Abstract

Yannu Zheng: Ph.D. candidate
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Sweden has long enjoyed a good reputation in the world for its openness, advanced technology and strong innovation capability. To maintain its leading position in research and innovation, attracting talented scientists and engineers, especially like inventors, who are strong drivers of technology advance and innovation, from other countries is extremely important for Sweden because of its limited local population resource. Therefore, it is crucial to get a more detailed understanding of demographic and social characteristics of foreign-born inventors, the relation between these characteristics and their invention performance and their role in contributing to technological progress and invention in Sweden. This could help the companies and policy makers adopt more effective policies to attract and inspire their potential inventive passion and promote Swedish technology development. However, until now, very little attention has been paid to foreign inventors by academic researchers.

Differing from earlier studies which usually just compare the performance of foreign-born inventors with local ones based on a limited set of variables, case studies and/or surveys in the USA (No and Walsh, 2008; Walsh and Nagaoka, 2009; Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010), we compare foreign inventors themselves by birth country in this paper. Moreover, we dig into their characteristics and backgrounds which could be strongly related to their performance. This has never been done before, mainly due to lack of data and limited attentions. Thanks to a newly compiled long-run and rich dataset which comprises matched patent information and individual demographics provided...
by the population register of Sweden 1978-2009, this can be performed. In the new dataset, matching of foreign
inventors is based on patents filed at the European Patent Office (EPO) with individual register data maintained by
Statistics Sweden using name and address. The basic characteristics of the foreign inventors are described by summary
statistics and regression analysis to explore the relationship between characteristics of foreign inventors and their
inventive performance.

According to the study, over the period 1978-2009, 2557 foreign inventors from ten different country groups were found
in Sweden, which amounts to 11.18% of the total share of Swedish inventors (here refer to who reside in Sweden at the
time when their patents were filed at the EPO. They may have or not have personal number. It includes both Swedish
local and foreign inventors), and they participated in 15.36% of the total Swedish patent applications in EPO. Among
them, 37.35% are from EU25 (excluding Denmark, Finland and Sweden), followed by the Nordic countries (excluding
Sweden) (28.43%), Asia (14.67%), Europe (except EU25 and the Nordic countries) (9.78%), North America (3.4%),
South America (2.11%), Africa (1.96%) etc. By studying their reasons for settlement in Sweden, we found that work,
family ties and studies are the top three reasons, which is different from different groups. We also found that their
demographic characteristics are quite different. For example, the rate of female inventors from the Asia group reaches
17.39%, while for EU25 and Nordic countries, their rates are only 8.28% and 8.56%. In addition, the average age of
inventors from the Nordic countries is 48 years old, while it is only 36 years for the ones from Oceania. Even more
discriminating is the gross yearly income. The groups from lowest groups of Oceania and Asia only make up 9.5% and
26.8% of the highest group from EU25. The obvious imbalances in the age and gross yearly income among different
groups are partly explained by the variation in shares of the female inventors, whose average age is much younger than
the male ones (41.3: 45.7) and whose gross yearly salary is much lower (9562:33159 kr) for all groups.

Key words: demographic characteristics, immigrating inventors, Sweden

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Characteristics of Foreign-born Inventors in Sweden
Yannu Zheng¹ Olof Ejermo²

This is a very primary paper, please quote only after permission.

Abstract
This paper describes the demographic characteristics and invention performance of the foreign-born inventors and compares them with the Swedish-born ones as well as the foreign-born ones themselves according to their birth regions. The paper indicates that 11.0% of the inventors resided in Sweden were born abroad and they contributed 11.7% of the Swedish patent applications filed in EPO over the period of 1985-2007. The paper shows that the distribution of numbers and shares of inventors, invention performance, gender, age, salary, education levels and fields of educations are quite different from the Swedish-born and foreign-born inventors as well as the foreign-born ones from different groups. The paper also reveals that work, family ties and study are the most important three reasons for settlement for the foreign-born inventors. At last, the paper indicates that the invention productivity is quite similar by the foreign-born and Swedish-born inventors.

Key words: demographic characteristics, immigrating inventors, Sweden

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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
I. Introduction

Sweden is famous for its openness, advanced technology and strong innovation capability. To maintain its leading position in research and innovation, attracting talented scientists and engineers, especially like inventors, who are strong drivers of technology advance and innovation, from other countries is extremely important for Sweden because of its limited local population resource. Therefore, it is crucial to get a more detailed understanding of demographic and social characteristics of foreign-born inventors, the relation between their characteristics and invention performance, their role in contributing to technological progress and invention in Sweden. This could help companies and policy makers adopt more effective policies to attract more creative foreign-born inventors, inspire their invention potential and promote Swedish technology development. However, until now, very little attention has been paid to foreign-born inventors by academic researchers.

Differing from earlier studies which usually just compare the performance of foreign-born inventors with local ones based on a limited set of variables, case studies and/or surveys in the USA (Stephan, Grant and Shiferaw, 2005; No and Walsh, 2008; Walsh and Sado, 2009; Hunt and Gauthier-Loiselle, 2010; No and Walsh, 2010), we also compare foreign-born inventors themselves by birth region in this paper. Moreover, we dig into their characteristics and backgrounds which could be strongly related to their performance. This has never been done before, mainly due to lack of data and limited attentions. Thanks to a newly compiled long-run and rich dataset which comprises matched patent information and individual demographics provided by the population register of Sweden 1985-2007, this can be performed. The basic characteristics of the foreign-born inventors are described by summary statistics to explore the relationship between characteristics of foreign inventors and their inventive performance.

The paper is organized as follows: in the next section, some earlier work related to my paper is surveyed. Section 3 describes the data used in this paper. Section 4 is the description and
comparison of the characteristics and invention performance of foreign-born and Swedish-born inventors. The last one is the discussion of policy implication and conclusion.

