Foreign-born Inventors in Sweden

- Immigration Background and Its Impact on Invention Performance

Yannu Zheng[1] Olof Ejermo[2]

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Abstract

Based on a new and unique database, which combines Swedish patent applications filed by Swedish inventors to the European Patent Office (EPO) from 1985 to 2007 with demographic information, we examine how foreign-born inventors perform in inventive activity compared with Swedish-born and factors that explain the differences. We also examine the inventive performance within the group of foreign-born inventors, based on immigration background, primarily birth region and reasons for settlement at the time of filing. We find that, the quality of patents contributed by the foreign-born and the Swedish-born is similar. The main differences concern that foreign-born inventors seem to have significantly better patent quality when educated in health and welfare. In general, the quality of patents for those of foreign-born inventors from different regions and reasons for settlement is also similar. However, there is difference between inventors from different regions but with same reason for settlement, education level, field of study and gender. It is the same for inventors from the same region but with different factors as mentioned above. These differences mainly can be attributed to the inventors' field of study. For example, the quality of patents for those from the rest of Europe who settled as

[1] Ph.D. candidate, CIRCLE and Department of Economic History, Lund University. Email: yannu.zheng@circle.lu.se
[2] Associate professor, CIRCLE and Department of Economics, Lund University. Email: olof.ejermo@circle.lu.se

permanent residents is not only better than those settled for family ties and “other reasons”, but also better than those from the other regions with the same reason. This is mainly because of the good performance of its inventors who studied in “other fields”.

Keywords: foreign-born inventors, competence, human capital, causes of migration, Sweden

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I. Introduction

Increasing the number of highly educated workers and introducing diversity into the workplace are considered as two reliable ways to generate ideas and innovation into an economy. This aim can be promoted by increasing the number of highly skilled immigrants (Goldin, Cameron and Balarajan, 2011: p167). This has been proven by the experience of the U.S. which has a high concentration of talented immigrants in its most dynamic industries (ibid). Recent studies also indicate that foreign-born talents have made important contributions to advancing technology and boosting innovation in the U.S. (e.g. Kerr, 2009; Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010; Hunt, 2011). Sweden, as a country with similar and increasing proportion of immigrants[3] (Ekberg, 2011) as well as good reputation for its openness, advanced technology and a strong innovation capability, as in the U.S. (OECD, 2008: p56), has also benefited from the creative and intellectual contribution of its diversified high skilled immigrants. For instance, about 13% of people engaged in science and technology aged 25-64 in Sweden were foreign born in 2006 (OECD, 2008: p77); around 17% of Swedish patent applications to European Patent Office (EPO) had at least one foreign-born co-inventor between 2001 and 2003 (OECD, 2007: p167). Swedish policymakers also try hard to attract and retain highly skilled immigrants (Mahroum, 2001; Shachar, 2006), such as inventors, who could be important driving force of technology development and innovation, to maintain and improve its competitive advantage in technology and innovation. For example, since 2001, Sweden provides tax discounts for foreign nationals

[3] The population of Sweden increased from 7.5 million in 1960 to 9.6 million in 2012. During this period, the share of foreign born residents increased from 4.0% to 15.4%. Retrieved 16th, May, 2013, from http://www.scb.se/Pages/TableAndChart____26041.aspx in

who work in highly skilled occupations for up to five years – no tax is paid on the first 25% of their income (Mahroum, 2001; Forskarskattenämnden, 2013).

Although Swedish policymakers well understand that talented immigrants can contribute to technology and innovation development and they offer considerable favorable policies, we still know little about the features and actual contribution of highly skilled immigrants in Sweden. Foreign-born inventors are good examples of highly skilled immigrants. Studying them can help us understand more about the characteristics of highly skilled immigrants and their impact on Swedish technology development.

Maybe because of difference in culture, education background or national characteristics, inventors from different birth regions could have different invention performance. Hunt (2011) indicates that the immigrants' birth region has an important effect on the probability of patenting. In the U.S., immigrants from Asia are statistically less likely to patent than those from Europe. However, in the U.S., more foreign-born inventors are found from China and India than from other countries (No and Walsh, 2010). In addition, Hunt (2011) points out that the foreign-born inventors with different types of entry visa perform differently: immigrants that arrive on temporary work or student/trainee visas perform better than native American college graduates in patenting; those with legal permanent residence visa perform similarly to natives and those who arrived with dependents or on other temporary visas perform worse than natives.

In this paper, we investigate whether birth region and immigration background such as reasons for settlement impact on the invention performance of foreign-born inventors in Sweden in line with what has been seen from for the U.S. by Hunt (2011) and No and Walsh (2010). To achieve this purpose, we use a unique dataset which comprises almost all patent applications filed by Swedish inventors (i.e. both Swedish-born and foreign-born inventors residing in Sweden at the time of filing) in EPO from 1985 to 2007. Later, using the identified Swedish ID[4] for the inventors, we match demographic and education information for each of them by data from Statistics Sweden. Based on this dataset, we examine the component and growing trend of foreign-born inventors in Sweden, their birth region, immigration background, invention performance as well as the interrelationship between the above factors. In addition to comparing the characteristics and performance differences between the foreign-born inventors with the native ones as has been done in prior studies (Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010; Hunt, 2011), our data also allow us to compare differences between foreign-born by birth region. In this paper, patent quality is measured by number of forward citations. Negative binomial model is applied for empirical estimation.

Our study shows that 11.0% of Swedish inventors are foreign-born and they contributed to 11.6% of Swedish patents filed to the EPO by fractional count. The quality of patents contributed by the foreign-born and the Swedish-born is similar. The main differences concern that foreign-born inventors seem to have significantly better patent quality when educated in health and welfare.

[4] Swedish ID is a unique identification number for each resident in Sweden, including foreigners who have a valid permit of residence at least one year in Sweden.

Most of foreign-born inventors in Sweden are from the other Nordic countries (27.5%), EU-19[5] (36.8%), the rest of Europe[6] (9.9%) and Asia (15.5%) (see Figure A1). Being permanent residents (60.9%) is the most important reason for settlement for the foreign-born inventors in Sweden when they filed their first patent, followed by work, family ties and “other reasons”, which include protection, humanitarian reasons and pensioners/persons with sufficient funds. Study reasons are especially important for those from Asia.

In general, the quality of patents for those of foreign-born inventors from different regions and reasons for settlement is also similar. However, there is difference between inventors from different regions but with same reason for settlement, education level, field of study and gender. It is the same for inventors from the same region but with different above factors. These differences mainly can be attributed to the inventors’ field of study. For example, the quality of patents for those from the rest of Europe who settled as permanent residents is not only better than those settled for family ties and “other reasons”, but also better than those from the other regions with the same reason. This is mainly because of the good performance of its inventors who studied in “other fields”.

[5] EU-19 is a construct made by us which includes Belgium, Greece, Luxembourg, Spain, the Netherlands, Germany, France, Portugal, Ireland, Italy, United Kingdom, Austria, Poland, the Czech Republic, Cyprus, Slovenia, Slovakia, Hungary and Malta. All these countries were European Union members by 31st, December, 2006.

[6] Rest of Europe includes two Central European countries - Liechtenstein, Switzerland; eleven Southern European countries - Andorra, Vatican, SM San Marino, Croatia, Bosnia and Herzegovina, Macedonia, Serbia, Crna Gora, Albania, Romania, Bulgaria as well as Turkey.

The paper is structured as follows. Section II summarizes existing literature on the importance and contribution of foreign-born inventors to their host countries and the factors that impact on their invention performance. Section III presents the databases and descriptive statistics. Section IV is dedicated to the methodology and factors that impact on patent performance. Section V reports the analysis of empirical results. The last section concludes the study and suggests some policy implications.

II. Literature review

Invention is a creative activity, which needs the accumulation and creation of knowledge. This can be driven by knowledge diffusion and spillovers, which enable people to exchange ideas among each other and lead to the creation of new knowledge (Carlino, 2001). Highly skilled individuals, who are well recognized as important knowledge carriers, can transfer and diffuse expertise and knowledge, especially tacit knowledge, from one place to another through mobility (Trippl, 2011) and face-to-face interaction. The international mobility of highly skilled people and knowledge flows can have profound and lasting effects on innovation capability, for example, by fostering diversity and collaboration, for the regions involved in such processes (Trippl, 2011).

In recent years, there has been an increased interest in the impact of highly skilled immigrants on invention and innovation development in their host countries. For example, over the period of 1993-1995, the share of patent applications at EPO owned by foreign residents in total patents invented domestically was 8.4% for Sweden, 5.0% for the U.S. and 6.5% for the EU. The corresponding figures in USPTO data were 18.4%, 2.6% and

18.9%, respectively (Guellec and van Pottelsberghe de la Potterie, 2001). Wadhwa (2009) finds that in 2006, foreign nationals living in the U.S. were inventors or co-inventors on a quarter of World Intellectual Property Organization (WIPO) patent applications filed from the United States. Foreign inventors contributed to more than 40% of the international patent applications filed by the U.S. government, which excludes immigrants who had become American citizens at the time of filing. Using a unique dataset based on a national survey of over 1,900 US-based inventors on 'triadic' patents, No and Wash (2010) find that almost 30% of lead inventors in the United States are non-US born, compared to only about 11% foreign born in the US population and about 22% of the college-educated S&E workforce. Hunt and Gauthier-Loiselle (2010) and No and Walsh (2010) and Hunt (2011) also find that foreign-born inventors perform better in terms of quality and quantity of patenting than native U.S. counterparts. This is mainly explained by advantages in terms of field of study and higher education degrees.

However, the performance of foreign-born inventors in patenting differs by birth region. Hunt (2011) indicates that there is a significant difference by birth region, with immigrants from Europe being more likely to patent than similar immigrants from Asia. She points out that the heterogeneity by birth region could reflect differences in immigrants' education quality, their related experience in the U.S. labor market, or unobserved characteristics related to self-selection that differ by region of origin. Moreover, Kerr (2008), Wadhwa (2009) and No and Walsh (2010) also document that there are more foreign-born inventors with Chinese and Indian names than from other countries in the United States. For example, No and Walsh (2010) find that lead inventors from China (including Hong Kong and Taiwan) and India each account for 25% and 15% of the foreign-born inventors in the U.S., while the proportion from other countries is lower.

As discussed in the introduction, Hunt (2011) has shown that patenting performance differs between foreign-born inventors with different types of visa and status. In addition, Chellaraj, Maskus and Mattoo (2008) indicate that foreign graduate students have a larger significant and positive impact on both patent applications and grants than other skilled immigrants to the United States. They claim that visa restrictions for foreign graduate students could significantly reduce US innovative activity. The research by Kerr and Lincoln (2010) indicates that higher levels of H-1B[7] admissions increase patenting in cities by inventors with Indian and Chinese name.

The reason why immigrants, especially foreign college graduates make exceptional contributions to technology and invention development in the US could be as follows. First, highly skilled and educated people are usually more likely to move than less skilled and educated ones and more easily get visa and work permits in the US. Second, foreign-born scientists and engineers who come to the U.S. to receive training, especially at the doctoral or postdoctoral level, are typically among the most able of their contemporaries. Moving to a new country entails a fixed cost. Highly skilled and educated people are often more willing to pay such "entrance fees" both because their high skills suggest that they can obtain a return for migration and because they are more likely to build up

[7] H-1B is a type of temporary work visas in the U.S., given to people in specialty occupations with at least a bachelor's degree (or equivalent).

relatively wealthier families that can cover those costs. Third, some evidence suggests that the average quality of US-born individuals choosing to get doctorates in S&E has declined over the past three decades as bright native students more often choose lucrative careers in business, law and medicine (Stephan and Levin, 2001). This opens up possibilities for foreign-born students in the S&E field, where limitations due to language and culture are less obvious.

As seen from the above literature, most earlier study focus on the performance of foreign-born inventors in the US. Thus, very little attention has been paid to the situation in the Europe, not to mention of Sweden, which is also a country with high rate of immigrants and strong innovation capability. In this paper, we fill this gap by studying immigrants' background and its impact on invention performance.

III. Data and Descriptive Statistics

1. Summary of data

For this study, we take advantage of a new and unique database, which combines Swedish patent applications filed by Swedish inventors to the EPO from 1985 to 2007 with demographic information (Ejermo and Jung, 2013). This material was complemented by data on birth region and reasons for settlement in Statistics Sweden, unique to this study. The base dataset consisted of information on inventors and inventions extracted from the Worldwide Patent Statistics (or PATSTAT) database[8] provided by the EPO. The population of inventors consists of those who filed patents to

[8] This material uses patents and inventors from the April 2010 version, later supplemented and updated with information from the April 2011 version.

the EPO and have a Swedish residence at the time of filing. EPO patents were selected for several reasons. First, it is one of the most common filing offices for Swedish inventors along with the Swedish Patent Office (PRV) and the USPTO. Second, as EPO patents mainly cover protection in multiple European countries and impose substantial filing costs on an applicant, the returns (strategic or sales) needed have to be higher. The patents filed by Swedish inventors to the EPO should therefore be of higher quality than e.g. those at the PRV. In addition, there is an artificial downward trend in PRV arising not because fewer inventions are developed, but since Swedish inventors more and more frequently go to other patent offices directly. For identification of inventors, EPO patents are highly useful since they provide street-level addresses of inventors, which are essential to gain a high match precision. In total, our database comprises 39,600 Swedish patent applications with 73,356 patent-inventor combinations filed from 1985 to 2007. Briefly, the matching was done in two stages. First, after cleaning data, inventors' Swedish IDs were added by a commercial company. Second, after additional manual matching, remaining inventors were matched with a virtually complete address directory of the whole Swedish population in 1990. This raised the match ratio substantially, especially for the 80s and 90s, and removed much of the temporal selection bias (Ejermo and Jung, 2013).

