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Foreign graduates in Sweden. The role of high tech sectors, STEM disciplines and cultural distance.

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Foreign graduates in Sweden. The role of high tech sectors, STEM disciplines and cultural distance.

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Abstract

This paper analyzes the career paths of foreign students in Sweden, after graduation. Matching individual data on foreign graduates in Sweden with information about their employers, we analyze the sectors in which they start their career after graduation in Sweden, during the period 2000-2014. We propose that foreign graduates are attracted by firms operating in sectors employing a higher level of knowledge codification and in expanding sectors with a higher growth of demand for skilled workers. Our findings indicate that foreign graduates are more likely than Swedish ones to work in high-tech sectors, both in manufacturing and services, and in expanding industries, such as the services with low knowledge intensity. Foreign students from more culturally distant locations are more likely to work in high-tech or in expanding sectors. Finally, STEM foreign graduates are the main driver of the propensity to work in high tech manufacturing sectors, but not in high tech services.

Keywords: foreign graduates, STEM, cultural distance, high tech, occupations

JEL Classification: O39, J2

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1. Introduction

The literature that studies the economic impact of skilled migration has convincingly shown that skilled immigrant workers provide substantial benefits to the host countries in terms of technological development (Bahar et al., 2020), knowledge circulation (Ganguli, 2015; Ferrucci, 2020), innovation (Hunt and Gauthier-Loiselle, 2010; Kerr and Lincoln, 2010; Ozgen et al., 2014; Fassio et al., 2019) and ultimately productivity growth (Peri et al., 2015).

This has led to a growing number of studies that analyze the economic impact of high-skilled workers and in particular of certain categories of them, such as inventors (Breschi et al., 2017; Miguelez et al., 2010) or beneficiaries of specific types of visa for STEM occupations, as in the case of the H1B visa in the United States (Kerr and Lincoln, 2010; Mayda et al., 2020).

Among the categories of skilled immigrants that may provide new knowledge and competences to the host countries, the existing literature has seldom considered the role of foreign students, i.e. students enrolled in a foreign university. Therefore, little is known about the specific career trajectories of this specific type of skilled immigrants. This is unfortunate since the international mobility of students represents a non-negligible portion of the overall phenomenon of high skilled mobility. Already in 2010 the total number of international students worldwide reached 3.5 million (Murat, 2014). The sustained growth of the number of foreign students enrolled in foreign countries in recent years has led to an increasing interest in this specific category of individuals by policy makers and businesses (Marhoum, 2000). Individuals that graduate in a foreign country are increasingly considered as valuable talents who, thanks to their knowledge and skills, are able to foster the competitiveness of the firms in which they are employed and ultimately of the host countries. Indeed, in many developed countries the acknowledgement of the importance of foreign graduates has also led to the introduction of policies (e.g., special work visas) specifically targeted at retaining foreign students in the host countries, once they graduate (Geddie, 2013).

A few studies in the international mobility literature have analyzed the impact of international graduates on innovation. Chellaraj et al. (2008) have shown that also foreign graduates substantially contribute to the number of patents in US universities, however their work was mostly focused on foreign graduates who work in the academic sector. A similar perspective is the one adopted by Ganguli and Gaule (2020), who look at the careers of foreign Phd students in US universities. Crown et al., (2020b) have instead studied the impact of foreign born graduates on the economy as a whole and they have shown the positive contribution of foreign born graduates

on patent production in Australia, spurred by a specific visa programme targeted at retaining this category of individuals.

The retention of foreign graduates in the host country in which they received their education has recently attracted some interest, since existing studies have shown that being an international student enhances the probability of engaging in an international career (Bozionelos *et al.,* 2015) and, in most cases, this is likely to start in the country in which they studied. It has been shown that a non-negligible share of foreign students graduating in countries such as the US, Canada and UK remain in the country where they graduated also in the years to follow (Bratsberg and Ragan, 2002; Finn, 2005; Suter and Jandl, 2008). Moreover, Grogger and Hanson (2015) document that international students who decide to remain in the US after their studies display on average higher quality in terms of skills. This on its turn provides a motivation to investigate the specific career trajectories of the foreign graduates in the countries in which they earned their education. Existing contributions have analyzed the factors that induce foreign students to engage in an international career in the country where they completed their education. These studies find that, together with labor opportunities in the host country, also family ties and cultural differences matter for the decision to stay or not (Barouch et al., 2007; Geddie, 2013; Mosneaga and Winther, 2013; Roh, 2015). However, the existing literature has not looked specifically at the role of the specific knowledge that foreign students bring with them and the match with the requirements of different types of sectors in the host country.

In this paper we analyze the employment choices of foreign graduates, as compared to those of native graduates, in the Swedish context. Sweden currently hosts about 25,000 foreign students in its university system (UNESCO, 2015), and in recent years it has witnessed a sustained increase of the overall share of foreign students in Swedish universities. Therefore, it represents an interesting case to study the career trajectories of foreign graduates. We look at the sectors in which foreign students start working after graduation. We analyze the role of the knowledge bases and of the demand for skills. We propose that foreign students will be more likely to work in sectors in which knowledge bases are more codified and analytical, and there is no big role for tacit and context-specific or communication skills. We also suggest that foreign students will be more likely to work in sectors with a higher growth of demand for skills, since in those sectors companies will be more willing to hire foreign students (vis à vis native students) because of their stronger need for new hires. Lastly, we analyze the role of two mediating factors: the specific cultural distance between the home country of the students and the host country and the effect of having a STEM education. Foreign graduates should be especially likely to work in sectors that

make use of analytical and codified knowledge if they come from countries that are more culturally different than Sweden. They should also be more likely to work in sectors that use analytical and codified knowledge if they graduated in STEM fields, which are known to use more abstract and formal models.

We use data about the foreign students who graduated in Swedish universities in the period 2000-2014 and remained in the country after graduation to work for a private firm. Our data allows us to identify these students and to follow their careers over time. Overall, we follow the careers of almost 4,000 foreign graduates. We are interested in understanding in which types of sectors they find their first job and how these sectors differs with respect to Swedish students. We study the probability that the foreign graduates will work in different types of sectors. We control for several factors that are likely to influence the career of graduates, such as the scientific discipline in which they graduated, the specific University in which they earned their tertiary degree, the level of education (bachelor, master or Ph.D.) and some additional individual factors such as the broad geographical area of origin, age and gender, and family conditions (such as being married or having kids). We also control for the occupational differentiation within each industrial sector. Using the ISCO-08 (SSYK) classification, for each sector, we check that our main results are not driven by foreign graduates employed in occupations for which they are over-qualified, therefore we restrict our sample to graduates employed as professionals or technicians.[3]

Our results show that foreign graduates are more likely than native ones to work in high-tech industries in manufacturing (pharmaceuticals, computer, electronics, and optical products) and in high-tech services (telecommunications, R&D and IT), and in less knowledge intensive services (*LKIS*), which span from retail trade to accommodation and food services. We interpret this as confirmation that high tech sectors with codified and analytical knowledge better suit the competences of foreign graduates. When it comes to the higher propensity to work in less knowledge intensive services (*LKIS*) we attribute it to the fact that this sector is expanding over time, hence to a demand effect. We also find that these effects are driven by foreign graduates from non Nordic European countries, i.e. from countries that are somewhat more culturally distant, although we do not find a consistent different pattern between European and extra European graduates. Lastly, we show that in the case of high tech manufacturing the higher probability to be hired in these sectors is primarily driven by foreign graduates with a STEM

[3] The ISCO-08 (SSYK) classification categorizes each occupation according to the level of skills required. Since our sample of international graduates have at least a Bachelor degree, we assume that they are not over- or under-qualified if they are employed as professionals or technicians (i.e. high-skilled occupations that require a university degree).

background, while this is not the case for the high-tech services, where having a STEM education is not the main driver to be employed in that sector.

Finally, when we control for the actual occupations that graduates are employed in, we find that foreign graduates in high-skilled occupations, such as professionals, have an even higher propensity to work in high-tech manufacturing sectors and in high-tech services. On the contrary, the higher probability to be hired in low knowledge intensive services is mainly driven by foreign graduates employed in low-skill occupations. This signals that foreign graduates in high tech are employed in occupations that are well matched with their competences, while in the low knowledge intensive services it hints at the possible presence of over-education (or skills mismatch) among foreign graduates (Chiswick and Miller, 2010).

The paper contributes to the literature that studies the careers of skilled immigrants by focusing on a specific category of immigrants, i.e. foreign graduates. We provide new evidence about the careers of foreign graduates in the host country where they earned their education. The relatively scarce literature that studied foreign graduates and their economic impact has shown that they can have a positive effect on innovation and growth (Crown et al. 2020b). In this respect, our findings show that foreign graduates are more likely than native graduates to be employed in high tech sectors, which may partly explain the positive effect on innovation found in the literature. Our results are also complementary to the existing literature that studies the careers of skilled immigrants in general, which found a general propensity to work in scientific and technical occupations. Chiswick and Taengnoi (2007) find that high-skilled immigrant in the United States whose native language is culturally distant from English have a greater propensity to be employed in occupations in which communication skills are less important, such as computer scientists and engineers; similar results are found by Crown *et al.* (2020a) in Australia. We find that this is also the case for young foreign graduates.

