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Beyond scientific excellence: International mobility and the entrepreneurial activities of academic scientists

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ABSTRACT

As the international mobility of academic scientists is ever increasing, its effects on outcomes beyond research productivity deserve more attention. In this paper, we therefore investigate to what extent academics with different international mobility experiences differ in their likelihood to commercialize their research through entrepreneurship. To answer this question, we make use of a detailed survey covering all academics employed at Danish universities in 2017. Empirically, we distinguish three groups of academics according to their international experience (stayers, returnee, and immigrants) and focus on entrepreneurial outcomes realized while residing in the host country, Denmark. The estimation of duration models reveals that returnees are more than 50% more likely to become academic entrepreneurs than stayers. Immigrants, however, were between 38 and 47% less likely to start a firm than returnees. This difference seems to increase at higher levels of commercially relevant research and international research stays at international top institutions.

1. Introduction

The value of basic research for economic growth and private innovation has long been established (Mokyr, 2002; Pavitt, 1991). However, outcomes of basic research are often too far away from commercial applicability and need to be translated into marketable products (Stokes, 1997). An important channel through which this translation takes place is the establishment of companies by faculty members, a phenomenon generally called "academic entrepreneurship" (Zucker and Darby, 2007). Despite the importance of institutional support for this type of activity (Bercovitz and Feldman, 2008), ultimately, the decision to commercialize research findings through academic entrepreneurship is made at the individual level on a discretionary base (Jain et al., 2009), and depends on the consideration of a complex combination of personal and professional factors. Isolating the individual determinants of academic entrepreneurship is therefore crucial to better understanding how to foster it.

While the general demographic characteristics and dispositions of academic entrepreneurs have been thoroughly investigated (e.g., Siegel and Wright, 2015), scholars continue to debate the precise motivations and barriers that academics may face as well as which types of research knowledge they may be able to leverage when starting a business alongside their academic employment. In this regard, it is especially important to consider recent changes in academic careers and the trade-offs academics may face when considering activities outside their main tasks (i.e., research, teaching, applying for grants, administrative tasks). One aspect that has recently become salient in academic careers is international mobility (see Scellato et al., 2015). While its importance in shaping academic careers and scientific productivity is now well established (e.g., Baruffaldi and Landoni, 2012; Franzoni et al., 2014; Jonkers and Cruz-Castro, 2013), the relationship between international mobility and academic entrepreneurship has been largely overlooked so far (notable exceptions are Krabel et al., 2012; Libaers and Wang, 2012; Yasuda, 2015), despite a growing literature highlighting the positive link between migration and entrepreneurship (Azoulay et al., 2020; Kerr and Kerr, 2016; Saxenian, 2000).

As experience in foreign contexts has become a common feature of the careers of university researchers across a range of fields, we argue that understanding its relationship with other activities that an academic may choose to engage in, such as entrepreneurship, warrants further investigation. Additionally, knowledge recombination theory links the mobility of individuals with the mobility of ideas, suggesting that the ability to access existing knowledge from distant sources is key for knowledge generation and creativity in general (Fleming, 2001;

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Hargadon and Sutton, 1997). Also a growing body of literature highlights the positive link between migration and entrepreneurship, showing that immigrants are overrepresented as founders of all types of start-ups (Azoulay et al., 2020), and that return migrants can benefit from cross border ties and access to ideas in the creation of new ventures (Wang, 2020). Finally, from a policy perspective, academics' international mobility weighs in importantly for the overall balance of "brain drain and brain gain." Current public policy in fact promotes the bi-directional exchange of university scientists, providing grants for stays abroad for post-docs and more experienced researchers (Ackers, 2005) as well as tax incentives for incoming scientists (Akcigit et al., 2016; Jacobsen Kleven et al., 2014). Thus, when aiming to understand the effects of such initiatives, it may be relevant to consider a broader set of academic outcomes, including entrepreneurship activities, and to take into account both inflows and outflows of researchers from the country.

This paper therefore aims to understand the differences in entrepreneurial outcomes between groups of academics with different international mobility backgrounds. We address this question in the context of Denmark, and take a host country perspective and distinguish three groups of academics according to their international experience (*stayers, returnee,* and *immigrants)* and focus on their entrepreneurial outcomes realized while residing in the host country. We first compare the entrepreneurial activities of two groups of academics who are both native to the focal country but differ in their international mobility experience by distinguishing those who have spent a considerable amount of time abroad for professional reasons (*returnees*) from native researchers with limited or no international experience (*stayers*). Subsequently, we contrast the entrepreneurial activities of returnees with those of foreign academics who work in a Danish university (*immigrants*). These two comparisons allow us to separate two aspects. The first comparison provides insights into how a spell of international mobility changes the propensity to start a firm in a focal country for academics who are native. The second comparison provides information about the effects of being an immigrant on starting a company in the host country, and potential barriers regarding integration and local networks. These groups are likely to differ along several dimensions, such as personality traits, which are related to both the choice of becoming internationally mobile and entering entrepreneurship; however, rich survey data allows us to control for these, as well as motivations and interest in commercialization. Additionally, we explore potential moderators for the relationship between international mobility and academic entrepreneurship, such as the role of formal barriers (e.g., visa requirements), language, research orientation, and length of residence.

We answer our research question by exploiting a unique dataset covering the entrepreneurial activities of immigrant and native academics in Denmark, which we augmented with publication data. Within a representative sample of more than 3,400 academics employed by Danish universities in 2017, we distinguish individuals by their country of birth and their professional experiences abroad. To estimate the differences between the groups, we employ a discrete time proportional hazard model (Jenkins, 2005). This model allows us to take account of the number of years that elapse until the formation of a firm, either beginning from the career start of returnees and academics who remain in Denmark, or from the time of migrating to or returning to Denmark from an extended stay abroad for the comparison of immigrants and returnees. In addition, the model quantifies how the time until firm formation is related to different personal and professional characteristics of academics.

Comparing the entrepreneurial activities of returnees and stayers, we find a positive and significant difference between these groups in terms of the likelihood of starting a company in Denmark, highlighting the possible benefits of international experience once returning to one's native country. However, when comparing the two groups of internationally mobile scientists—returnees and immigrants—we find that immigrants are significantly less likely to start a company in Denmark. These differences remain robust, even after controlling for demographic and personality characteristics, as well as academic performance. This result suggests that international mobility is positively associated with entrepreneurship; however, mobility may not be enough to overcome some barriers that immigrant academics face in starting a company in Denmark. Factors associated with the type of mobility, commercial research orientation, and the length of residence in Denmark can account for differences within the investigated groups, but do not moderate the relationship between being an immigrant and starting a research based company.

This paper offers a number of contributions. First, it contributes to the literature on academic entrepreneurship by investigating the role of internationally mobile scientists as academic entrepreneurs. In line with prior work (Krabel et al., 2012; Yasuda, 2015), it highlights the positive association of return migration with academic entrepreneurship. It further shows that this relationship is likely linked to foreign research activities, as it is most pronounced if academics actively conducted research in a world leading institution during their spells abroad. Additionally, the paper contributes to the literature on returnee and immigrant entrepreneurship. The comparison between stayers and returnees confirms prior findings that exposure to different environments and access to international networks foster entrepreneurial entry (Wang, 2020). However, by offering a direct comparison between immigrants and returnees and testing potential moderators, this paper highlights how returnees may be more able to translate the benefits of international mobility into the entrepreneurial commercialization of their research. This result constitutes our third contribution, and points towards limitations to the findings of a "universal right-shift" in entrepreneurial activities of immigrants (Azoulay et al., 2020), highlighting the importance of the country specific context (Parey et al., 2017). This paper also has important policy implications. Considering the potentially positive spillovers of academic entrepreneurship on the local economy, our findings suggest that public incentives to promote the attraction of foreign scientists should be complemented with initiatives to facilitate entrepreneurial entry.

The remainder of the paper proceeds as follows. In Section 2, we present the current research landscape of the international mobility of scientists and develop our theoretical reasoning, including linking international mobility and academic entrepreneurship and describing possible mechanisms. Section 3 describes the data and our empirical framework, and Section 4 presents the results, including robustness checks and additional analyses. Section 5 discusses the policy implications of our study and offers suggestions for future research.

2. Literature review and hypotheses development

Pushed by widespread agreement on the value of promoting the commercialization of knowledge and research generated at universities, academic entrepreneurship has become an important focus for both policymakers and scholars (for reviews, see Djokovic and Souitaris, 2008; Grimaldi et al., 2011; Siegel and Wright, 2015). The term academic entrepreneurship has often been used in the literature to indicate a wide range of activities, including other forms of university research commercialization and even broader forms of academic engagement (for a discussion about the differences and similarities between academic research commercialization and academic engagement, see Perkmann et al., 2013). In this paper, we use the narrower definition of academic entrepreneurship as "the creation of new business to commercialize knowledge developed in universities" (Fini et al., 2016).

Within this literature, most contributions have focused on institutional environments and organizational contexts. For example, authors have analyzed the impact of various policy changes, such as the Bayh–Dole Act or the abolition of the Professor's Privilege in a range of other countries (Grimaldi et al., 2011), and the influence of specific organizational structures, such as Technology Transfer Offices and science parks (Markman et al., 2005; Phan et al., 2006). However, it is

important to remember that any entrepreneurial activity at the university level is influenced by the extent to which scientists are willing to engage in the active commercialization of their research results (Tartari and Breschi, 2012). For example, research has shown that the propensity to become an academic entrepreneur is positively associated with being male (Colyvas et al., 2012) and being highly productive (Stuart and Ding, 2006; Toole and Czarnitzki, 2009). Hence, it is crucial to account for individual-level antecedents of academic entrepreneurship. One important element of academic careers that has not yet received much attention in this stream of literature is international mobility; however, there are several reasons why its role in determining academic entrepreneurship merits further investigation.