Next, these data were matched with detailed population directory data held by Statistics Sweden using the Swedish ID. In this way, we access demographic information for inventors, which are combined with patent information to constitute our rich database. We keep inventors who are 65 years or younger in our sample (mean age: 43.9) to make the data more representative and reliable[9]. Finally, we use 77.4% of data on inventor-patent combinations where inventors are identified and 65 years or younger (see Table 1). Out of 73,356 patent-inventor combinations, we matched 56,771 lines, which covered 20,350 unique inventors. Among the identified inventors, 11.0% or 2,239 persons are foreign-born. These identified foreign-born inventors contributed to 11.6% (=3,309/28,470) of identified Swedish patent applications in EPO during 1985 to 2007 by fractional count. On average, each foreign-born inventor contributed to slightly more patents than Swedish-born ones by fractional count. As there are still 22.6% unidentified patent-inventor combinations, we tested for sample selection problem by randomly picking 100 unidentified combinations each from five different application years: 1986, 1991, 1996, 2001 and 2006. From inventors' names, we conclude that 87.5% of them are with Swedish names, which is very similar to the share of identified inventions by Swedish-born inventors (88.4%). Therefore, we conclude that there is not likely a large sample selection issue with respect to foreign participation in our data

[9] 1,402 identified inventor-patent combinations were removed as the inventors' ages are older than 65. However, there are 113 inventors (146 lines) whose age information is missing. We consider them as 65 years or younger and retain them in the sample.

Table 1. Number and share (%) of identified Swedish inventors and inventions they contributed to, 1985-2007

	Identified foreign-born (age<=65)	Identified Swedish-born (age<=65)	**Total identified** (age<=65)	Unidentified /age>65	**Total**
Total No. / share of patent-inventor combination lines	6,574 *(9.0%)* *(11.6%)*	50,197 *(68.4%)* *(88.4%)*	*56,771* *(77.4%)* ***(100%)***	16,585 *(22.6%)* -	*73,356* ***(100%)*** -
No. / share of identified inventors	2,239 *(11.0%)*	18,111 *(89.0%)*	*20,350* ***(100%)***	-	-
No. / share of fractional count of identified applications contributed to	3,308 *(11.6%)*	25,161 *(88.4%)*	*28,470* ***(100 %)***	-	-
Average No. of patents contributed to	1.5	1.4	*1.4*	-	-

Source: Statistics Sweden and CIRCLE data on inventors

2. Component and growing trends of foreign-born inventors by birth region

We divided foreign-born inventors into five groups by birth region. The largest group is from EU-19, which accounts for 36.8% of total identified foreign-born inventors. It is followed by those born in other Nordic countries, Asia and then the rest of Europe, with shares of 27.5%, 15.5% and 9.9%, respectively. The “others” group, which accounts for 10.4% of the identified foreign-born inventors, is composed of six small subgroups. They are the Former Soviet Union, Africa, North America, South America, Oceania and unknown. The proportion of inventions in each group is quite the same as the proportion of inventors, except for the inventors from other Nordic countries and EU-19, which are underrepresented by 1.14% and overrepresented by 1.17%.

Table 2. Number and share (%) of foreign-born inventors and inventions they contributed to, fractional count – by birth region, 1985-2007

Birth region	No. of inventors	Share (%) of inventors (1)	No. of inventions	Share (%) of inventions (2)	Gap= (2)-(1) (%)
Other Nordic countries	615	27.47	871	26.33	-1.14
EU-19	824	36.80	1,256	37.97	1.17
Rest of Europe	221	9.87	354	10.70	0.83
Asia	346	15.45	500	15.11	-0.34
Others	233	10.40	327	9.89	-0.51
Former Soviet Union	37	1.65	59	1.78	0.13
Africa	48	2.14	66	2.00	-0.14
North America	80	3.57	134	4.05	0.48
South America	51	2.28	48	1.45	-0.83
Oceania	16	0.71	20	0.60	-0.11
Unknown	1	0.04	2	0.06	0.02
Total	***2,239***	***100***	***3,308***	***100***	

Source: Statistics Sweden and CIRCLE data on inventors

Note: Every country only belongs to one group with no overlap. The rest of Europe and Asia are exclusive of the Former Soviet Union. Turkey is included in the rest of Europe. Central America and the Caribbean are included in North America.

Figure 1 shows that the main trend of inventions participated in by foreign-born inventors has grown year by year between 1985 and 2007, except for a clear decrease in 1994. This could be related to the long economic depression at the beginning of the 1990s in Sweden, when the employment situation deteriorated more for foreign–born than for native born, no matter how skilled the immigrants were. This is probably because of discrimination. In 1994, immigrants suffered badly in the labour maket, when the employment rate for the foreign-born was 25 percent lower than those of natives. In the late 1990s, along with recovery of the Swedish economy, the employment situation started to improve for the foreign-born relative to the Swedish-born (Ekberg, 2011). However, the trend was different for different immigrant groups. The absolute number of inventions participated in by inventors from EU-19 and Asia grew much faster than the number from those of other Nordic countries, the rest of EU and "others" since 1995.

Different from the clear growth in the number of inventions contributed by foreign-born inventors from other Nordic countries and EU-19 is that their share in the total amount of inventions has been decreasing over the period (see Figure 2). The proportion of inventions contributed by inventors from other Nordic countries was 43.6% in 1986 and has since declined to 20.1% in 2007. The proportion for EU-19 also decreased: from 59.2% in 1985 to 34.7% in 2007. By contrast, the proportion for those from the rest of Europe, and especially Asia, has been growing. The proportion for Asia grew dramatically from 3.2% in 1985 to 21.2% in 2007.

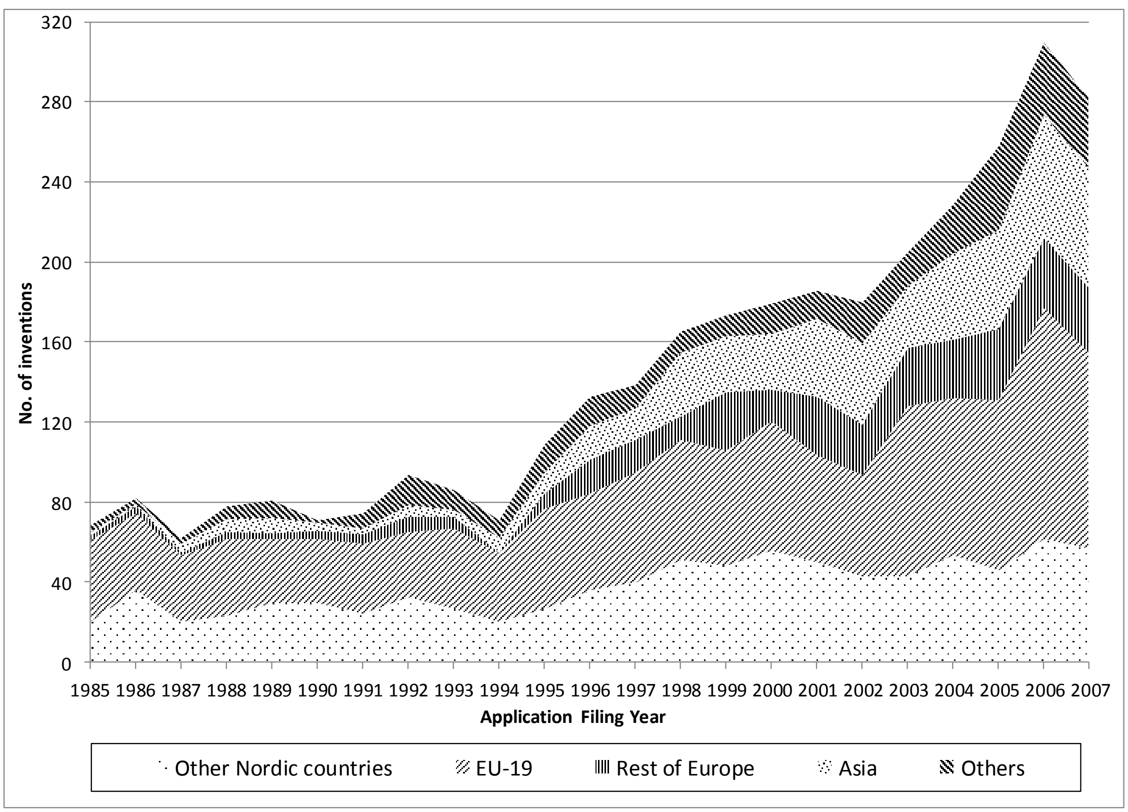

Figure 1. Number of inventions contributed by foreign-born inventors in each year, fractional count - by birth region, 1985-2007

Source: Statistics Sweden and CIRCLE data on inventors

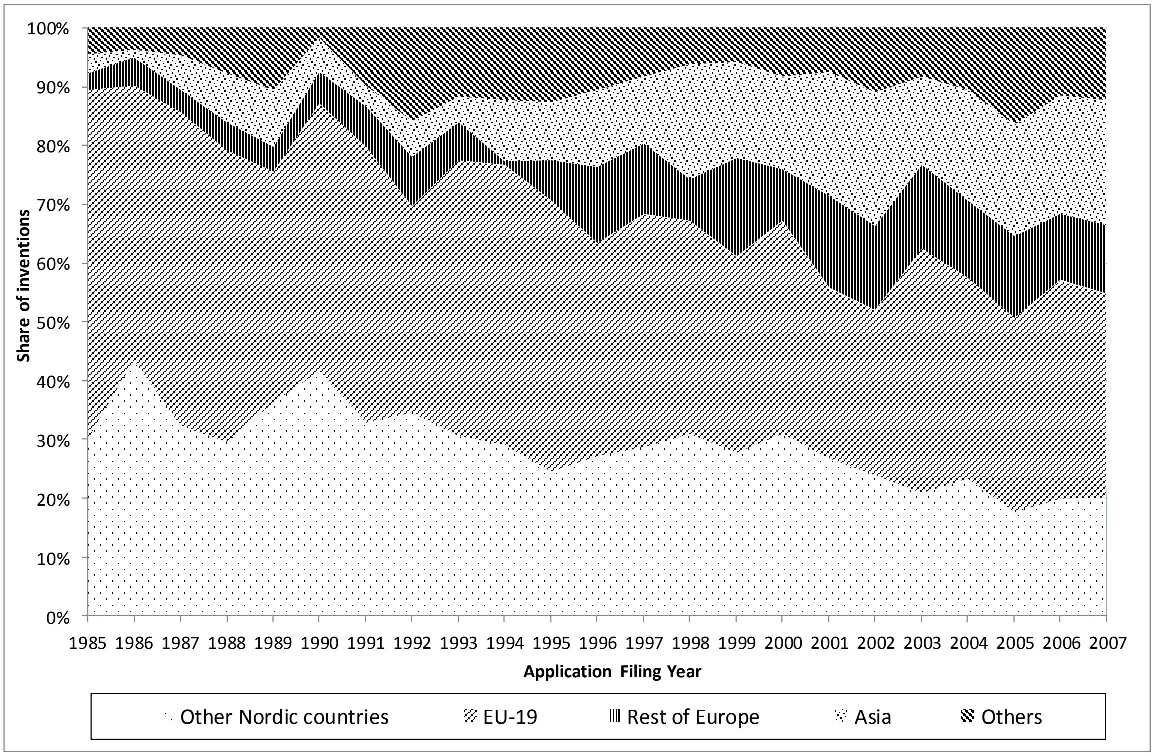

Figure 2. Share of inventions participated by foreign-born inventors in each year, fractional count - by birth region, 1985-2007

Source: Statistics Sweden and CIRCLE data on inventors

3. Reasons for settlement

We use foreign-born inventors' reasons for settlement at the time of filing instead of entry visa (as done by Hunt, 2011) because the data on entry reason are very limited as they are only available from 1990 onwards. There would be only 29.0% of data on this variable left if we use entry reason, which are not representational enough and could bias our study results. In addition, usually it takes a very long time for immigrants in Sweden to become inventors[10] and their entry visa cannot represent their current capability and living situation very well. For example, the reason as work at the time of filing can better

[10] Our data show on average it takes 15.7 years for the foreign-born inventors to apply for their first patents at the EPO from their first entrance to Sweden.

represent real capability of inventor, who arrived for family ties at first. The results also could help policymakers and companies better understand that contemporarily which types of people are more inventive and more probable to be inventive.

We divide the reasons for settlement into five groups: i) permanent residents, ii) work, iii) family ties, iv) study and v) “other reasons”. Except for permanent residents, the other four are divided based on reason for settlement which are used by Statistics Sweden. In this paper, permanent residents include foreign-born inventors who became Swedish citizens or inventors that are or have been citizens of other Nordic counties. Citizens of other Nordic counties are put in this group as they do not need a residence permit to stay in Sweden according to the agreements signed among the Nordic countries in 1954 (Stalker, 2002). They have very similar rights as permanent residents in Sweden. The “other reasons” here include protection, humanitarian reasons and pensioners/persons with sufficient funds. Unfortunately, as mentioned above, except for the reason of permanent residents, data on other reasons for settlement are unavailable before 1990.

Finally, we have data on reason for settlement on 90.5% of patent-inventor combinations for the foreign-born inventors in Sweden. For 89.5% (=2,003/2,239) of foreign-born inventors we can observe their reason for settlement at the first time of filing a patent. Among them, 60.9% of foreign-born inventors were permanent residents in Sweden at their first time of filing, 15.9% stayed for reasons of work, 10.0% for family ties, 5.4% for study and 7.8% for “other reasons”. Although being permanent resident is the most common reason for foreign-born inventors to reside in Sweden regardless of birth region, the distribution differs by region. Work is the second most important reason for inventors from the EU-19 and the rest of Europe, but the third and fourth important reason for the ones from “others” and Asia. Family reunification is ranked second for inventors from the other regions, ranked third and fourth for those from the EU-19 and rest of Europe, but ranked last for those from Asia. There is a much higher share (18.3%) of inventors from Asia that stayed for study than from other groups. This can be attributed to the large number of international students in Sweden who are from Asia. According to UIS[11] data, China, Pakistan, Iran and India are the top four countries of origin for tertiary-level international students in Sweden. For example, these four Asian countries shared 43% of tertiary-level international students in Sweden in 2010 (UNESCO, 2013). The proportion of inventors from Asia and the rest of Europe with “other reasons”, which comprise those that stay in Sweden as refugees or asylum seekers, are also much higher than those in other groups. This can be explained by the higher number of people engaged in science and technology in Sweden from regions like the Middle East (e.g. Turkey, Lebanon, Iran and Iraq) and the former Yugoslavia (Westin, 2003), who came to Sweden as refugees or asylum seekers when they arrived (Gaillard, 2002).