II. Literature Review

Globalization and migration is a strong trend in modern society. Along with it, more and more advanced technological talents migrate between different countries and contribute to the technology development in the countries they move to. This phenomenon also has attracted some researchers’ attention to analyze how these skilled immigrants contributing to the invention and innovation development in the host countries. For example, Guellec and van Pottelsberghe de la Potterie (2001) revealed that from 1993 to 1995, the shares of patent applications at EPO (USPTO) owned by foreign residents in total patents invented domestically in US, European Union and OECD were 5.0%, 6.5% and 11.7% (2.6%, 18.9%, 8.4%), respectively. Levin and Stephan (1999) indicated that the heavy inflow of foreign talent, especially since the 1970s, is changing the face of American science. They found that in 1980, less than one out of five doctoral scientists in the scientific labor force in the US was born abroad, while in 1990, the rate increased to one out of four. Their research shows that the US has benefited from the inflow of foreign-born talent. Moreover, by collecting detailed information on a sample of inventors in the US, Walsh and Sadao (2009) found that foreign-born inventors share almost 30% of the total inventors in the US. Their result even shows that inventions by foreign-born inventors have higher value, and the gap is even larger when comparing the most educated foreign-born and native-born inventors. This result is also proved by No and Walsh (2010), who found that scientists and engineers born outside of the US play a major role not only in scientific output but also in innovation output in the US. They indicated that the quality of the patents by lead inventors born outside of the US is higher on average, although the foreign-born individuals are no more likely to invent. Moreover, the contribution of foreign-born inventors in the US could be even larger if taking possible spillover effects into account. These indicate that the large number of foreign-born inventors is a source of strength in the US innovation system (No and Walsh 2008).
Furthermore, some studies paid special attention to invention performance of the foreign-born college graduates in the US. For example, the 2003 National Survey of College Graduates shows that college graduate immigrants in the US patent at double the native rate, and that this is entirely accounted for by their disproportionately holding degrees in science and engineering. This result is supported by Hunt and Gauthier-Loiselle (2010). Using a 1940-2000 state panel, they showed that immigrants do have positive spill-overs, resulting in an increase in patents per capita of nine to eighteen percentages in response to a one percentage point increase in immigrant college graduates. They also found that immigrants who are scientists and engineers, or who have postcollege education, boost patents per capita more than college graduate immigrants. Chellaraj, Maskus and Mattoo (2008) also indicated that the presence of foreign graduate students has a significant and positive impact on both future patent applications and future patents awarded to university and non-university institutions. By using a model of idea generation, their central estimates suggest that a 10% increase in the number of foreign graduate students would raise patent applications by 4.5%, university patent grants by 6.8% and non-university patent grants by 5.0%. In addition, they found that increases in skilled immigrants have a positive, but smaller impact on patenting than foreign graduate students. Stephan et al. (2005) even found the relationship between patent counts and international PhDs who are permanent residents is positive and significant, while it is negative for those on temporary visas. On the other side, patents depend positively on the presence of international post-doctoral students. Therefore, No and Walsh (2010) suggested the government be wary of negative affect of restriction of visa for foreign-born talents who contribute a lot to the US innovation system. In particular, they suggested that the government should continue to allow high-skilled immigrants, especially those with degrees from US graduate schools, the opportunity to work in the US in order to capture the returns from US investment in training those with graduate degrees.

The reasons why immigrants, especially foreign college graduates make exceptional contribution to technology and invention development in the US could be as follows: first, high skilled and educated people are usually more likely to move than the less skilled and
educated ones and easier to get visa and work permit in the US; second, foreign-born scientists and engineers who come to the US to receive training, especially at the doctoral or postdoctoral level, are typically among the most able of their contemporaries; third, some evidence suggests that the average quality of US-born individuals choosing to get doctorates in S&E has declined during the past three decades as the bright native students devoted more to the more lucrative careers such as business, law and medicine (Stephan and Levin, 2001). It offers more chances for the foreign-born students in S&E field, where limitations such as language and culture are less obvious.

As seen from the above literature, most of it focuses on studying the performance of foreign-born inventors in the US, while very little of it pays attention to the situation in the Europe, not to mention of Sweden, which is also a country with high rate of immigrants, with 1.43 million people or 15.1% of foreign-born inhabitants in 2011 (Population statistics, 2012).

III. Data

Patent is the most commonly used indicator of invention in current innovation studies (Griliches 1990) and applied in this paper as it has lots of unique advantages (Griliches, 1990; OECD, 1994; Smith, 2005, p159). For example, the patent data offer systematical records of inventions; they almost cover every field of technology and offer very detailed classification; patent documents also include many interesting details, such as application year, assignee, name and address of inventors, backward and forward patent citations and so on, which are rich sources for various types of analysis. Moreover, as patents documents are legal files, the statistical processing of patent data is largely free of errors. However, patent data also have a lot of shortcomings. For example, not all inventions are patentable and patented; the inventions that are patented differ greatly in "quality"; the economic value of patents is highly skewed; plenty of them are even never translated into commercially viable products and processes; the propensity to patent differs significantly across firms and industries, which is due to the differences in the effectiveness of patent

We collected almost all of the Swedish patents filed at European Patent Office (EPO) from 1985 to 2007. The matching of inventors who resided in Sweden when their patent applications were filed in EPO is based on filed patents at EPO with individual register data maintained by Statistics Sweden using name and address. There are three important reasons for the particular EPO patent database selected. First, data there are more plentiful as lots of patents bypass Swedish patent office but directly apply in EPO. Second, EPO patent documents contain detailed data on inventors’ addresses, making it much easier to match against the Swedish register data than data from other database such as United States Patent and Trademark Office (USPTO). Third, as it is very expensive to apply for a patent in EPO, it is believable that the patents there are valuable to some extent (Ejermo, 2011). That is also one reason why we can use the application data but do not need to use granted ones. The more important reason to use application data is that it usually takes around five years for a patent to be granted since it is filed. As the time period and observations in our data are limited, we prefer to use the application data to keep more observations.