Looking at the more general entrepreneurship literature, we have witnessed an increasing interest in the phenomenon of immigrant entrepreneurship, particularly in the high-tech sector. Saxenian (2000) documented the presence of immigrants as founders of high-tech start-ups in Silicon Valley in the 1980s and 1990s, finding that they accounted for around 24% of founders. Anderson and Platzer (2006) reported that between 1990 and 2005, immigrants started 40% of public venture-backed companies in the US that were operating in the high-tech space. Additionally, Wadhwa et al. (2007) interviewed 144 engineering and technology companies that were founded in the US between 1995 and 2005 and found that 25% had foreign-born CEOs or CTOs, while Hart and Acs (2011) found that in around 16% of the companies in their sample, at least one founder was reported as being foreign born. Moreover, researchers have also explored the role of immigrants as knowledge creators and transmitters, including their subsequent effect on growth and development. In particular, recent works have investigated the role of highly skilled migrants in diffusing knowledge across regional (Marx et al., 2015) or national borders and in influencing host-country productivity (Canello, 2016), innovative capacity (Filatotchev et al., 2011; Gibson and McKenzie, 2014; Qin, 2015), and the codification and recombination of knowledge in general (Choudhury and Kim, 2018). Furthermore, the decision to migrate involves balancing relatively high risks and uncertain future returns; therefore, international mobility may indeed be seen as an entrepreneurial act in itself (Borjas, 1987; Lin, 2010; Zucker and Darby, 2007). Taken together, these results suggest that immigrants may play an important role in academic entrepreneurship.

Moving to the more specialized academic entrepreneurship literature, few studies have explored the role of international mobility specifically concerning the creation of academic ventures, and those that have done so included a variety of mobility types and contexts. Krabel et al. (2012) found that foreign-born and foreign-educated scientists at the Max Planck Institutes in Germany were more likely to start a new company than were their domestic counterparts, arguing that this result was likely due to their experience with different research methods and cultural environments. Similarly, Libaers and Wang (2012) explored whether foreign-born scientists were more active as academic entrepreneurs (they also looked into a broader notion of entrepreneurial academics, such as a greater likelihood of obtaining government grants). In a representative sample of 2000 US academics, they found that foreign-born academics were more successful at attracting research resources but less successful at exploiting their inventions through entrepreneurship. This was mostly due to their more basic research orientation and their underdeveloped local social networks, especially networks outside academia. Yasuda (2015) explored the relationship between different types of mobility (including international mobility) regarding the likelihood of becoming an academic entrepreneur in a sample of Japanese university researchers. Drawing on opportunity recognition theory, Yasuda showed that international mobility had a positive influence on the likelihood of becoming an academic entrepreneur. Finally, while international mobility was not the key variable of interest in the study *per se*, in a sample of ISI Highly Cited Researchers, Trippl (2013) found no effect of either being a returnee or an expatriate on the likelihood of starting a business as an academic. Hence, the existing research has yielded conflicting results on the direction of the association between researchers' international mobility and academic entrepreneurship.

One important element we believe will help in clarifying the relationship between international mobility and academic entrepreneurship is the distinction between groups of individuals who have experienced different types of international mobility. The first group is composed of *returnees*—natives of the focal country who have returned to it after spending one or more substantial periods abroad. The second group is composed of *immigrants*—academics who have migrated to the focal country and now work there. On the one hand, immigrants and returnees share the possibility of reaching and recombining distant knowledge thanks to their international experience. On the other hand, immigrants represent an outgroup compared to the citizens of the focal country, while returnees may have more characteristics in common with stayers, such as nationality, ethnicity, and culture. To develop our hypotheses, we therefore discuss the possible relationship between international mobility and academic entrepreneurship separately for the groups of returnees and immigrants.

2.1. Returnees

We define returnees as individuals native to a focal country who have been internationally mobile before returning to the focal country itself. They are an interesting group to study, as their mobility has likely increased their human capital, and simultaneously, they are still likely to share important characteristics with their counterparts who have not moved outside of the country, such as ethnicity, language, and culture. Several contributions have highlighted the possible advantages of internationally mobile researchers compared to their stayer counterparts in some scientific endeavors. The reasoning behind these studies is mainly based on the relationship between the mobility of people and the mobility of ideas and that the possibility of accessing knowledge from distant sources is favorable to innovation (Fleming, 2001; Hargadon and Sutton, 1997). It can be argued that scientists' international mobility may give them access to more distant and diverse knowledge and networks, making them more effective at problem-solving and/or generating new ideas (Berliant and Fujita, 2009; Page, 2007; McEvily and Zaheer, 1999), especially in research-intensive (Fujita and Weber, 2004), highly creative (Franzoni et al., 2018), and entrepreneurial activities (Wang, 2020).

For example, several authors have explored the connection between international mobility and scientific performance. In a series of publications, Franzoni et al. 2012, 2014) explored the patterns of international mobility of around 20,000 scientists, finding that migrant scientists (not residing in their country of birth) tend to outperform their colleagues who are natives to the focal country in terms of scientific performance and size of international research networks. Similar results for returnee academics (namely, researchers who return to their country of birth after having spent a period abroad for professional reasons) have been shown in the contexts of isolated (Gibson and McKenzie, 2014) and developing (Jonkers and Cruz-Castro, 2013; Jonkers and Tijssen, 2008) economies.

Scholars have also begun exploring the association of international mobility with other aspects of the academic profession, namely academic engagement and commercialization. Several studies have investigated the effect of the foreign-born status of academics on their patenting activity, finding largely non-significant results (Göktepe-Hulten and Mahagaonkar, 2010; Sauermann et al., 2010). A few contributions have also been made with respect to academic engagement in general. Edler et al. (2011) found that mobile German scientists engage in knowledge transfer activities both with firms in Germany and abroad. A similar result was reported by Trippl (2013) in a sample of ISI Highly Cited researchers.

Conversely, international experience may also be associated with some disadvantages for academics who want to start their own

businesses. In particular, returnees may face the loss of domestic social capital while spending time outside their home country. Li et al. (2012) discussed this challenge with regard to venture performance. In their study of Chinese returnees, they found that new technology ventures led by returnee entrepreneurs generally underperformed those led by locals. In another study in the Chinese context, Qin et al. (2017) found that returnees were slower to set up new ventures compared to local entrepreneurs. A broad social network that spans the boundaries of academia is vital for academics who aspire to become entrepreneurs, as the private information that is exchanged in such a network can facilitate the recognition of commercial opportunities (Stuart and Sorenson, 2007). Moreover, scientists with broader networks are better able to acquire the resources that they need to initiate the commercialization process from external sources (Shane and Stuart, 2002). This is why the loss of social capital following mobility may be detrimental for prospective entrepreneurs.

Notwithstanding such barriers, the literature links international mobility with superior scientific performance. Further, the most scientifically productive academics possess intellectual human capital with extraordinary scientific and pecuniary value (Zucker and Darby, 1996), which enables them to contribute disproportionately to innovation and growth when engaged in entrepreneurial activities. Therefore, we hypothesize the following:

H1: Returnee academics are more likely to engage in entrepreneurial activities than their counterparts who lack international experience.

2.2. Immigrants

The comparison between returnees and stayers provides only a limited perspective on international mobility because new immigrant researchers may display the same advantages as returnees while perhaps facing some idiosyncratic challenges. We believe that a comparison between returnees and immigrants (excluding native stayers) is meaningful because both groups share the experience (and possibly the advantages) of international mobility yet differ in terms of belonging to a particular country, which implies differences in nationality, language, and culture.

In terms of similarities, both returnees and immigrants tend to outperform native stayers in terms of scientific productivity. Stephan and Levin (2001) found that foreign-born and foreign-educated scientists are overrepresented in the US among those scientists making exceptional contributions, including being elected to the National Academy of Sciences. Borjas and Doran (2012) showed that Russian mathematicians who emigrated to the US after the collapse of the Soviet Union are more productive than their American counterparts, and (Gaulé and Piacentini 2013) found a similar result for Chinese PhD students employed in US chemistry departments. This superior performance is generally believed to result from the advantages these individuals can draw from knowledge recombination (Agrawal et al., 2011; Saxenian, 2005) and better matching after migration (Jones, 2008). Both groups may also have an advantage when engaging in entrepreneurial activities because they can recombine distant knowledge thanks to their international experiences. The literature on highly skilled immigrant entrepreneurship has frequently highlighted that foreign-born entrepreneurs can draw from their international knowledge and experiences to start more innovative businesses (Saxenian, 2000), which places them in an advantageous position compared to their native counterparts. Moreover, immigrants are likely to be positively selected based on their entrepreneurial traits, such as being more open minded (Edler et al., 2011). Because they have gone through a migration experience, they are expected to possess certain personal characteristics that could be useful in entrepreneurial endeavors, such as being more open to new experiences.

Despite the similarities in their international experiences, immigrants differ from returnees in important dimensions, which likely affect their entrepreneurial outcomes. Along with considering academics' differing international experiences, distinguishing the various dimensions is thereby important for gaining a better understanding of which mechanisms may drive the relationship between international mobility and academic entrepreneurship.

The local culture and language may act as barriers to entrepreneurship for immigrants. It has been found that language proficiency is one of the most important determinants of labor market success for immigrants (Borjas, 1999). For most foreign-born academics, the language of their host country may be their second (or even third) language, which may deter them from engaging with actors outside university boundaries (Lawson et al., 2019; Libaers, 2014), as spoken language is particularly relevant for informal face-to-face interactions (Grimpe and Fier, 2010; Link et al., 2007). Indeed, a recent contribution by Lawson et al. (2019) explored in detail the geographical patterns of engagement of academics in the United Kingdom, finding that foreign-born academics tend to collaborate more with international actors, while their native counterparts are more oriented toward national partners.