[11] “UIS” refers to United Nations Educational, Scientific and Cultural Organisation (UNESCO) Institute for Statistics

Table 3: Share (%) of each observed reason for settlement at the first time of filing[1]- by birth region, 1985-2007

Birth region	Permanent residents[2]	Work	Family ties	Study	Other reasons[3]	*Sum of share*	*No. of inventors*
Other Nordic countries	99.8	0.2[4]	-	-	-	***100***	601
EU-19	54.8	26.6	13.5	2.5	2.6	***100***	683
Rest of Europe	36.1	23.2	11.9	6.2	22.7	***100***	194
Asia	28.0	15.2	13.1	18.3	25.3	***100***	328
Others	42.1	20.3	21.8	10.2	5.6	***100***	197
Sum of share	60.9	15.9	10.0	5.4	7.8	***100***	
No. of inventors	***1,219***	***318***	***201***	***109***	***156***		***2,003***

Source: Statistics Sweden and CIRCLE data on inventors

Notes: [1] data on reasons for settlement at the first time of filing are missing for 236 foreign-born inventors. If there are different reasons in different filing years for the same person, then we only consider the reason at their first time of filing a patent. There are 62 foreign-born inventors who had more than one reason in different filing years. Except for reason of being permanent residents, the data for other reasons are only available from 1990.

[2] "Permanent residents" include both the foreign-born inventors who have obtained Swedish citizenship (921) and who were citizens of other Nordic countries (298) at the time of filing.

[3] "Other reasons" include reasons such as protection, humanitarian reasons and pensioners/persons with sufficient funds.

[4] This person has changed his citizenship to one of EU-19 countries at the time of filing.

The high share for the "other reasons" from Asia and the rest of Europe is highly related to major historical events that took place in their birth regions, such as wars (see below for examples). It is also highly consistent with the main trend of immigration in Sweden according to the first entrance time for foreign-born inventors[12] (Westin, 2000; Ekberg, 2011). There is a considerable number of foreign-born inventors who came to Sweden as refugees or asylum seekers and changed to Swedish citizenship at the time of filing, as it is relatively easier for foreigners who come to Sweden with asylum permits to obtain Swedish citizenship than those who come with work or study visas (Eger, 2010). Our data show that 85% of the foreign-born inventors with the "other reasons" for settlement at the first time of filing have obtained Swedish citizenship later. The corresponding

[12] Data are available from 1961 onwards. We used the first recorded time of immigration for each foreign-born inventor as the first entrance time. We excluded inventors where the first recorded time of immigration comes after their first recorded time of emigration or first application year.

figures for those with reasons of work, study and family ties are only 13%, 21% and 39%, respectively.

Table A1 (in the Appendix) shows that the peak period for the immigration of foreign-born inventors from other Nordic countries and EU-19 was 1969-1970, which corresponds to the peak in the general population of immigrants (Ekberg, 2011). In those days, Sweden was enjoying a boom in its economy, and attracted around 70,000 immigrants per year, including individuals who would become inventors later (Ekberg, 2011). These immigrants were mainly blue-collar workers from the other Nordic countries, the former Yugoslavia, Greece and Turkey (Stalker, 2002; Gailland, 2002; Eger, 2010). The high immigration from the other Nordic countries can be attributed to the common labour market established by the Nordic countries in 1954, which allowed for free movement of manpower and drew a large-scale immigration of Finns to Sweden (Westin, 2000; Stalker, 2002; Gailland, 2002). In addition, throughout the Cold War, a flow of Eastern Europeans sought asylum in Sweden. Especially, the Prague Spring in 1968 swayed many refugees from Eastern Europe to come to Sweden between 1968 and 1970 (Westin, 2000; Westin, 2003: p111). Table A2 shows that the majority of foreign-born inventors from EU-19 who arrived between 1968 and 1970 obtaining Swedish citizenship at the time of filing. It is reasonable to believe that some of these people came as refugees or asylum seekers at first for the reasons mentioned above. In 1972, all manpower immigration from non-Nordic countries was effectively stopped as a result of objections from the Labour Organization of Sweden (Westin, 2000; Westin, 2003: p111).

Over the period 1972-1990, refugees and asylum seekers with a subsequent process of family reunification from the third world, especially the Middle East and South America, dominated immigration to Sweden (Westin, 2000). This is reflected in Table A1, which shows that over the period 1984-1990, there was a significant increase of foreign-born inventors from Asia to Sweden. The largest group from the Middle East was the Iranians, who looked for protection in Sweden following the Iran-Iraq War since the early 1980s. However, the majority of them were young and from urban middle class families and many of them were academics and intellectuals from Teheran (Westin, 2000). Consistent with this interpretation, we see from Table A2, that most of the foreign-born inventors from Asia who arrived in Sweden in1984 have become Swedish, as it is easier for immigrants to get Swedish citizenship with asylum permits. The same pattern can be observed for inventors who immigrated from 1976 to 1984 in the group "others". Moreover, the majority of inventors from Asia who immigrated between 1986 and 1990 stayed for "other reasons" when they filed their patents.

Between 1993 and 1994, we can observe a significant increase in the number of immigrants from the rest of Europe who later became inventors (see Table A1). Most of them stayed as refugees or asylum seekers at the time of filing (see Table A2). This could be attributed to the breakdown of the Yugoslav federation in 1992 and a series of wars, which resulted in a high number of asylum seekers (Westin, 2000).

In addition, many of the foreign-born inventors that came to Sweden after 1995 are from the EU-19 (see Table A1). Most of them settled for work and family reunification reasons (see Table A2). This is mainly because the European Economic Area (EEA) treaty came into effect in Sweden in 1994 and Sweden joined the EU in 1995 (Westin, 2000), which made the migration of manpower much easier.

The reason why the immigration of foreign-born inventors started to decrease in the 21st century is a statistical artifact. On average it takes 15.7 years for the foreign-born inventors to apply for their first patents at the EPO from their first entrance to Sweden. Therefore, for individuals that arrived in the 21st century, we have not yet completely observed if they become inventors or not.

IV. Methodology

We now turn to how inventor background affects their performance. We measure performance in two ways: 1) productivity measured by fractional count of number and share of patent applications contributed by inventors from different birth regions as done in "Data and Descriptive Statistics"; 2) patent quality estimation by average number of forward citations each inventor obtained for each contributed patent (see below). STATA 12.0 is used for the regression analyses.

We construct two samples of inventors to assess the quality of foreign-born inventors' patents. In the first sample we combine all foreign-born inventors into one subgroup and compare the quality of patents contributed by them with those of Swedish-born inventors, from 1985 to 2007. In the second sample, we compare differences between foreign-born inventors only to test whether immigration background, such as: birth region, reasons for settlement, education background and demographic characteristics, impact on the quality of patents they contributed to. For the second sample, we only use the data from 1990 to 2007 as full data on reasons for settlement are only observable from 1990 onwards.

Listwise deletion is used for dealing with missing values. In total, we kept 93.9% of our observations when we compare the patent quality of Swedish-born inventors with those of foreign-born ones (see Table 4). The data used for comparison within the foreign-born groups are 77.3%. This is because of a considerable amount of missing data for reasons of settlement, which are only available from 1990 onwards.

1. Dependent variable

It is a difficult task to assess the value of patents, since the distribution of their value is highly skew (Harhoff, Scherer and Vopel, 2003). Numerous researchers have tried to explore approximate indicators to estimate the patent value, such as market value of patents, number of forward citations, patent scope, opposition procedure, family size, the number of claims and renewal data (Trajtenberg, 1990; Lerner, 1994; Lanjouw, Pakes and Putnam, 1996; Putnam, 1996; Harhoff et al, 1999; Harhoff et al., 2003; Sapsalis et al., 2006; Potterie and Navon, 2006; Ejermo, 2009; Ejermo and Kander, 2011). In this paper, we use the number of forward citations (NFC) as our dependent variable to measure the quality of patents to proxy for importance or "quality". We use the number of patents citing, within five years after filing, the original patent or one of its family members using the INPADOC[13] extended family size definition.

[13] INPADOC is short for International Patent Documentation Center.

NFC is used as our indicator of patent quality here because virtually all studies on patent value have demonstrated that it has a significant and positive correlation with the value of a patent (Trajtenberg, 1990; Harhoff, et al, 1999; Harhoff, et al, 2003; Hall, Jaffe and Trajtenberg, 2005; Gambardella, Harhoff, Verspagen, 2008). Although these studies admit that the relationship is quite noisy (Harhoff, et al. 1999; Gambardella, et al., 2008) and it is not likely to lead to the best possible approximation of patent value using forward citation counts alone (Harhoff, et al., 2003; Gambardella et al., 2008), NFC is the most popular indicator for estimating the value of patents and even considered as the strongest predictor of patent value compared with other indicators (Lanjouw and Schankerman, 1999; Sapsalis, et al., 2006). Moreover, it is also considered as a proxy for effective use or importance of a patent to new inventions (Sapsalis, et al., 2006). Harhoff et al. (1999) indicate that inventions with higher economic value estimate are more likely to be cited by subsequent patents.

Table 4 shows that the mean values of NFC for the Swedish-born group (1.46) and for the whole foreign-born group (1.41) are quite similar. The mean values differ much more between the different foreign-born subgroups, ranging from 1.34 to 1.65. The distribution is also more dispersed between the foreign-born subgroups (S.D.: 2.35- 3.36) than between the Swedish-born and foreign-born (S.D.: 2.90 vs. 2.68).

2. Independent variables (see Table 4)

Birth region. This is the main variable of interest that we would like to test. It indicates whether inventors from different birth regions perform differently with respect to patent quality. First, we merge all foreign-born inventors into one group and compare them with the Swedish-born. Second, we divide the foreign-born into five subgroups as mentioned above to compare the difference between them. We do this rather than comparing each foreign-born group with the native-born because we want to see whether the foreign-born as a whole have performed differently on inventions compared with the native-born. In addition, as there is a considerable amount of missing data on reasons for settlement, we would like to keep as many observations as possible when we compare the foreign-born with the Swedish-born to make the results more representative.

Highest education level at the time of filing. Earlier studies indicate that better performance of immigrants in patenting in the US can be attributed to their higher education level and field of study (Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010; Hunt, 2011). We also want to test whether the case is the same in Sweden. We divided the education level into three group, which are <= short post-secondary education[14] (<3 years), long post-secondary education (>=3 years) and Ph.D. Table 4 shows that the shares by education level differ substantially between the foreign-born and the Swedish-born. Among the Swedish-born inventors, 42.1% had obtained long post-secondary education at the time of application, while 32.4% of them had an education <= short post-secondary education (<3 years)[15] and 25.5% of them had a Ph.D. By contrast, the most common highest education level for the foreign-born inventors is the Ph.D. level

[14] “<=short post-secondary education” includes education in primary, secondary and post-secondary education <3 years. The group of education levels is according to International Standard Classification of Education 97 (ISCED 97).

[15] “Short post-secondary education” includes education in primary, secondary and post-secondary education < 3 years. The education levels follow the International Standard Classification of Education 97 (ISCED 97).

(44.8%), followed by long post-secondary education (33.0%) and <= short post-secondary education (22.1%). This ordering of the most common education backgrounds pertain across foreign-born background except for the inventors from other Nordic countries, where the share of inventors that had <=short post-secondary education was a little higher than those with long post-secondary education (33.8% vs. 31.1%). The share of Ph.D. educated was 35.2%, still higher than among the Swedish-born.

Field of study for the highest education level at the time of filing. We divided the field of study into four groups, which are Engineering, Manufacturing and Construction (E, M&C), Science, Mathematics and Computing (S, M&C), Health and Welfare (H&W) and “other fields”. E, M&C is the most common field of study for both Swedish-born (75.3%) and foreign-born inventors (57.9%). Different from the Swedish-born group, which is much more evenly distributed in the other three fields, the share is much higher for the foreign-born group in the field of S, M&C (10.0% vs. 26.4%). In the subgroups of foreign-born inventors, the shares of inventors with education in the field of E, M&C ranged from 44.4% to 60.6%, and in the field of S, M&C, they range from 21.8% to 35.1%. There are higher shares of inventors from Rest of Europe (13.4%) and Asia (10.5%) with an education in H&W than in the other subgroups.

Edu_SE[16]. This dummy variable records whether the inventor had an education in Sweden or not, regardless of the level[17]. Education place could be related to the

[16] 28.3% of observations have missing values. Among them, 23.1% of data are for the Swedish-born inventors, and 68.3% are for the foreign-born inventors. The missing data are filled in by inference according to other related variables.
[17] At least, 68.3% of the data on this variable recorded the highest education level for the inventors.

education quality, which could further affect the quality of inventors and patents. We coded 1 if the inventor had an education in Sweden and 0 otherwise. We assume that all Swedish-born inventors took their education in Sweden. For missing data for foreign-born inventors, we fill in values mainly based on their highest education level, their graduation year of having it[18] and their first arrival year in Sweden. If an inventor's first arrival year is missing (as we only have these data from 1961), we assume this person arrived before 1961. If an inventor's first arrival year is earlier than the year when he/she had his/her highest education, we assume that the inventor got his/her education in Sweden. Finally, 55.4% of foreign-born inventors are found or recorded as having obtained their education in Sweden. The shares for the subgroups of foreign-born inventors range from 47.0% to 71.1%.

Age and age square. It has been discussed in the literature that invention productivity varies with age of inventors (Mariani and Romanelli, 2006; Jones, 2010; Ejermo and Jung, 2013). People have argued that creativity is a curvilinear (inverted U) function of age (Simonton, 2000). Arguably, innovative activity is greater at younger ages and peak in the late thirties or early forties (Lehman, 1953; Simonton, 1991; Jones, 2010). Therefore, we control age and age square in the estimations. Table 4 shows that the average age of Swedish-born inventors is a little lower than that of foreign-born (43.7 vs. 45.1). It ranges from 42.2 to 46.6 for different foreign-born subgroups.

[18] If data are missing, we then generate them based on inventors' birth year and general age when they get graduated for their highest education level by the Swedish education system (Halldén, 2008). For instance, if one inventor was born in 1950 and took his/her highest education in Master (belong to long post-secondary education), which age is 24 for general students, then his/her graduation year is 1974 (=1950+24).

