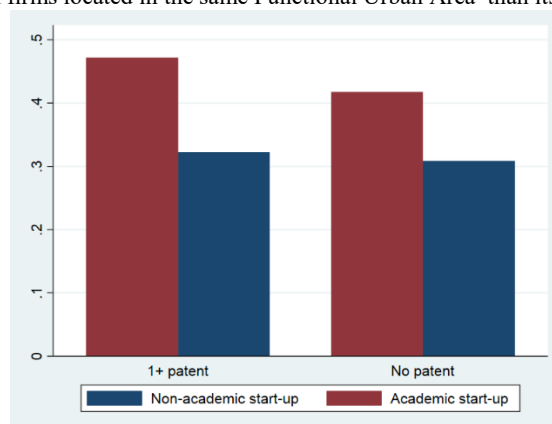
Source: Authors' elaborations on www.crunchbase.com

Figure 8 further explores the differences in location pattern of academic and non-academic start-ups depending on whether they patent or not. Patenting activity, in this case, is used as a proxy for high innovation intensity, assuming that patenting ISUs are more innovative and research-intensive than non-patenting ones. It shows that the higher probability of academic ISUs to be located in the same Functional Urban Area of the alma mater university than non-academic ISUs is even higher for patenting companies (having filed one or more patent applications).

This finding therefore points to the important role of spatial proximity in facilitating the knowledge flow from RIs to ISUs, especially for highly innovative business ventures. It suggests that connections with academic networks are an important factor for academic start-up success. This is consistent with a wide stream of economic research showing that spatial proximity and agglomeration economics are becoming increasingly important in a knowledge-based society, as discussed previously.

Figure 8. Innovative academic start-ups are located closer to their alma mater

Proportion of firms located in the same Functional Urban Area than its alma mater RI



Note: Sample restricted to firms that report information on city and that can be geo-located in a Functional Urban Area (FUA) or a region, and linked to a university that can be geo-located in in a Functional Urban Area or a region.

Source: Authors' elaborations on www.crunchbase.com and PATSTAT data

Box 2. Academic innovative entrepreneurship in Canada

The Canadian government is particularly active in fostering academic entrepreneurship. For instance, the “Innovation Superclusters initiative” is a CAD 950M on-going programme that lists among its objectives “[to] strengthen collaborations between private, academic and public sector organizations” (see <http://www.ic.gc.ca/eic/site/093.nsf/eng/home> visited on Oct. 8th, 2018). In the light of the centrality of the issue in the policy agenda, this box provides a focus on selected empirical evidence available for Canada.

A first aspect of interest is whether academic entrepreneurship is concentrated around few important centres. In order to explore the issue,

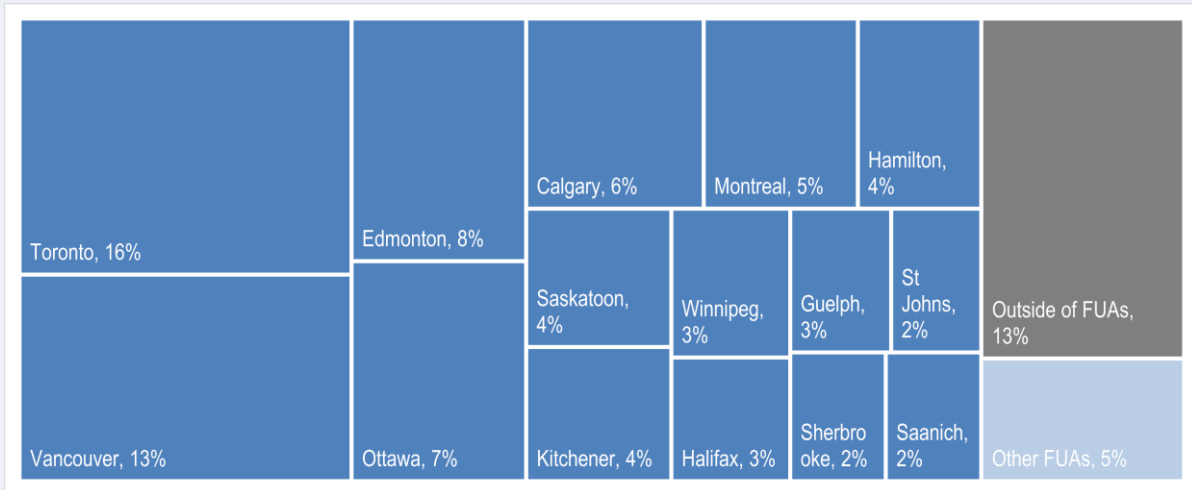
Figure 9 and Figure 10 show the concentration of universities and start-ups across Functional Urban Areas (FUA).