Our results also provide new evidence to the literature that studies the role of STEM immigrants (Breschi et al., 2020; Miguelez and Temgoua, 2020): we show that also when it comes to recently graduated workers, STEM education is an important factor behind the propensity of foreign graduates to work in high tech sectors. However, we also show that this is mostly true for manufacturing high tech and less so for high tech services. Finally, we contribute to the literature on the international migration and cultural distance. This literature shows that, in general, greater cultural dissimilarity between the sending country and the host country exerts a negative influence on migration (White, 2003, White and Buehler, 2018). Our evidence suggests that this is not necessarily the case for foreign graduates from more culturally distant countries. We find that they

are more likely to end up working in high-tech sectors than Swedish graduates, both in service and in manufacturing.

The reminder of the paper is as follows: Section 2 presents the main theoretical framework and the hypotheses, Section 3 introduces the data used, Section 4 presents the methodology. The results of the empirical analysis are presented in Section 5, while Section 6 includes conclusions and policy implications.

2. Theoretical framework

There is little existing evidence about the career choices of foreign students after graduation in the host countries. Existing studies have generally found a preference for STEM types of occupations, but no systematic theory has analyzed what could be the drivers of the careers of this type of students. In this section we outline a number of rationales that may explain the specific directions of the careers of foreign graduates. We focus on the different sectors in which foreign graduates start working after the end of their studies in the host country.

The type of knowledge

The type of knowledge used in a specific sector may influence the probability that foreign graduates will find an employment in that sector. Economic sectors differ between each other for the type of knowledge that is implemented in the operations that lead to the creation of final outputs (Breschi et al., 2000; Castellacci, 2010). A typical dichotomy used in the economic and innovation literature is the one of codified versus tacit knowledge (Polanyi's, 1967; Nelson and Winter, 1982). In some economic activities, typically those performed in high-tech sectors, the knowledge used to create new products and processes has a higher degree of codification and formalization with respect to the activities performed in less technology intensive sectors. A related and complementary way to distinguish sectors according to the type of knowledge used relies on the distinction between analytical, synthetic and symbolic knowledge bases (Asheim and Gertler, 2005; Martin and Moodysson, 2011). The analytical knowledge base, which relies on formal models, abstract and codified science, is the one typically used in science-based sectors, such as biotechnology, or pharmaceutical sectors. Synthetic knowledge bases instead involve innovation processes that result from the application of existing knowledge or from the recombination of existing knowledge bits, often aimed at solving concrete problems. The type of knowledge used in these sectors is hence mostly tacit, since innovation stems from learning by

doing, learning by using and through interaction with customers and suppliers. This type of knowledge base is usually associated with sectors such as plant engineering, industrial machinery and automotive. Lastly, a third type of knowledge base is the symbolic one, in which innovation efforts are geared to the creation of aesthetic value or images. This type of knowledge base has been typically associated with cultural industries, such as television, publishing, music, fashion or design (Pina and Tether, 2016). A specific feature of this type of knowledge base is its strong context specificity, where innovation requires a deep understanding of the cultural specificities of the local social groups to which new products are aimed to.

Sectors can hence be broadly distinguished between those that rely more on codified knowledge and on an analytical knowledge base – typically high tech sectors- and those that instead rely on more tacit knowledge and synthetic knowledge bases - such as mid and low tech manufacturing - or even symbolic knowledge bases, in the case of some services sectors.

In sectors that rely more on codified knowledge and on analytical knowledge base foreign students may find it easier to apply the competences that they earned through education. In these sectors context-specific (i.e., country-specific) knowledge is indeed less relevant and hence the competencies of foreign students are as valuable as those of native students. Indeed, this is very much in line with findings in the literature that studies skilled migration and the distribution of migrants in the labour market. Foreign skilled workers tend to concentrate in the more technical and high tech fields (Kerr and Lincoln, 2010), where there is a higher demand for quantitative and analytical skills, partly pushing native workers towards sectors that require higher communication skills (Peri and Sparber, 2011), i.e., in sectors where mastering the symbolic knowledge base is more important.

However, with respect to the usual distinction between foreign and native skilled workers, in the case of foreign and native graduates it can be argued that these different specializations may be less strong. This is because during their studies foreign students may familiarize with the host national culture. This may occur both in terms of language skills (although they will still have a comparative disadvantage with respect to native students) and in terms of work ethos, practices, and routines that they may be exposed to already during their student career: for example, through internship, workshops and through general interaction with native teachers and other native students.

Nevertheless, we can still expect that, with respect to native students, foreign students may find it easier to apply their knowledge to sectors where there is a higher level of codified and scientific

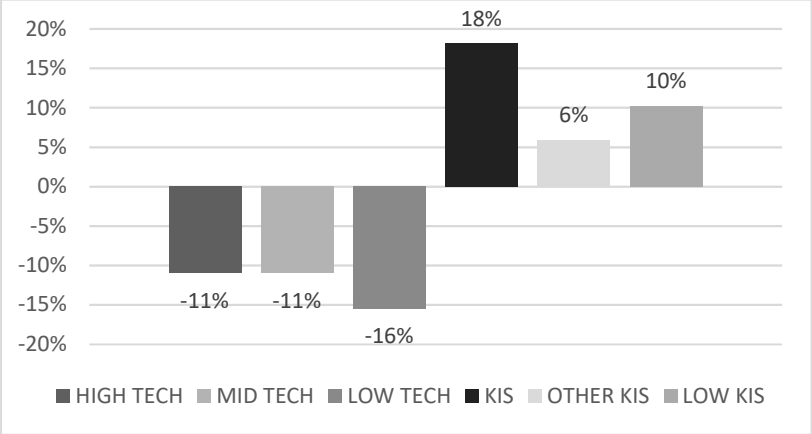
knowledge. The sectors in which codified knowledge and analytical knowledge bases are prevalent are the high-tech sectors of manufacturing (pharmaceuticals, computer, electronics, and optical products) and the knowledge intensive services (R&D, telecommunications, and IT). Therefore, our first hypothesis is that:

H1: All else equal foreign graduates are more likely than native graduates to work for companies in sectors that rely on codified and analytical knowledge.

The demand for skills

There is an additional factor that needs to be considered when analyzing the types of sectors in which foreign students may be employed after graduation, and this is the specific demand for skills of each sector. The processes of structural change that affect the economy often lead to very divergent patterns among industrial sectors (Castaldi and Sapio, 2008) . Some sectors decrease over time the total level of employment, while some others increase it substantially. In the last 20 years many countries in Europe have witnessed a decrease of employment levels in manufacturing vis à vis an increase of employment in the services sector, in particular, in the knowledge intensive services sectors (Antonelli and Fassio, 2014). In this respect, Sweden is not an exception (Eriksson et al., 2017): as shown by the Figure 1 in the period 2005-2015 employment increased substantially in most of the services sectors, especially in the most knowledge intensive ones (KIS), and decreased in all manufacturing sectors (OECD, 2021).

Figure 1. Total percentage growth of employment in Sweden 2005-2015, by sector



Source STAN dataset – OECD (2021)

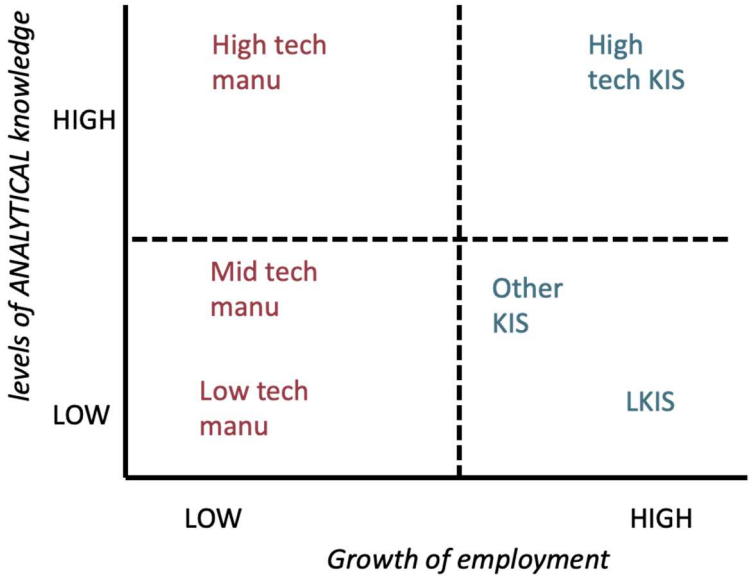
Firms operating in expanding sectors, with increasing levels of employment, hence require also brand new human capital, typically graduates, able to bring the required competencies necessary to increase the levels of operations. While this is particularly true for KIS sectors which, due to the high level of codification and analytical knowledge involved, require new employees with tertiary education, in principle all expanding sectors will also require white collar employees with a tertiary degree. Therefore, compared to companies in sectors with stagnating or even declining levels of employment, companies that are active in expanding sectors will be in higher need of hiring fresh graduates. In expanding sectors new companies will be founded and they will need to hire their first employees. Also incumbent firms may have the opportunity to scale up their operations and increase their existing levels of employment. It is reasonable to assume that, all else equal, native students still have a comparative advantage in the labour market with respect to foreign students, because of better communication skills and better knowledge of the national context and of the local working practices. Possibly also because of a better network of contacts. The existence of this comparative dis-advantage of foreign graduates may imply that their chances of being employed will be slimmer in stable or declining sectors, where the demand for new hires is low, as in those sectors companies may be better able to screen the graduates who better fit their preferences. On the contrary, in expanding sectors, in which the demand for new hires is high, companies' screening process will be less tight and hence foreign graduates may find more opportunities. Companies in these sectors will be those in higher need of fresh graduates and might hence be willing to hire competent graduates, even if their communication skills or knowledge of the local context are weaker than native students. Accordingly, foreign graduates will be more likely than natives to work for companies active in expanding sectors. In the specific context of Sweden, the sectors with the highest employment growth in the period considered are the services sectors (in particular the knowledge intensive ones). Based on these considerations, we spell out the second hypothesis as follows:

H2: All else equal foreign graduates are more likely than native graduates to work for companies in sectors that have a high growth of employment.