Gender. It has been well documented that there is a gender difference in patenting performance (e.g. Whittington and Smith-Doerr, 2005; Ding, Murray and Stuart, 2006; Azoulay, Ding, and Stuart, 2007), which can be attributed to differences in personal characteristics, structural positions, organizational reasons and marital status (Xie and Shauman, 1998). Therefore, we control for gender in the estimations, with male as excluded category. There is a little higher share female inventors among foreign-born than among Swedish-born inventors (8.4% vs. 6.7%). The distribution for the foreign-born subgroups is uneven. The share of invention observations contributed by female from Asia is double that observed from other Nordic countries (14.0% vs. 7.0%).

Reasons for settlement. This variable is only used when testing for differences between foreign-born subgroups. The distribution of shares by each group used in the estimations is similar to that reported in Table 3 except that a higher share of inventions was contributed by inventors with study reasons instead of family ties for those from rest of Europe in Table 4. In addition, the shares of inventions contributed by inventors from Asia with reasons of work, study and “other reasons” are more evenly distributed than those reported in Table 3.

After_1971. Migration policy is considered to be a principal factor that determines the size and character of contemporary labor flows (Salt, 2008) and it can have unintended and unforeseen consequences (Goldin et al, 2011: p118). Immigration policy in Sweden keeps changing, following different economic, social and international situations. One big immigration policy change after World War II was in 1972, when labour immigration to Sweden from non-Nordic countries came to an end as a result of objections from the Labour Organization of Sweden (Westin, 2000; Westin, 2003: p111). After that, immigration to Sweden has been dominated by refugee, asylum-seekers and family reunification from Third World countries and South-eastern Europe (Westin, 2000). We want to test whether foreign-born inventors perform differently depending on whether they arrived before or after 1971, to gauge the effect of change in immigration policy. Foreign-born inventors are coded as "1" if they arrived after 1971 and "0" if they arrived before or in 1971. In total, 70.9% of inventors are recorded as "1". The shares differ a lot for different regions. Only 55.4% of inventors from the other Nordic countries arrived after 1971, but 95.8% of Asian inventors arrived after 1971.

Interaction variables. In order to test the additive effect of birth region on patent performance variables, we include dummy interaction variables between birth region and i) highest education level, ii) field of education, iii) gender, iv) reasons for settlement and v) after_1971 in the estimations.

Control variables on patent characteristics

Application year. We include 23 time dummies for application year when compare between the foreign-born and the Swedish-born and 18 time dummies when compare between different subgroups of foreign-born to control for differences in citation behavior over time and possible differences in the accumulation of citations over time (Sapsalis, et al., 2006). Even though we expect that by counting citations within five years after application, should deal with such issues to a large extent.

Number of inventors. This reflects the number of researchers participated in the project. To some extent, this could be considered as an indicator of the importance or the amount of resources used for the research project leading up to a patent, and that this could affect the quality of patent (Sapsalis, et al, 2006).

3. Negative binomial model

We employ the negative binomial model to assess the influence of immigration background on invention performance, which is more appropriate than the Poisson model in this case. This is because the value of our dependent variable NFC is both count data and overdispersed. Almost half (49.5%) of the observations received zero citation and they have a larger standard deviation (=2.87) than mean value (=1.46). Because 46% of inventors have contributed to more than one invention, we employ negative binomial regression models with cluster-robust standard errors to control for intra-inventor correlation.

Table 4. Statistics on dependent and independent variables used in the regressions

Birth region	No. of forward citations[2]			Highest education level (%)			Field of study[3] (%)				Edu_SE (Yes, %)	Age	Gender (%)[4]		Reasons for settlement[5] (%)					After_ 1971 (Yes, %)	Total No. of obs. used in reg. (1)	% of data used in reg.[6]
	Mean	S.D.	Max	<= Short post-2nd	Long post-2nd	PhD	E,M &C	S,M &C	H& W	O			F	M	PR	W	F	S	O			
All Swedish inventors	**1.46**	**2.87**	**60**	**31.3**	**41.2**	**27.6**	**73.4**	**11.8**	**6.7**	**8.2**	**95.2**	**43.9**	**6.9**	**93.1**	**-**	**-**	**-**	**-**	**-**	**-**	**53,300**	**93.9**
Swedish-born	1.46	2.90	60	32.4	42.1	25.5	75.3	10.0	6.6	8.2	100	43.7	6.7	93.3	-	-	-	-	-	-	47,531	94.7
Foreign-born	1.41	2.68	48	22.1	33.0	44.8	57.9	26.4	7.5	8.2	55.4	45.1	8.4	91.6	-	-	-	-	-	-	5,769	87.8
All foreign-born in used subgroups[1]	**1.42**	**2.70**	**48**	**21.0**	**32.2**	**46.8**	**57.5**	**27.6**	**7.2**	**7.8**	**57.9**	**44.6**	**9.0**	**91.0**	**56.5**	**19.4**	**10.2**	**6.9**	**7.1**	**70.9**	**5,079**	**77.3**
Other Nordic countries	1.34	2.40	31	33.8	31.1	35.2	59.5	21.8	7.6	11.1	60.4	46.4	7.0	93.0	100	-	-	-	-	55.4	1,377	82.0
EU-19	1.38	2.35	24	17.8	31.8	50.4	60.6	30.0	4.0	5.5	47.0	44.2	7.2	92.8	44.0	31.7	15.8	3.9	4.7	69.7	1,721	68.3
Rest of Europe	1.65	3.23	22	28.5	34.5	36.9	44.4	27.1	13.4	15.1	59.9	45.7	8.6	91.4	44.6	24.4	6.5	10.8	13.6	63.8	536	82.5
Asia	1.45	2.94	44	7.6	27.0	65.3	59.9	27.6	10.5	2.0	71.1	43.4	14.0	86.0	27.1	22.5	9.4	20.4	20.5	95.8	906	89.8
Others[8]	1.46	3.36	48	13.7	43.0	43.2	51.2	35.1	4.3	9.5	62.5	42.2	11.9	88.1	46.6	19.3	23.0	7.6	3.5	79.2	539	75.6

Source: Statistics Sweden and CIRCLE data on inventors

Notes: 1. the rows sum to 100 if a variable is accounted by %.

2. [1] we only use the data from 1990 to 2007 as full data on reasons for settlement are from 1990 onwards.

3. [2] Min of No. of forward citation is 0 for all of groups.

4. [3] "E, M&C" = Engineering, Manufacturing and Construction; "S, M&C" = Science, Mathematics and Computing; "H&W" = Health and Welfare; "O" = other fields.

5. [4] "F" = Female; "M" = Male.

6. [5] "PR" = Permanent residents; "W" = Work; "F" = Family ties; "S" = Study; "O" = other reasons.

7. [6] = (1) / total No. of obs. in database for each group.

8. [7], the "unknown" foreign-born inventor mentioned in Table 2, who participated in 4 patents, is excluded in the regressions

V. Results

Table 5 presents the regression results when comparing the foreign-born with Swedish-born inventors, while Table 6 shows the results when comparing between the subgroups of foreign-born inventors. We control for independent variables one by one in different regressions to see the impact of each variable on patent quality.

1. Foreign-born vs. Swedish-born

No significant difference in the quality of patent is found between foreign-born and Swedish-born inventors if when we control for their birth region, education level, dummies of application year and number of inventors involved (see Table 5, col.1 and col.2). In general, the education level of foreign-born inventors is higher than that for the Swedish-born (see Table 4). We subsequently step-wise run regressions where we interact birth region with education, and find that the foreign dummy turns negative when we include the birth region * long-post secondary education (col.3), although the interaction variable itself is insignificant. It shows that the quality of patents contributed by foreign-born inventors is significantly lower ($p<0.1$) than that by Swedish-born inventors. The disadvantage of foreign-born is, however, eliminated when including all interaction variables between birth region and education level (col, 4). However, additional controls in the field of study (col.5) makes the quality of patent contributed by foreign-born inventors significantly worse again ($p<0.1$). This is because the inventors educated in S, M&C as well as H&W performed significantly better than those educated in E, M&C. As shown in Table 4, a much higher share of foreign-born inventors studied in the former two fields than the Swedish-born ones. The quality is even worse for the foreign-born after additional controls using interaction between birth region and H&W (p<0.05, col.10), in which field the foreign-born performed significantly better than the Swedish-born (p<0.1, col.6). However, control in all interaction between birth region and field of study eliminates the disadvantage of the foreign-born. Additional control in Edu_SE, age, age square, gender and its interaction with birth region do not change the picture qualitatively (col. 8-10). Whether the inventors has had education in Sweden or not and gender do not have significant effect on patent quality, but the older the inventors are, the lower the quality of their patents is. In summary, we find that, the quality of patents contributed by the foreign-born and the Swedish-born is similar. The main differences concern that foreign-born inventors seem to have significantly better patent quality when educated in H&W.

Table 5. Determinants of NFC: foreign-born vs. Swedish-born, 1985-2007

Indep. var	1	2	3	4	5	6	7	8	9	10
	Birth	**Edu**	**B*E2**	**B*E_all**	**Field**	**B*F3**	**B*F_all**	**Edu_SE**	**Age**	**Female**
Foreign-born (omit: Swedish-born)	0.015	-0.034	-0.085*	-0.084	-0.105*	-0.131**	0.164	0.176	0.204	0.204
	(0.047)	(0.046)	(0.045)	(0.056)	(0.058)	(0.064)	(0.292)	(0.288)	(0.316)	(0.317)
Edu Level (omit: long post-2nd)										
Short post-2nd		-0.347***	-0.335***	-0.335***	-0.323***	-0.323***	-0.318***	-0.318***	-0.262***	-0.261***
		(0.029)	(0.030)	(0.030)	(0.031)	(0.031)	(0.030)	(0.030)	(0.032)	(0.032)
Ph.D.		0.102***	0.118***	0.118***	0.037	0.041	0.040	0.040	0.084**	0.085**
		(0.030)	(0.030)	(0.031)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.036)
Edu Level (omit: long post-2nd)										
FB*short post-2nd				-0.002	0.012	0.033	-0.002	0.024	0.019	0.018
				(0.091)	(0.092)	(0.094)	(0.119)	(0.116)	(0.113)	(0.114)
FB*long post-2nd			0.142	0.141	0.118	0.136	0.110	0.127	0.142	0.142
			(0.107)	(0.113)	(0.113)	(0.115)	(0.100)	(0.100)	(0.101)	(0.101)
FB*Ph.D.				-	-	-	-	-	-	-
Field of edu (omit: E, M & C)										
S, M & C					0.229***	0.230***	0.228***	0.228***	0.244***	0.240***
					(0.040)	(0.040)	(0.045)	(0.045)	(0.044)	(0.044)
H & W					0.196***	0.173***	0.171***	0.170***	0.220***	0.214***
					(0.040)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
other fields					-0.011	-0.011	-0.047	-0.048	-0.026	-0.027
					(0.054)	(0.054)	(0.042)	(0.042)	(0.041)	(0.041)
Birth region*Field of edu (omit: Swedish-born* field of edu)										
FB*E, M & C							-0.315	-0.305	-0.326	-0.326
							(0.284)	(0.273)	(0.301)	(0.302)
FB*S, M & C							-0.285	-0.256	-0.312	-0.314
							(0.305)	(0.287)	(0.313)	(0.314)
FB*H & W						0.178*	-0.109	-0.099	-0.133	-0.132
						(0.098)	(0.300)	(0.289)	(0.317)	(0.318)
FB*other fields							-	-	-	-
Edu_SE								0.089	0.049	0.047
								(0.075)	(0.077)	(0.077)
Age									-0.039***	-0.039***
									(0.011)	(0.011)
Age_sqr									0.000***	0.000**
									(0.000)	(0.000)
Female (omit: male)										0.056
										(0.045)
No. of inventors	0.120***	0.106***	0.106***	0.106***	0.102***	0.102***	0.102***	0.102***	0.097***	0.097***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Constant	-0.364***	-0.231***	-0.239***	-0.239***	-0.261***	-0.260***	-0.256***	-0.344***	0.770***	0.767***
	(0.089)	(0.087)	(0.087)	(0.087)	(0.086)	(0.086)	(0.086)	(0.113)	(0.272)	(0.273)
Chi-square	2,229	2,373	2,460	2,462	2,676	2,685	2,726	2,720	2,756	2,754
Log Likelihood	-83,761	-83,429	-83,424	-83,424	-83,361	-83,358	-83,351	-83,349	-83,207	-83,205

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

Notes: 1. No. of observations in each regression: 53,300. No. of inventors: 18,233.
2. Application year is included in each regression: 23 dummies (1985-2007) and 1985 is omitted.
3. "FB" = foreign-born; "E, M & C" = Engineering, Manufacturing and Construction; "S, M & C" = Science, Mathematics and Computing; "H & W" = Health and Welfare
4. Single regressions on FB*short post-2nd, FB*E, M & C, FB*S, M & C, FB*other fields, FB*female (omit: Swedish-born*female), FB*male (omit: Swedish-born*male) are not shown in the table as the results on each variable is insignificant and similar as those excluding them.
5. "-" means that variables are included in the regressions, but the results are omitted because of collinearity.

2. Subgroups of foreign-born

2.1) Compare between subgroups of foreign-born inventors with the same reason for settlement, education level, field of study and gender.

No difference in the quality of patents is found between subgroups of foreign-born inventors if simply control their birth region and reasons for settlement (see Table 6-A, col.1 and col.2). Additional controls for interacting birth region and reason for settlement (col.3-7) shows that there is a difference in the quality of patents contributed by inventors from different regions with different reasons for settlement. Among the inventors who settled as permanent residents, the quality is significantly higher for those who were from the rest of Europe than for those from other regions ($p<0.05$, col. 3). Meanwhile, the quality is significantly higher for those who settled for work than for inventors with other reasons for settlement ($p<0.1$, col.3) if the interaction variable of birth region and permanent residents is controlled for, no difference in the quality of patents is found between the subgroups of inventors who settled for work (col. 4) and study. Nevertheless, the quality becomes significantly lower by inventors with "other reasons" if the inventors who settled for work are controlled for ($p<0.1$, col. 4). Among the inventors that settled for family ties and "other reasons", the quality is significantly lower among those who were from the rest of Europe compared with those from other regions ($p<0.01$, col.5, col.6). Including controls for all interaction variables between birth region and reasons for settlement shows that, among the inventors who settled as permanent residents and work, the quality of patents is significantly higher for those from the rest of Europe, compared with those from other regions ($p<0.01$, col.7). The result is very robust for the later one as it holds for all the following models after inclusion of additional controls. Meanwhile, the quality of patents becomes significantly worse for inventors from the rest of Europe than that by those from other regions after controlling its inventors who had better performance ($p<0.01$, col.7). Column 8 shows that the quality of patents is significantly higher for inventors that immigrated after 1971 than for those arriving before 1971 ($p<0.05$). However, this result reverses when examining those from the rest of Europe ($p<0.01$, col. 9). Again, this result holds for all of the following models with additional controls. In column 9 we control for inventors from the rest of Europe who immigrated after 1971, the quality of patents is even better for those who after 1971 ($p<0.01$, col. 9) and it is not significantly worse any more for those from the rest of Europe than that for the other groups. Meanwhile, among the inventors who settled as permanent residents, the quality of patents by the inventors from rest of Europe is not higher any more. This is because among the inventors who settled as permanent residents and immigrated before 1971, the quality of patents is higher by the inventors from rest of Europe than that by those from other regions ($p<0.01$). However, among those who immigrated after 1971, the quality is significantly lower by those from rest of Europe ($p<0.01$) than that by those from other regions. Full control in the interaction variables of birth region and after_1971 eliminates the advantage of inventors who immigrated after 1971 (col. 10).