Furthermore, differences may be present in research orientation. A survey conducted by Sauermann et al. (2010) in the US showed that foreign-born scientists were less likely to conduct applied research than they were to conduct basic research compared to their native counterparts. This may be so, especially in the US, because researchers are attracted to the country for reasons that are related to the research environment, which may cause them to focus their energy purely on scholarly work (Libaers, 2014). This is important because it has been shown that academics who perform more applied or user-oriented research are more likely to engage in commercialization and entrepreneurial efforts (Kenney and Goe, 2004; O'Shea et al., 2005). Finally, exploiting entrepreneurial opportunities requires individuals to not only draw on their personal attributes and resources but also to mobilize their social capital to acquire the resources and expertise needed to establish their businesses (Davidsson and Honig, 2003). The network in which they are embedded determines entrepreneurs' social capital, and it is often highly dependent on the location in which they want to begin their activities (Stuart and Sorenson, 2007). Immigrant academics have smaller non-academic social networks than do natives (DiTomaso et al., 1993); therefore, they have fewer ties outside academia that may help them in the commercialization of their research (Owen-Smith and Powell, 2003; Stuart and Ding, 2006). While there is no research in this area that directly compares the networks outside academia of immigrants versus returnees, given the abovementioned barriers, we can expect the external networks of immigrants in their host country to be no more developed than those of returnees.

To summarize, while returnees and immigrants share some benefits that are associated with having international experience (such as personal traits that are more conducive to entrepreneurship and a greater ability to recombine knowledge from distant sources), immigrants may suffer from disadvantages that are idiosyncratically linked to their foreignness. We thus hypothesize the following:

H2: *Immigrant academics are less likely to engage in entrepreneurial activities than returnee academics.*

3. Empirical framework

3.1. The Danish context

Our study is situated in the context of Denmark, a small European country with an advanced economy. Denmark is often listed amongst the most business- and entrepreneurship-friendly environments in the world and was ranked fourth behind New Zealand, Singapore, and Hong Kong

SAR (China), ahead of the US and the UK in the 2020 World Bank's "Ease of doing business" indicator.[1] It has an internationally open private and public sector, with many firms using English as an official language (Sanden and Kankaanranta, 2018). When reviewing academic entrepreneurship rates, about 11% of our respondents reported involvement in setting up a company. This number closely resembles the academic entrepreneurship rates in other advanced economies, such as Sweden (Klofsten and Jones-Evans, 2000) and the UK (D'Este and Perkmann, 2011). There are no differences in the rules for business registration for residents in Denmark based on their citizenship.

In terms of the structure of the higher education sector, there are currently eight universities in Denmark, located in all five administrative regions of the country, although half of them are situated in the capital region.[2] All universities in Denmark are public, and are therefore regulated by the same set of rules and procedures, making them a relatively homogenous set, especially if compared to the institutional variety of higher education institutions in other countries, such as the US or the UK. While commercialization outcomes differ across universities (mainly because of different disciplinary focus), researchers face highly homogenous legal frameworks regarding their ability to start a company while employed in a university. Also regarding the ownership of the intellectual property rights, Denmark has moved away from the professor's privilege assigning primary ownership of inventions to universities (Geuna and Rossi, 2011), and therefore providing homogenous requirements of disclosure, and even the division on royalties stemming from academic inventions.

3.2. Data and sample

We combined data from different sources to empirically assess the validity of our hypotheses. The main data source was a survey of all researchers employed at a Danish university, which was conducted in October 2017. The population includes active researchers who have conducted research work for which a Ph.D. or an equivalent degree would usually be required during the five years prior to the survey. Thus, Ph.D. students, technicians, administrative staff, and inactive researchers were excluded. A total of 4,836 faculty members responded to the survey, representing an overall response rate of 38%.[3]

Although the survey represents a cross-section of academics in Denmark in 2017, the collected data provides rich longitudinal information on the respondents' migration histories and their professional experience since the start of their careers. We reconstructed the academic career of each respondent until 2017, beginning from their career start. We operationalized the career start as the year in which the Ph.D. was awarded minus four years.[4] To be able to match our respondents to additional data (such as publications), we limited our sample to academics who started their careers after 1960 and before 2015 and (re-) entered Denmark before 2016.

We further included information on the academics' entrepreneurial activity and international mobility. In the case of entrepreneurial activity, we determined how many companies a researcher started and the year in which each company was established. Regarding international mobility and migration, we asked foreign-born researchers in which year they came to Denmark and to indicate the start year and duration of stays outside Denmark or their country of birth that exceeded nine months, which is a period that requires a significant relocation and corresponds to the length of an academic year (up to 10 stays, which may have happened at any time in their life). The answers to this question were censored to the category of "5 years or more"; therefore, we manually looked up the end year of the stays that fell into this category using publicly available CV information from university profiles and LinkedIn. Additionally, we asked each respondent about which country was visited and their activities abroad. This resulted in a detailed longitudinal record of the international mobility and academic entrepreneurship events of researchers across their entire careers until 2017. Additionally, the survey included other variables, such as personality traits, risk preferences, and perceptions of various aspects of academic engagement.

Furthermore, we matched the survey data to bibliographic information that was extracted from Scopus. We were able to match 84% of the survey population and 90% of the respondents to a Scopus profile, thereby adding yearly information about publication output and citations to the data. The unmatched respondents included individuals who could not be matched (e.g., due to name changes or misspellings) and researchers with no publications in a journal indexed in Scopus.

Finally, to assess the importance of the method biases that are often associated with surveys, such as recall bias or common source bias (Podsakoff et al., 2003), we triangulated our findings with measures of start-up activity derived from other sources. Specifically, we added information from the public business registry to verify the information that the respondents provided about their entrepreneurial activities.

3.3. Variables

To evaluate differences in the entrepreneurial activities between groups of academics with different backgrounds of international mobility, we conducted our empirical analysis on two sub-samples. The first consisted of a comparison between Danish researchers with international experience and those without (i.e. stayers and returnees, "the native sub-sample"). The second sub-sample consisted of internationally mobile researchers (i.e. returnees and immigrants, "the mobile sub-sample"). The definition of the dependent variable and some independent variables differed between the two sub-samples, as described in detail below. The first comparison illustrates how a spell of international mobility changes the probability of an academic starting a firm. The second comparison provides insights into the effects of different types of mobility: by comparing the "entrepreneurial hazard" of returnees and immigrants from the moment they enter Denmark, our analysis provides information about the effects of being foreign, and potential barriers regarding integration and local networks.

3.3.1. Dependent variable and time at risk

Our empirical approach relied on observing the timing of startups relative to researchers' careers and their international mobility histories. The binary dependent variable *StartComp* took the value 1 in the year in which a company is started while residing in Denmark and 0 otherwise. The data is right-censored in the year in which a respondent starts a company or in 2017, which is the year of sampling.

This definition implied two critical modeling choices. Consistent with prior studies that have provided strong evidence that entrepreneurs establish firms where they reside (Dahl and Sorenson, 2009), the geographical reach of the definition reflected our focus on entrepreneurial activities while residing in the host country, Denmark. We controlled for any company started either in Denmark or abroad prior to the mobility event. Our analysis is thereby also compatible with instances of "transnational entrepreneurship," i.e., "individuals that migrate from one country to another, concurrently maintaining business–related linkages with their former country of origin" (Drori et al.,

[1] World Bank/IBRD: Doing Business 2020.

[2] For a detailed overview on Danish universities, see Online Appendix 1

[3] Details on the survey design and administration can be found in the Online Appendix 2.

[4] While this information was available from the survey for all respondents who had obtained their Ph.D. outside Denmark, we had to complement this information for those who obtained it at a Danish institution. To do so, we made use of the Danish Ph.D. database ("Forskningsdatabasen") and linked the information based on name and scientific field. For unmatched respondents, we inferred their year of career start based on their first publication minus four years (or the establishment of their first research-based company minus one year).

2009, p. 1001). Given this definition of the dependent variable, it is also critical to keep track of the periods in which the academic is "at risk" of starting a company in Denmark. The relevant periods vary according to the mobility groups being compared. Fig. 1 illustrates the variable definitions through three stylized scientist careers.

We first compared the group of native academics who started their careers in Denmark, stayers and returnees. They are considered at risk of starting a company throughout their careers, except for the periods spent abroad by the returnees. The first part of Fig. 1 refers to this subsample of natives. It depicts 20 years of the careers of a returnee and a stayer. Both started their careers in the same year. The number of years at risk increased by 1 for each year a respondent stayed in Denmark. For the stayer, the years at risk also reflected his academic age. The returnee stayed abroad in the 6th and 7th year of her career. Thus, starting in year eight of the returnee's career, the prior international mobility dummy will take the value 1. Further, during her stay abroad, the returnee is not considered at risk of starting a company in Denmark. This means that the count of years at risk will not increase, and any firms started during this period will be assumed to be started abroad and therefore not be considered relevant for the outcome variable.[5] Consequently, her first relevant company was started in 2013. Combined, the length of her stay abroad and her years of being at risk in Denmark amount to her academic age. In contrast, the stayer is considered at risk for his entire career, and consequently, his first company in year 6 is relevant for the dependent variable.

Second, we compared internationally mobile academics, namely immigrants and returnees. As we are concerned with start-ups that happen in the focal country of our study, Denmark, we only considered companies begun after either immigrating to Denmark (immigrants) or after the first stay abroad (returnees). The second part of Fig. 1 exemplifies the careers of a returnee and an immigrant. Notably, the time at risk is now measured after the mobility event. In this comparison, the returnee is only considered at risk once she returns to Denmark at an academic age of eight years. The immigrant academic starts being at risk once she enters Denmark. Hence, the risk start may happen at different career stages. Companies started prior to risk start are not considered for the dependent variable but are considered as a control for prior entrepreneurship experience.