Figure 2 provides a graphical representation of how the hypotheses H1 and H2 apply to the different sectors of the economy in Sweden. In brown are the manufacturing sectors, with a relatively low growth of employment and different degrees of codified/analytical knowledge (high for high-tech manufacturing sectors and low for low tech manufacturing), in blue are the services sectors, with a relatively higher growth of employment and, again, differentiated degrees of levels of codified/analytical knowledge (typically higher for high-tech Knowledge intensive sectors). In

the Appendix in Table A1 we also show the detail of the industry classification, to show which specific sectors are included in each of the categories of Figure 2.

Figure 2. Sectors: levels of analytical knowledge and growth of employment



Cultural difference

The higher likelihood of foreign graudates to work in high-tech sectors assumes that they are less able to master the context-specific tacit type of knowledge which is required in industries that make use of synthetic knowledge bases and the context-dependent cultural values that is needed in sectors that rely on the use of symbolic knowledge base. The ability to master these types of knowledge depends to a large extent on the cultural difference between the home culture and the host culture.[4] A lower cultural difference between the two countries will facilitate the foreign graudates in their ability to master the local tacit and symbolic knowledge. It is important to stress that the subset of foreign students in Sweden is very heterogeneous: a Danish student may be closer in terms of cultural norms, values and language to a Swedish graduate than a Chinese student. While all foreign graduates are to some extent culturally different from Swedish ones, some may be closer than others, according to their geographical region of origin.

[4] It may also depend on the individual propensity of an international student to learn a foreign language and a foreign culture and on the length of stay in the country.

When we include the degree of cultural difference as a moderating factor of the previously two introduced factors - the importance of analytical codified knowledge and the level of demand for skills in a sector- we argue that a higher cultural difference should increase the likelihood that an international student will work in sectors with a high use of analytical competences and in sectors with a high growth of employment. Indeed, international students from culturally different countries may find it harder to master the context-specific tacit knowledge required in non-high tech sectors. Also, international students from culturally distant countries may have a larger competitive disadvantage with respect to native students, because of their inability to master the communication skills and context-specific norms and values: this would push them more towards expanding sectors. Therefore, our third set of hypotheses is:

H3a: Cultural difference positively moderates the higher likelihood of foreign graduates (with respect to native ones) to work in sectors that use analytical and codified knowledge

H3b: Cultural difference positively moderates the higher likelihood of foreign graduates (with respect to native ones) to work in sectors that have a growing demand for skills.

STEM education

Another important moderating factor is the role of STEM education on the career trajectories of international students. STEM graduates are the ones whose education curriculum provides them with the highest levels of formalized and analytical, scientific skills. These types of graduates, with respect to graduates in social sciences, medical sciences or humanities are the ones who master better rational abstraction, objective reasoning, empirical testing and the formalized models (Asheim et al., 2007, Chiswick and Taengnoi, 2007, Foged and Peri, 2016) that are needed in the high-tech sectors that make use of analytical knowledge bases. Therefore, it is likely that it will be especially foreign students with a STEM degree that will have a higher probability than native students to work in these types of sectors. For foreign graduates with other types of disciplinary background instead this may be less the case.

For what concerns instead the role of the demand for skills in boosting the probability that a foreign student is hired in a specific sector, the fact that a graduate has a STEM education is not likely to play a big role. The demand for skills of expanding sectors is in principle unrelated to the specific disciplinary background of the foreign students. Booming sectors may also be those that make a large use of synthetic or symbolic knowledge (for example services sectors, such as design studios or advertising). These types of sectors may not necessarily need new hires able to master

analytical knowledge. The need for new hires is what decreases the preference of these companies for native graduates, regardless of whether the foreign graduates are STEM or not. Accordingly, we spell out our fourth hypothesis:

H4: STEM education positively moderates the higher likelihood of foreign graduates (with respect to native ones) to work in sectors that use analytical and codified knowledge

3. Data

Our dataset is built using several different datasets provided by the Swedish Statistical Office (SCB). The dataset is a matched employer-employee dataset including both individual and firm level information during the period 2000-2014. Information on the educational history of foreign students in Sweden is taken from the "University education registry" (*Universitets och högskoleregistret*), which allows to retrieve the date of first and last exams passed in Sweden, as well as the university of graduation and the educational field of the study programme. This information is then linked through a personal id to the Longitudinal Individual Database (LISA): this database includes personal information about gender, age, family, residence and employment data (whether the individual is in employment or not). For the individuals who at some point were employed by an organization it was possible to create a matched employer-employee dataset using the Business Statistics database (FEK) and the Group information dataset (*Koncernregistret*), which provide balance sheet and group level information about the firms in which graduates end up working: these include the firms' sector of affiliation.

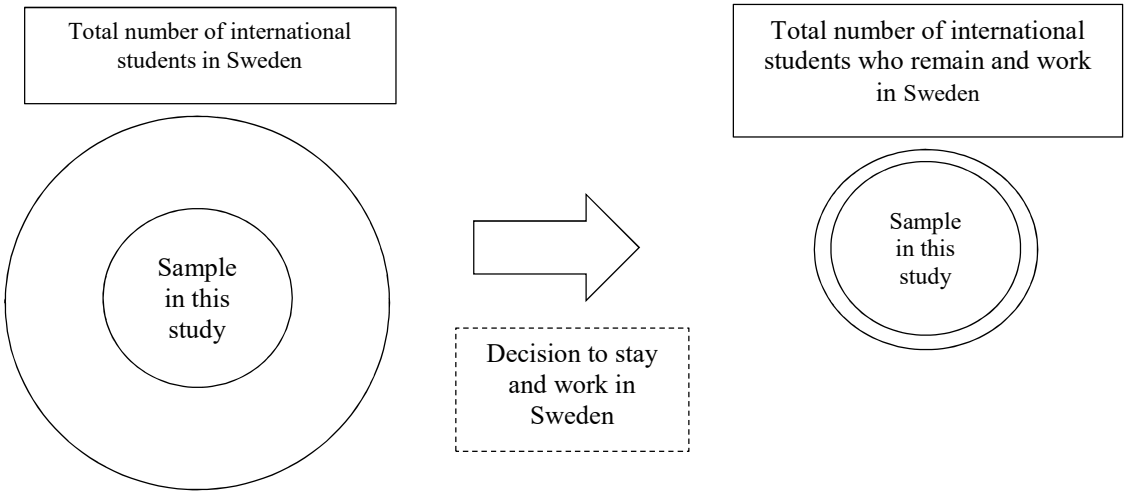
We define foreign graduates as individuals with a foreign citizenship who:

a) arrived in Sweden in the period 1998-2012
b) enrolled in a tertiary degree programme not later than a year after their arrival in Sweden
c) earned a tertiary degree in a Swedish University.

Through this definition we identify 29,113 individuals in the period 1998-2012. We then further restrict our sample by excluding all the individuals who became unemployed after completing their degree. Among those that became employed we excluded those employed by a public institution (such as universities or governmental and municipal institutions), since in this study we are only interested in students who work in private firms. Lastly, as a further restriction, we only focused on individuals who completed their last study degree before the age of 32 years. While this restriction is not very binding, it allows to account also for students who did a Ph.D. or started a master in Sweden as a second master, after receiving an education in their own country of

origin. After these restrictions we end up with a smaller number of individuals who graduated from a Swedish university in the period 2000-2014 and who stayed and worked in Sweden for a private company after the completion of their studies: 3780 individuals.[5]

Figure 3. Representativeness of the sample



It is important to stress that if the students stay in Sweden for short periods and do not register themselves at the Tax Office (Skatteverket) they are not included in the data that we use for this study. This is especially true for exchange students, i.e., students who come to Sweden to attend some courses during one or more semesters, but which are formally enrolled in other foreign universities (i.e., Erasmus students). In some cases, also foreign students enrolled in Swedish universities for only one-year masters may not be included in the data. Accordingly, the data used in this paper is not supposed to cover the overall number of foreign students who at some point in time come to study in Sweden. Indeed, according to Swedish statistics, the yearly number of international students in Swedish universities rose up to 46,700 in 2010/2011.This means that our sample is not representative of all international students who did part (or all) of their studies in Sweden. Conversely, by construction our sample is extremely well fitted to cover the international

[5] It must be stressed that our definition does not restrict the definition of foreign students to those who arrived in Sweden for study reasons. The Swedish Migration Office collects information about the reasons for settlement of any individual who comes to Sweden even if for a relatively short period. This is especially true for citizens of countries not included in the European Union. For 75% of the individuals that are included in our dataset we find that the reason for moving to Sweden is "study reasons". However, for about 15% of the students this information is missing and the remaining 10% is in the country for reasons related to work, reunion with relatives, refugee status or other reasons. Restricting the sample to those with a study visa would also have meant for example to exclude all students from Nordic countries (Denmark, Finland and Norway).

students who instead decided to stay and work in Sweden after the completion of their studies. Figure 3 provides a graphical description of the above.