Column 11 (see Table 6-B) shows that education <= short post-secondary has significant negative effect on patent quality. Meanwhile, the quality of patents contributed by the inventors from rest of EU who settled for work and immigrated after 1971 is a little better than those in column 10 (1.13 vs. 0.97; -1.43 vs. -1.51, $p<0.01$). This is because there is less share of them had education level <= short post-secondary than those settled for other reasons and immigrated before 1971. For example, there is only18.7% of the inventors from rest of Europe who immigrated after 1971 had education level <= short post-secondary, while the corresponding figure is 45.9% for those immigrated before 1971. When comparing the inventors from different birth regions with the same education levels, we find only those from “Others” with education level <= short post-secondary is worse than the corresponding ones from other regions (p<0.1, col. 12). Controlling these badly performed inventors improves the quality of patents by the inventors with the same education level (-0.34 vs. -0.47). Study in the field of S, M&C and H&W has significantly positive effect on patent quality than in other fields (p<0.01, col. 13) and the result is very robust. Meanwhile, among the inventors with long post-secondary education, the quality of patents by inventors from rest of Europe becomes significantly higher than that by those from other regions (p<0.1). This is because among the inventors who had long post-secondary education and used to study in the “other fields”, there is much higher share of them from rest of Europe (31.9%) than those from the other regions (1.6%-9.7%). As column 17 shows, the inventors from rest of Europe who used to study in the “other fields” performed significantly better than those from the other regions (p<0.01). In addition, the negative effect of education <= short post-secondary on patent quality eliminates. It is the same for inventors from “others” with education <= short post-secondary. This is because among the inventors who had education <= short post-secondary, higher share of them from “others” studied in the “other fields” than those from other regions (29.8% vs. 19.4%). As column 17 shows, the inventors from “others” used to study in the “other fields” performed significantly better than those from the other regions (p<0.05) except the ones from rest of Europe. Column 14 shows that for inventors who studied in the field of E, M&C, those from EU-19 (p<0.05) and Asia (p<0.1) performed significantly better than those from other regions. It is the reverse for those studied in the field of S, M&C, including those from rest of

Europe ($p<0.05$, col.15). Meanwhile, inventors from rest of Europe with long post-secondary education did not perform significantly better any more. Column 16 shows that for inventors who studied in the fields of H&W, those from "others" performed significantly worse than those from other regions ($p<0.01$, col.16). It is the opposite for those studied in the "other fields" ($p<0.05$, col.17), including those from rest of Europe ($p<0.01$, col.17). Meanwhile, among the inventors with education <= short post-secondary, those from "others" performed significantly worse again. This is mainly because there is high share of them studied in "other fields" (29.8%), who had good performance are controlled. Full control in all interaction variables of birth region and field of study makes the sign for rest of Europe becomes significantly positive ($p<0.05$, col.18). This is attributed to the control in those badly performed inventors from rest of Europe in three main fields of study ("E, M & C"; "S, M&C"; "H&W") ($p<0.1$, col.18) as well as those who immigrated after 1971. Meanwhile, the inventors from "others" studied in three main fields also performed significantly worse than those from other regions except those from rest of Europe (col.18). These results are robust in the following models after additional controls in gender and its interaction of birth region as well. Among the inventors with education <= short post-secondary, same as those from "others", those from EU-19 also becomes significantly worse than those from other regions ($p<0.1$, col.18). Whether the inventors have had education in Sweden or not as well as their age and gender do not have significant effect on the quality of their patents. However, among the female inventors, those from EU-19 and Asia performed significantly better than those from other regions ($p<0.05$, col.19), which is the reverse for the male inventors ($p<0.05$, col.20). Meanwhile, the quality of patents by female inventors becomes significantly worse than that by male ones after the control of well performed female ones (p<0.05, col.19). In addition, the quality of patents contributed by inventors from rest of Europe is even better compared to that in column 18 (p<0.01).

In summary, by comparing between the inventors from different birth regions with the same reason for settlement, education level, field of study and gender, we find that in general, there is no difference in quality of patents by inventors from different birth regions and reasons for settlement. However, there is difference between the inventors from different regions with the same factors as mentioned above. Among the inventors settled as permanent residents and work, those from the rest of Europe performed better than those from other regions. The former ones who settled as permanent residents can perform better because those immigrated before 1971 performed better than the corresponding ones from other regions. This is mainly due to its inventors who had long post-secondary education had significant better performance than the corresponding ones from other regions (see Table A3, p<0.01, col.3). Among the inventors who settled as work, those from the rest of Europe can perform better than those from other regions is mainly because its inventors who had education <=short post-secondary performed better than the corresponding inventors from the other regions (see Table A4, p<0.01, col.2 & col.5). In addition, these inventors even performed better than those who are also from rest of Europe but had higher education levels (Table A4, p<0.01, col.6). This result is the reverse to the significant negative effect of <=short post-secondary education on patent quality. In total, the inventors immigrated after 1971 performed better than those immigrated before 1971, but it is the reverse for those from rest of Europe. For the inventors from the rest of Europe, if excluding those who settled as permanent residents and work, they performed worse than those from other regions. The inventors from rest of Europe who immigrated after 1971 performed significantly worse than those immigrated before 1971 is partly because of its high share of inventors studied in the main three fields (96.5% vs. 64.4%), where they had significantly worse performance than those from other regions. Inventors from the rest of Europe even performed better than those from other regions if control the field of study ($p<0.05$, col.18). In general, foreign-born inventors who studied in the fields of S, M&C and H&W performed significantly better than those studied in E, M&C and "other fields". Especially those from other Nordic countries, who studied in the former two fields performed significantly better than those from other regions. The results also show that whether take education in Sweden or not, age and gender have no effect on patent quality. However, the female inventors from EU-19 and Asia performed significantly better than those from other regions, which is the reverse for the male inventors. Excluding the well performed female inventors from EU-19 and Asia, the male inventors performed better than the female ones.

Table 6-A, 6-B are here

2.2) Compare between subgroups of foreign-born inventors, within a subgroup by different reasons for settlement, education levels, fields of study and gender.

In this section, we exam in the same subgroup, whether the inventors perform differently if they have different reasons for settlement, education levels, fields of study and gender. Column 1 (see Table 7-A) shows that among the inventors from EU-19, those settled with "other reasons" performed significantly better than those with other reasons ($p<0.1$). Meanwhile, the quality of patents by inventors with "other reasons" becomes significantly lower than that by inventors settled with other reasons ($p<0.05$) after controlling the well performed inventors from EU-19 who settled with "other reasons".

Among the inventors from rest of Europe (col.2), the quality of patents by those settled with family ties ($p<0.01$), study ($p<0.1$) and "other reasons" ($p<0.01$) is significantly lower than that by those settled as permanent residents. Meanwhile, quality of patents by inventors from rest of Europe becomes significantly higher ($p<0.1$) than that by those from other subgroups after controlling the badly performed inventors as mentioned above. The result of controlling in all interaction variables of birth region and reason for settlement (col.3) is only a little different from that in column 2. Among the inventors from rest of Europe, the significant negative effect of study eliminates. However, the quality of patents by those settled for work becomes significantly higher ($p<0.1$) compared with that by those with other reasons. Same as that shown in Table 6-A, inventors immigrated after 1971 performed significantly better than those immigrated before 1971 ($p<0.01$, col. 4). Meanwhile, among the inventors from rest of Europe, the quality of patents by those settled for work also becomes significantly worse ($p<0.1$). In addition, the positive effect of work on patent quality also eliminates. Again, same as that in Table 6-A, we can see that different from the general better performed inventors who immigrated after 1971, among the inventors from the rest of Europe, those immigrated after 1971 performed significantly worse than those immigrated before 1971 ($p<0.01$, col. 5). This result is very robust as it holds for all of the following models after additional control. Meanwhile, in contrast to that in column 4, among the inventors from rest of Europe, those settled for work performed significantly better than those by permanent residents after controlling its badly performed inventors who immigrated after 1971. It is the same for those settled for study. In addition, the significant negative effect of family ties and other reasons on patent quality also eliminates. The quality of patent by inventors from rest of Europe becomes even better than that by other subgroups (0.92 vs. 0.70, p<0.01, col.5). Full control in all interaction variables of birth region and after 1971 eliminates the significant effect of work and study for inventors from rest of Europe.

Same as that shown in Table 6-B, inventors with <=short post-secondary education level performed significantly worse than those with higher education levels, but there is no significant difference between inventors with long post-secondary education and Ph.D. (p<0.01, col.7, Table 7-B). This result is very robust even with additional controls in the next models (p<0.01, col.7-16). Meanwhile, the quality of patents by inventors from Asia started to become significantly lower than that by other subgroups (p<0.05). This implies that without advantage of higher share of inventors who had education in long post-secondary and Ph.D. (see Table 4), inventors from Asia could not perform as well as those from other regions. Full control in interaction variables of birth region and education level shows that, among the inventors from other Nordic countries, those with education level <= short post-secondary even performed significantly better than those with higher education level (p<0.1, col.8) and this result is very robust (col.8-16). The disadvantage of inventors from Asia also eliminates. Same as that in Table 6-B, column 9 (Table 7-B) shows that generally, inventors who used to study in the field of S, M&C as well as H&W performed significantly better than those studied in the other fields (p<0.01). This is applied for the inventors from other Nordic countries (col.10). Meanwhile, inventors from EU-19 started to perform significantly better (p<0.1, col.10) than other subgroups except rest of Europe after control in well performed inventors from other Nordic countries. In addition, the advantage of inventors studied in the field of S, M &C eliminates after controlling the well performed inventors who studied in S, M &C from other Nordic countries. Within different subgroups, inventors studied in the different fields performed differently. Among the inventors from EU-19, those studied in the “other fields” performed significantly worse than those studied in other fields ($p<0.01$, col. 11), which is the reverse for inventors from the rest of Europe ($p<0.01$, col.12) and “others” ($p<0.05$, col.13). Control in the badly performed inventors who studied in the “other fields” in EU-19 makes the general inventors who studied in “other fields” also have significantly better performance than those studied in E, M&C ($p<0.05$, col.11). However, control in the well performed inventors who studied in the “other fields” in rest of Europe eliminates the advantage of inventors from rest of Europe compared to those from other regions. Meanwhile, among the inventors from rest of Europe, those who settled for work, study and with education level <=short post-secondary performed significantly better than those settled with other reasons and had higher education levels ($p<0.1$, col.12). In addition, the disadvantage of those immigrated after 1971 also reduced a little bit. Different from better performed inventors who studied in the “other fields”, among the inventors from “others”, those studied in H&W performed significantly worse than those studied in other fields ($p<0.05$, col.13). Full control in the interaction variables of birth region and field of study shows that, in each subgroup except “others”, those studied in H&W performed significantly better than those studied in other fields, which is the reverse for those studied in “other fields” from other Nordic countries and EU-19 (col.14). Meanwhile, after control in well performed inventors who studied in H&W in each subgroup, the advantage of study in H&W on patent quality eliminates, which is the reverse for those studied in “other fields”. Same as shown in column 12, for inventors from rest of Europe, the general advantage of them eliminates but those who settled for work, study and with education level <=short post-secondary performed significantly better. The results in column 14 is very robust after additional controls in the following models except for inventors from rest of Europe becomes significant better ($p<0.1$, col.15-16) again when there is additional control in interaction variables of birth region and gender. Column 15 shows, among inventors from other Nordic countries, female inventors performed worse than the male ones ($p<0.05$), but this eliminates after full control in birth region and gender (col.16).

In summary, mainly there is no difference among the inventors from the same subgroup but with different reasons for settlement except those from rest of Europe. Among the inventors from rest of Europe, those settled for family ties and other reasons performed significantly worse than those with other reasons. The inventors from rest of Europe even can perform better than those from other regions if excluding those settled for family ties, other reasons and immigrated after 1971, which is mainly attributed to the good performance of its inventors who studied in "other fields". Inventors from Asia benefits from their higher education levels, otherwise they could not perform as well as those from other regions. Although generally inventors had education <=short post-secondary performed significantly worse than those with higher education level, it is the reverse for inventors from other Nordic countries. The inventors from the same subgroup but studied in the different fields of study performed differently. In general, the foreign-born inventors studied in the field of S, M&C can perform significantly better than those studied in E, M&C and "other fields" is mainly attributed to the well performed inventors from other Nordic countries who studied in this field. Among the inventors from other Nordic countries, those studied in H&W also performed better than those studied in E, M&C and "other fields". Among the inventors from EU-19, those studied in "other fields" performed significantly worse than those studied in other fields. If controlling these inventors, inventors who studied in "other fields" also can perform better than those studied in E, M&C. Among the inventors from "others", those studied in "H&W" performed worse than those studied in other fields, which is the reverse for those studied in "other fields". In general, there is no gender difference between inventors from the same subgroup, except those from other Nordic countries, where female inventors performed significant worse than the male ones.