In total, over the period of 1985-2007, there are 73 356 invention observations in our database. Among them, 58 173 observations have been identified by Swedish personal number and the match rate reaches 79.3% (see Table 1 below). Among the identified ones, we find 2295 foreign-born inventors (11.0%) with 6768 invention observations (11.6%). These identified 2295 foreign-born inventors participated in amount of 6150 inventions, which share 17.9% of total amount of Swedish inventions filed in EPO. If we calculate the identified inventions by fractional count, we can find that the share of the inventions invented by foreign-born inventor reaches 11.7% of total identified Swedish inventions, which is a little bit higher than their share of identified inventors resided in Sweden (11.0%). This implies that, although there could be like culture and language obstacles, the output of inventions by foreign-born inventors is as high as the local ones according to the amount of inventions.
### Table 1. Data statistics, 1985-2007

<table>
<thead>
<tr>
<th></th>
<th>Identified foreign-born</th>
<th>Identified Swedish-born</th>
<th>Total identified</th>
<th>Unidentified</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No. of obs.</td>
<td>6768</td>
<td>51405</td>
<td>58173</td>
<td>15183</td>
<td>73356</td>
</tr>
<tr>
<td>Share of total obs.</td>
<td>9.2%</td>
<td>70.1%</td>
<td>79.3%</td>
<td>20.7%</td>
<td>100%</td>
</tr>
<tr>
<td>Share of identified obs.</td>
<td>11.6%</td>
<td>88.4%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of identified inventors</td>
<td>2295</td>
<td>18536</td>
<td>20831</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of identified inventors</td>
<td>11.0%</td>
<td>89.0%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute No. of participated app., &gt;= 1 obs. in an app. has/have been identified</td>
<td>6150</td>
<td>31564</td>
<td>34405</td>
<td>11577*</td>
<td>39600#</td>
</tr>
<tr>
<td>Share of participated app., &gt;= 1 obs. in an app. has/have been identified</td>
<td>17.9%</td>
<td>91.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fractional count of identified app. participated by inventors resided in Sweden</td>
<td>3438</td>
<td>25971</td>
<td>29409</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of fractional count of identified app. participated by inventors resided in Sweden</td>
<td>11.7%</td>
<td>88.3%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** MONA database, Statistics Sweden

**Note:**
1. “obs.” refers to observations; “app.” refers to applications; it is the same in the following paper.
2. * at least >=1 obs. is/are unidentified in a patent application.
3. # total number of patent applications, which could be partly/totally identified or unidentified in each application.

### IV. Descriptive Analysis

1. **Component of the foreign-born inventors from different countries**

According to the birth regions of the foreign-born inventors, we divide them into ten groups (see Table 2). Among these groups, the largest share of foreign-born inventors is from EU25 (excl. DK, FI & SE) (hereinafter to be referred as EU25), which reaches 36.86%, followed by the ones from Nordic countries (excl. SE) (hereinafter to be referred as Nordic countries), Asia, and Europe (excl. EU25 & Nordic countries) (hereinafter to be referred as Europe), which shares are 27.80%, 15.29% and 9.76%, respectively. The ones from the other five groups, Former Soviet Union, Africa, North America, South America, Oceania and unknown only share the left 10.28% of foreign-born inventors. The shares of inventions participated by each group of foreign-born inventors are quite similar as their shares of inventors, except for the inventors from Nordic countries and EU25, which are 1.96% underrepresented and 1.64% overrepresented. This implies that the average output of inventions by inventors from different countries is quite similar.
Table 2. Number and share of foreign-born inventors and the inventions participated by them - by birth regions, 1985-2007

<table>
<thead>
<tr>
<th>Birth-region</th>
<th>No. of inventors</th>
<th>Share of inventors (1)</th>
<th>No. of obs.</th>
<th>Share of obs. (2)</th>
<th>Gap= (2)-(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic countries (excl. SE)</td>
<td>638</td>
<td>27.80%</td>
<td>1749</td>
<td>25.84%</td>
<td>-1.96%</td>
</tr>
<tr>
<td>EU25 (excl. DK, FI &amp; SE)</td>
<td>846</td>
<td>36.86%</td>
<td>2606</td>
<td>38.50%</td>
<td>1.64%</td>
</tr>
<tr>
<td>Europe (excl. EU25 &amp; Nordic countries)</td>
<td>224</td>
<td>9.76%</td>
<td>670</td>
<td>9.90%</td>
<td>0.14%</td>
</tr>
<tr>
<td>Asia</td>
<td>351</td>
<td>15.29%</td>
<td>1019</td>
<td>15.06%</td>
<td>-0.24%</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>38</td>
<td>1.66%</td>
<td>130</td>
<td>1.92%</td>
<td>0.27%</td>
</tr>
<tr>
<td>Africa</td>
<td>49</td>
<td>2.14%</td>
<td>148</td>
<td>2.19%</td>
<td>0.05%</td>
</tr>
<tr>
<td>North America</td>
<td>81</td>
<td>3.53%</td>
<td>281</td>
<td>4.15%</td>
<td>0.62%</td>
</tr>
<tr>
<td>South America</td>
<td>51</td>
<td>2.22%</td>
<td>117</td>
<td>1.73%</td>
<td>-0.49%</td>
</tr>
<tr>
<td>Oceania</td>
<td>16</td>
<td>0.70%</td>
<td>44</td>
<td>0.65%</td>
<td>-0.05%</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>0.04%</td>
<td>4</td>
<td>0.06%</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