3.3.2. Explanatory variables

Our estimations included variables that relate to mobility status and international experience of the different groups of academics. For the first part of our analysis, in which we compare stayers and returnees, we included the dummy variable *PrevAbroad*, taking the value 1 for returnees after their return and 0 otherwise. Hence, returnees were considered equivalent to stayers prior to their stay abroad. We also ran an alternative specification, where instead of including a dummy for prior international experience, we included the cumulative number of years spent abroad (*YearsAbroad*). In the second part of the analysis, comparing returnees and immigrants, we included the dummy variable *Immigrant* taking the value 1 for foreign-born academics. However, if an immigrant came to Denmark more than five years before starting their Ph.D., they were considered a native, assuming that they received most of their education and professional exposure in Denmark.

3.3.3. Control variables

One set of control variables was included to account for differences in the time of being at risk of setting up a company. How the relevant time related to academic age differed between mobility groups. For the comparison of stayers and returnees, our main control was the variable *YearsAtRisk*, which counts the number of years in which an academic was present in Denmark. For returnees spending long periods abroad, there was a large divergence between academic age and *YearsAtRisk*. This problem was addressed in the alternative specification, where we included the cumulative number of years spent abroad (*YearsAbroad*) instead of the dummy variable for prior mobility. Similarly, for the comparison of returnees and immigrants, we counted the number of years elapsed since an immigrant academic entered Denmark or a returnee reentered the country (*YearsAtRiskPost*). Considering that immigrants and returnees might have come to Denmark at different career stages, we controlled for their academic age upon (re-)entry either as an additional control variable (*AcadAgeEntry*) or by including a full set of academic age dummies.

Another control variable relevant for the comparison of immigrants and returnees considered possible instances of pre-mobility entrepreneurship. Hence, we included a dummy variable *Prior firm*, taking the value 1 if an academic had been involved in a startup that happened before the mobility event and 0 otherwise. The variable applied to any startup established before an immigrant moved to Denmark or, in the case of returnees, before their reentry into Denmark after their stay abroad.

Common to all our specifications, a third set of variables was included that has been shown to be related to academic entrepreneurship by previous studies. As prior studies showed that male academics are more likely to become academic entrepreneurs, we included a gender dummy for *Male*. The respondents' genders were determined based on their first name, using the *genderize.io* API. It was also to be expected that there would be significant differences between scientific fields regarding the commercializability of research as well as norms within the field. We therefore included dummies for scientific field. Based on the respondents' survey responses, we differentiated between six scientific fields, including Arts and Humanities, Engineering, Medical and Health, Natural Sciences, Social Sciences, and Agricultural Sciences (which serves as the baseline category).

Further, the literature suggests that internationally mobile individuals may possess certain traits that might also positively influence their willingness to become entrepreneurs (Borjas, 1987; Lin, 2010; Zucker and Darby, 2007). Hence, we included controls for a set of personality characteristics to allow for separation of the effect of the experience gained abroad from the possible intrinsic predisposition of certain researchers to engage in academic entrepreneurship.[6] *Risk tolerance* is often associated with both entrepreneurial activity and the decision to become internationally mobile. Therefore, we collected a revealed measure of risk tolerance, in which each respondent had to select a preferred gamble from six different gambling options, which differed in terms of their expected trade-offs and associated risks (Charness et al., 2013). There is a large body of literature that links personality traits to entrepreneurial outcomes (for a review, see Zhao et al., 2010), which shows that openness to experience is positively related to entrepreneurial intentions. Because this trait has been shown to relate to migration as well (Jokela, 2009; Otto and Dalbert, 2012), it was important to control for personality, given that some of its aspects may predict both entrepreneurial activity and international mobility. We therefore administered a set of questions to measure the Big Five personality characteristics (i.e., *Openness, Neuroticism, Conscientiousness, Agreeableness, Extroversion)*, which are based on the work of Rammstedt and John (2007), who proposed a ten-item version of the Big Five Inventory.

Engaging in academic entrepreneurship is a choice that is driven by individual motivations and perceptions of the activity itself (Tartari and Breschi, 2012); thus, we further included variables about attitudes toward research commercialization. These included barriers to academic engagement (Tartari et al., 2012), such as the perception that the research would not be relevant to anyone outside academia (*Lack of relevance*), as well as how important it was to commercialize their

[5] There was a total of 7 instances of returnees reporting a start-up while being abroad. Results remain robust to excluding these observations from the sample.

[6] The Online Appendix 2 presents the exact questions.

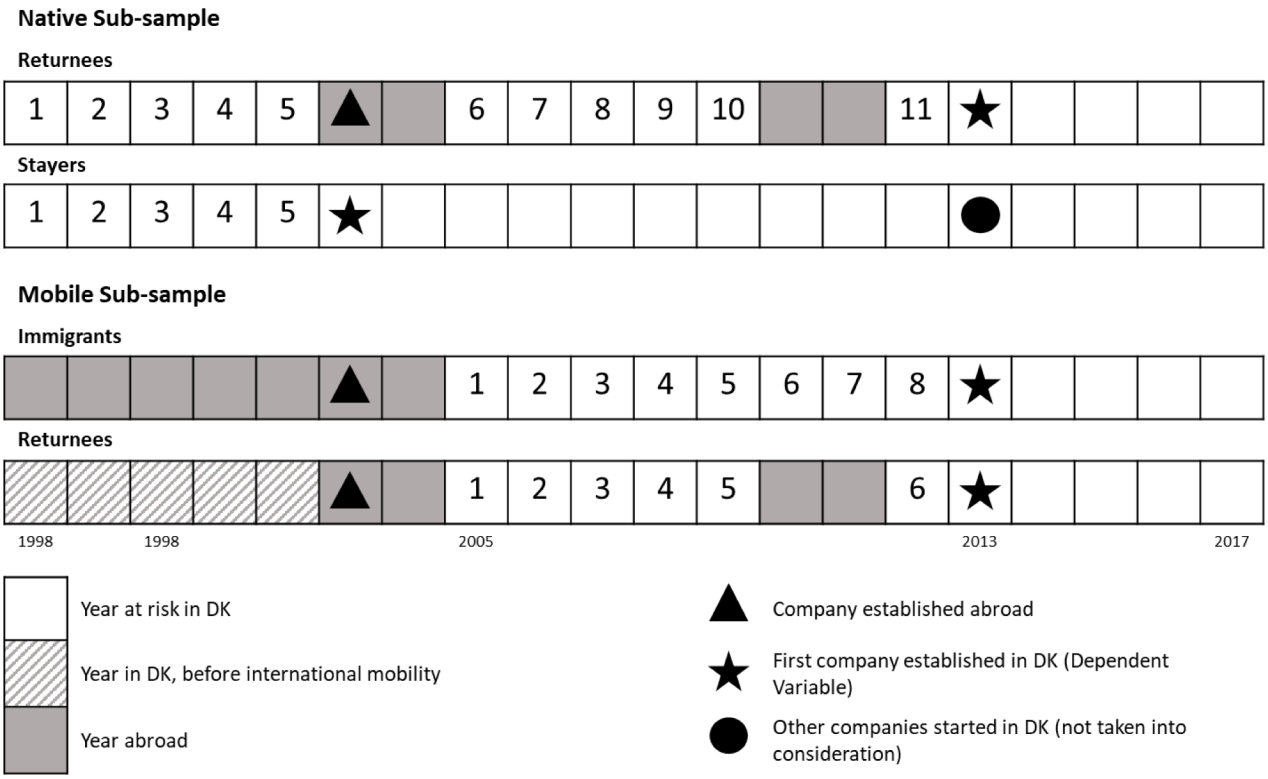

Fig. 1. Stylized Subsamples

This figure illustrates how the key variables are defined in the two sub-samples. Years spent in Denmark have a white background, however not all are counted for the definition of years at risk, and relevant years are numbered. The native sub-sample, depicts 20 years of the careers of a returnee and a stayer. Both started their careers in the same year. The number of years at risk increased by 1 for each year a respondent stayed in Denmark. For the stayer, the years at risk also reflected his academic age. The returnee stayed abroad in the 6th and 7th year of her career. Thus, starting in year eight of the returnee's career, the prior international mobility dummy will take the value 1. Further, during her stay abroad, the returnee is not considered at risk of starting a company in Denmark. This means that the count of years at risk will not increase, and any firms started during this period will be assumed to be started abroad and therefore not be considered relevant for the outcome variable. Consequently, her first relevant company was started in 2013. Combined, the length of her stay abroad and her years of being at risk in Denmark amount to her academic age. In contrast, the stayer is considered at risk for his entire career, and consequently, his first company in year 6 is relevant for the dependent variable. The second part of Fig. 1 exemplifies the careers of a returnee and a foreigner. Notably, the time at risk is now measured after the mobility event. In this comparison, the returnee is only considered at risk once she returns to Denmark at an academic age of eight years. The immigrant academic starts being at risk once she enters Denmark. Hence, the risk start may happen at different career stages. Companies started prior to risk start are not considered for the dependent variable but are considered as a control for prior entrepreneurship experience.

research (*Importance of commercialization*).[7] Additionally, to elicit the extent to which the respondents were intrinsically or extrinsically motivated in their academic job, we administered a set of eight questions that referred to different types of motivations, such as salary or independence. We then conducted a factor analysis on them to ensure that the two types of motivations were orthogonal to each other (Sauermann et al., 2010).[8]

A final set of control variables considered the researchers' scientific productivity, which in previous research was positively correlated with academic entrepreneurship (Stuart and Ding, 2006). Therefore, we included the cumulative number of publications in *t*-2 (*Cumulative Publications t-2*) as well as the number of publications per year in *t*-1 (*Publications per year t-1*; Azoulay et al., 2017). All models also included university fixed effects and a full set of year dummies.

3.4. Estimation

Our estimation model was set up as a duration model in which we aim to model academics' entrepreneurial activity as a function of years residing in Denmark, either from career start or moving to Denmark. We followed recent studies to estimate the determinants of mobility (Azoulay et al., 2017; Breschi et al., 2018) or entrepreneurship (Rocha and van Praag, 2017) and employed a discrete-time proportional hazard model (Jenkins, 2005). This allowed us to model the binary dependent variable while including the basic time dimension in terms of years at risk and controlling for individual and institutional characteristics.