Table 7-A, 7-B are here

2.3) Conclusion for the subgroups of foreign-born inventors

According to 2.1 and 2.2 above, we find that in general, there is no significant difference in quality of patents by inventors from different birth regions and reasons for settlement. However, there is difference between the inventors from different regions with the same reason for settlement, education level, field of study and gender, which is the same for inventors from the same subgroup but with different factors as mentioned above. Inventors immigrated in different time periods also performed differently. Inventors from the rest of Europe who settled as permanent residents not only performed significantly better than those from the other subgroups with the same reason, but also better than those from the same place but settled for family ties and "other reasons". In addition, inventors from the rest of Europe who settled for family ties and "other reasons" also performed worse than those from the different subgroups with the same reasons. It is the reverse for those who settled for work after full control in the interaction variable of the birth region and reason for settlement. In general, inventors immigrated after 1971 performed better than those immigrated before 1971. However, it is the reverse for those from rest of Europe. This is partly because of its high share of inventors studied in the main three fields (96.5% vs. 64.4%), where they had significantly worse performance than those from other regions. Inventor from rest of Europe can even performed better than those from other regions if control in those badly performed inventors who settled as family ties and “other reasons”. This result is even more robust after additional control for those immigrated 1971. This is mainly because of the good performance of its inventors who studied in “other fields”

In General, inventors had education <=short post-secondary performed significantly worse than those with higher education level, however, it is the reverse for inventors from other Nordic countries. Among the inventors had education <=short post-secondary, those from “others” performed worse than those from other regions. The foreign-born inventors studied in the field of S, M&C and H&W performed significantly better than those studied in E, M&C and “other fields”. This is mainly because the well performed inventors from other Nordic countries who studied in the former two fields. These inventors did not only perform better than those from other regions who studied in the same fields, but also better than those from the same subgroup but studied in the different fields. In general, there is no gender difference in patent quality. However, among the female inventors, those from EU-19 and Asia performed better than those from other regions. It is the reverse for the male inventors. If control in the well performed female inventors from EU-19 and Asia, female inventors performed significantly worse than male inventors. Among the inventors from other Nordic countries, female inventors also performed worse than the male ones.

VI. Discussion and Conclusion

In recent years, more and more attention has been paid to foreign-born highly skilled immigrants and their role and contribution to host countries. Most prior work is limited by survey data or case studies in the USA (e.g. Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010; Hunt, 2011) by only comparing with the native ones and foreign ones. This study extends our insight to another country, Sweden, based on a recently established database, which combines Swedish patent application data filed by Swedish inventors to the EPO from 1985 to 2007 with detailed demographic information. In addition, our data also allow us to compare differences between foreign-born inventors by birth region.

From earlier studies (e.g. Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010; Hunt, 2011), we know that foreign-born talent perform better than the native ones in invention, which is explained by their advantage in higher education level and field of study. Our study shows that foreign-born inventors contribute to similar amount of patents as the Swedish-born according to the share of inventors, and the quality of patents contributed by the foreign-born and the Swedish-born is similar. The main differences concern that foreign-born inventors seem to have significantly better patent quality when educated in H&W.

The different performance of foreign-born inventors in Sweden and the US could be attributed to the difference in origins of immigrants. First, there is no doubt that the US is one of the most attractive place for the best talents, who are attracted from all over the world to there, while the major component of highly skilled immigrants in Sweden are asylum seekers or under family reunification when they arrived (Gaillard, 2002). Among the reasons for settlement at the first time for foreign-born inventor's patent filing, except for settling as permanent residents and work, we find that family ties and the "other reasons", which include reasons such as protection and humanitarian reasons, are also important, especially for those from Rest of Europe, Asia and "Others". Additionally, we find that the first entrance time for those who became permanent residents later is quite highly related to historical events such as wars that took place in their birth region. It is reasonable to assume that there is a considerable number of these people immigrated as asylum seekers or refugees as well. Second, as mentioned in the literature review that in the US, the average quality of US-born individuals choosing to get doctorates in S&E has declined as bright native students more often choose lucrative careers in business, law and medicine (Stephan and Levin, 2001). However, in Sweden, major native born PhDs still choose to study in the S&E field. For example, in 2010/2011, 75% Swedish-born PhDs who were under 65 years old got graduated in the S&E field, while the corresponding figure is 80% for the foreign-born PhDs (Statistics Sweden, 2013, p370). Third, compared with immigrants in Sweden, it is relatively less limitation such as language and culture for those in the US. This is because English is more widely used in the US and the American culture is also more widely spread and accepted by the world than Swedish and Swedish culture. At last, in the US, the main proportion of foreign-born talent is from Asia countries such as China (including Taiwan and Hongkong) and India (Kerr, 2008; Wadhwa, 2009; No and Walsh, 2010). People from these counties are famous for their hard work and talent in science and technology, especially in IT. However, the majority foreign-born inventors in Sweden are from EU-19 (36.8%) and other Nordic countries (27.5%).

Although in general, study is not a popular reason for foreign-born inventors to settle in Sweden (6.4% in Table 3), it is relatively important for inventors from Asia (18.4% in Table 3). Unfortunately, Sweden has introduced tuition fee for non-EU and non-EEA/Switzerland students in undergraduate and master program since August 2011. This leads to a sharp drop registration of international students from Asia[19], which is the most important origin for international students in tertiary-level education in Sweden. Although the real effect of this policy change is not known yet, we think it conflicts with Sweden's efforts to attract highly skilled immigrants from the world to improve its competitive power. We are worried that in the long run, it can hurt Sweden's technology development and international communication as normally lots of international students would choose to stay in Sweden and work here after graduation or even work as "brain circulation" between their mother country and Sweden (Saxenian, 2006). Imitating the tuition fee such as that in the US or Britain seems not to be a clever idea. This is because compared with these large and English countries, Sweden is usually not as attractive for the international students as them because of problems like culture and language for foreigners. Although it can cost a considerable amount of money for the Swedish government to invest in international study programs, we believe Sweden can benefit from it in the long run.

Most of foreign-born inventors in Sweden are from the other Nordic countries (27.5%), EU-19 (36.8%), the rest of Europe (9.9%) and Asia (15.5%). Being permanent residents (54.0%) is the most important reason for settlement for the foreign-born inventors in Sweden when they filed their first patent, followed by work, family ties and "other

[19] E.g., see http://monitor.icef.com/2012/09/sweden-on-the-rebound-from-tuition-fee-fallout/, retrieved from 03, July, 2013.

reasons”, which include protection and humanitarian reasons and pensioners/persons with sufficient funds. Study reasons are especially important for those from Asia.

In general, the quality of patents for those of foreign-born inventors from different regions and reasons for settlement is also similar. However, there is difference between inventors from different regions but with same reason for settlement, education level, field of study and gender. It is the same for inventors from the same region but with different factors as mentioned above. These differences mainly can be attributed to the inventors’ field of study.

Most of foreign-born inventors in Sweden are from the other Nordic countries (27.5%), EU-19 (36.8%), the rest of Europe (9.9%) and Asia (15.5%). Being permanent residents (54.0%) is the most important reason for settlement for the foreign-born inventors in Sweden when they filed their first patent, followed by work, family ties and “other reasons”, which include protection and humanitarian reasons and pensioners/persons with sufficient funds. Study reasons are especially important for those from Asia.

The quality of patents for those from the rest of Europe who settled as permanent residents is not only better than those settled for family ties and “other reasons”, but also better than those from the other regions with the same reason. This is mainly because of the good performance of its inventors who studied in “other fields”. In general, inventors immigrated after 1971 performed better than those immigrated before 1971. However, it is the reverse for those from rest of Europe. This is partly because of its high share of inventors studied in the main three fields (96.5% vs. 64.4%), where they had significantly worse performance than those from other regions.

In General, inventors had education <=short post-secondary performed significantly worse than those with higher education level, however, it is the reverse for inventors from other Nordic countries. The foreign-born inventors studied in the field of S, M&C and H&W performed significantly better than those studied in E, M&C and “other fields”. This is mainly because the well performed inventors from other Nordic countries who studied in the former two fields.

Female inventors from EU-19 and Asia performed better than those from other regions. It is the reverse for the male inventors. If control in the well performed female inventors from EU-19 and Asia, female inventors performed significantly worse than male inventors. Among the inventors from other Nordic countries, female inventors also performed worse than those male inventors.

The study does have several limitations which may raise further questions. First, we only estimate the invention performance for the foreign-born inventors based on patent data, which only represent part of contribution by highly skilled immigrants. In reality, it could be less active for a foreign-born to apply a patent in Sweden because of the culture, language, access to resources or even discrimination problems. Second, we do not consider about commercialization of patents and other innovative activities such as publication in as the limitation of space of the paper as well as availability of data.

Nevertheless, this is the first detailed study to research on the foreign-born inventors in Sweden. It is also the first time to compare the performance of foreign-born inventors in one country according to their birth regions. It develops our understanding of foreign-born inventors' invention performance in Sweden compared with the native ones. The study also provides information to the Swedish government and companies about which type of inventors are more inventive and they should try to attract and retain.

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Table 6-A: Determinants of NFC: comparison of subgroups of foreign-born inventors with same reasons for settlement, 1990-2007

Indep. var	**1 Birth**	**2 Reason**	**3 B*PR**	**4 B*Work**	**5 B*Family**	**6 B*Other**	**7 B*R_all**	**8 Aft_1971**	**9 R_EU_71**	**10 All_1971**
BR (omit: Nordic)										
Rest_EU	0.287	0.283	-0.176	0.307	0.323	0.358	-0.854***	-0.805***	0.758	0.695
	(0.238)	(0.268)	(0.214)	(0.315)	(0.268)	(0.269)	(0.307)	(0.308)	(0.486)	(0.501)
EU-19/Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)										
Work		0.077	0.218*	0.124	0.077	0.085	0.185	0.054	0.014	0.117
		(0.131)	(0.124)	(0.128)	(0.128)	(0.125)	(0.128)	(0.147)	(0.147)	(0.196)
Family/Study		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other reasons		-0.240	-0.082	-0.261*	-0.238	0.048	0.103	-0.032	-0.073	0.028
		(0.155)	(0.166)	(0.155)	(0.154)	(0.211)	(0.210)	(0.224)	(0.224)	(0.258)
BR* rea for set (omit: EU-19*each rea for set) [1]										
Each BR*PR										
Rest_EU*PR			0.766**				1.443***	1.506***	0.159	0.260
			(0.375)				(0.438)	(0.443)	(0.359)	(0.383)
Asia/Others*PR			Yes				Yes	Yes	Yes	Yes
Each BR*work										
Rest_EU*work				-0.125			0.981***	0.977***	0.975***	0.974***
				(0.374)			(0.373)	(0.372)	(0.372)	(0.372)
Asia/Others*work				Yes			Yes	Yes	Yes	Yes
Each BR*fam										
Rest_EU*family					-0.968***		0.138	0.143	0.119	0.119
					(0.349)		(0.400)	(0.401)	(0.406)	(0.406)
Asia/Others*family					Yes		Yes	Yes	Yes	Yes
Each BR*study [2]							Yes	Yes	Yes	Yes
Each BR*other reasons										
Rest_EU*other reasons						-1.164***	-	-	-	-
						(0.374)	-	-	-	-
Asia/Others*other reasons						Yes	-	-	-	-
After_1971 (omit: before 1971)								0.225**	0.299***	0.259
								(0.103)	(0.103)	(0.281)
Each BR*after_1971 (omit: each BR*before 1971) [3]										
Rest_EU*after_1971									-1.546***	-1.507***
									(0.372)	(0.454)
Nordic/ EU_19/Asia/Others*after_1971										Yes
No. of inventors	0.111***	0.110***	0.113***	0.110***	0.111***	0.110***	0.112***	0.108***	0.109***	0.109***
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	-0.230	-0.221	-0.198	-0.215	-0.224	-0.212	-0.196	-0.318	-0.343*	-0.350*
	(0.237)	(0.235)	(0.234)	(0.234)	(0.234)	(0.235)	(0.234)	(0.205)	(0.200)	(0.205)
Chi-square	277	306	345	310	323	321	352	352	361	368
Log likelihood	-7,885	-7,881	-7,867	-7,879	-7,875	-7,872	-7,858	-7,852	-7,838	-7,837

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

Notes: 1. No. of observations in each regression: 5,079. No. of inventors: 1,762.

2. Application year is included in each regression: 18 dummies (1990-2007) and 1990 is omitted.

3. "Yes" means the variables are included in the regressions, but the results are not shown in the table as they are not significant.

4. "-" means that variables are included in the regressions, but the results are omitted because of collinearity.

5. "BR" means birth region; "Nordic" means other Nordic countries; "Rea for set" means reasons for settlement; "PR" means permanent residents; "family" means family ties.

6. [1], in each BR*rea for set, other Nordic countries are not included because there is collinearity between other Nordic countries*PR and birth region of other Nordic countries. This is because most of inventors (only 29 obs. are exceptions) who were born in other Nordic countries either have changed their citizenship to Sweden (879 obs.) or retained their Nordic citizenship (841 obs.) at the time of filing, which are both considered as PR here.