**Total** 2295 100% 6768 100%

**Source**: MONA database, Statistics Sweden

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

Figure 1 shows that generally the number of foreign-born inventors was growing year by year over the period of 1985-2007, and reaching its peak in 2006. However, their growing trends among the different groups are quite different. The number of inventors from European countries grew very fast, especially the ones from EU25 since 1995. The situation was quite similar for the group of Asia. There was also a bit growth for the group of North America since 1993 but is not that obvious and stable. The growing trends for the other groups such as Africa, South America and Former Soviet Union were very small and unstable, which even could be negligible.
Different from the obvious growing number of the foreign-born inventors from Nordic countries and EU25, their shares in the total amount of foreign-born inventors were generally decreasing over the period (see Figure 2). The shares of foreign-born inventors from Nordic countries decreased from its highest share of 40.9% in 1990 to 19.6% in 2007. The shares of EU25 group also decreased from its highest share of 59.0% in 1985 to 35.9% in 2007. On contrary, the shares of foreign-born inventors from Europe and Asia were generally growing, especially for the group of Asia, which share grew quite dramatically from 6.6% in 1987 to 19.6% in 2007 with a little drop in 1991. Europe also grew from 2.0% from 1985 to 10.6% in 2007 with a small drop in 1994. Among the left six groups, North America enjoyed the highest share and kept quite stable from 2.0% in 1985 to 5.3% in 2007, followed by Africa and South America. The foreign-born inventors from Former Soviet Union were used to be active from 1992 to 1997 with its highest share 6.9% in 1993, but became much less active later. The inventors from Oceania started participating in invention in Sweden in 1995. Since 2000, they also
became a stable group of foreign-born inventors in Sweden although their share was still quite low.

![Graph showing share of foreign-born inventors by birth regions, 1985-2007](image)

**Figure 2. Share of foreign-born inventors in each year - by birth regions, 1985-2007**  
*Source: MONA database, Statistics Sweden*

**Immigrating and emigrating of the foreign-born inventors**

Now there is quite a lot of discussion about the effect of immigrations to Sweden. A dominant viewpoint is that on average, immigrations place a large burden to the public sector (Gustafsson, Österberg, 2000; Storesletten, 2003; Eger, 2010). However, they also pointed out that different types of immigrants have different effect which is highly related to their age structure and labour market situation (Ekberg, 1999; Storesletten, 2003). For example, immigrants between the age of 20 to 30 represent a positive gain for Sweden, while ones older than 50, the net cost is substantial (Storesletten, 2003). During the 1950s to 1970s, the immigrants had positive income effects for the native Swedes. Nowadays there are negative effects due to deteriorating employment situation among immigrants (Ekberg, 1999). In addition, Gustafsson and Österberg (2000) pointed out that although
on average immigrants have a burden on the public sector budget but after a few years their negative effect on public financial can decrease.

In earlier studies, they did not distinguish the different types of immigrants such as according to their reasons for settlement in Sweden when they calculate the average effect of immigrants. Refugees, who play a large share of immigrants in Sweden and many of them never enter the labour market, initially put a large burden on the public sector budget than other immigrants (Gustafsson and Österberg, 2000). However, according to our data, only 8.8% of foreign-born inventors came to Sweden because of the reason of need for protection (see Table 3) over the period of 1990 to 2007, which includes refugees. Moreover, among all of the 6768 observations, we find that 91.4% of them were employed in their patent application filing years and their average age was 45.6 years old (see Table 4). This implies that most of the foreign-born inventors are young workers in Sweden and it is believable on average they have contributed to the public finance rather than been a burden for it.

According to our data, we matched the immigrating years for 1926 foreign-born inventors (83.9% of all foreign-born inventors) and find they immigrated 2168 times over the period of 1961-2007. Among these inventors, 88.6% of them just immigrated into Sweden once, 10.4% of them immigrated twice, 0.9% of them immigrated three times and 0.1% of them immigrated even four times. We also find 294 foreign-born inventors (12.8% of all foreign-born inventors) had emigrated from Sweden for 337 times between 1968 and 2007. Among these 294 inventors, 88.8% of them emigrated by once, 10.5% of them emigrated by twice, 1.4% of them emigrated by three times and 0.3% emigrated by five times. Figure 3 shows that there were many more foreign-born inventors immigrating into Sweden than the ones emigrating out every year between 1968 and 2006. This implies that Sweden is an attractive country for the foreign-born inventors.

During 1968 to 1970, immigration of foreign-born inventors reached its peak, which was about three times more than 1966 and 1971. This follows the main trend of immigration in Sweden (Westin, 2000). From Figure 4, we can see that it is mainly because more
foreign-born inventors from Nordic countries and EU25 immigrated into Sweden during that period. That is possibly because since the end of the 1940s, Swedish export industry became flourished and there was a constant shortage of labour and foreigners were welcome to work there. In particular, in 1954 the five Nordic countries set up a common labour market, abolishing restrictions on the movement of manpower between the countries. This treaty made large-scale immigration from Finland, Norway and Denmark to Sweden (Westin, 2000). In addition, probably because of Prague Spring and crisis in Czechoslovakia since 1968, a lot of refugees from Eastern Europe immigrated into Sweden between 1968 and 1970 (Ekberg, 1994). However, in the early 1970s, thoughts about curbing labour migration began to appear simultaneously in Western Europe. Labour immigration to Sweden from non-Nordic countries came to an end in 1972. The Labour Organization in Sweden objected to further labour immigration, which marked the end of free immigration to Sweden (Ekberg, 2000).

Figure 4 also shows a big increase in the number of immigrants who later became inventors from Asia between 1984 and 1992. These people probably came to Sweden as refugees from the Middle East, such as countries of Lebanon and Syria, Iran and Iraq. Among them, the largest group from the Middle East is the Iranians, mainly consisting of young urban middle class families, many of them are academics and intellectuals from Teheran (Westin, 2000). In 1993, there were more immigrants from Europe than any other time during the whole period. This probably was caused by the breakdown of the Yugoslav federation and a series of wars there, which generated the highest wave of refugees from Eastern Europe after World War II. It also generated a high number of asylum seekers from the former Yugoslav republics, which amounted to 85,000 in 1992 in Sweden. The situation is similar for Albanians from Kosovo and Bosnians in 1993. This is reflected in Table 3, from which we can find that during the period 1990-1999, there is 3.7% of foreign-born inventors from Europe came to Sweden because of need for protection, which is the second important reason for them during that period.
In addition, the big increase of foreign-born inventors from EU25 between 1995 and 2002 also contributed a lot to the small sharp of immigrants during that period. This is mainly because the EEA treaty started to apply in Sweden in 1994 and Sweden joined the EU in 1995 (Westin, 2000), which make the migration of manpower much easier. However, since 2003, the number of immigrants decreased very fast.