Figure 9 presents the share of total expenditures of universities by FUA (annual average over the period 2001-2016 computed from CAUBO data) and reveals that, according to this indicator, university activity is not strongly concentrated in specific cities or regions. On the contrary, Figure 10 shows that academic start-ups are instead much more concentrated in a limited number of FUA. For instance, 59% of academic start-ups are located in the region of Toronto. Toronto’s primacy may depend on two different phenomena: many academic ISUs are spin-offs of local universities; or academic ISUs emanating from other universities are locating in Toronto. Figure 10 disentangle the two phenomena, as it shows the share of academic start-ups located in a given FUA that have their alma mater in a different FUA. The figure shows that Toronto and Vancouver attracts start-ups founders that attended a university in a different FUA, while Montreal and Ottawa primarily host start-ups emanating from local universities.

Table 6 reports the exact numbers that underlie these graphs. The table lists the most important Canadian universities in terms of academic entrepreneurship for two different groups: the 15 most research intensive universities in Canada (U15, top panel) and others universities (bottom panel). In the group of U15, the University of Waterloo ranks first, and before University of Toronto or McGill University, despite a smaller research output according to the CWTS Leiden ranking. In the group of other universities, Carleton University is the leading institution. The number of start-ups receiving Venture Capital and total funding are an indicator of start-up success in the VC market. Several institutions, for instance McGill University or University of Guelph, produce particularly successful companies, despite relatively low number of founders.

Figure 11 addresses a related question: are students and professors creating the ISU in the same country in which they studied or worked as researchers? The answer to this question has direct implications for education and entrepreneurship policy. It shows that for every 100 academic founders with education or research experience in a Canadian university, 68 are located in Canada, while 21 are in the United States. **Error! Reference source not found.** in Appendix shows that researchers are most likely to create a start-up abroad, while around 56 % of PhD and 80% of B.Sc students create the venture in Canada. Note that this also includes US citizens who join Canadian universities, which is a sizeable phenomenon especially for undergraduate courses.

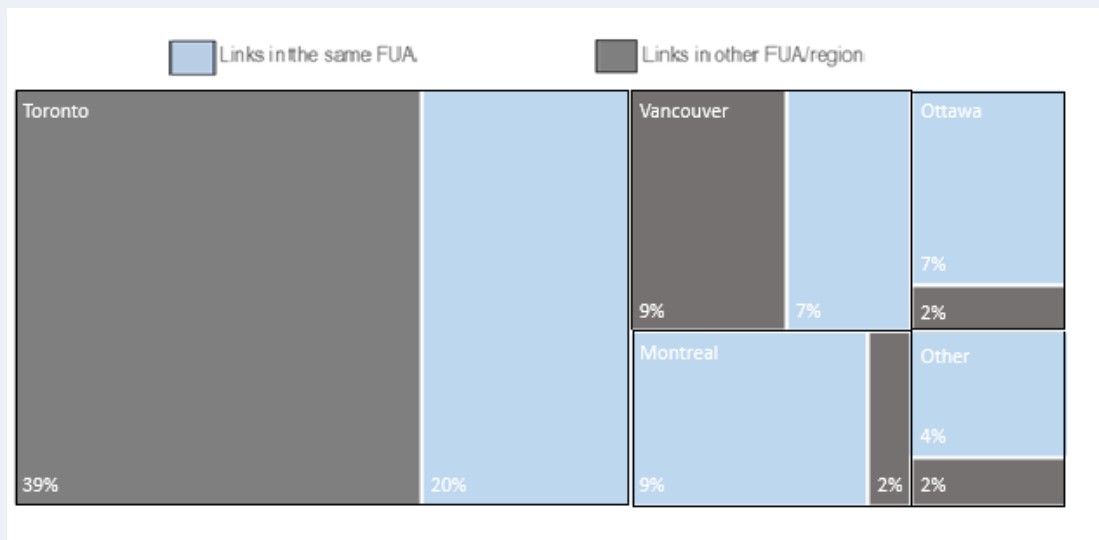
Figure 9. Spatial distribution of university expenditures