Our dataset also includes 168,347 Swedish individuals who graduated in the same period of analysis (2000-2014). The data has been constructed in the same way and it also allows to match Swedish graduates with the sectors they are hired in. This provides us with a control group of students for which we have the same set of variables of the international graduates.

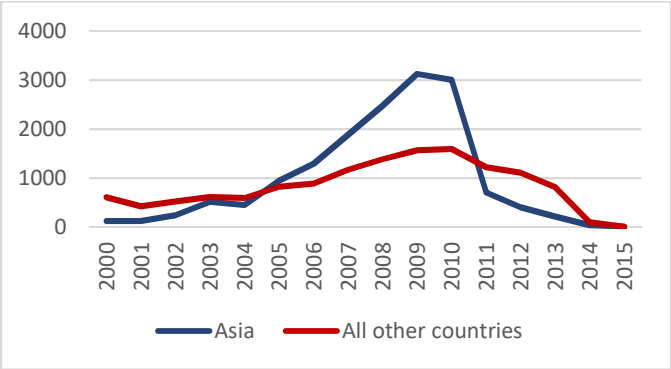
Descriptive statistics

In Table 1, we show the number of foreign graduates who work in a private company in Sweden in the year after they graduate and in Figure 4 we also distinguish by geographical area of origin. We observe a steady increase of the number of foreign graduates over time. This is due to two reasons. The first one is that by only selecting individuals who arrived and started to study in Sweden in the period 1998-2012 in the first year of our sample (year 2000) most of these individuals had not yet completed their studies. The second reason is the steady growth of international students in the mid 2000's, which is also reported by Swedish official statistics (SCB Statistics, 2019). The main factor behind the increase of the number of students was driven by the sudden increase of Asian students, which already in 2005 became the majority of graduates in our sample.

Table 1. Number of foreign graduates included in the sample who work in Sweden in the year after graduation

Year	Num.	%
2000	5	0.13
2001	7	0.19
2002	21	0.56
2003	25	0.66
2004	52	1.38
2005	93	2.46
2006	148	3.92
2007	199	5.26
2008	194	5.13
2009	274	7.25
2010	410	10.85
2011	529	13.99
2012	605	16.01
2013	634	16.77
2014	584	15.45
Total	3,780	100.00

Figure 4. Number of foreign students entering the sample each year by geo-area of origin



In Table 2 we show the composition of the sample of foreign graduates who are employed one year after graduation in terms of family characteristics, demographic characteristics (age and gender) and level of education. Among foreign graduates there is a majority of men (58%); 24% of the graduates are married and only 9% has children. The average age is 27.3, which is almost the same as the median age (27). Compared to the sample of Swedish graduates among foreign graduates the share of men is higher (58% vs 49.6%), the number of married individuals is higher (20% vs 7.6%), while the number of individuals with children is lower (6% vs 12%). The average age of the sample of Swedish graduates is also one year lower (26.2 vs 27.3), as well as the median which is 26 years old. Foreign graduates mainly have a master's degree as their highest level of degree (68%), while among Swedish graduates this share is much lower (27.5%) and 72.5% of them have a bachelor. Thus, our sample of foreign graduates is made of a slight majority of men, mainly without kids, one fourth is married and they mostly have a master's degree. They are on average slightly older than the students in the Swedish sample, they are more educated (more masters' degrees) and they are more likely to be men and to be married, while they are less likely to have kids.

In Table 3 we show the distribution of fields of education among Swedish and foreign graduates over the entire period: the most visible difference is the higher share of foreign graduates in Engineering and Informatics and Computing, with respect to Swedish graduates.

Table 2. Number of foreign and Swedish graduates employed the year after graduation distinguished by individual characteristics

	Foreign graduates		Swedish graduates	
Gender				
Women	1,575	41.7%	84,893	50.4%
Men	2,205	58.3%	83,454	49.6%
Family characteristics				
Married	760	20.1%	12,802	7.6%
Not married	3,020	79,9%	155,545	92.4%
Has children	229	6.1%	20,602	12,2%
No children	3,551	93.9%	147,745	87.8%
Level of education				
Bachelor's degree	1,197	31,7%	122,007	72.5%
Master's degree	2,571	68.0%	46,283	27.5%
Ph.D.	12	0.3%	57	0.03%
Geographical distribution				
Nordic	466	12.3%		
EU	900	23.8%		
Other nationalities	2414	63.9%		
Age	mean	median	min	max
Foreign graduates	27.3	27	21	31
Swedish graduates	26.2	26	20	31

Table 3. Number of foreign and Swedish graduates employed the year after graduation distinguished by field of education

Field of study	Code	Swedish graduates		Foreign graduates	
Teacher training and education science	14	10,993	6.5%	73	1.9%
Social and behavioural science	31	9179	5.5%	230	6.1%
Business and administration	34	32,346	19.2%	591	15.6%
Life sciences	42	2456	1.46%	64	1.7%
Computing	48	7586	4.5%	341	9.0%
Engineering and engineering trades	52	50,976	30.3%	1506	39.8%
Architecture and building	58	12,375	7.3%	152	4.0%
Health	72	14,069	8.4%	114	3.0%
Others	-	28,367	17.3%	709	18.9%
Total		168,347	100.0%	3780	100.0%

In Table 4a we compare the sectoral distribution of the foreign graduates and the Swedish graduates. We adopt the Eurostat detailed classification of sectors, which allows not only to distinguish between high-tech and low-tech manufacturing sectors, but also includes distinctions within the services sectors. This is especially important in the case of foreign graduates, as a large share of them are employed by firms active in the services industry. We distinguish between high-tech sector, mid-tech sectors, and low tech sectors among manufacturing firms. In the services sectors we distinguish between Knowledge intensive services (KIS) and Less Knowledge Intensive Services (LKIS). Moreover, since these categorizations still includes a very wide array of different services sectors in each group, among the KIS we further distinguish between high-tech KIS (which include, among others, Telecommunications, computer programming, Information service activities and Scientific research and development) and all the other types of KIS sectors. In the Appendix in Table A1 we provide a detailed description of the sectors included in each macro-category.

Table 4a shows that the distribution of foreign graduates is slightly more geared towards high-tech manufacturing (8% vs 3%) and high-tech KIS sectors (18% vs 13%), that they are substantially less frequent among other types of knowledge intensive sectors (other KIS: 30% vs 43%), but more frequent among services with low knowledge intensity (LKIS), which include postal activities, personal services activities and households related services (5% vs 1%).[6] In Table 4b, using the ISCO classification of occupations, we compare also the occupational distribution among foreign graduates and natives, focusing only on skilled occupations, such as "Professionals" and "Technicians and associate professionals". We observe that, consistently with the fact that these students have earned a tertiary degree, skilled occupations, such as professionals or technicians represent a high share of all occupations among both foreign and Swedish graduates: respectively 57% and 64%. Among foreign graduates, professionals represent a larger share (42%) than among Swedish graduates (38%), while technicians and associate professionals are more frequent among Swedish graduates (26%) than among foreing ones (15%).

[6] Additionally, we also checked whether these differences in the distributions are a temporary effect that vanishes over time as the student engage in their careers within firms. The results not displayed here for the sake of brevity, change slightly but we still observe similar differences.

Table 4a. Comparison of the sectoral distribution of employed foreign and Swedish graduates in the year after they graduate

Sector	Swedish graduates		Foreign graduates		Total	
High-tech manufacturing	5,449	3.2%	300	7.9%	5,749	3.3%
Mid-tech manufacturing	17,866	10.6%	423	11.2%	18,289	10.6%
Low-tech manufacturing	5,169	3.1%	48	1.3%	5,217	3.0%
High tech KIS	21,466	12.8%	686	18.1%	22,152	12.9%
Other KIS	75,704	45.0%	1,278	33.8%	76,982	44.7%
Less KIS	35,083	20.8%	987	26.1%	36,070	21.0%
Elect. & Construction	7,610	4.5%	58	1.5%	7,668	4.5%
Total	168,347	100%	3,780	100%	172,127	100%

Table 4b. Comparison of the occupational distribution of employed foreign and Swedish graduates in the year after they graduate (only Professionals and Technicians and associate professionals, i.e. highly skilled ones)

Occupation (2-digit)	Swedish graduates		Foreign. graduates		Total	
Professionals	64,244	38%	1,585	42%	65,829	38%
Technicians and associate professionals	42,953	26%	583	15%	43,536	25%
Professionals + Technicians	107,197	64%	2168	57%	109,365	64%
Total graduates	168,347	100%	3,780	100%	172,127	100%

Note: ISCO-08/SSYK occupation classification. Professionals include the category 2 and Technicians and associate professionals the category 3 at 2-digit of ISCO-08 (SSYK) classification, respectively.

4. Methodology

Our aim is to identify the effect of being a foreign graduate (as compared to Swedish graduates) on the sector of activity of the firm the students work for after graduation. We adopt a multivariate econometric strategy that can account for the different factors that influence this probability. In other words, we want to make sure that we compare students who are similar in most individual and education-related characteristics (such as age, family conditions, discipline of study and university of graduation), except for the fact that they are foreign graduates or Swedish ones. In

this way we can isolate the "foreign graduates effect". We are mainly interested in the first job that individuals take the year after graduation.