Comparing with the big rise and fall of the number of immigration of inventors, the number of foreign-inventors emigrated from Sweden was quite stable until 2005 but with a big increase in 2006 and 2007 (see Figure 5). There were more foreign-born inventors from European countries from 2006 to 2007 and Asia in 2007 emigrating out of Sweden. However, the inventors from Nordic countries were mainly more frequently to move out than the ones from other countries. That may be because it is easier for them to move in and out of Sweden than the ones from other countries.

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**Figure 3. Number of foreign-born inventors immigrated into and emigrated from Sweden, 1961/1968-2007**

*Source: MONA database, Statistics Sweden*
Figure 4. Number of foreign-born inventors immigrated into Sweden -by birth regions, 1961-2007
Source: MONA database, Statistics Sweden

Figure 5. Number of foreign-born inventors emigrated from Sweden -by birth regions, 1968-2007
Source: MONA database, Statistics Sweden
2. **Reasons for settlement for the foreign-born inventors**

When digging into the reasons for settlement for the foreign-born inventors in Sweden in their patent application filing years from 1990 to 2007 (see Table 3), we find that work, family ties and study are the top three reasons for them to settle down in Sweden, which shares reach 48.0%, 22.2% and 15.2%, respectively. In addition, there are 8.8% of foreign-born inventors settled for protection, 2.7% of them for humanitarian reasons and 3.1% for other reasons such as pensioners/ persons with sufficient funds, short term conditions because of difficulties to order a person to leave the country, misconduct or medical reasons. When looking at the different periods, we can see that work is still the most important reason for both periods 1990-1999 and 2000-2007. However, for the first period, study was the second important reason rather than the family ties.

Comparing the reasons for settlement for the foreign-born inventors among different groups over the period 1990-2007, we find they varied a lot. Instead of work, which was the most important reason for settlement for most of groups, family ties worked as the most important reason for the group of Africa and North America, which reached 43.6% and 57.4% respectively. Meanwhile, work ranks as the second important reason for both of them (38.2% and 34.9%). Family ties worked as the second important reason only for EU25 (26.1%) and Former Soviet Union (31.4%), but worked as the third and fourth important reason for groups of South America (14.6%) and Oceania (21.4%), Europe (12.1%) and Asia (12.7%). For groups like Europe, Asia, South America and Oceania, study was the second important reason, which reached 16.4%, 29.7%, 24.4% and 35.7%, respectively. For groups of Asia (24.5%) and Africa (10.9%), need for protection was the third important reason, which is more important than any other groups. A large part of them are refugees from countries like Iran and Iraq and Somalia. Humanitarian reason is especially important for the group of Europe, which reached 13.3% and ranked as the third important reason. It is also quite important for the groups of Former Soviet Union (9.8%) and South America (4.9%), which ranked as the fourth important reason for them.
Others reason is more important for the group of EU25 (6.5%) than any other groups which ranked as the third important reason.

When divide the periods into two, we find the reasons for settlement for different groups are also quite different. During the period of 1990 to 1999, we find that work is the most important reason for all of the identified groups except for South America and Africa, which most important reasons were study (9.8% and 1.8%) and family ties (1.8%). During the period of 2000 to 2007, family ties became the most important reason for groups of Former Soviet Union (9.8%), Africa (41.8%) and North America (51.2%) instead of work. Family ties was the second important reason for EU25 (2.8%) and North America (6.2%) in the first period, and for EU25 (23.3%) and South America (14.6%) in the second period. However, it only worked as the fourth one for the groups of Europe (10.5%) and Asia (11.0%) in both periods. Study worked as the second important reason for settlement for the groups of Europe (13.0%), Asia (23.9%), South America (14.6%) and Oceania (35.7%) in the second period. It is the same for the groups of Asia (5.8%) and Former Soviet Union (3.9%) in the first period. Study worked as the third important reason for groups of EU25 (2.2%) and Europe (3.4%) in the first period, and so it did for the groups of Former Soviet Union (9.8%) and North America (5.4%) in the second period. The interesting thing is that need for protection ranked as the second important reason for group of Europe (3.7%), the third one for the group of Former Soviet Union (2.0%) in the first period, Africa (10.9%) in the second period and Asia for both periods (5.0% and 19.5%, respectively). This is mainly because of series of wars and a long-time political repression in these places forcing the intellectuals there to look for protection in other humanitarian countries such as Sweden. In addition, humanitarian reasons ranked as the third important reason for the groups of Europe (12.4%) and Former Soviet Union (9.8%), which were more important than any other groups. In particular, other reasons enjoyed a larger share for the group of EU25 in both periods than any other groups.
Table 3: Settlement reasons for the foreign-born inventors in their application filing years - by birth regions, 1990-2007

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>W F S P H O Sub</td>
<td>W F S P H O Sub</td>
<td>W F S P H O Sub</td>
</tr>
<tr>
<td>Nordic countries (excl. SE)</td>
<td>- - - - - - 1</td>
<td>- - - - - - 1</td>
<td>- - - - - - 1</td>
</tr>
<tr>
<td>EU25 (excl. DK, FI &amp; SE)</td>
<td>102 31 24 6 - 12 175</td>
<td>570 260 46 5 - 60 941</td>
<td>672 291 70 11 - 72 1116</td>
</tr>
<tr>
<td>Europe (excl. EU25 &amp; Nordic countries)</td>
<td>27 6 12 13 3 - 61</td>
<td>151 37 46 13 44 2 293</td>
<td>178 43 58 26 47 2 354</td>
</tr>
<tr>
<td>Asia</td>
<td>49 12 40 35 1 137</td>
<td>165 76 166 135 12 3 557</td>
<td>214 88 206 170 13 3 694</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>6 2 1 9</td>
<td>14 16 5 1 5 1 42</td>
<td>20 16 7 2 5 1 51</td>
</tr>
<tr>
<td>Africa</td>
<td>- - - - - - 2</td>
<td>21 23 2 6 1 - 53</td>
<td>21 24 3 6 1 - 55</td>
</tr>
<tr>
<td>North America</td>
<td>10 8 1 1 - 20</td>
<td>35 66 7 1 - 109</td>
<td>45 74 8 2 - 129</td>
</tr>
<tr>
<td>South America</td>
<td>2 - - 4 9</td>
<td>48.8% 14.6% 24%</td>
<td>35</td>
</tr>
<tr>
<td>Oceania</td>
<td>- - - - - - - 2</td>
<td>18 2 15</td>
<td>4.9%</td>
</tr>
<tr>
<td>Unknown</td>
<td>- - - - - - - 4</td>
<td>100 %</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>196 58 84 56 4 12 410</td>
<td>999 493 293 162 64 66 2077</td>
<td>1195 551 377 218 68 78 2487</td>
</tr>
</tbody>
</table>