Source: Authors' elaborations on www.crunchbase.com and CAUBO for financial information about universities.

Figure 10. Spatial distribution of academic start-ups

By location of alma mater university



Note: Sample restricted to firms that report information on city and that can be geo-located in a Functional Urban Area or a region, and linked to a university that can be geo-located in in a Functional Urban Area or a region.

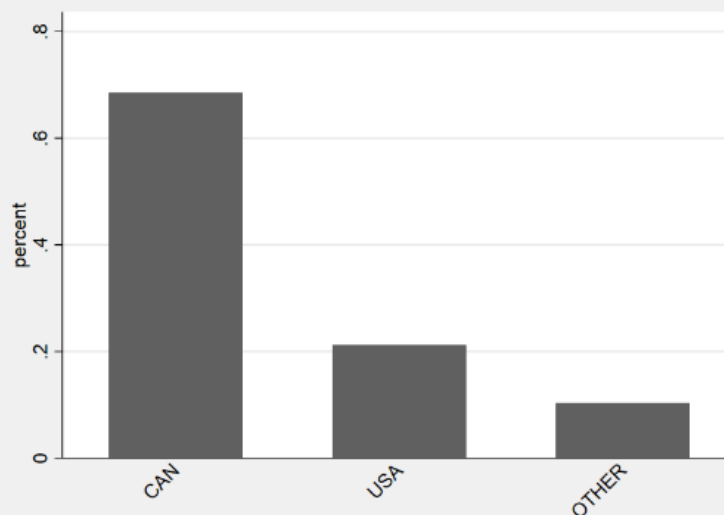
Source: Authors' elaborations on www.crunchbase.com

Table 6. Statistics on founders and start-ups emanating from Canadian universities

	Number of founders	Number of academic founders	Number of start-ups receiving funding	Total funding (USD)	Number of successful exit
Universities belonging to group of the 15 most research intensive universities in Canada (U15)					
University of Waterloo	264	28	83	2 325 931 080	18
University of Toronto	213	26	66	794 056 599	16
McGill University	183	18	71	1 387 957 617	13
The University of British Columbia	133	9	46	672 926 515	8
University of Alberta	53	2	20	168 040 001	8
Universities outside U15					
Carleton University	61	7	15	262 499 754	3
Ryerson University	42	3	10	121 518 136	1
University of Guelph	32	2	15	330 701 679	3
University of New Brunswick	18	1	6	18 729 307	2
Royal Roads University	12	5	2	1 962 118	0

Note: Top 5 universities in terms of number of founders linked to this university for groups of most research intensive (U15) and other universities. Academic founders are individuals creating a start-up within four years after start of B.Sc, seven years after start of PhD, and three years after end of experience as a researcher. The sample is restricted to universities with a positive number of academic start-ups and total funding.

Source: Authors' elaborations on www.crunchbase.com

Figure 11. Country of start-ups created by students and researchers of Canadian universities

Note: The sample is restricted to start-ups for which one alma mater university is reported and is located in Canada.