We introduce a probit model in order to measure the probability to work in a specific sector of the economy in the year after the students graduate. We use employment information about the sector of activity of the firm for which the individual works in the year after ($t+1$) he or she completed the tertiary degree. This allows us to keep into account that there may be a slight lag (one year) between the completion of the studies and the start of the career.

$$SECTOR_i^j = a + a_1\, FOREIGN_i + \sum_m a_2\, IND_{im_1} + \sum_n a_3\, FIELD_{in} + \sum_l a_4\, UNI_{il} + \lambda_t + \varepsilon_i \quad (1)$$

In equation (1) *SECTOR* is a dummy variable equal to 1 if the student is employed in a firm active in the specific sector j in the year after he or she graduated, and zero otherwise. All the independent variables refer instead to the year of graduation, hence to the year before the observed employment outcome. *FOREIGN* is a dummy equal to 1 if the student is a foreign grduate and zero if he is a native Swedish graduate. *IND* indicates a set of controls that control for demographic and individual characteristics such as age, family characteristics (having kids, being married, etc.), *FIELD* is a set of dummy variables indicating in which disciplinary field the student earned his latest tertiary degree. *UNI* is another set of dummy variables that indicate the university in which the student earned his degree. λ denotes a set of year dummies, while ε is the idiosyncratic error term. Tables 5 provides a brief description of each of the variables included in the model of equation (1), while Table 6a and 6b provide a summary statistics of each variable of the sample of respectively foreign and Swedish students.

Table 5. Description of variables

Variable	Description
Foreign graduate	Dummy for being a foreign graduate, zero for being a Swedish graduate
Male	Dummy for being a man
Age	Continuous
Age squared	Continuous
Not married	Dummy
KidsD	Has kids (dummy)
Wage income in 100,000 SEK	Wage income in 100,000 SEK (continuous, in logarithm)
level of education (reference is bachelor)	
Bachelor	Has a bachelor's degree (dummy)
Master	Has a master's degree (dummy)
Ph.D.	Has a PhD (dummy)

Disciplines of tertiary education	
STEM	STEM education (dummy)
Pedago	Pedagogical education (dummy)
Humanarts	Humanities and art education (dummy)
Social	Social sciences education (dummy)
Health	Medical education (dummy)
Top universities in Sweden	
KTH	Graduated at KTH Stockholm (dummy)
Lund	Graduated at Lund (dummy)
Uppsala	Graduated at Uppsala (dummy)
Stock	Graduated at Stockholm (dummy)
Chalmers	Graduated at Chalmers (dummy)
Goteborg	Graduated at Goteborg (dummy)
Karolinska	Graduated at Karolinska (dummy)
Nationalities of foreign graduates	
Nordic	Foreign graduate from Denmark, Finland, Norway (dummy)
EU	Foreign graduate from other European countries (dummy)
Other nationalities	Foreign graduate from Africa, Asia, North America, Oceania, South America (dummy)

Table 6a. Summary statistics related to the sample of foreign graduates (3,780 obs.)

Variable	Mean	Std. Dev.	Min	Max
Male	0.58	0.49	0	1
Age	26.20	2.24	20	31
Age squared	690.91	119.30	400	961
Not married	0.80	0.40	0	1
KidsD	0.06	0.24	0	1
Wage (log)	7.59	1.45	0	10.42
level of education				
Bachelor	0.31	0.46	0	1
Master	0.68	0.47	0	1
PhD	0.00	0.06	0	1
Disciplines of tertiary education				
STEM	0.61	0.49	0	1
Pedago	0.02	0.14	0	1
Humanarts	0.07	0.25	0	1
Social	0.25	0.43	0	1
Health	0.03	0.18	0	1
Top universities in Sweden				

KTH	0.22	0.42	0	1
Lund	0.07	0.26	0	1
Uppsala	0.05	0.22	0	1
Stockh	0.08	0.27	0	1
Chalmers	0.10	0.30	0	1
Goteborg	0.07	0.26	0	1
Karolinska	0.01	0.11	0	1
Nationalities of foreign graduates				
Nordic	0.12	0.33	0	1
EU	0.24	0.43	0	1
Other nationalities	0.64	0.48	0	1

Table 6b. Summary statistics related to the sample of Swedish graduates (168,347 obs.)

Variable	Mean	Std. Dev.	Min	Max
Male	0.50	0.50	0	1
Age	26.17	2.24	20	31
Age squared	689.64	119.04	400	961
Not married	0.92	0.27	0	1
KidsD	0.12	0.33	0	1
Wage (log)	7.79	0.91	0	10.29
level of education				
Bachelor	0.72	0.45	0	1
Master	0.27	0.45	0	1
PhD	0.00	0.02	0	1
Disciplines of tertiary education				
STEM	0.46	0.50	0	1
Pedago	0.07	0.25	0	1
Humanarts	0.05	0.21	0	1
Social	0.31	0.46	0	1
Health	0.09	0.29	0	1
Top universities in Sweden				
KTH	0.07	0.26	0	1
Lund	0.10	0.29	0	1
Uppsala	0.07	0.26	0	1
Stockh	0.07	0.25	0	1
Chalmers	0.07	0.25	0	1
Goteborg	0.06	0.25	0	1
Karolinska	0.02	0.15	0	1

5. Results

5.1. Main specification

In Table 7 we show the results of a set of probit estimations on the probability of foreign and native students to work in a specific type of sector one year after they graduate. We control for different characteristics that are likely to influence the probability that a student is hired in a specific sector, such as the discipline of the tertiary degree, the level of education (bachelor, master, Ph.D.), the university in which they earned it and a set of other controls such as age, gender, being married or having kids.

The results show that foreign graduates are more likely to work in high-tech manufacturing sectors. As a corollary, we find that they are slightly less likely to work in all the sectors of manufacturing that are not high tech (mid-tech, and low tech). Foreign graduates are more likely to work in high-tech services (*high tech KIS*). On the contrary they are much less likely to work in sectors with high knowledge content that are not high-tech -*other KIS*- (such as legal professions, financial professions, artistic or publishing activities). Lastly foreign graduates are also more likely to work in services sectors with less knowledge intensity (*LKIS*).

The higher likelihood to work in high tech manufacturing (a non-expanding sector relying on codified and formalized knowledge) provides support for *H1*. The higher likelihood to work in *high tech KIS* (an expanding sector relying on codified and formalized knowledge) provides support for both *H1* (higher likelihood of foreign graduates to work in sectors that use analytical and codified knowledge) and *H2 (*higher likelihood of foreign graduates to work in expanding sectors). Lastly the higher likelihood to work in services sectors with less knowledge intensity (*LKIS*), i.e. an expanding sector which does not rely to a large extent on formalized knowledge, provides support for H2. In the case of *other KIS* (an expanding sector which does not rely on codified/analytical knowledge) H2 does not apply, as we see a lower likelihood to work in this sector for international graduates with respect to natives. In the case of low and mid-tech sectors (non-expanding sectors not relying on codified knowledge) both H1 and H2 would predict a low likelihood of employability for foreign graduates: in this case the results confirm our hypotheses.

Among the other controls included in the specification in Table 7 we find that (for both Swedish and foreign graduates) having a master level of education is associated with employment in more knowledge-based types of sectors (such as *high-tech* and *mid-high tech manufacturing*, *high tech KIS* and *other types of KIS*), while it is negatively related with employment in services with low knowledge content and with low-tech manufacturing. STEM workers are more likely to work in

high and mid-high manufacturing sectors and in *high tech KIS*. On the contrary they are less likely to work in *other types of KIS* and in services with low knowledge content (*LKIS*).[7]

The university dummies, which identify the effect of graduating from one of the 6 top universities in Sweden (with respect to all other universities) show that most of these universities increase the likelihood of students to work in *non-high tech KIS* (except Uppsala and Goteborg university). This may suggest that these universities train people who enter specific professional categories, or it could simply be an urban effect since most of these universities are located close to the three main cities of Sweden (Stockholm, Goteborg and Malmo), where professional services firms are mainly concentrated.

Persistency of the effect

In Table 8 we check whether the effects estimated in Table 7 are temporary, or they are still present also after three years from the year of graduation. The reason to check if the results differ 3 years after is that the entry job in the labor market for young graduates may not always correspond to the job that a graduate is actually looking for, it may also be a temporary solution to earn an income. This is especially true for foreign graduates who need to comply with work-visa requirements in order to stay in Sweden after they complete their university studies. The results in Table 8 show that the positive effect for high tech manufacturing does not change overtime: in the case of high-tech KIS the coefficient increases in size, becoming larger than for high-tech manufacturing. On the contrary the coefficient decreases in *LKIS*. This suggests that international graduates may develop a preference for high tech KIS at a later stage, while in the case of LKIS they may decide to start their career in this sector, possibly for lack of alternatives, but they often switch to other sectors in the second or third year after graduation.

Moderating role of cultural distance

In Table 9 we also check whether the effect found for international graduates is moderated by the cultural distance between the foreign graduates and the Swedish culture. In other words, we want to test if these differences are stronger for graduates who come from more distant cultures. We distinguish between a) foreign students from other Nordic countries (Norway, Denmark or

[7] The same is true for social sciences, with the difference that for graduates in social sciences there is also a higher probability to work in all type of *KIS* (both high tech and non-high tech).