Table 6-B: Determinants of NFC: comparison of subgroups of foreign-born inventors with same education level, field of education and gender, 1990-2007

Indep. var.	11	12	13	14	15	16	17	18	19	20
	Edu	**B*E1**	**Field**	**B*F1**	**B*F2**	**B*F3**	**B*F4**	**B*F_all**	**B*Fem**	**B*Male**
BR (omit: Nordic)										
Rest_EU	0.397	0.453	-0.157	-0.375	0.133	-0.033	-0.133	1.353**	1.515***	1.710**
	(0.450)	(0.479)	(0.500)	(0.498)	(0.489)	(0.532)	(0.497)	(0.581)	(0.578)	(0.718)
EU-19/Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)										
Work/Family/Study/ Other reasons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR* each rea for set (omit: EU-19*each rea for set) [1]										
Each BR*PR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*work										
Rest_EU*work	1.127***	1.136***	1.337***	1.366***	1.425***	1.292***	1.133***	1.235***	1.195***	1.195***
	(0.404)	(0.391)	(0.460)	(0.462)	(0.461)	(0.462)	(0.406)	(0.414)	(0.401)	(0.401)
Asia/Others*work	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*family	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*study [2]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*other rea	-	-	-	-	-	-	-	-	-	-
After_1971	0.261	0.233	0.159	0.098	0.135	0.173	0.172	0.156	0.123	0.123
(omit: before 1971)	(0.270)	(0.268)	(0.274)	(0.288)	(0.284)	(0.270)	(0.268)	(0.279)	(0.293)	(0.293)
BR*After_1971 (omit: each BR*before_1971) [3]										
Rest_EU*after_1971	-1.434***	-1.424***	-1.144***	-1.013***	-1.097***	-1.207***	-0.917***	-0.876**	-0.949***	-0.949***
	(0.399)	(0.405)	(0.376)	(0.382)	(0.376)	(0.387)	(0.356)	(0.356)	(0.355)	(0.355)
Nordic/EU-19/Asia/ Others*after_1971	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Edu level (omit: long post-2nd)										
Short post-2nd	-0.465***	-0.342**	-0.210	-0.169	-0.133	-0.200	-0.158	-0.060	0.020	0.020
	(0.094)	(0.136)	(0.148)	(0.139)	(0.133)	(0.150)	(0.148)	(0.136)	(0.134)	(0.134)
Phd	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*each edu level (omit: Nordic *each edu level) [4]										
Each BR*short post-2nd										
EU-19*short		-0.291	-0.231	-0.341	-0.352	-0.242	-0.222	-0.392*	-0.410*	-0.410*
		(0.185)	(0.216)	(0.224)	(0.224)	(0.222)	(0.217)	(0.237)	(0.237)	(0.237)
Others*short		-0.451*	-0.333	-0.327	-0.391	-0.406	-0.533*	-0.683**	-0.734**	-0.734**
		(0.260)	(0.289)	(0.286)	(0.303)	(0.292)	(0.285)	(0.299)	(0.299)	(0.299)
Rest_EU/ Asia*short		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*long post-2nd										
Rest_EU*long			0.621*	0.667*	0.489	0.553	0.112	0.017	0.045	0.045
			(0.355)	(0.360)	(0.330)	(0.358)	(0.289)	(0.281)	(0.265)	(0.265)
EU-19/Asia/others*long			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*Phd			-	-	-	-	-	-	-	-
Field of study (omit: E, M & C)										
S, M & C			0.254***	0.486***	0.623***	0.251***	0.260***	0.675***	0.726***	0.726***
			(0.093)	(0.157)	(0.180)	(0.093)	(0.092)	(0.186)	(0.185)	(0.185)
H & W			0.355***	0.577***	0.366***	0.456***	0.400***	0.617***	0.702***	0.702***
			(0.102)	(0.147)	(0.100)	(0.155)	(0.098)	(0.158)	(0.162)	(0.162)
Other fields			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR* each field of study										
Each BR* E, M & C (omit: Nordic*E, M & C)										
EU-19*E, M & C				0.377**				0.482	0.462	0.462
				(0.181)				(0.317)	(0.322)	(0.322)
Rest_EU*E, M & C				0.027				-1.242***	-1.275***	-1.275***
				(0.241)				(0.317)	(0.325)	(0.325)
Asia*E, M & C				0.423*				0.079	0.098	0.098
				(0.235)				(0.513)	(0.508)	(0.508)
Others*E, M & C				0.024				-0.730**	-0.700**	-0.700**
				(0.233)				(0.339)	(0.342)	(0.342)

Each BR* S, M & C (omit: Nordic*S, M & C)										
EU-19*S, M & C					-0.431**			-0.038	-0.109	-0.109
					(0.219)			(0.380)	(0.385)	(0.385)
Rest_EU*S, M & C					-0.813**			-2.029***	-2.033***	-2.033***
					(0.332)			(0.440)	(0.428)	(0.428)
Asia*S, M & C					-0.622**			-0.604	-0.646	-0.646
					(0.257)			(0.549)	(0.543)	(0.543)
Others*S, M & C					-0.263			-1.026***	-1.024***	-1.024***
					(0.257)			(0.390)	(0.387)	(0.387)
Each BR* H & W (omit: Nordic* H & W)										
Rest_EU* H & W						-0.264		-1.415***	-1.408***	-1.408***
						(0.322)		(0.392)	(0.398)	(0.398)
Others* H & W						-1.026***		-1.816***	-1.856***	-1.856***
						(0.383)		(0.499)	(0.499)	(0.499)
EU_19/Asia* H & W						Yes		Yes	Yes	Yes
Each BR* other fields (omit: Nordic*other fields)										
Rest_EU*other fields							1.296***	-	-	-
							(0.321)			
Others*other fields							0.735**	-	-	-
							(0.327)			
EU-19/Asia*other fields							Yes	-	-	-
Edu_SE,/age, age_sqr,/Female[5]									Yes	Yes
Female (omit: male)									-0.416**	-0.416**
									(0.208)	(0.208)
Each BR*female (omit: Nordic*female)										
EU-19*female									0.505**	
									(0.246)	
Asia*female									0.659**	
									(0.315)	
Rest_EU/others *female									Yes	
Each BR*male (omit: Nordic*male)										
EU_19*male										-0.505**
										(0.246)
Asia*male										-0.659**
										(0.315)
Rest_EU/others*male										Yes
No. of inventors	0.104***	0.103***	0.099***	0.100***	0.102***	0.098***	0.099***	0.102***	0.103***	0.103***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Constant	-0.076	-0.156	-0.282	-0.374*	-0.346	-0.292	-0.266	-0.371*	-0.141	-0.141
	(0.212)	(0.220)	(0.224)	(0.216)	(0.212)	(0.228)	(0.228)	(0.217)	(0.683)	(0.683)
Chi-square	411	428	491	530	548	510	533	594	651	651
Log likelihood	-7,812	-7,808	-7,791	-7,783	-7,780	-7,788	-7,773	-7,759	-7,747	-7,747

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

Notes: 1-7, same as that mentioned in Table 6-A.

8. [4]&[5], single models test on each BR*Phd, edu_SE , age and female are not shown in the table as they are insignificant and the results of model do not change quantitatively.

Table 7-A: Determinants of NFC: comparison of subgroups of foreign-born inventors, within a subgroup by different reasons for settlement, 1990-2007

Indep. Var.	1 EU25*Rea	2 Rest_EU*Rea	3 All_BR*Rea	4 Aft_1971	5 Rest_EU_1971	6 All_1971
BR (omit: Nordic)						
Rest_EU	0.339	0.589*	0.590*	0.701**	0.917***	0.955***
	(0.282)	(0.329)	(0.329)	(0.334)	(0.325)	(0.325)
EU-19/Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)						
Work	-0.027	0.164	0.344*	0.265	0.245	0.264
	(0.210)	(0.109)	(0.203)	(0.206)	(0.205)	(0.264)
Family/Study	Yes	Yes	Yes	Yes	Yes	Yes
Other reasons	-0.407**	0.000	0.037	-0.037	-0.059	-0.039
	(0.189)	(0.133)	(0.350)	(0.353)	(0.352)	(0.390)
BR* rea for set (omit: BR*PR)						
EU-19*rea for set						
EU-19*work/family/study	Yes		Yes	Yes	Yes	Yes
EU-19*other reasons	0.510*		0.067	0.005	-0.015	0.067
	(0.275)		(0.403)	(0.402)	(0.401)	(0.467)
Rest Europe*rea for set						
Rest Europe*work		-0.442	-0.621	-0.740*	0.585*	0.567
		(0.398)	(0.426)	(0.424)	(0.346)	(0.385)
Rest Europe*family		-1.364***	-1.492***	-1.601***	-0.292	-0.310
		(0.405)	(0.454)	(0.455)	(0.387)	(0.423)
Rest Europe*study		-0.799*	-0.545	-0.658	0.674*	0.655
		(0.477)	(0.463)	(0.465)	(0.388)	(0.424)
Rest Europe*other reasons		-1.341***	-1.376***	-1.501***	-0.174	-0.192
		(0.406)	(0.511)	(0.511)	(0.447)	(0.478)
Asia*rea for set[1]			Yes	Yes	Yes	Yes
Others*rea for set[2]			-	-	-	-
After_1971				0.225**	0.299***	0.152
(omit: before 1971)				(0.103)	(0.103)	(0.194)
Each BR*After_1971 (omit: each BR*before_1971)[3]						
Rest_EU*after_1971					-1.546***	-1.400***
					(0.372)	(0.412)
Nordic/EU_19/Asia/Others *after_1971						Yes
No. of inventors	0.110***	0.112***	0.112***	0.108***	0.109***	0.109***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	-0.189	-0.200	-0.196	-0.318	-0.343*	-0.350*
	(0.233)	(0.237)	(0.234)	(0.205)	(0.200)	(0.205)
Chi-square	314	344	352	352	361	368
Log likelihood	-7,877	-7,860	-7,858	-7,852	-7,838	-7,837

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

Notes: 1. same as 1-6 in Table 6-A.

2. For [1], [2] and [3], single models which test on "Asia*rea for set", "Others*rea for set", "Nordic/ EU_19/Asia/others*after_1971" are not shown in the table as the results are insignificant in these interaction variables and they do not change the model significant compared with the former one.

Table 7-B: Determinants of NFC: comparison of subgroups of foreign-born inventors, within a subgroup by same education level, field of education and gender, 1990-2007

Indep. Var.	7 Edu	8 Edu_all	9 Edu_field	10 Nor_F	11 EU-19_F	12 R_EU_F	13 Others_F	14 All_F	15 Nor_Fem	16 All_Fem
BR (omit: Nordic)										
EU-19	-0.016	0.172	0.197	0.290*	0.274*	0.198	0.197	0.330**	0.388**	0.388**
	(0.116)	(0.173)	(0.163)	(0.157)	(0.162)	(0.162)	(0.163)	(0.156)	(0.157)	(0.158)
Rest_EU	0.844***	1.048***	1.013***	1.029***	0.879***	0.261	1.073***	0.350	0.441*	0.435*
	(0.247)	(0.365)	(0.360)	(0.325)	(0.330)	(0.237)	(0.369)	(0.231)	(0.232)	(0.233)
Asia	-0.375**	-0.289	-0.222	-0.129	-0.206	-0.226	-0.225	-0.111	0.036	0.036
	(0.181)	(0.231)	(0.227)	(0.216)	(0.228)	(0.227)	(0.225)	(0.210)	(0.224)	(0.225)
Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)										
Work/Family/Study/ Other reasons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BR* rea for set (omit: BR*Nordic)										
EU-19*rea for set	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rest Europe*rea for set										
Rest Europe*work	0.501	0.573	0.548	0.592	0.563	0.778*	0.648	0.885**	0.969**	0.963**
	(0.417)	(0.415)	(0.422)	(0.415)	(0.419)	(0.420)	(0.423)	(0.416)	(0.413)	(0.406)
Rest Europe*study	0.620	0.659	0.648	0.667	0.640	0.792*	0.645	0.774*	0.833*	0.788*
	(0.460)	(0.425)	(0.433)	(0.426)	(0.433)	(0.422)	(0.437)	(0.425)	(0.429)	(0.430)
Rest Europe*family/ other reasons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Asia*rea for set	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Others* rea for set	-	-	-	-	-	-	-	-	-	-
After_1971	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*After_1971 (omit: each BR*before_1971)										
Rest Europe* After_1971	-1.272 ***	-1.177 ***	-1.078 ***	-1.076 ***	-1.039 ***	-0.816 ***	-1.091 ***	-0.825 ***	-0.903 ***	-0.868 ***
	(0.350)	(0.308)	(0.320)	(0.305)	(0.313)	(0.288)	(0.323)	(0.286)	(0.284)	(0.285)
Nordic/EU_19/Asia/ Others*after_1971	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Edu level (omit: long post-2nd)										
short post-2nd	-0.465 ***	-0.820 ***	-0.786 ***	-0.855 ***	-0.839 ***	-0.720 ***	-0.913 ***	-0.918 ***	-0.881 ***	-0.858 ***
	(0.094)	(0.241)	(0.243)	(0.240)	(0.236)	(0.257)	(0.243)	(0.245)	(0.241)	(0.238)
Phd	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*each edu level[1]										
Nordic*each edu level (omit: Nordic*long post-2nd)										
Nordic*Short post-2nd		0.538*	0.576**	0.796***	0.604**	0.556*	0.722**	0.859***	0.900***	0.878***
		(0.291)	(0.283)	(0.276)	(0.274)	(0.294)	(0.285)	(0.280)	(0.274)	(0.272)
Nordic*Phd		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		(0.278)	(0.258)	(0.249)	(0.252)	(0.260)	(0.256)	(0.242)	(0.246)	(0.246)
EU-19*each edu level (omit: EU-19*long post-2nd)		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rest Europe*each edu level (omit: Rest Europe*long post-2nd)										
Rest Europe* short post-2nd		0.335	0.317	0.423	0.475	0.672*	0.393	0.863**	0.798**	0.775**
		(0.409)	(0.412)	(0.387)	(0.391)	(0.347)	(0.421)	(0.337)	(0.331)	(0.329)
Rest Europe*Phd		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Asia*each edu level (omit: Asia*long post-2nd)		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Others*each edu level (omit: Others*long post-2nd)		-	-	-	-	-	-	-	-	-
Field of study (omit: E, M & C)										
S, M & C			0.254***	0.130	0.305**	0.279***	0.240**	0.379*	0.380*	0.402*
			(0.093)	(0.098)	(0.121)	(0.097)	(0.101)	(0.197)	(0.205)	(0.207)
H & W			0.355***	0.268**	0.382***	0.383***	0.381***	-0.470	-0.485	-0.454
			(0.102)	(0.123)	(0.125)	(0.107)	(0.105)	(0.372)	(0.375)	(0.379)
other fields			0.086	0.203	0.290**	-0.116	-0.003	0.631**	0.597**	0.614**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			(0.117)	(0.158)	(0.134)	(0.129)	(0.123)	(0.287)	(0.293)	(0.289)
Each BR* each field of study										
Nordic* each field of study (omit: Nordic*E, M&C)										
Nordic* S, M&C				0.545***				0.296	0.345	0.323
				(0.211)				(0.270)	(0.277)	(0.279)
Nordic*H&M				0.350*				1.086***	1.187***	1.156***
				(0.201)				(0.406)	(0.410)	(0.413)
Nordic*other fields				-0.302				-0.730**	-0.682**	-0.700**
				(0.241)				(0.339)	(0.346)	(0.342)
EU-19*each field of study (omit: EU-19*E, M&C)										
EU-19*S, M&C					Yes			Yes	Yes	Yes
EU-19*H&M					-0.037			0.813**	0.813**	0.783*
					(0.192)			(0.400)	(0.399)	(0.403)
EU-19*other fields					-0.870***			-1.212***	-1.146***	-1.162***
					(0.293)			(0.387)	(0.394)	(0.392)
Rest Europe*each field of study (omit: Rest Europe*E, M&C)										
Rest Europe*S, M&C						Yes		Yes	Yes	Yes
Rest Europe*H&W						0.060		0.913**	1.012**	1.022**
						(0.239)		(0.429)	(0.432)	(0.440)
Rest Europe* other fields						1.255***		0.512	0.577	0.574
						(0.290)		(0.386)	(0.393)	(0.391)
Asia*each field of study (omit: Asia*E, M&C)[2]										
Asia*H&W								0.792*	0.827*	0.794*
								(0.440)	(0.443)	(0.447)
Asia*S, M&C/ other fields								Yes	Yes	Yes
Others*each field of study (omit: Rest Europe*E, M&C)										
Others*S, M&C							Yes	-	-	-
							(0.217)			
Others*H&W							-0.846**	-	-	-
							(0.383)			
Others*other fields							0.643**	-	-	-
							(0.312)			
Edu_SE/Age, age_sqr/Female[3]									Yes	Yes
Each BR*Female (omit: each BR*male)										
Nordic*female									-0.502**	-0.353
									(0.235)	(0.322)
EU-19/Rest Europe/ Asia/Others*female [4]										Yes
No. of inventors	0.104***	0.105***	0.099***	0.102***	0.099***	0.098***	0.099***	0.102***	0.103***	0.103***
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Constant	-0.076	-0.213	-0.282	-0.374*	-0.326	-0.259	-0.279	-0.371*	-0.172	-0.141
	(0.212)	(0.225)	(0.224)	(0.217)	(0.219)	(0.226)	(0.225)	(0.217)	(0.682)	(0.683)
Chi-square	411	437	491	522	496	532	511	594	638	651
Log likelihood	-7,812	-7,805	-7,791	-7,780	-7,783	-7,777	-7,786	-7,759	-7,749	-7,747

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

Notes: 1. same as 1-6 in Table 6-A.