Source: Authors' elaborations on www.crunchbase.com

5. Policy discussion

It is now an established fact that, across all OECD countries, a tiny share of new firms play a crucial role for innovation, job creation, and productivity work. However, little is known on the ideas and on the people that lead to the success of these innovative start-ups (ISUs). Given their important role in the production of new knowledge and in the training of skilled researchers, higher education institutions (HEIs) and public research institutes (RIs) could potentially play an important role in fostering innovative entrepreneurship through the provision of skilled people and knowledge. However, so far it has been extremely difficult to explore the issue in depth and across countries, due to data limitations. Given the policy relevance of the issue, and the substantial amount of public investment involved, further empirical research on this topic may fruitfully contribute to the current policy debate.

This paper provides a first and preliminary exploration of the linkages between research institutions and innovative entrepreneurship across countries. The analysis unveils a number of policy-relevant findings. First, in the specific sample under scrutiny, academic start-ups are a non-negligible share of all start-ups, especially in science-based technological field. For instance, they account for 23-24% of all ISUs in biotechnology. While in biotech most founders of academic ISUs are experienced researchers, across other fields they are more often undergraduate students. Exploring the characteristics of different types of academic ISUs appears useful, as this uncovers some important differences from comparable non-academic ISUs. In particular, significant differences emerge between ISUs founded by undergraduate students, and ISUs founded by PhD or academic researchers.

Students have founded some of the most successful and disruptive start-ups of the last decades – including e.g. Snapchat and Facebook. Does the empirical analysis suggest that those are the norm or the exception? The results show that ISUs founded by students tend to patent less often than non-academic ISUs, but their patent portfolio is more radical on average, radicalness being defined by the extent to which a patent differs from inventions it relies upon. Students' ISUs are also less likely to receive funding, and when they do, the amount is remarkably lower. Conditional on the amount received, they are also less likely to exit. Regarding inclusiveness, the analysis shows that their founding team is less likely to include a woman.

Conversely, ISUs founded by PhD students and academic researchers are significantly more likely to patent. They are also slightly more likely to include a woman in the founding team. Furthermore, these ISUs are not significantly different from non-academic ISUs in terms of success indicators (VC deals and exit). This is also true when the whole team of founders is composed by academic researchers only, suggesting that academic ISUs are not critically hampered by the lack of management skills. Finally, academic ISUs are more likely to be located within the same urban areas of the RI they emanate from. Overall, these results therefore suggest that RIs are playing an important role in enriching the skills of prospective innovative entrepreneurs, especially in technology fields that are closer to science.

Table 7. Summary of main findings

Linkages between public research institutions (RIs) and innovative start-ups (ISUs)

Research question	Results
Is academic entrepreneurship a sizeable phenomenon?	Academic ISUs account for more than 20% of all ISUs in science-based technology fields (e.g., biotech), and for around 14-15% overall
Are academic ISUs introducing breakthrough innovations?	Among patenting ISUs, academic ISUs patent portfolio is more radical and closer to science
Are academic ISUs more inclusive?	ISUs founded by PhD and academic researchers are more likely to have at least one woman in the team of founders
Do academic ISUs differ in their success?	ISUs founded by undergraduate students receive less VC funding, while academic researchers' ISUs appear to be as successful as comparable non-academic ISUs
Are local spillovers more important for academic ISUs?	Academic ISUs are more likely to be localized in the same city of the university from which they emanate

6. Questions for future work

The rich micro-data used for this analysis can be further exploited to expand the analysis along different directions. First, in order to better understand the difference in success between the different types of academic ISUs and their non-academic counterparts, it is important to consider alternative measures of start-up performance that go beyond funding and exit. Other indicators could include revenue or employment growth for instance. However, these data are not readily available in Crunchbase and particular effort should be undertaken to build such variables, possibly exploiting information contained in companies' websites.