Finalnd), b) foreign students from other European countries and c) foreign students from non-European countries (Africa, Asia, North America, Oceania, South America) In Table 9 we only show the coefficient of our main variables of interest, as the coefficients of the other control variables are not the main focus of this analysis.

The first finding is that graduates from other Nordic countries do not display significant differences with respect to Swedish graduates in any sector. When we look at the high tech sectors in manufacturing, we find that the largest (positive) coefficient is that of non-European students, followed by European students. This provides support for *H3a*, according to which students from more culturally distant countries (such as non-European countries) will work in sectors with less required tacit/local knowledge. When it comes to *high tech KIS*, we again find that foreign Nordic students do not show any significant difference, although the coefficient for European students is positive and higher than that for non-European ones. Overall, this result provides some mixed evidence about *H3a*, according to which the higher the cultural distance the higher the likelihood a foreign student will work in a high tech sector. This is confirmed in high tech manufacturing, but not in high tech KIS. With respect to the high tech manufacturing sector, the high tech services are in general characterized by a greater frequency of interaction between the scientist/engineer and the client on the project's technical specifications, as in the case of R&D consultancy services (La, Patterson and Styles, 2005). Therefore, graduates who are culturally closer to the client of their employer are more likely to be in charge of tasks requiring a greater interaction, which may partially explain the higher propensity to work in *high tech KIS* for EU graduates relative to non-EU ones. Lastly, when looking at an expanding sector, such as *LKIS,* we see especially non-European students are much more likely than Swedish ones to work there. This provides some confirmation for *H3b*, according to which graduates from culturally distant countries will be more likely to work in expanding sectors.

Moderating role of STEM

In Table 10 instead we interact the foreign graduate dummy with the STEM dummy. In this way we can test H4, according to which it is especially foreign students with a STEM degree who will work in sectors with high levels of codified/analytical knowledge. The results in column (1) show that indeed being a foreign graduate *per se* does not increase the probability to work in a high tech sector (with respect to Swedish graduates), as shown by the non significant coefficient of the variable *Foreign graduate*. Only the interacted coefficient is significant: this implies that the

higher likelihood for foreign graduates to work in high tech sectors is driven by foreign STEM graduates. On the contrary, when we look at the *high-tech KIS* in column (4) we find that the coefficient of the interacted variable is not significantly different from zero. This suggest that in the case of *high tech KIS* having a STEM education does not increase the chances to be hired for foreign students. All in all these results find only support for H4 among high tech manufacturing, but not among *high tech KIS*.

5.2. Robustness checks: selection issues

A potential issue related with our methodology has to do with the so-called selection into migration effect. In other words, the type of students who engage in an international curriculum may have different motivations and also different intrinsic qualities with respect to the students who study in their home country. For example, foreign graduates may be more motivated to engage in creative and challenging jobs in the high tech sectors. While it is difficult to say a priori whether foreign graduates have a higher or lower average quality with respect to native ones, this remains a potential issue of our estimation strategy. So far our way of solving this issue was to control for the university in which they graduated, especially when it comes to the most prestigious universities, since graduating in one of those universities requires a generally high level of cognitive abilities (Grogger and Hanson, 2015). A direct way to control for ability may be to use the final grades of the students, while an indirect measure would be the parental background of foreign graduates (Meghir and Palme, 2005), but unfortunately we do not have access to these two measures. We hence decided to control for the quality of students by introducing an additional control in our baseline specification: the level of the salary in the first year of employment. Assuming that entry salaries are correlated with the ability of graduates (for example because the brightest students will be hired by the best companies, with higher productivity, which often offer higher salaries) we introduce this additional control as a proxy of graduates' ability and check whether our baseline results change. In Table 11 we show the new results using the same exact specification of Table 7, but this time including the log of the salary. We find that our main results are very robust to this new specification, hinting at the fact that this selection issue may not be particularly important for our sample of students. The results do not change also when we consider the sectoral affiliation three years after graduation, in Table 12.

5.3. Robustness checks: controlling for occupations

As a last robustness check of our main results, we control for skill differentiation within each sector, by restricting the analysis to two types of occupations at one digit, those that refer to high- and medium skills (ISCO-08-SSYK classification), namely the so-called "Professionals" and the so-called "Technicians and associate professionals". This is because by checking the specific occupations in which graduates are employed we can be sure that our results are not driven by occupational choices of graduates who do not match the high level of skills that they earned during their education. Especially in the case of foreign graduates we want to make sure that our patterns are not driven by second-best choices of these graduates, who may accept jobs for which they are over-qualified to get a first employment contract.

In Table 13 we consider only graduates who work as "professionals" in the first year after graduation and in Table 14 only graduates who work as "technicians and associate professionals". The results of Table 12 show that foreign graduates employed as "professionals" one year after their graduation have a much higher propensity than Swedish graduates to work in *high-tech manufacturing* and *high-tech KIS*. We also find a positive effect of being a foreign graduate on the probability to work in *LKIS*, although the coefficient is considerably lower than the one found in the baseline specification of Table 7. All in all this confirms our previous results in Table 7: additionally it informs us that the large positive effect found for *LKIS* is due to the fact that in these sectors foreign graduates work in positions which do not require a very high level of competences.

When we look at graduates who work as "technicians and associate professionals", in Table 14, we find that the positive effect of being a foreign graduate on high tech manufacturing is lower than for professionals. Foreign students in these occupations are instead more likely to work in mid-tech manufacturing. In the *high tech KIS* the coefficient of foreign graduates is positive and as large as for professionals. Again we find that the coefficient for the probability to work in LKIS is much lower than in Table 7: in this case it is not significantly different from zero. This confirms that the foreign graduates who end up working in *LKIS* are in most of the cases working in occupations with relatively low levels of qualifications.

Our findings are persistent also three years after graduation in Table 15 and 16. This provides a further confirmation of our findings: the larger propensity of foreign graduates to work in high tech sectors (either in the manufacturing or services) applies especially to students who work in occupations such as "professionals" and "technicians".

6. Conclusions

This paper has tested whether foreign graduates who remain in Sweden after studying in a Swedish university are more or less likely than Swedish graduates to work in different sectors of the economy. We argue that foreign graduates will be more likely than native students to be employed in high-tech sectors – both in manufacturing and in services – due to the high level of knowledge formalization and technical skills required for these sectors. We also suggest that foreign graduates will be more likely to work in expanding sectors that are particularly in need of new competences. We also propose that the likelihood to work in sectors with more formalized knowledge and with higher expansion will be stronger the higher is the cultural distance of the foreign graduates to the host country. Finally, we claim that the higher propensity with respect to Swedish students to work in high tech sectors is mainly driven by STEM foreign graduates, because of their higher acquaintance with analytical knowledge, formalized models and basic science.

We find that indeed foreign graduates are more likely to work in high tech manufacturing and in high-tech services (so-called *high tech KIS*). This confirms our first hypothesis about the importance of formalized and analytical knowledge in the employment opportunities for foreign graduates. We also find that foreign graduates are more likely to work in expanding sectors, even when the use of codified knowledge is not high: this is the case of the less knowledge intensive sectors (*LKIS*), where foreign graduates are more likely to work than Swedish graduates.

We find some support about the moderating role of cultural distance: foreign graduates from other Nordic European countries (the most culturally close) are not more likely to work in high tech or expanding sectors than Swedish graduates, while foreign students from other EU countries do. Likewise, we do find that non-European students (arguably the least culturally close) are more likely to work in high tech manufacturing sectors with respect to European ones.

Lastly, we find that the higher probability (with respect to Swedish graduates) of foreign graduates to work in high tech manufacturing sectors is driven by STEM graduates. However, in the high tech services sectors (*high tech KIS*) this is not the case: the higher probability of foreign graduates to work in such sectors is not driven by STEM graduates.

In our robustness checks we find that our results about the high tech sectors (both in manufacturing and in services) is mainly driven by foreign graduates working in occupations such as professionals or technicians, hence confirming that in those sectors they are employed in jobs for which they are not over-qualified. On the contrary we find that the higher propensity of

foreign graduates to work in services with low knowledge intensity (LKIS) is mainly driven by over-education: i.e. it is driven by foreign graduates who work in occupations that do not necessarily require the high level of competences earned through university education.

Overall, our results suggest that in recent years foreign students are to be considered an important source of new competences in the high tech sector in Sweden, both in manufacturing and in services. The paper also provides novel evidence to the literature that studies international mobility, and to the growing phenomenon of international students, showing that this type of international mobility could greatly affect the high tech sectors of the receiving countries.

Our results are not free of limitations. Most importantly we compare foreign graduates who stay in Sweden with Swedish graduates who live in Sweden. This may induce some bias in our estimates, due to the fact that foreign graduates may have different motivations and different abilities with respect to Swedish ones. While we are not able to fully measure this difference in abilities, we have included two measures that may partially capture this. The first is the university of study, controlling in particular for the most prestigious universities in Sweden (Uppsala, Lund, Stockholm, etc): graduating in one of these universites requires some basic level of abilities for both foreign and Swedish students. Additionally in our robustness checks we have also included the salary of graduates when they start working, assuming that this may also capture part of the hidden abilities of these students. Even if this may partly compensate our selection problems, our results shold be interpreted keeping in mind this potential limitation.