2. For [1] to [4], single models which test on "Nordic/EU-19/Rest Europe/Asia/Others*each edu level", "Asia*each field of study", "Edu_SE/Age, age_sqr/Female" and "EU-19/Rest Europe/Asia/Others*female" are not shown in the table as the results are insignificant in these interaction variables and they do not change the model significant compared with the former one.

Appendix

Figure A1. Map of each region.

Table A1. Number of foreign-born inventors and their first arrival time - by birth region, 1961-2007

Year	Other Nordic countries	EU-19	Rest of Europe	Asia	Others	*Total*
1961-67	90 *(13/year)*	79 *(11/year)*	30 *(4/year)*	4 *(1/year)*	6 *(1/year)*	***209*** ***(30/year)***
1968	19	15	4	1	4	***43***
1969	**28**	**28**	7	2	3	***68***
1970	**26**	**43**	4	1	7	***81***
1971	9	9	3	6	4	***31***
1972-83	117 *(10/year)*	130 *(11/year)*	28 *(2/year)*	61 *(5/year)*	60 *(5/year)*	***396*** ***(33/year)***
1984	6	13	2	**15**	10	***46***
1985	5	14	5	**17**	2	***43***
1986	6	9	4	**22**	1	***42***
1987	3	11	5	**34**	7	***60***
1988	6	11	6	**25**	6	***54***
1989	12	8	3	**21**	6	***50***
1990	11	11	6	**23**	8	***59***
1991	6	11	6	15	**12**	***50***
1992	4	11	6	16	6	***43***
1993	3	12	**26**	10	1	***52***
1994	6	12	**12**	10	6	***46***
1995	5	**21**	3	7	9	***45***
1996	3	**29**	2	4	2	***40***
1997	6	**20**	1	8	4	***39***
1998	4	**22**	8	5	12	***51***
1999	4	**23**	8	9	9	***53***
2000	8	**25**	12	7	4	***56***
2001	7	20	5	3	5	***40***
2002	8	16	4	4	2	***34***
2003-07	17 *(3/year)*	43 *(9/year)*	6 *(1/year)*	9 *(2/year)*	17 *(3/year)*	***92*** ***(18/year)***
Total	***419***	***646***	***206***	***339***	***213***	***1,823***

Source: Statistics Sweden and CIRCLE data on inventors

Table A2. Observed reasons for settlement at the first time of filing - by birth region and first arrival time, 1961-2007

Year	Other Nordic countries		EU-19					Rest of Europe					Asia					Others					*Total*
	SE	**W**	**SE**	**W**	**F**	**S**	**O**	**SE**	**W**	**F**	**S**	**O**	**SE**	**W**	**F**	**S**	**O**	**SE**	**W**	**F**	**S**	**O**	
1961-67	56	-	48	-	-	-	-	26	-	-	-	-	4	-	-	-	-	4	-	-	-	-	***138***
1968	**12**	1	**13**	-	-	-	-	3	-	-	-	-	1	-	-	-	-	3	-	-	-	-	***33***
1969	**20**	-	**24**	-	-	-	-	4	-	1	-	-	1	-	-	-	-	3	-	-	-	-	***53***
1970	**17**	-	**33**	1	-	-	-	3	-	-	-	-	1	-	-	-	-	6	-	-	-	-	***61***
1971	5	-	9	-	-	-	-	3	-	-	-	-	4	-	-	-	-	1	-	-	-	-	***22***
1972-83	43	-	84	1	3	1	-	20	-	-	-	-	53	1	-	2	1	43	-	2	1	1	***256***
1984	2	-	6	2	-	-	-	2	-	-	-	-	**12**	-	-	1	1	**6**	-	-	2	-	***34***
1985	2	-	2	2	6	-	-	2	1	-	1	-	4	5	3	2	1	-	-	-	-	1	***32***
1986	1	-	-	4	5	-	-	-	-	1	-	3	4	1	2	3	**12**	1	-	-	-	-	***37***
1987	2	-	-	4	3	-	2	-	-	3	-	2	1	2	4	3	**24**	-	1	1	2	1	***55***
1988	1	-	-	2	5	1	1	-	-	1	-	4	-	-	5	4	**15**	-	-	6	-	-	***45***
1989	1	-	-	1	4	-	1	-	-	1	-	2	-	6	4	1	**9**	1	-	2	1	1	***35***
1990	-	-	-	4	6	1	-	-	2	3	-	1	1	3	4	7	**8**	-	3	4	-	1	***48***
1991	-	-	1	5	5	-	-	-	3	-	1	2	-	3	4	5	3	-	4	4	2	2	***44***
1992	-	-	-	3	6	2	-	-	2	1	1	2	-	4	2	5	5	-	2	2	2	-	***39***
1993	-	-	1	5	6	-	-	-	4	2	2	**18**	-	3	5	-	2	-	1	-	-	-	***49***
1994	-	-	-	5	2	2	3	-	1	1	1	**9**	-	4	1	5	-	-	1	3	1	1	***40***
1995	1	-	-	**10**	**8**	-	3	-	2	-	-	1	-	1	1	3	2	-	3	4	-	2	***41***
1996	-	-	1	**14**	**7**	3	3	-	1	-	1	-	-	1	2	1	-	-	2	-	-	-	***36***
1997	-	-	-	**10**	**9**	-	-	-	1	-	-	-	-	3	4	1	-	-	2	1	1	-	***32***
1998	-	-	1	**10**	**7**	3	1	-	5	3	-	-	-	-	-	5	-	-	3	6	1	1	***46***
1999	-	-	-	**13**	**9**	-	1	-	5	3	-	-	-	5	2	2	-	-	4	3	2	-	***49***
2000	1	-	-	**17**	**7**	1	-	-	8	2	2	-	-	3	1	2	-	-	1	1	1	-	***47***
2001	-	-	-	16	2	1	-	-	4	1	-	-	-	1	1	-	-	-	3	1	1	-	***31***
2002	-	-	-	12	2	2	-	-	2	-	2	-	-	2	-	2	-	-	-	2	-	-	***26***
2003-07	-	-	-	37	1	-	3	-	4	1	1	-	-	5	-	3	-	-	12	2	3	-	***72***
Total	***164***	***1***	***223***	***178***	***103***	***17***	***18***	***63***	***45***	***24***	***12***	***44***	***86***	***53***	***45***	***57***	***83***	***68***	***42***	***44***	***20***	***11***	***1,401***

Source: Statistics Sweden and CIRCLE data on inventors

Note: 1. "SE" means have obtained Swedish citizenship, "W" means work, "F" means family ties, "S" means study, "O" means the "other reasons".

2. Only consider the reasons for settlement at the first time of filing for foreign-born inventors if there were different reasons for settlement in different filing years for the same inventor.

3. Reasons for settlement are unknown for 422 foreign-born inventors, whose first immigration years are known (compared with Table A1).

Table A3: Determinants of NFC: comparison of subgroups of inventors who settled as permanent residents, immigrated before 1971 in different education levels, 1990-2007

Indep. Var.	1	2	3	4	5	6
	Edu	**Edu_1**	**Edu_2**	**Edu_3**	**Edu_all**	**Rest EU_P_bef71_edu**
BR (omit: Nordic)						
EU-19/Rest Europe/Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)						
Work/Family/Study/Other reasons	Yes	Yes	Yes	Yes	Yes	Yes
policy_1971	Yes	Yes	Yes	Yes	Yes	Yes
BR*PR*before_1971 (omit: EU-19*PR*before_1971)						
Rest Europe*PR*	1.006***	1.299***	0.669***	1.041***	0.880***	1.475***
before_1971	(0.296)	(0.299)	(0.223)	(0.327)	(0.261)	(0.259)
Asia*PR*before_1971	-0.355*	-0.380	-0.642**	-0.146	-0.919***	-0.328
	(0.204)	(0.240)	(0.268)	(0.150)	(0.331)	(0.209)
Others*PR*before_1971	Yes	Yes	Yes	Yes	Yes	Yes
Edu level (omit: long post-2nd)						
Short post-2nd	-0.455***	-0.382***	-0.394***	-0.456***	-0.374***	-0.383***
	(0.099)	(0.101)	(0.099)	(0.099)	(0.102)	(0.099)
Phd	Yes	Yes	Yes	Yes	Yes	Yes
BR*PR*before_1971*edu level (omit:EU-19*PR*before_1971*edu level)						
BR*PR*before_1971*short post-2nd						
Rest Europe*PR*		-0.741**			-0.322	-0.911***
before_1971*short post-2nd		(0.289)			(0.241)	(0.250)
Asia*PR*		0.473*			1.014***	
before_1971*short post-2nd		(0.263)			(0.349)	
Others*PR*		-0.477			-0.703*	
before_1971*short post-2nd		(0.311)			(0.362)	
BR*PR*before_1971*long post-2nd						
Rest Europe*PR*before_1971*			0.799***		0.599**	
long post-2nd			(0.238)		(0.277)	
Asia*PR*before_1971*			0.492*		0.771**	
long post-2nd			(0.253)		(0.316)	
Others*PR*before_1971*			-0.108		-0.354	
long post-2nd			(0.288)		(0.328)	
BR*PR*before_1971*Phd						
Rest Europe*PR*before_1971*				-0.197	-	-0.602**
Phd				(0.346)		(0.276)
Asia*PR*before_1971*				-0.791**	-	
Phd				(0.316)		
Others*PR*before_1971*				0.437	-	
Phd				(0.306)		
No. of inventors	0.104***	0.105***	0.105***	0.104***	0.105***	0.105***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	-0.065	-0.110	-0.111	-0.062	-0.117	-0.117
	(0.212)	(0.211)	(0.210)	(0.211)	(0.210)	(0.210)
Chi-square	382	396	434	418	450	427
Log likelihood	-7,824	-7,818	-7,817	-7,822	-7,815	-7,817

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

Note: same as 1-5 in Table 6-A

Table A4: **Determinants of NFC: comparison of subgroups of foreign-born inventors who settled for work in different education levels, 1990-2007**

Indep. Var	**1**	**2**	**3**	**4**	**5**	**6**
	Edu	**W_edu_1**	**W_edu_2**	**W_edu_3**	**W_edu_all**	**Rest_EU_w_edu**
BR (omit: Nordic)						
EU-19/Rest Europe/ Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes
Rea for set (omit: PR)						
Work/Family/Study	Yes	Yes	Yes	Yes	Yes	Yes
Other reasons	-0.250*	-0.262*	-0.254*	-0.246	-0.278*	-0.261*
	(0.152)	(0.152)	(0.152)	(0.151)	(0.152)	(0.151)
Edu level (omit: long post-2nd)						
Short post-2nd	-0.497***	-0.543***	-0.483***	-0.496***	-0.529***	-0.534***
	(0.114)	(0.113)	(0.116)	(0.115)	(0.115)	(0.110)
Phd	Yes	Yes	Yes	Yes	Yes	Yes
BR*work*edu level (omit: Asia*work*edu level)						
BR*work*short post-2nd						
EU-19*work*		0.419			0.564	
short post-2nd		(0.352)			(0.438)	
Rest Europe*work*		1.413***			1.465***	1.372***
short post-2nd		(0.211)			(0.355)	(0.247)
Others*work*		0.128			0.299	
short post-2nd		(0.522)			(0.581)	
BR*work*long post-2nd						
EU-19*work*			0.334		0.455	
long post-2nd			(0.214)		(0.333)	
Rest Europe*work*			-0.986***		-0.820*	
long post-2nd			(0.302)		(0.420)	
Others*work*			-0.29		-0.092	
long post-2nd			(0.310)		(0.397)	
BR*work*Phd						
EU-19*work*Phd				-0.224	0.039	
				(0.193)	(0.298)	
Rest Europe*work*				-0.299	-0.059	-0.124
Phd				(0.328)	(0.411)	(0.317)
Others*work*Phd				0.268	0.485	
				(0.226)	(0.313)	
No. of inventors	0.103***	0.103***	0.104***	0.105***	0.104***	0.103***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	-0.01	-0.002	-0.018	-0.034	-0.018	-0.008
	(0.231)	(0.231)	(0.231)	(0.229)	(0.230)	(0.230)
Chi-square	352	556	374	369	603	568
Log likelihood	-7,849	-7,840	-7,841	-7,845	-7,829	-7,840

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

Note: same as 1-5 in Table 6-A