It can also be useful to explore the role of multidisciplinary and “atypical combinations” (Mukherjee et al., 2015^[69]) in explaining start-ups' success. The relevance of such an analysis is reflected in the fact that there are several contributions looking at the role of atypical combinations in explaining breakthrough and exceptionally successful outcomes in scientific publications and patents (Mukherjee et al., 2015^[69]; Uzzi et al., 2013^[70]), but the applications in the field of innovative entrepreneurship are scarcer. There are several different ways in which this stream of research can be applied in the field of innovative entrepreneurship, e.g., atypical combinations could be defined based on: i) patent data linked to start-ups; ii) based on the education and professional background of the founders; or, iii) based on keywords contained in the company descriptions. The degree to which different start-ups are characterised by atypical combinations can be both a dependent and independent variable in the econometric analysis. In the former case, the analysis will assess whether and which atypical combinations are predictor of subsequent start-up success. In the latter case, the analysis will look at institutional elements and framework conditions that are associated with multi-disciplinarity and atypical combinations, and how this is affected by links with the public research base.

The data can also be used to identify national policies and framework conditions that act as “catalysers” of the transformation of scientific discovery into innovative entrepreneurship, in order to explore whether different policy settings can explain the heterogeneous impact of publicly funded research on innovative entrepreneurship across countries and technologies. The analysis may also help identify some policy settings that are hampering the transformation of public research excellence into innovative entrepreneurship. These findings would ultimately be useful to address the apparent “innovation paradox” shared by many countries – especially in Europe – that are struggling to translate world-class public research into a commensurate flow of commercial innovations.

Finally, further work may also relate to inclusiveness. Ongoing OECD work is analysing the striking gender gap in start-up creation – with less than 15% of ISUs having at least one woman in the team of founders – assessing whether the observable characteristics of the founders could at least partially explain it. Further work may also look at the role of immigrant entrepreneurs. The very important role of some ethnical minorities in some countries in the high-tech start-up community is well known, but the lack of data has so far limited the systematic analysis of the issue across OECD countries. However, new sources of data may enable to identify more precisely immigrant entrepreneurs, at least in some selected countries (see e.g. Bernstein et al. (2018^[68])).

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Annex A. Additional tables and figures

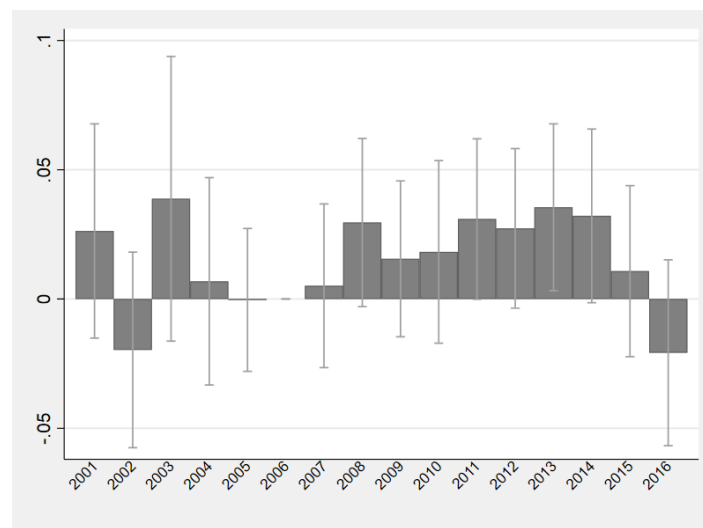
Table A.1. Summary statistics of main variables - VC recipients only