Source: MONA database, Statistics Sweden

Note: 1.”W” refers to Work; “F” refers to Family ties; “S” refers to Study; “P” refers to Protection; “H” refers to Humanitarian reasons; “O” refers to Others; “Sub” refers to Subtotal.

2. Total number of observations is 6768.

3. The reasons for settlement data in Mona is only available from 1990, therefore, the observations which application filing year before 1990 is not known. The Number for such observations is 592.

4. Data is unavailable for those who have changed their citizenship to Sweden before their application filing years as reasons for settlement data are only recorded for non-Swedish. The Number for such observations after 1990 is 2341.

5. Immigrants who are citizens of a Nordic country do not need a residence permit to stay in Sweden, therefore, the settlement reasons are unavailable for these people. The Number for such observations after 1990 is 796. There is one observation from Nordic countries. This is because the person who was born in one of Nordic countries has changed his/her nationality to one of EU25 when he immigrated into Sweden.

6. There are 552 observations that we cannot find their reasons for settlement in Mona except the above reasons. Among them, 292 obs. are during the period 1990-1999, 260 obs. are during the period 2000-2007. Therefore, the real identified share of reasons for settlement which should be identified during 1990 to 1999 is 410 / (410+292) = 58.4%, during 2000-2007 is 2077 / (2077+260) = 88.9%.

7. Grouping principles of reasons for settlement here is according to the basis of settlement grouped by Statistics Sweden before 2005.

8. “Others” refers to reasons such as short term conditions because of difficulties to order a person to leave the country, misconduct or medical reasons.
3. Gender, age and salary distribution among the Inventors resided in Sweden

With the development of economy and society, women’s social status has been greatly improved. They obtain more chances to receive advanced education as well as play more and more important roles in the science and technology development as men. As a country pays a lot attention to equity, it is interesting to check whether the inventors by different gender and different countries in Sweden perform equally and whether they really share the equal treatment.

From Table 4, we can see that not only the distribution of number of inventors and their performance in invention within and between different groups are quite uneven, but also the distribution of inventors by gender and their salary are quite unbalanced over the period of 1985 to 2007. Female inventors only share 8.1% of all inventors resided in Sweden. This result is quite similar as the one found by Frietsch et al. (2009), who revealed that from 2003 to 2005, Swedish women’s contribution to patent applications in EPO was 7.6%. The share of foreign-born female inventors is much higher than the Swedish-born ones, which is 11.2% vs. 7.8%. Moreover, among the different groups, female inventors from Asia share the highest rate than any other groups, which reaches 17.0%, followed by Former Soviet Union (15.8%), Europe (15.5%), Africa (14.3%), North America (12.7%), South America (11.8%), EU25(9.5%) and Nordic countries (8.5%).

However, the invention performance of the female inventors from all groups is even worse than their shares of the amount of inventors except the ones from Africa. On average, they only participated in 6.6% of all Swedish inventions. The output of inventions by foreign-born female inventors was still a little higher than ones by the Swedish-born ones, but the gap between them was smaller than the gap of their shares of inventors (1.9% vs. 3.4%). Among the different groups of foreign-born female inventors, the ones from Europe are most inactive in invention performance according to the gap between their shares of inventors and inventions (-7.7%=7.8%-15.5%), followed by
Former Soviet Union (-5.0%=10.8%-15.8%) and North America (-4.1%=8.6%-12.7%) etc.

The average age for all Inventors resided in Sweden is 44.6 years old. The female ones in each group are much younger than the male ones. On average, the Swedish and foreign-born female inventors are 4.5 and 3.4 years younger than the corresponding male ones. Especially for the ones from Africa, the age difference between the female and male inventors reaches 11.7 years. Moreover, both female and male foreign-born inventors are older than the Swedish-born ones. Among all groups, the ones from Former Soviet Union are the oldest ones (49.4), both for female (48.8) and male inventors (49.5).

The treatment on average yearly gross salary among the inventors from different groups is also quite uneven. On average, the salary of the Swedish-born inventors is higher than that of the foreign-born ones (101.2% vs. 91.0%), both for the female (51.5% vs. 46.0%) and the male (104.5% vs. 95.1%) if comparing with the average gross yearly salary for all of Inventors resided in Sweden. The inventors from Nordic countries, rather than the Swedish-born ones, got the highest average salary among all groups (120.7%), followed by the ones from EU25 (107.8%) and Sweden (101.2%), while the inventors from all the other groups got the salary lower than the average salary for all Inventors resided in Sweden.