Another important limitation has to do with the empirical context of our study and the external validity of our results. Sweden is a particular case of open economy with a large high tech sector both in the manufacturing (companies such as Ericsson) and in the services (such as Spotify) which requires a constant inflow of new recruitments. This is a special case that does not necessarily apply to all the host countries, not even within Europe. So it could be that in countries where the high tech sectors do not play such a big role as in Sweden foreign graduates may have a less easy access to jobs in these sectors. Additionally using Sweden as an empirical context may also imply that some foreign graduates chose to study in Sweden precisely because of the possibility to work later in the high tech industry. This could induce some specific attraction bias for foreign students in Sweden.

Keeping in mind these important limitations we believe that our results can contribute to the current debate on the economic impact of international students on the host countries and allow

policy makers to gain valuable insights about the potential impact of policies aimed at attracting and retaining foreign students in the university system of the host countries.

First of all our results show that indeed foreign graduates can contribute significantly to the development of the high tech sectors of the host countries in which they earned their education. This confirms that policies aimed at the attraction (and especially at the retention) of foreign graaduates can have an impact also on the development of more high tech sectors. Moreover our findings also suggest that the foreign graduates who contribute to the growth of high-tech sectors are not only STEM ones, especially in the high tech services. Therefore this calls for policies to attract and retain also foreign students graduating in non-STEM disciplines.

The flip side is that there are also sectors in which foreign graduates are much less likely to work: these are the mid and low tech sectors in manufacturing and the professionists services (legal services, financial services, HR, etc). In these sectors the type of knowledge used is more tacit and more dependent on the communication skills of individuals. Policies that aim to increase the inclusion of foreign graduates in these sectors should probably consider either creating better opportunities to learn the host country language for such students (already during their studies) or policies aimed at promoting English as the working language also in firms in these sectors.

The last implication has to do with the higher probability to be employed in services with low knowledge intensity (*LKIS*): this result suggests some type of polarization in the job market. Some foreign graduates end up doing very qualified jobs in the high tech manufacturing or services, while some others may be employed in jobs which may not even require a university education such as in services with little knowledge intensity. It is reassuring to see that this effect fades away after a few years. However, policies should make sure to avoid that foreign university graduates are employed in jobs for which they are over-qualified, as this looks like a mismatch between their potential and actual contribution to the host economy.

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REGRESSIONS

Table 7. Baseline: probability to be hired in different types of sectors in the year AFTER graduation

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Foreign graduate	0.040***	-0.005	-0.012***	0.027***	-0.132***	0.135***
	(0.004)	(0.004)	(0.002)	(0.005)	(0.008)	(0.009)
Male	0.000	0.012***	-0.006***	0.044***	-0.027***	0.034***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Age	0.011***	0.012**	-0.003	0.015**	0.065***	0.084***
	(0.003)	(0.005)	(0.003)	(0.007)	(0.011)	(0.009)
Age squared	-0.000***	-0.000**	0.000	-0.000**	-0.001***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Not married	-0.003**	-0.003	-0.001	-0.004	0.015***	0.002
	(0.001)	(0.002)	(0.002)	(0.003)	(0.005)	(0.004)
KidsD	-0.003***	0.004**	0.002*	-0.020***	0.008**	0.007**
	(0.001)	(0.002)	(0.001)	(0.002)	(0.004)	(0.003)
level of education (reference is Bachelor)						
Master	0.005***	0.012***	-0.001	0.011***	0.028***	0.053***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Phd	0.031	0.034		-0.034	0.044	-0.038
	(0.024)	(0.037)		(0.032)	(0.067)	(0.043)
Disciplines of tertiary education						
STEM	0.051***	0.128***	-0.014***	0.200***	-0.189***	0.187***
	(0.005)	(0.006)	(0.002)	(0.008)	(0.007)	(0.005)
Pedago	-0.009***	-0.038***	-0.026***	-0.022***	0.350***	0.167***
	(0.003)	(0.004)	(0.001)	(0.007)	(0.007)	(0.003)
Humanarts	-0.002	-0.003	-0.017***	0.205***	-0.001	-0.005
	(0.004)	(0.006)	(0.001)	(0.014)	(0.009)	(0.007)
Social	0.011***	0.049***	-0.018***	0.102***	-0.019**	-0.013**
	(0.004)	(0.006)	(0.002)	(0.009)	(0.008)	(0.006)
Health	0.027***	-0.048***	-0.016***	-0.012	0.110***	0.049***
	(0.007)	(0.003)	(0.001)	(0.008)	(0.009)	(0.006)
University of graduation						
KTH	0.005***	-0.019***	-0.017***	0.005*	0.046***	0.008*
	(0.001)	(0.002)	(0.001)	(0.003)	(0.005)	(0.005)
Lund	-0.003***	-0.033***	0.000	0.025***	0.050***	0.012***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.004)	(0.004)
Uppsala	0.015***	-0.029***	-0.019***	0.030***	-0.009*	0.028***
	(0.002)	(0.002)	(0.001)	(0.003)	(0.005)	(0.004)
Stockh	-0.001	-0.051***	-0.018***	0.047***	0.092***	0.023***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)	(0.004)
Chalmers	-0.001	-0.000	-0.010***	-0.035***	0.135***	0.066***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.005)	(0.004)
Goteborg	0.010***	-0.013***	-0.002	0.009***	-0.012**	0.029***

	(0.002)	(0.002)	(0.001)	(0.003)	(0.005)	(0.004)
Karolinska	-0.010***	-0.040***	-0.015***	-0.027***	0.230***	0.105***
	(0.002)	(0.006)	(0.002)	(0.009)	(0.010)	(0.005)
Observations	172,127	172,127	172,058	172,127	172,127	172,127
Log-likelihood	-21893	-48653	-22638	-60058	-108122	-86346
Pseudo R-squared	0.131	0.126	0.0315	0.0911	0.0864	0.0662

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (one year after graduation). The table presents the marginal effects of a probit estimator. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8. Probability to be hired in different types of sectors three years after graduation

	(1)	(2)	(3)	(4)	(5)	(6)
	High-tech	Mid-tech	Low-tech	KIS-high	Other KIS	Low KIS
VARIABLES						
Foreign graduate	0.040***	0.001	-0.009***	0.066***	-0.154***	0.099***
	(0.005)	(0.005)	(0.003)	(0.008)	(0.009)	(0.010)
All other controls	YES	YES	YES	YES	YES	YES
Observations	144,882	144,882	144,813	144,882	144,882	144,882
Log-likelihood	-20784	-43955	-19340	-53071	-89829	-71631
Pseudo R-squared	0.110	0.123	0.0263	0.0839	0.0930	0.0584

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (three years after graduation). The table presents the marginal effects of a probit estimator. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 9. Probability to be hired in different types of sectors in the year after graduation, distinguishing by nationalities

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Nordic	0.002	-0.001	-0.007	0.017	0.013	-0.017
	(0.007)	(0.012)	(0.007)	(0.015)	(0.024)	(0.018)
EU	0.032***	-0.002	-0.010**	0.044***	-0.076***	0.040***
	(0.008)	(0.009)	(0.004)	(0.012)	(0.017)	(0.015)
Other nationalities	0.048***	-0.006	-0.014***	0.023***	-0.183***	0.208***
	(0.005)	(0.004)	(0.003)	(0.006)	(0.009)	(0.011)
All other controls	YES	YES	YES	YES	YES	YES
Observations	172,127	172,127	172,058	172,127	172,127	172,127
Log-likelihood	-21884	-48653	-22638	-60056	-108081	-86277
Pseudo R-squared	0.131	0.126	0.0316	0.0912	0.0868	0.0670

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (one year after graduation). The table presents the marginal effects of a probit estimator. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 10. Probability to be hired in different types of sectors, one year after graduation. Interaction of STEM variable with the dummy Foreign graduate

VARIABLES	(1) High-tech	(2) KIS-high
Foreign graduate	0.009	0.032***
	(0.006)	(0.011)
STEM	0.039***	0.120***
	(0.001)	(0.002)
STEM * Foreign graduate	0.030***	0.003
	(0.011)	(0.011)
All other controls	YES	YES
Observations	172,127	172,127
Log likelihood	-21964	-60836
Pseudo R-squared	0.128	0.0793

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (one year after graduation). The table presents the marginal effects of a probit estimator for the high tech sectors, manufacturing and KIS services, respectively. Note that the benchmark category for the variale STEM is all the other disciplines: this implies that in this specification the other discipline dummies are excluded. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.