	Number of observations	Mean	Standard deviation	Min	Max
Academic start-ups					
Academic ISU	12 511	0.15	0.35	0.00	1.00
One founder with research experience	17 822	0.03	0.17	0.00	1.00
One PhD founder	17 826	0.03	0.18	0.00	1.00
One student founder	17 716	0.07	0.26	0.00	1.00
Founders characteristics					
Number of founders	23 029	2.07	1.04	1.00	9.00
One founder holds a MBA	20 118	0.21	0.41	0.00	1.00
One founder holds a PhD	20 118	0.15	0.36	0.00	1.00
One woman	22 992	0.18	0.38	0.00	1.00
One founder from ethnic minority	8 223	0.11	0.31	0.00	1.00
Funding					
Funding dummy	23 029	1.00	0.00	1.00	1.00
Total funding (millions USD)	19 676	19.22	119.05	0.00	11 457.45
Exit	23 029	0.13	0.34	0.00	1.00
Patents					
Patent application dummy	23 029	0.20	0.40	0.00	1.00
Num. of patent applications	23 029	4.54	55.69	0.00	6 325.00
Non-Patent Literature citations	3 982	0.13	0.21	0.00	1.00
Radicalness	3 970	0.46	0.22	0.00	1.00

Note: The number of observations reported correspond to the biggest sample for which information is available on the given variable. The education background is available only for a subsample of founders, therefore education variables are typically defined for a smaller set of start-ups. The sample is limited to firms having received at least one VC investment.

Source: Authors' elaborations on www.crunchbase.com and PATSTAT data.

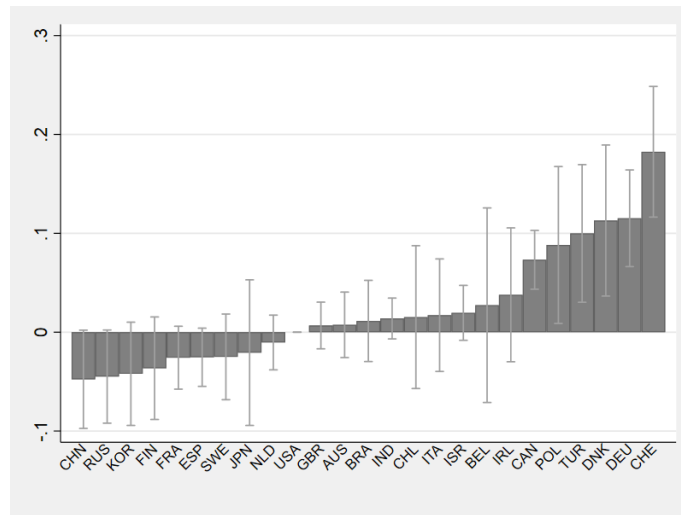
Figure A.1. Share of ISUs linked to RIs by year – robust graph



Note: The graph reports country fixed effects from an OLS regression of a dummy variable indicating an academic start-up onto technology, founded year, and funding dummy variables. Whisker lines report 10% confidence intervals. For more details, see (Breschi, Lassébie and Menon, 2018^[22])

Source: Authors' elaborations on www.crunchbase.com

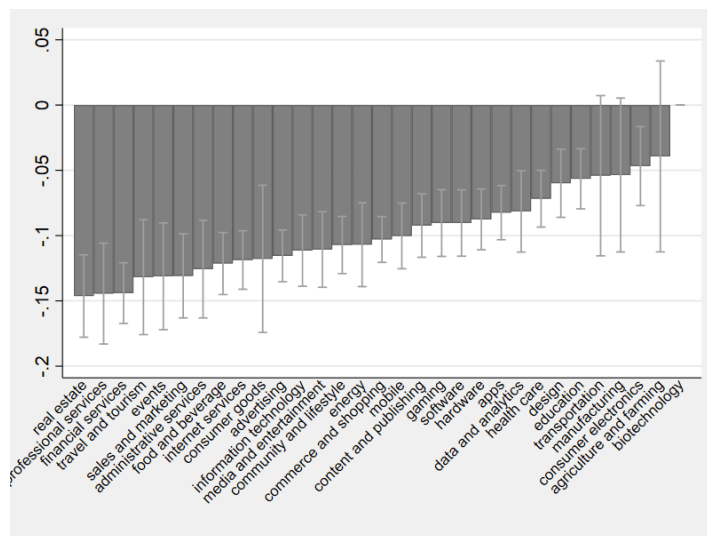
Figure A.2. Share of ISUs linked to RIs by country – robust graph