Accordingly, we estimated for each person i at a given year the hazard h of the complementary log-log type would be:

$$h_i(t) = 1 - \exp[-\exp(z(t))],$$

where

$$z(t) = c(t) + \beta' X,$$

and t denotes the number of years that have elapsed from risk start until a company is started. In this specification, $c(t)$ is the baseline hazard function, and $\beta' X$ is a vector of the explanatory and control variables, as described above. In their exponentiated form, the β coefficients reflect the hazard ratios relative to the baseline hazard. The discrete-time

[7] Ideally, we would like these measures to be taken for every year of the analysis. Unfortunately, as they can only be retrieved to survey, this is not possible. We therefore use the variables measured at the time of survey (2017), as we consider them an adequate proxy for the general attitudes towards commercialization of the researchers in our sample.

[8] The Online Appendix 3 reports the results of the factor analysis.

implementation of this specification models a discrete outcome on a year by year basis, and has the advantage that it allows the inclusion of time-constant as well as time-variant *X* variables. In the main specification, we log transform the years at risk variable, assuming that there are decreasing returns to time spent in Denmark. We also apply specifications in which we do not impose a functional form to the baseline hazard function, as well as exponential time and linear time for additional robustness checks (see also Breschi et al., 2018; Gaulé, 2014).[9]

4. Results

4.1. Descriptive statistics

A summary of the characteristics of the scientists in the two sub-samples can be found in Tables 1 and 3. Table 1 presents the descriptive statistics for the native sub-sample, which contained 29,318 person-year observations for 1,583 individuals. Table 2 presents the corresponding statistics for the mobile sub-sample, composed of 12,276 person-year observations for 1,044 individuals.[10]

Table 3 provides summary statistics on entrepreneurial outcomes for the different mobility groups. It shows that the share of entrepreneurs is highest among returnees, with 17.8%, whereas only 9.5% of immigrants and 9.0% of stayers were at some point in their career involved in starting a firm based on their research. Only considering firms started while the academic was residing in Denmark, reduces the share of entrepreneurial immigrants to 6.8%, and the share of entrepreneurial returnees to 16.6% respectively. 3.9% of immigrants and 2.8% of returnees started a company before becoming mobile.

Differences between the groups are also present regarding the timing of entrepreneurship. Stayers had on average an academic age of 15.5 years. Considering the mobile sub-sample, returnees started a company on average 21.2 years after starting their Ph.D., or after spending 12 years in Denmark. Immigrants on the other hand, started their first company after residing in Denmark for 8.0 years, or 16.5 years after starting their PhD. Regarding international mobility, the five most frequent countries of origin are Germany, Italy, China, UK, and US, which together account for 52% of immigrants. Considering returnees, the average stay abroad lasts 3.7 years, and the most frequent destination countries are the US, UK, Germany, and France, with the US being the destination country for about 41% of returnees.

Table 1
Summary statistics of native sub-sample ($n = 29{,}318$).

	Mean	SD	Min	Max
PrevAbroad	0.217	0.412	0	1
YearsAbroad	0.841	2.000	0	23
YearsAtRisk (log)	2.256	0.887	0	3.689
Male	0.684	0.465	0	1
Risk tolerance	3.577	1.920	1	6
Openness	3.473	0.750	1	5
Neuroticism	2.381	0.750	1	5
Conscientiousness	4.201	0.607	1.5	5
Agreeableness	3.865	0.596	2	5
Extroversion	3.465	0.859	1	5
Extrinsic motivation	−0.120	0.773	−3.012	1.893
Intrinsic motivation	0.035	0.693	−4.583	1.181
Lack of relevance	0.080	0.271	0	1
Importance of commercialization	0.425	0.494	0	1
Cumulative number of publications (*t*-2)	19.569	37.849	0	1061
Publications per year (*t*-1)	2.211	4.254	0	210

Table 2
Descriptive statistics of mobile sub-sample ($n = 12{,}276$).

	Mean	SD	Min	Max
Immigrant	0.478	0.500	0	1
YearsAtRisk (log)	1.905	0.918	0	3.689
AcadAgeEntry	7.913	5.987	1	40
Prior firm	0.024	0.1519	0	1
Male	0.731	0.443	0	1
Risk tolerance	3.523	1.896	1	6
Openness	3.584	0.727	1.5	5
Neuroticism	2.420	0.770	1	5
Conscientiousness	4.147	0.623	1.5	5
Agreeableness	3.791	0.623	1.5	5
Extroversion	3.377	0.863	1	5
Extrinsic motivation	−0.024	0.803	−2.980	1.989
Intrinsic motivation	0.060	0.683	−3.362	1.181
Lack of relevance	0.113	0.316	0	1
Importance of commercialization	0.457	0.498	0	1
Cumulative number of publications (*t*-2)	29.520	51.805	0	1162
Publications per year (*t*-1)	3.143	5.185	0	133

Table 3
Overview of entrepreneurial activities, by group.

	Immigrants		Returnees		Stayers	
	N	pct.	N	pct.	N	pct.
Entrepreneurship general						
0	556	90.55	356	82.22	1,047	90.96
1	58	9.45	77	17.78	104	9.04
Total	*614*		*433*		*1,151*	
Pre-mobility entrepreneurship						
0	590	96.09	421	97.23		
1	24	3.91	12	2.77		
Total	*614*		*433*			
Entrepreneurship in Denmark (post-mobility for immigrants and returnees)						
0	572	93.16	361	83.37	1,047	90.96
1	42	6.84	72	16.63	104	9.04
Total	*614*		*433*		*1,151*	

4.2. Main results

We estimated two sets of duration models: one for the comparison of stayers and returnees and another for comparing returnees to immigrant academics. Throughout, the outcome variable was *StartComp*—the indicator for having established a firm in Denmark in a given year. Hypothesis 1 is addressed in Table 4, which compares the two groups of native academics: stayers and returnees. Model 1 captures the association between academic entrepreneurship and international mobility in terms of the variable *PrevAbroad*, which indicates the group of returnees. In this simple comparison, returnees were at 1.9 times the risk of starting a company compared to those who did not leave the country for any significant amount of time. Model 2 shows the results after including all control variables. As expected, controlling for a number of variables commonly associated with academic entrepreneurship and with mobility somewhat reduced the estimated premium for internationally mobile academics to a factor of 1.6.

Furthermore, aligned with previous findings (Colyvas et al., 2012), male academics were more likely than females to start a company with a relative hazard ratio of 1.7. The differences between fields were less pronounced, except academics in engineering fields, who were about three times more likely to start companies than academics in agricultural science (the reference group). Personality traits had some explanatory power. In particular, we found a positive and significant effect of *openness* to experience and the opposite effect regarding *conscientiousness*. The other traits and our measure of *risk tolerance* were

[9] Results are robust to a cross-sectional specification taking into account years at risk, see Appendix A1

[10] Correlation matrices are presented in Appendix A2

Table 4
Results of discrete time hazard model for the sub-sample of stayers and returnees.

	(1) Start Comp	(2) Start Comp	(3) Start Comp
PrevAbroad	1.876***	1.550*	
	(0.000)	(0.012)	
YearsAbroad			1.099**
			(0.002)
YearsAtRisk (log)	1.539***	1.563***	1.617***
	(0.000)	(0.000)	(0.000)
Male		1.660*	1.654*
		(0.015)	(0.016)
Risk tolerance		1.009	1.009
		(0.826)	(0.834)
Openness		1.384**	1.397**
		(0.006)	(0.005)
Neuroticism		0.927	0.937
		(0.500)	(0.560)
Conscientiousness		0.768	0.764*
		(0.051)	(0.044)
Agreeableness		0.848	0.856
		(0.207)	(0.236)
Extroversion		1.149	1.164
		(0.165)	(0.128)
Extrinsic motivation		1.070	1.080
		(0.504)	(0.455)
Intrinsic motivation		1.504**	1.498**
		(0.001)	(0.001)
Lack of relevance		1.052	1.048
		(0.862)	(0.873)
Importance of commercialization		2.912***	2.958***
		(0.000)	(0.000)
Cumulative number of publications (*t*-2)		0.998	0.998
		(0.452)	(0.424)
Publications per year (*t*-1)		1.030*	1.031*
		(0.015)	(0.015)
Calendar Year F.E.	Yes	Yes	Yes
Field F.E.	No	Yes	Yes
University F.E.	No	Yes	Yes
*# of r*esearchers	1,583	1,578	1,578
# of observations	26,623	26,533	26,533
Log pseudolikelihood	−999.062	−934.043	−932.991

Note. Exponentiated coefficients; *p*-values in parentheses, standard errors are clusters on respondent level
* $p < 0.05$
** $p < 0.01$.
*** $p < 0.001$. The first calendar year with a non-zero outcome included in the model is 1984.

not significantly correlated with starting a company in our sample. Regarding different types of motivations, only *intrinsic motivation* was positive and significantly related to starting a company. This finding was somewhat surprising because setting up a company may also provide a source of additional income for academics. As expected, a positive attitude toward the *commercialization* of research findings had a positive and significant coefficient. A perceived *lack of relevance* of one's own research to external partners (representing a potential barrier to entrepreneurship) showed no effect. There were mixed results in terms of the importance of the researchers' publication productivity: only recent *publications per year (t-1)* had any appreciable effect on setting up a company in Denmark. Finally, our estimates of university fixed effects were insignificant, indicating that differences across institutions in terms of support for entrepreneurship and the type of research conducted were less important in explaining individual-level variations between researchers.