ROBUSTNESS CHECKS

Table 11. Probability to be hired in different types of sectors in the year after graduation, controlling for the graduate's wage level

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Foreign graduate	0.044***	0.002	-0.012***	0.027***	-0.139***	0.132***
	(0.004)	(0.004)	(0.002)	(0.005)	(0.008)	(0.009)
Wage (in log)	0.013***	0.028***	0.001	0.002*	-0.022***	-0.007***
	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)
Male	-0.001	0.009***	-0.006***	0.044***	-0.026***	-0.033***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Age	0.007***	0.005	-0.003	0.015**	0.072***	-0.082***
	(0.003)	(0.005)	(0.003)	(0.007)	(0.012)	(0.009)
Age squared	-0.000***	-0.000	0.000	-0.000**	-0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Not married	-0.003***	-0.004*	-0.001	-0.004	0.017***	0.002
	(0.001)	(0.002)	(0.002)	(0.003)	(0.005)	(0.004)
KidsD	-0.000	0.010***	0.002*	-0.020***	0.003	0.006*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.004)	(0.003)
level of education (reference is Bachelor)						
Master	0.003***	0.008***	-0.001	0.011***	0.031***	-0.052***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Phd	0.025	0.032		-0.034	0.051	-0.036
	(0.021)	(0.036)		(0.032)	(0.067)	(0.044)
Disciplinary of tertiary education						
STEM	0.045***	0.121***	-0.014***	0.200***	-0.186***	-0.186***
	(0.004)	(0.006)	(0.002)	(0.008)	(0.007)	(0.005)
Pedagi	-0.007***	-0.035***	-0.026***	-0.022***	0.348***	-0.167***
	(0.003)	(0.004)	(0.001)	(0.007)	(0.007)	(0.003)
Humanarts	0.003	0.011*	-0.017***	0.208***	-0.020**	-0.010
	(0.004)	(0.007)	(0.001)	(0.015)	(0.009)	(0.007)
Social	0.009***	0.046***	-0.018***	0.102***	-0.018**	-0.012**
	(0.004)	(0.006)	(0.002)	(0.009)	(0.008)	(0.006)
Health	0.025***	-0.046***	-0.016***	-0.012	0.110***	-0.049***
	(0.006)	(0.003)	(0.001)	(0.008)	(0.009)	(0.006)
University of graduation						
KTH	0.003***	-0.020***	-0.017***	0.005*	0.048***	0.009*
	(0.001)	(0.001)	(0.001)	(0.003)	(0.005)	(0.005)
Lund	-0.003***	-0.033***	0.000	0.025***	0.051***	-0.012***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.004)	(0.004)
Uppsala	0.013***	-0.029***	-0.019***	0.030***	-0.007	0.029***
	(0.001)	(0.002)	(0.001)	(0.003)	(0.005)	(0.004)
Stockh	-0.001	-0.050***	-0.018***	0.047***	0.093***	-0.022***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)	(0.004)

Chalmers	-0.001	-0.002	-0.011***	-0.035***	0.136***	-0.066***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.005)	(0.004)
Goteborg	0.009***	-0.013***	-0.002	0.009***	-0.013**	0.028***
	(0.002)	(0.002)	(0.001)	(0.003)	(0.005)	(0.004)
Karolinska	-0.009***	-0.040***	-0.015***	-0.027***	0.231***	-0.105***
Observations	172,127	172,127	172,058	172,127	172,127	172,127
Log-likelihood	-21670	-48317	-22637	-60055	-107994	-86323
Pseudo R-squared	0.140	0.132	0.0316	0.0912	0.0875	0.0665

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (three years after graduation). The table presents the marginal effects of a probit estimator. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 12. Probability to be hired in different types of sectors three years after graduation, controlling for the graduate's wage level

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	High-tech	Mid-tech	Low-tech	KIS-high	Other KIS	Low KIS
Foreign graduate	0.051***	-0.004	-0.010***	0.067***	-0.151***	0.068***
	(0.006)	(0.005)	(0.003)	(0.009)	(0.010)	(0.010)
Wage (in log)	0.014***	0.022***	0.002***	-0.000	-0.027***	0.008***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
All other controls	YES	YES	YES	YES	YES	YES
Observations	120,281	138,764	120,235	120,281	120,281	138,764
Log-likelihood	-18635	-40513	-16728	-45749	-74149	-64145
Pseudo R-squared	0.111	0.130	0.0278	0.0772	0.0841	0.0554

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (three years after graduation). The table presents the marginal effects of a probit estimator. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 13. Probability of Professionals to be hired in different types of sectors for in the year after graduation

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	High-tech	Mid-tech	Low-tech	KIS-high	Other KIS	Low KIS
Foreign graduate	0.100***	0.006	-0.009***	0.053***	-0.155***	0.021**
	(0.009)	(0.006)	(0.002)	(0.011)	(0.013)	(0.009)
All other controls	YES	YES	YES	YES	YES	YES
Observations	65,829	65,829	64,350	65,829	65,829	65,829
Log-likelihood	-10639	-18710	-5891	-28739	-37843	-22052
Pseudo R-squared	0.142	0.103	0.0509	0.131	0.17	0.0578

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (one year after graduation). The table presents the marginal effects of a probit estimator. Professionals' category is included at 2-digit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 14. Probability of technicians and associate professionals to be hired in different types of sectors for in the year after graduation

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Foreign graduate	0.019**	0.051***	-0.021***	0.055***	-0.049**	0.004
	(0.008)	(0.015)	(0.005)	(0.013)	(0.021)	(0.018)
All other controls	YES	YES	YES	YES	YES	YES
Observations	43,536	43,536	43,528	43,528	43,536	43,536
Log-likelihood	-6298	-15969	-6934	-10285	-26516	-20845
Pseudo R-squared	0.112	0.147	0.0359	0.0600	0.104	0.0762

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (one year after graduation). The table presents the marginal effects of a probit estimator. Professionals' category is included at 2-digit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 15. Probability of Professionals to be hired in different types of sectors for three years after graduation

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Foreign graduate	0.097***	-0.005	-0.008**	0.114***	-0.181***	0.001
	(0.011)	(0.007)	(0.003)	(0.015)	(0.015)	(0.010)
All other controls	YES	YES	YES	YES	YES	YES
Observations	56,358	64,723	55,509	56,358	56,358	64,723
Log-likelihood	-10662	-19017	-5500	-26464	-33570	-21730
Pseudo R-squared	0.114	0.0949	0.0441	0.102	0.137	0.0480

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (three years after graduation). The table presents the marginal effects of a probit estimator. Professionals' category is included at 1-digit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 16. Probability of technicians and associate professionals to be hired in different types of sectors three years after graduation

VARIABLES	(1) High-tech	(2) Mid-tech	(3) Low-tech	(4) KIS-high	(5) Other KIS	(6) Low KIS
Foreign graduate	0.016	0.068***	-0.020***	0.034**	-0.034	-0.037**
	(0.011)	(0.020)	(0.007)	(0.015)	(0.027)	(0.019)
All other controls	YES	YES	YES	YES	YES	YES
Observations	34,305	39,466	34,294	34,305	34,305	39,466
Log-likelihood	-5570	-14349	-5874	-8445	-20251	-18906
Pseudo R-squared	0.0896	0.157	0.0370	0.0484	0.0873	0.0676

The dependent variable is the probability that a graduate is hired by a firm in a specific sector (three years after graduation). The table presents the marginal effects of a probit estimator. Professionals' category is included at **2**-digit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

APPENDIX

Table A1: Sectoral Classification

MANUFACTURING SECTORS
High -technology
21 Manufacture of basic pharmaceutical products and pharmaceutical preparations;
26 Manufacture of computer, electronic and optical products
Medium-high-technology
20 Manufacture of chemicals and chemical products;
19 Manufacture of coke and refined petroleum products;
22 Manufacture of rubber and plastic products;
23 Manufacture of other non-metallic mineral products;
24 Manufacture of basic metals;
25 Manufacture of fabricated metals products, excepts machinery and equipment;
27 Manufacture of electrical equipment;
28 Manufacture of machinery and equipment n.e.c.;
29 Manufacture of motor vehicles, trailers and semi-trailers;
30 Manufacture of other transport equipment
33 Repair and installation of machinery and equipment
Low-technology
10 Manufacture of food products
11 Manufacture of beverages
12 Manufacture of tobacco products,
13 Manufacture of textiles
14 Manufacture of wearing apparel
15 Manufacture of leather and related products
16 Manufacture of wood and of products of wood and cork
17 Manufacture of paper and paper products
18 Printing and reproduction of recorded media
31 Manufacture of furniture
32 Other manufacturing
SERVICES SECTORS
High-tech Knowledge-intensive services (High tech KIS)
59 Motion picture, video and television programme production, sound recording and music publishing activities
60 Programming and broadcasting activities
61 Telecommunications
62 Computer programming, consultancy and related activities
63 Information service activities
72 Scientific research and development;
Other Knowledge-intensive services (Other KIS)
50 to 51 Water transport; Air transport;
58 Publishing activities;
64 to 66 Financial and insurance activities (section K);
69 Legal and accounting activities;
70 Activities of head offices, management consultancy activities;
71 Architectural and engineering activities, technical testing and analysis;
73 Advertising and market research;
74 Other professional, scientific and technical activities;
75 Veterinary activities;
78 Employment activities;
80 Security and investigation activities;
84 to 93 Public administration and defence, compulsory social security (section O); Education (section P), Human health and social work activities (section Q); Arts, entertainment and recreation (section R).
Less knowledge-intensive services
45 to 47 Wholesale and retail trade; Repair of motor vehicles and motorcycles (section G);
49 Land transport and transport via pipelines;
52 Warehousing and support activities for transportation;
53 Postal and courier activities;
55 to 56 Accommodation and food service activities (section I);
68 Real estate activities (section L);

77 Rental and leasing activities; 79 Travel agency, tour operator reservation service and related activities; 81 Services to buildings and landscape activities; 82 Office administrative, office support and other business support activities; 94 Activities of membership organisation; 95 Repair of computers and personal and household goods; 96 Other personal service activities 97 to 99 Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use (section T); Activities of extraterritorial organisations and bodies (section U).

Note: the macro-sectoral classifications are based on the OECD classification using Nace Rev 2 sectors and calculated using the harmonized SNI-codes (SNI2007, Nace Rev 2).