It is the same for the distribution of average salary among female and male inventors. The female inventors got much less in each group than the male ones except for the ones from Europe. For both Swedish and foreign-born inventors, the female inventors only got less than half of the salary than the male ones. Even the ones from EU25, who got the highest salary among the female inventors of all groups, still only got 68.9% of the salary comparing with the average one for all Inventors resided in Sweden, followed by the ones from Nordic countries (64.1%), Sweden (51.5%) and Europe (42.7%) etc. therefore, other groups outside Europe got even less than the ones from European countries.
### Table 4. Distribution of number of inventors, average age and average gross salary between female and male inventors resided in Sweden - by birth regions, 1985-2007

<table>
<thead>
<tr>
<th>Birth-country</th>
<th>Female No./Share of inventors</th>
<th>Female Ave. age</th>
<th>Female Ave. gross salary</th>
<th>Male No./Share of inventors</th>
<th>Male Ave. age</th>
<th>Male Ave. gross salary</th>
<th>Total No./Share of inventors</th>
<th>Total Ave. age</th>
<th>Total Ave. gross salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1,687 (8.1%)</td>
<td>40.5 (4.5%)</td>
<td>12,173 (50.7%)</td>
<td>19,032 (91.9%)</td>
<td>44.9 (0.3%)</td>
<td>24,841 (103.5%)</td>
<td>20,719 (100%)</td>
<td>44.6 (0.1%)</td>
<td>24,003 (100%)</td>
</tr>
<tr>
<td>Sweden</td>
<td>1,433 (7.8%)</td>
<td>40.2 (4.4%)</td>
<td>12,364 (51.5%)</td>
<td>17,025 (92.2%)</td>
<td>44.7 (0.2%)</td>
<td>25,095 (104.5%)</td>
<td>18,458 (100%)</td>
<td>44.4 (0.2%)</td>
<td>24,282 (101.2%)</td>
</tr>
<tr>
<td>Non-Sweden</td>
<td>254 (11.2%)</td>
<td>42.5 (2.1%)</td>
<td>11,048 (46.0%)</td>
<td>2,007 (88.8%)</td>
<td>45.9 (1.4%)</td>
<td>22,839 (95.1%)</td>
<td>2,261 (100%)</td>
<td>45.6 (1.0%)</td>
<td>21,849 (91.0%)</td>
</tr>
<tr>
<td>Nordic countries (excl. SE)</td>
<td>53 (8.5%)</td>
<td>43.5 (1.1%)</td>
<td>15,378 (64.1%)</td>
<td>574 (91.5%)</td>
<td>47.4 (2.9%)</td>
<td>29,893 (124.5%)</td>
<td>627 (100%)</td>
<td>47.2 (1.0%)</td>
<td>28,969 (120.7%)</td>
</tr>
<tr>
<td>EU25 (excl. DK, FI &amp; SE)</td>
<td>79 (9.5%)</td>
<td>43.1 (1.5%)</td>
<td>16,548 (68.9%)</td>
<td>754 (90.5%)</td>
<td>46.1 (1.6%)</td>
<td>26,625 (110.9%)</td>
<td>833 (100%)</td>
<td>45.9 (1.4%)</td>
<td>25,884 (107.8%)</td>
</tr>
<tr>
<td>Europe (excl. EU25 &amp; Nordic countries)</td>
<td>34 (15.5%)</td>
<td>42.1 (1.5%)</td>
<td>10,261 (42.7%)</td>
<td>186 (84.5%)</td>
<td>46.8 (2.2)</td>
<td>9,812 (40.9%)</td>
<td>220 (100%)</td>
<td>46.4 (1.8%)</td>
<td>9,847 (41.0%)</td>
</tr>
<tr>
<td>Asia</td>
<td>59 (17.0%)</td>
<td>42.6 (1.4%)</td>
<td>4,274 (17.8%)</td>
<td>288 (83.0%)</td>
<td>43.7 (0.8)</td>
<td>14,318 (59.7%)</td>
<td>347 (100%)</td>
<td>43.6 (1.8)</td>
<td>12,956 (54.0%)</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>6 (15.8%)</td>
<td>48.8 (2.0)</td>
<td>14,132 (17.2%)</td>
<td>32 (84.2%)</td>
<td>49.5 (4.9)</td>
<td>23,555 (98.1%)</td>
<td>38 (100%)</td>
<td>49.4 (0.8)</td>
<td>21,463 (89.4%)</td>
</tr>
<tr>
<td>Africa</td>
<td>7 (14.3%)</td>
<td>32.5 (1.4)</td>
<td>3,214 (13.4%)</td>
<td>42 (85.7%)</td>
<td>44.2 (0.4)</td>
<td>14,840 (61.8%)</td>
<td>49 (100%)</td>
<td>42.4 (0.2)</td>
<td>13,033 (54.3%)</td>
</tr>
<tr>
<td>North America</td>
<td>10 (12.7%)</td>
<td>40.0 (4.6)</td>
<td>3,605 (15.0%)</td>
<td>69 (87.3%)</td>
<td>41.9 (2.7)</td>
<td>14,993 (62.5%)</td>
<td>79 (100%)</td>
<td>41.7 (0.8)</td>
<td>13,965 (58.2%)</td>
</tr>
<tr>
<td>South America</td>
<td>6 (11.8%)</td>
<td>39.5 (5.1)</td>
<td>4,650 (19.4%)</td>
<td>45 (88.2%)</td>
<td>43.1 (1.4)</td>
<td>12,891 (53.7%)</td>
<td>51 (100%)</td>
<td>42.8 (0.8)</td>
<td>12,116 (50.5%)</td>
</tr>
<tr>
<td>Oceania</td>
<td>- (-)</td>
<td>- (-)</td>
<td>- (-)</td>
<td>16 (100%)</td>
<td>35.5 (-9.0)</td>
<td>4,556 (19.0%)</td>
<td>16 (100%)</td>
<td>35.5 (19.0%)</td>
<td>4,556 (10.0%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>- (-)</td>
<td>- (-)</td>
<td>- (-)</td>
<td>1 (100%)</td>
<td>33.8 (-10.8)</td>
<td>3,697 (15.4%)</td>
<td>1 (100%)</td>
<td>33.8 (15.4%)</td>
<td>3,697 (15.4%)</td>
</tr>
</tbody>
</table>

**Source:** MONA database, Statistics Sweden

**Note:** (*) for average age= average age-(*). It means the average age difference between each group and total average age for all Swedish inventors.