As evident from the significant and positive coefficient of *YearsAtRisk,* the baseline annual risk of setting up a company increased across the length of time that an academic is active in Denmark. This effect may also partly reflect the general effects of academic seniority. For stayers, academic age goes one-to-one with time at risk. However, for returnees, we can partly control for this by including the length of their stay abroad (which was zero for stayers). The variable *YearsAbroad* was added to the specification in Model 3. The results demonstrated a relative hazard factor of 1.1 per year for *YearsAbroad.* With 4.5 years spent abroad on average by returnees in our sample, this is largely consistent with an overall premium for returnees of 55%, as estimated from Model (2). The remaining coefficients and their significance were largely unaffected by this extension of the model.

Overall, the regressions in Table 4 suggest a substantial difference in the entrepreneurial propensities between native academics based on their international mobility experience. Across specifications, academics with international experience showed a relative increase in the risk of starting a company in Denmark by 1.6–1.9 times. Moreover, the evidence in favor of Hypothesis 1 was robust in controlling for an extensive set of determinants commonly associated with academic entrepreneurship.

Table 5 presents the results of comparing academic scientists with different types of international experience. Model 1 shows the gross difference in entrepreneurial propensities after the mobility event for immigrants as compared to returnees. The variable *Immigrant* takes a

Table 5
Results of the discrete time hazard model for returnees and immigrants.

	(1) Start Comp	(2) Start Comp	(3) Start Comp
Immigrant	0.625*	0.529*	0.501**
	(0.023)	(0.012)	(0.004)
YearsAtRiskPost (log)	1.132	1.427**	1.299*
	(0.240)	(0.004)	(0.018)
AcadAgeEntry			1.012
			(0.484)
Prior firm		8.304***	5.336***
		(0.000)	(0.000)
Male		1.251	1.298
		(0.434)	(0.335)
Risk tolerance		1.070	1.057
		(0.250)	(0.310)
Openness		1.754***	1.733***
		(0.001)	(0.001)
Neuroticism		0.909	0.882
		(0.506)	(0.381)
Conscientiousness		0.709	0.719
		(0.051)	(0.058)
Agreeableness		0.787	0.831
		(0.177)	(0.320)
Extroversion		1.091	1.089
		(0.516)	(0.505)
Extrinsic motivation		0.987	1.024
		(0.921)	(0.844)
Intrinsic motivation		0.700*	0.765
		(0.044)	(0.131)
Lack of relevance		0.967	1.022
		(0.922)	(0.950)
Importance of commercialization		3.070***	2.744***
		(0.000)	(0.000)
Cumulative number of publications (*t*-2)		0.998	0.998
		(0.357)	(0.184)
Publications per year (*t*-1)		1.013	1.020
		(0.414)	(0.187)
Ac age risk start F.E.	No	Yes	No
Calendar Year F.E.	Yes	Yes	Yes
Field F.E.	No	Yes	Yes
University F.E.	No	Yes	Yes
# of respondents	1,043	937	970
# of observations	9,470	8,401	8,692
Log pseudolikelihood	−572.094	−505.782	−523.488

Note. Exponentiated coefficients; *p*-values in parentheses, standard errors are clusters on respondent level.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$. The first calendar year with a non-zero outcome included in the model is 1984.

value of one for foreigners and zero for returnees. With a hazard ratio of 0.625, the raw comparison revealed that immigrants were about 38% less likely to start a company in Denmark. Model 2 includes all control variables. Academic age upon (re-)entry did not have a strong impact, and it did not matter whether it was included as a set of dummies (Model 2) or a linear term (Model 3). Previous entrepreneurial activity (*Prior firm*), on the other hand, had a large positive effect on the likelihood of starting a company after the mobility event. This speaks to learning effects and to intrinsic preferences of commercializing research through venture creation. In contrast to previous estimations, there was no significant difference between men and women among mobile academics in terms of starting a company. In the previous comparison of stayers and mobile natives, gender appeared to be related to unobserved factors that affect both mobility and entrepreneurship. However, once we controlled for mobility by comparing the two mobile groups of academics, there was little difference in entrepreneurial propensity between the genders.

Additionally, there was also no difference across scientific fields. The effects of personality characteristics were comparable to those in the previous set of regressions, although intrinsic motivation was no longer strongly significant. Further, control variables for scientific performance and affiliation had no significant effect. Among the variables that measure attitudes toward entrepreneurship, only the attitude toward *commercialization* of one's own research had a highly significant and positive effect. Overall, the results support the foreignness discount suggested by Hypothesis 2, estimating that immigrants are 38–47% less likely than returnees to start a company in Denmark in any given year.

To illustrate the differences between the groups, we plotted the predicted hazard functions for stylized careers of scientists who only differ regarding their international experience. Therefore, we set all continuous covariates to the sample mean. The factorial variables were set at the most frequent value in the sample (i.e., male for gender, natural sciences as the scientific field, and Copenhagen University as the affiliation). Fig. 2 shows the difference between stayers and returnees. As expected, the premium only arose after return, and the returnee's curve was steeper. Fig. 3 shows hazard curves for a returnee and immigrant who entered Denmark at academic age 8 and resided in the country for 30 consecutive years, illustrating the large discount associated with foreignness.

4.3. Potential explanations

In Section 2 we argued for a number of factors that might explain the differences in entrepreneurial activities between stayers, returnees and immigrants. In this section, we therefore explicitly test whether these factors can indeed explain the observed differences between the groups.

The first factor we discussed was work experience in different contexts and exposure to different research environments, particularly those providing access to frontier knowledge (Krabel et al., 2012). Thus, as instances of international mobility of academics may vary in terms of their quality and intensity of research, we construct a dummy variable (*Research active abroad*), which takes the value 1 if a scientist published at an internationally leading research institution during an academic stay abroad, as research stays that resulted in a publication are likely qualitatively different and can be considered as an indicator of revealed research activity. To construct this variable, we rely on a combination of survey and publication data. Thus, academic stays are defined based on the survey and include those stays outside of Denmark or the home country, where the activity abroad was defined as "attending or working at a university". We further consider an academic to have been research active during such a stay, if the respondent published a paper no later than five years after the indicated end year of the stay and if the country of their affiliation corresponds to the indicated country of the stay abroad. Finally, top institutions are defined based on the CWTS Leiden Ranking and defined as the top 50 Universities, with the highest proportion of publications in the top 10% of the most frequently cited papers in a given field and year.[11] Results for the native sub-sample are presented in Table 6, Model 1. As stayers can by definition not publish abroad, we divided the group of returnees in those with publications at a top institution (*Research active abroad*), and those who did not (*Not research active abroad*). They are largely consistent with the prior analysis, but researchers publishing with an international top affiliation, are more than twice as likely as their non-mobile peers to become entrepreneurs. Also the difference between returnees who were research active at a top institution and their peers who were not, are sizeable and significant at the 10% level ($p = 0.066$). To conduct this analysis for the mobile sub-sample, we included an interaction term of the *immigrant* dummy with *Research active abroad.* For immigrants, *Research active abroad* includes publication activities either in third countries or their home countries. Results for the mobile sub-sample can be found in Table 7, Model 1 and suggest a similar picture. The main effect for *Research active abroad* is significant at the 10% level, and suggests that returnees who were research active at a top institution are 78% more likely to become entrepreneurs than their returnee peers. The interaction term, which is significant at the 10% level, suggests that such stays are associated with a larger immigrant discount. Thus, comparing the two groups of immigrants indicates that the type of international experience and exposure to different research environments can reveal differences within the groups, and that its association with entrepreneurial outcomes is stronger for returnees than for immigrants.

The second factor discussed was research orientation. We therefore construct a variable, measuring the commercial potential of a scientist's research. To do so, we build on work by Marx and Fuegi (2020), and make use of a *journal's commercial impact factor (JCIF)*, which is measured in terms of citations from patents to papers published in the focal journal. As this distribution is highly skewed we define for each year the 1% of journals with the highest JCIF. We then calculate the share of each scientist's publications published in such journals until year *t-1* (*ShareCommPub*). Results are presented in Table 6 for the native sub-sample. Model 2 shows the interaction effect between prior international mobility and the share of commercially valuable publications (*ShareCommPub*). The main effect of commercial value of research is positive and significant. However, the interaction effect is not significant, indicating that the relationship is similar for returnees and stayers. Table 7, Model 2 presents corresponding results for the interaction with the immigrant dummy. In the mobile sub-sample, conducting commercially valuable research has a sizable positive association with entrepreneurial entry. While not significant ($p = 0.181$), the interaction effect suggests that for higher levels of commercially relevant research, the immigrant discount might even be larger. This finding is in line with the other findings, suggesting that immigrants may be less able or willing to commercialize their research through entrepreneurship in the host country.