Note: The graph reports country fixed effects from an OLS regression of a dummy variable indicating an academic start-up onto technology, founded year, and funding dummy variables. Whisker lines report 10% confidence intervals. For more details, see (Breschi, Lassébie and Menon, 2018^[22])

Source: Authors' elaborations on www.crunchbase.com

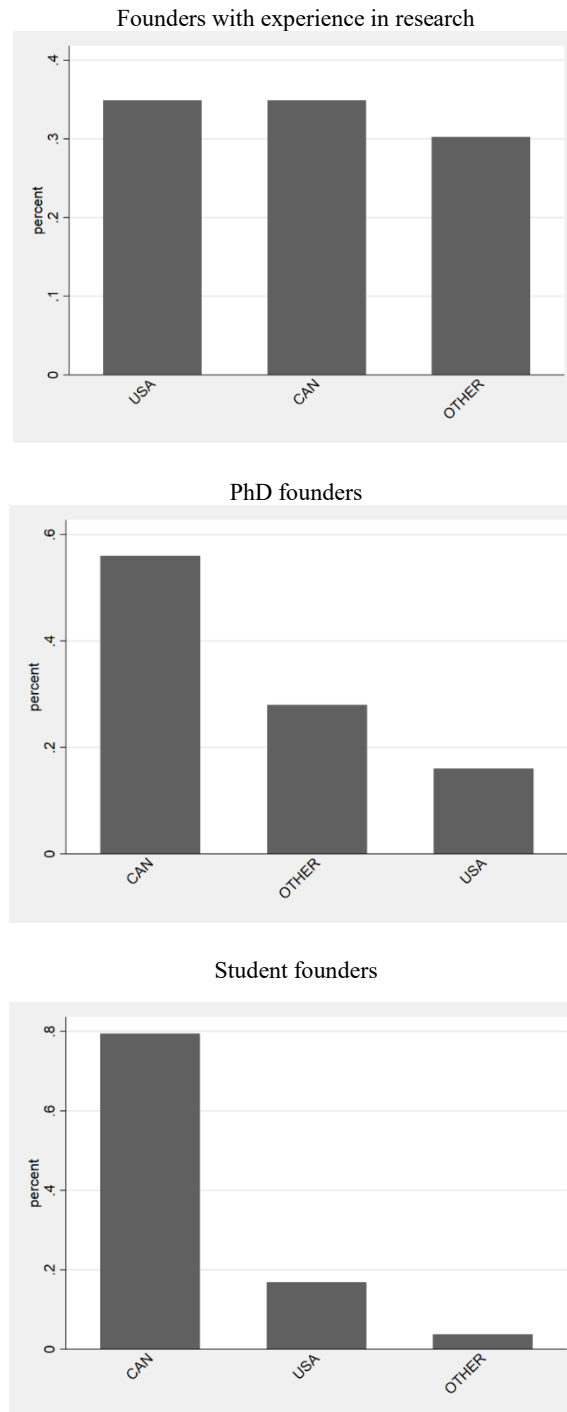
Figure A.3. Share of ISUs linked to RIs by technology field – robust graph



Note: The graph reports technology fixed effects from an OLS regression of a dummy variable indicating an academic start-up onto country, founded year, and funding dummy variables. Whisker lines report 10% confidence intervals. For more details, see (Breschi, Lassébie and Menon, 2018^[22])

Source: Authors' elaborations on www.crunchbase.com

Figure A.4. Country of location of academic start-ups created by students and researchers of Canadian universities



Note: The sample is restricted to start-ups for which one alma mater university is reported and is located in Canada. The category “OTHER” includes OECD and BRICS countries except the United States and Canada; it is mainly composed of Great Britain, Israel, Germany, Australia, and the Netherlands.

Source: Authors’ elaborations on www.crunchbase.com

Endnotes

¹ See e.g. Nicolas Colin, “Startups Don't Need Universities As Much As They Used To”, *Forbes*, available at <https://www.forbes.com/sites/nicolascalin/2018/09/25/startups-dont-need-universities-as-much-as-they-used-to/#5f64f8164091> (visited on September 27th, 2018).