An additional variable that could potentially moderate the relationship between being foreign and academic entrepreneurship is the time spent in the focal country. Thus, as returning or immigrant academics stay longer in their host country, the more they integrate with the local community, thereby decreasing barriers such as local networks, knowledge about the institutional context and language proficiency. We include an interaction term between the mobility group of interest and the time spent in Denmark. For the native sub-sample, Table 6, Model 3 shows that returnees accumulate positive benefits at a similar rate as non-mobile natives do (the interaction term is insignificant). Similarly, Table 7, Model 3 shows a negative interaction effect between years of residence in Denmark and being foreign, albeit statistically not significant. This finding does not provide any evidence that the immigrant

[11] This classification is conducted for 2010-2013 period, and considered constant over sample period (www.leidenranking.com). 39 of top 50 Universities appear as affiliations in our sample, none of them was Danish (see Appendix A3)

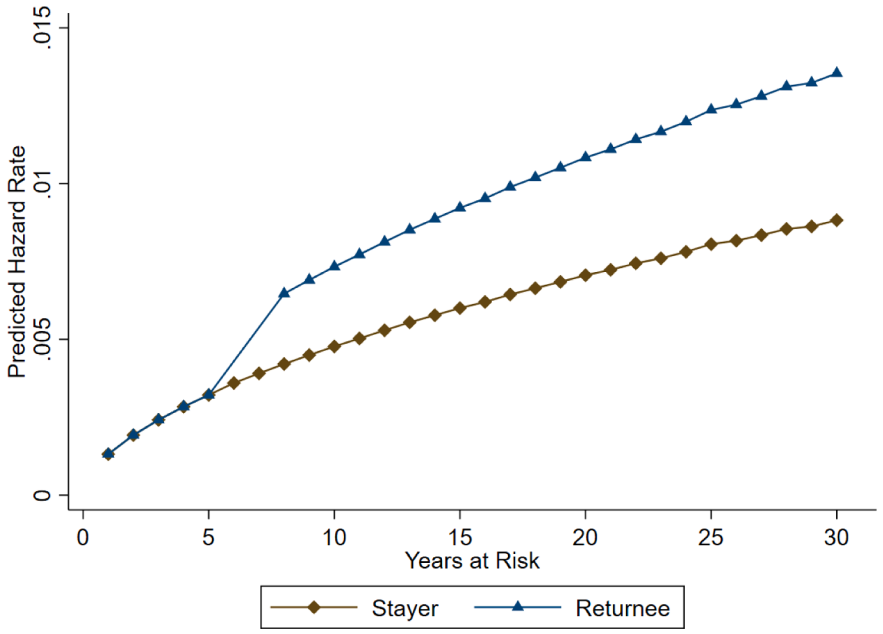

Fig. 2. Hazard Function Stayers vs. Returnees
This figure shows the difference between stayers and returnees from the career start until academic age 30. The hazard for returnees changes upon return to Denmark in year 8, where the variable *PrevAbroad* changes from 0 to 1.

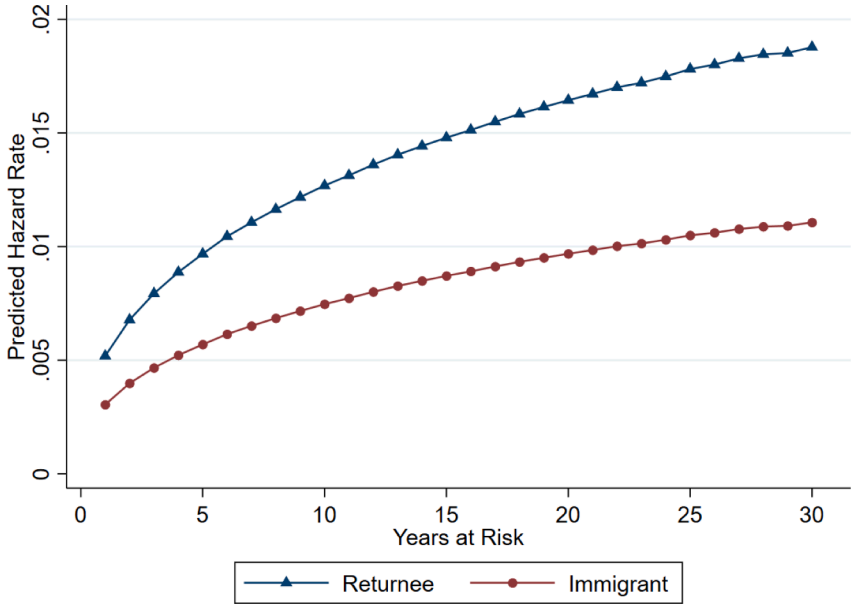

Fig. 3. Hazard Function Immigrants vs. Returnees
This figure shows hazard curves for a returnee and immigrant who returned to/entered Denmark at academic age 8 and resided in the country for 30 consecutive years.

discount becomes smaller the longer immigrants live in Denmark.

Finally, we discussed that immigrants could face particular barriers related to language as well as legal and bureaucratic factors. Thus, Table 7, Model 4 explores the effect of bureaucratic barriers (such as requirements for visas and work permits) on the entrepreneurial activity of internationally mobile academics. We divided the group of immigrants into those from countries with which Denmark has freedom of movement (FoM) of workers agreements and those from countries requiring an additional work permit. Immigrants in the latter group are subject to the rules dictated by their visa, which may preclude them from holding jobs outside their main employment (which is the sponsor of their visa). We therefore expected non-FoM immigrants to be the least likely to become academic entrepreneurs. Sixty-two percent of immigrants were from EU countries, and we found that immigrants from FoM countries were 45% less likely to start a company than returnees, while there was a similar discount for non-FoM immigrants in their likelihood of becoming academic entrepreneurs.[12] This is not conclusive evidence that formal barriers do not exist in our context, but it is an indication that formal barriers cannot fully explain the difference between

[12] A Wald test also revealed that there was no statistical difference between the two groups of immigrants (see Table 7, Model 1).

Table 6
Differences within groups of native scientists.

	(1) Start Comp	(2) Start Comp	(3) Start Comp
PrevAbroad		1.434	1.731**
		(0.059)	(0.003)
Not research active abroad	1.381		
	(0.099)		
Research active abroad	2.367**		
	(0.001)		
ShareCommPub		9.328**	
		(0.002)	
PrevAbroad × ShareCommPub		1.428	
		(0.717)	
YearsAtRisk (log)			1.664***
			(0.000)
PrevAbroad × YearsAtRisk (log)			0.798
			(0.231)
Wald tests	Nopubret_top = Pubret_top $p = 0.066$		
Controls	Yes	Yes	Yes
Calendar Year F.E.	Yes	Yes	Yes
Field F.E.	Yes	Yes	Yes
University F.E.	Yes	Yes	Yes
# of respondents	1,578	1,578	1,578
# of observations	26,533	26,533	26,533
Log pseudolikelihood	−932.421	−927.932	−933.596

Exponentiated coefficients; *p*-values in parentheses.
All specifications contain the same control variables as included in Model 2 in Table 4.
For a better interpretability of the main effects, we mean centered the YearsAtRisk variable in Model 4.
First year with non-zero outcome included is 1984.
The variables *Research active abroad* and *Not research active abroad* distinguish returnees whose first stay abroad resulted in a publication from an international top institution The variable *ShareCommPub* denotes the share of commercially relevant publications.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

returnees and immigrants.

Model 5 in Table 7 explores the effect of language proficiency as a potential barrier to entrepreneurial and engagement activities of foreign academics (Lawson et al., 2019; Libaers, 2014). This possibility may be even more relevant in our context because few immigrants master the Danish language when they first arrive in the country. However, some immigrants may be in a better position to pick up the local language, particularly natives of other countries with a language similar to Danish. We therefore included a dummy variable, where 1 represented immigrants for whom their main language is a Germanic language (e.g., Austria, Belgium, Switzerland, Germany, Luxemburg, Netherlands, Iceland, Sweden, Norway, Australia, USA, Great Britain, New Zealand, Canada, Ireland) and 0 otherwise; this assumed that immigrants speaking a Germanic language are advantaged compared to immigrants speaking more distant languages in terms of interactions with the local business community. Forty-five percent of immigrant academics were from Germanic-speaking countries. Using returnees as a reference group, we again found a marginally significant discount of about 45% for immigrants from countries speaking a Germanic language and a similar difference with non-Germanic immigrants.[13] Language, therefore, does not seem to explain the difference between immigrants and returnees. As noted previously, this could reflect the high ability level of the local population to speak English and the increasing pervasiveness of English as a business language in Denmark.

4.4. Robustness checks

A first concern was that the use of a survey-based, retrospective outcome variable could have caused recall bias. To ensure that our results were not driven by respondents reporting the establishment of companies with which they were not directly involved, we matched the respondents in our sample to the Danish business registry based on the researchers' names and performed manual searches on their university webpages (and LinkedIn profiles, if available) to ascertain their true role in each start-up. Based on this, we refined the outcome variable to define only those respondents who were also linked to a company in the business registry as entrepreneurs.[14] In the mobile sample, the overall number of researchers who could be categorized as entrepreneurs fell from 114 to 75. The reduced number could have been caused by various involvements in setting up firms (e.g., involvements prior to formalisation, employment relationships outside of board membership) or by mismatching or misspellings names. Despite the refinement of the dependent variable, the results were again qualitatively similar the main results, although the significance levels dropped to around 10% for some specifications (see Appendix A4).

As a second robustness check, and aligned with the literature on high-tech entrepreneurship and STEM researcher migration, we ran the models on a sub-sample that included only STEM-field researchers. While leaving out *Arts and Humanities* and *Social Sciences* reduced the available number of respondents by about a quarter, all results remained within close range of the main results, confirming the existence of a significant immigrant discount and no overall qualitative change in the results (see Appendix A5).

As a third robustness check, we also employed nearest neighbor matching and re-ran our analyses on matched samples to make comparisons that were likely to be more balanced in terms of unobservable determinants of both international experience and academic entrepreneurship. For the first comparison, we matched stayers and returnees based on the year of career start and exactly based on gender and scientific field. This resulted in a sample of 342 matched pairs of scientists, who were also fairly balanced based on other characteristics, except returnees, who were on average more intrinsically motivated though less well published (during their first year abroad) than stayers (see Appendix A6, Table 9). The regression results, which can be found in Appendix A6, Table 10, were largely confirmed, and the mobility premium appeared to be even larger. For the comparison between immigrants and returnees, we matched based on the year of career start, academic age at risk start, and exactly based on scientific field, gender, and prior academic entrepreneurship. This resulted in a sample of 230 matched pairs. Again, the results from the main analyses were largely confirmed, and the discount for immigrants was even larger than in the main specification (see Appendix A6, Table 12).

In a further robustness check, we tackled the problem of unobserved individual heterogeneity. We therefore included individual-level random effects and ran so-called frailty models (see Appendix A7). These findings also confirmed our results. Finally, we also ran the model using non-parametric time dependence by including dummies for each year at risk. Further, we included *YearsAtRisk* as a linear and a quadratic term. As shown in Appendix A8, these choices did not affect the size and significance of our variables of interest.