² See, e.g. Egli, Johnstone, and Menon (2015_[71]) for the case of climate change mitigation technologies.

³ See e.g. Almeida and Kogut (1997_[1]); Baumol (2004_[2]); Zucker, Darby and Peng (1998_[3]).

⁴ <https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020> visited on February 21st, 2017.

⁵ <https://www.nsf.gov/about/glance.jsp> visited on February 21st, 2017.

⁶ Deep technologies – deeptech – are those cutting-edge and disruptive technologies based on scientific discoveries. The business strategy of startups in deeptech is built around unique, differentiated, often protected or hard to reproduce, technological or scientific advances. Arguably, this is characteristic of academic start-ups.

⁷ More recent studies also confirmed initial Jaffe’s findings. For instance, a recent OECD paper (Paunov, Borowiecki, and Planes Satorra, 2017) collects statistical evidence based on data for 1 275 regions in Europe in 2011-13 to show that larger regional university systems are associated with stronger regional patenting activities.

⁸ The Bayh–Dole Act enhanced the incentives for firms and universities to commercialize university-based technologies. Specifically, the legislation instituted a uniform patent policy across federal agencies and removed many restrictions on licensing. Furthermore, it allowed universities to own the patents arising from federal research grants. Bayh–Dole also stipulated that researchers working on a federal research grant are required to disclose their inventions to the technology licensing office (Mowery and Sampat, 2004_[73]; Popp Berman, 2008_[72]).

⁹ Results presented in this report are robust to considering as student founders individuals that created a start-up within five years after the start of their undergraduate studies.

¹⁰ As these data are based on country of origin of US immigrants, founders living in the US are excluded from the analysis.

¹¹ For instance, in Great Britain, the first name Hadley belongs to the first half of the distribution so it would be considered as from a minority according to criterion a). However, 48% of all worldwide Hadley are in Great Britain and criterion b) helps to identify these cases.

¹² This consolidated list of universities compiled by OECD uses several sources of data: (1) the European Tertiary Education Register (RISIS Consortium, 2018a_[76]), (2) the Integrated Postsecondary Education Data System (Institute of Education Sciences, 2018_[75]), (3) the World Higher Education Database (International Association of Universities, 2018_[78]), (4) the Register of Public-Sector Organizations (RISIS Consortium, 2018b_[77]), and (5) the Scopus database (Elsevier, 2018_[74]).

¹³ See Breschi, Lassébie and Menon (2018_[22]) for further methodological details on the “robust graphs”.

¹⁴ An analysis of the correlation of the ranking with size shows a very weak negative correlation among the two variables.

¹⁵ The proxy for patent radicalness is taken from Squicciarini, Dernis, and Criscuolo (2013_[60]) and is based on the idea that the more a patent cites previous patents in classes other than the ones it is in, the more the invention should be considered radical, as it builds upon paradigms that differ from the one to which it is applied. Citations to non-patent literature (NPL) are expressed as a share in total citation (thus including citations to NPL and to patents) and are a proxy of the patent closeness to academic research.

¹⁶ An analysis of the fields in which academic start-ups patent is outside the scope of this paper and represents an interesting avenue for future work. However, it should be noted that the fields (patent classes) in which start-ups patent may not necessarily be related exclusively (or even primarily) to a particularly tagged category group, for several reasons. First, firms can report several categories. This work considers the first reported category as their main category. Second, even if this is their main category firms typically patent also outside the area of their core business. Third, some category groups may exhibit very different propensities to patent. Fourth, the historical patent portfolio of relatively old companies are likely to reflect a technological specialisation that is not necessarily aligned with the current one.

¹⁷ For instance 35% of students ISUs register in the database before they receive a first VC investment, while this share is equal to 28% for PhD students ISUs, and 22% for ISUs founded by researchers.