[13] A Wald test revealed again that there was no statistical difference between the two groups of immigrants (see Table 7, Model 2).

[14] We were not able to implement similar refinements in terms of the pre-move entrepreneurial experience of immigrants, which would most likely have been related to a foreign firm. The dummy variable for pre-move experience thus still relied on the survey information.

Table 7
Differences within groups of mobile scientists.

	(1) Start Comp	(2) Start Comp	(3) Start Comp	(4) Start Comp	(5) Start Comp
Immigrant	0.662	0.592	0.507*		
	(0.148)	(0.051)	(0.012)		
Research active abroad	1.782				
	(0.061)				
Immigrant × Research active abroad	0.345				
	(0.088)				
ShareCommPub		14.52***			
		(0.000)			
Immigrant × ShareCommPub		0.206			
		(0.181)			
YearsAtRiskPost (log)			1.643**		
			(0.003)		
Immigrant × YearsAtRiskPost (log)			0.744		
			(0.227)		
Freedom of Movement				0.543*	
				(0.023)	
Visa				0.498	
				(0.054)	
Germanic					0.558*
					(0.040)
Non-Germanic					0.489*
					(0.034)
Wald test				FoM = Visa	Ge. = Non-Ge.
				$p = 0.80$	$p = 0.71$
Controls	Yes	Yes	Yes	Yes	Yes
Ac. age risk start F.E.	Yes	Yes	Yes	Yes	Yes
Calendar Year F.E.	Yes	Yes	Yes	Yes	Yes
Field F.E.	Yes	Yes	Yes	Yes	Yes
University F.E.	Yes	Yes	Yes	Yes	Yes
# of respondents	937	937	937	937	937
# of observations	8,401	8,401	8,401	8,401	8,401
Log pseudolikelihood	−503.538	−502.023	−505.057	−505.782	−505.709

Exponentiated coefficients; *p*-values in parentheses.
All specifications contain the same control variables as included in Model 3 in Table 5.
For a better interpretability of the main effects, we mean centered the YearsAtRisk variable in Model 4.
First year with non-zero outcome included is 1984.
The variable *Research active abroad* defines researchers whose stay abroad resulted in a publication from an international top institution The variable ShareCommPub denotes the share of commercially relevant publications.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

5. Discussion and conclusions

Our analyses suggest that internationally mobile university researchers are more likely to start companies than their colleagues without experience abroad, while, compared to returnees, immigrant scientists are under-represented in knowledge-intensive entrepreneurship activities in Denmark. Compared to native stayers, returnees were between 1.6 and 1.9 times more likely to become entrepreneurs in any given year. Finally, comparing returnees to immigrants, the immigration discount lowered the entrepreneurship propensity to about half for the latter group.

Our study assigns an important role to returnee academics as likely contributors to the local economy in terms of research-based start-ups. While return migrants have been at the center of an extensive policy discussion related to migrants returning to emerging economies (Lissoni, 2018), our results open a range of potential policy issues in the context of advanced economies as well as for academic returnees. As an important aspect of academic mobility extending beyond scientific excellence in a narrow sense, this paper suggests that there might be a potential trade-off between international mobility and the entrepreneurial commercialization of research, at least for the group of foreign scientists.

Furthermore, our analysis suggests that immigrants are under-represented in knowledge-intensive entrepreneurship among comparable academics who are employed in Denmark. Following our theoretical framework, our analysis indicates that explanations that are usually found in the literature may not be sufficient to attain an overall picture of the relationship between international mobility and academic entrepreneurship. Concerning policy regulations, we found no significant difference between immigrants with EU citizenship and those without. Language could be another potential barrier; however, we found that immigrants from Germanic-speaking countries, whose native language is arguably closer to Danish than most other languages, faced a similar discount as that of other immigrants in terms of entrepreneurial activity. Similarly, we found that research orientation could not explain the observed discount. However, research activity at an international top institution was identified as a strong predictor for academic entrepreneurship and allowing this variable to affect immigrants and returnees differently, revealed that it would likely increase the immigrant discount. Better understanding the causes of this difference is therefore a question that should be a priority for future research endeavors in this area.

A main limitation of this study refers to its generalizability and comparability to prior studies. Most studies documenting an over representation of immigrants amongst high-tech entrepreneurs have been conducted in the US or UK (Azoulay et al., 2020; Hunt, 2010; Kerr and Kerr, 2016). These countries are home to the world's leading research institutions, and have also shown to attract the most skilled workers from a wide range of origins (Kerr, 2018; Parey et al., 2017). Thus, immigrants choosing to come to Denmark might simply differ in terms of

their entrepreneurial intentions and pre-dispositions. However, many small and mid-sized European countries provide a similar academic job market as Denmark, so our study extends this debate by adding a non-Anglo-Saxon perspective.

Other potential limitations of our analysis are related to the fact that we made use of a cross-sectional survey. As such, we were unable to observe individuals who left academia because they either became successful entrepreneurs or left the country before the survey year. Moreover, the data is right-censored in terms of observed entrepreneurial activities and international mobility events. Further, it is possible that the survey responses were biased toward the academics' most recent and most successful ventures. Although our data stem from a survey of the full population of academics and has a comparatively high response rate, it imposes some rather strict limits on the number of observations in each of the subgroups that underlie our analyses. Thus, while our additional analyses uncover sizable differences within the different mobility groups, standard errors are large. A final limitation of using survey data links to the fact that we are unable to observe the full employment history of academics. While we are able to differentiate between pre and post mobility academic entrepreneurship, also prior spells of self-employment and work experience in industry might increase an academic's likelihood to commercialize their research through entrepreneurship (Stuart and Ding, 2006).

Moreover, it is important to consider the motivations of why scientists become internationally mobile, as most researchers do not necessarily move with the idea of starting a business. Their motivations are rather related to career advancement such as social status, level of independence and a general taste for science (Baruffaldi and Landoni, 2012; Pellens, 2012). We have shown that even after controlling for such factors, an immigrant discount is remains, which raises the important question, how entrepreneurial activities, particularly of foreign scientists, could be fostered. Regarding this, one may give particular importance to the university level, as prior literature suggests that it is the appropriate environment that stimulates entrepreneurial activities of scientists (Krabel et al., 2012). Our findings, however, suggest that there are no statistically significant differences between Danish universities in explaining entrepreneurial activities, beyond individual level factors. While this finding is in line with prior studies assigning the strongest and most direct predictor of entrepreneurial entry to the individual and department level, and only an indirect role to the university level initiatives and TTOs (Bercovitz and Feldman, 2008; Clarysse et al., 2011; Qin and Estrin, 2015; Rasmussen and Wright, 2015), it remains to be investigated whether initiatives at the university level could indeed be adequate to reduce the observed discount of foreign scientists to become entrepreneurs.

This paper also offers important implications for the more general literature on immigrant entrepreneurship. As such, our findings contradict those of previous studies, indicating an immigrant premium in the broader context of highly skilled migration and entrepreneurship. There might be several reasons for this. For example, because we considered academics, who are by definition drawn from the right tail of the education distribution, we did not face differential education levels between immigrants and natives as a potential confounder of the immigrant premium. This contrasts with existing studies situated mainly in the US high-tech entrepreneurship context (Hunt, 2010). Additionally, considering the full population of academics, we avoided selection on the outcome variable (Hart and Acs, 2011). Further, by comparing immigrants and returnees, our study assigns a particular importance to international mobility, but at the same time suggests the importance of localness and implies that return migrants are better able to translate the benefits of international mobility into entrepreneurial activities.

With these caveats, our findings can still speak to a wider policy discourse. Many governments are actively incentivizing the migration of highly skilled people to their countries (OECD et al., 2015) and anticipating large contributions to the economy as a result. However, our findings suggest that immigrants face substantial barriers, which may prevent them from contributing fully to society. Actively lowering such barriers should thereby be a priority in the design of immigration policies, as it would increase the societal benefits of highly skilled immigration.

As it is critical to establish the entrepreneurial effect of international mobility in greater detail, the limitations of our study open avenues for future research. Identifying whether all migration instances are equal or whether exposure to an entrepreneurial culture promotes subsequent entrepreneurship (Bercovitz and Feldman, 2008) should be a first priority. Additionally, in our analysis, we were unfortunately unable to control for different motivations for international mobility, especially regarding returnees. While international mobility research seems to believe that migration decisions are mostly based on socioeconomic reasons, such as accessing better career opportunities (Franzoni et al., 2012), scholars are increasingly exploring the roles of family and cultural ties regarding their effects on return migration patterns (Lee and Kim, 2010). They may help determine who returns to their home country for reasons beyond their scientific performance. Family ties and cultural proximity transcend reasons that are related to economic mobility; thus, we expect them to bring home some "stars" in terms of performance—who may have otherwise stayed abroad if they had only applied economic logic. Additionally, immigrants may be driven to a specific country by reasons beyond strict economic considerations, such as following a partner or choosing a country that reflects their values and offers attractive living conditions. Future studies, especially those that employ a survey, should focus on these different motivations to understand if they may relate to academics' willingness to engage in the commercialization of their research.

Finally, it is crucial to understand in more detail which specific barriers impede immigrant academics to start up a company. Thus, by including more elaborate measures of any formal or informal barriers, such as cultural or linguistic distance, or more precise measurements of the local networks that immigrants could leverage, future studies could aim to understand how local market conditions and the institutional context affects entrepreneurial activities of foreign scientists. Another way to understand the role of institutional barriers is to exploit policy changes, such as requirements for visas and work permits, or university level incentives for commercialization (e.g., Eesley et al., 2016). Moreover, evidence on the importance of these factors in a more causal way is required to guide public policies aimed at facilitating the entrepreneurial commercialization of the entire spectrum of research conducted at local universities.

CRediT authorship contribution statement

Wolf-Hendrik Uhlbach: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Valentina Tartari:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Funding acquisition. **Hans Christian Kongsted:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

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Supplementary materials

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