(*) for Ave. gross salary= Ave. gross salary for each group /(#). It means the percentage of average gross salary each group get comparing with the total average gross salary for Swedish inventors.

There are 45 and 100 missing data of gender and average age for foreign-born inventors and Swedish-born inventors, respectively.

There are 291 and 145 missing data of gross salary for foreign-born inventors and Swedish-born inventors, respectively.
4. **Analysis of education levels**

93.9% of the foreign-born inventors’ highest education level in their application filing years and 99.2% of the Swedish-born inventors has been matched in our data over the period of 1985 to 2007. According to International Standard Classification of Education 97 (ISCED 97), we divided the education levels of the Inventors resided in Sweden into six. Over the period of 1985-2007 (see Figure 6), we find that for both Swedish-born and foreign-born inventors, around 80% of them have received education equal or higher than post-secondary education levels. However, the distributions of education levels between these two groups were also quite uneven. For example, the shares of inventors who got Ph.D. education were much higher for the foreign-born inventors than the Swedish-born ones (42.8% vs. 24.9%). However, it is on opposite for these two groups for the ones who got post-secondary education at least for 3 years (32.8% vs. 41.2%).

Meanwhile, it is the same for the foreign-born inventors from different groups. The shares of inventors who obtained Ph.D. educations and post-secondary education at least for three years are almost on opposite for each foreign group. Figure 6 indicates that the inventors from Oceania enjoy the highest share of Ph.D. education level, which reached 67.4%, followed by Asia (64.8%). However, the shares of inventors who obtained post-secondary education at least for three years in these two groups are the lowest among all non-Swedish groups, which are only 23.3% for the group of Oceania and 28.8% for the group of Asia. On the contrary, the inventors from Former Soviet Union and North America had the lowest share of inventors who had Ph.D. education, which are just 26.0% and 31.6%. Nevertheless, they enjoy the highest share of inventors who got the second highest education level, which are 55.9% and 50.2%, respectively. The shares of inventors who obtained Ph.D. education for the groups of Africa, South America and EU25 are also higher than the shares of the inventors in those groups who got the second highest education level (55.5% vs. 41.1%, 51.8% vs. 32.5%, 43.7% vs. 33.7% respectively). The inventors from the Nordic countries and Europe seem to have the lowest average education levels than the other groups. Their shares between the Ph.D.
education level and the second highest level are quite similar, which are 31.9% vs. 29.5% for the inventors from Nordic countries and 34.9% vs. 33.3% for the ones from Europe. In addition, their shares of inventors obtained education equal or under the level of post-secondary education less than three years are much higher than the other groups, which reached 38.6% and 31.7%, respectively.

Comparing with the trends of the shares of foreign-born and Swedish-born inventors in different education levels year by year (see Figure 7 and Figure 8), we find that their main trends are similar to each other, but still with some different. For both groups, the shares of inventors just having the education level equal or lower than the secondary education were decreasing year by year. Especially the shares of inventors having the secondary education level were decreasing very fast for both groups. It is even faster for the group of foreign-born inventors, which share decreased from 39.1% in 1985 to 4.5% in 2007. While for the Swedish-born inventors, its share decreased from 36.8% to 10.6%. However, for both groups of inventors, their shares in education level equal or higher than post-secondary education at least for 3 years were increasing year by year, but quite different for these two different levels. For the foreign-born inventors, there was a dramatic increase in the share of inventors owing Ph.D. education level, which increased from 18.5% in 1985 to 53.2% in 2007, but the share of ones who obtained the secondary highest education level only increased from 27.2% to 35.5%. While for the Swedish-born
inventors, there was a dramatic increase in the share of inventors owing second highest education level, which increased from 29.4% in 1985 to 46.7% in 2007, but the share of the ones who obtained Ph.D. education level just increased from 17.4% to 27.7%. The growing trends of the shares of inventors owned education level in post-secondary education less than 3 years are on opposite for the two groups. For the foreign-born inventors, it decreased a little bit, which is from 9.8% in 1985 to 6.2% in 2007. While for the Swedish-born inventors, its share increased from 7.9% in 1985 to 13.5% in 2007.

![Figure 7. Share of foreign-born inventors in different education levels, 1985-2007](image)

**Source:** Mona database, Statistics Sweden
5. **Analysis of fields of education**

The match rates for the fields of education that the Inventors resided in Sweden took part in for their highest education level over the period 1990-2007 in our data are 99.0% for the Swedish-born inventors and 91.1% for the foreign-born ones. We find that for both of groups, around 85% of inventors took their highest education degrees in the fields of science, mathematics and computing or engineering, manufacturing and construction (see Figure 9). Although these were the most popular two fields of education for both groups, their shares in these two fields are on opposite. 75.2% of the Swedish-born inventors took their education in engineering, manufacturing and construction, but only 57.4% of the foreign-born inventors in this field. However, the shares of Swedish-born inventors and foreign-born ones in science, mathematics and computing were 9.9% vs. 26.8%. Their shares in the other fields of education were quite similar to each other. For both of them,
the field of health and welfare was the third most popular field, which reached 6.5% for the Swedish-born ones and 7.7% for the foreign-born ones.

The shares of inventors in the different fields of education for the different foreign-born groups are also quite different, although fields of science, mathematics and computing as well as engineering, manufacturing and construction are still the most popular two fields for all of the groups. Rather than taking the highest education in the fields of engineering, manufacturing and construction like most of the groups, more inventors from Oceania and Africa took their education in the fields of science, mathematics and computing, which reached 69.0% and 47.9%, respectively. There are more inventors from Europe, Asia and South America took the fields of education in health and welfare than the other groups, which reached 12.3%, 10.6% and 10.9% respectively. Moreover, there are 11.0% and 17.5% of inventors from Europe and North America took their fields of education in social sciences, business and law, which is much higher than the other groups.

![Figure 9. Share in different education fields for inventors resided in Sweden-by birth regions, 1990-2007](image)

Source: Mona database, Statistics Sweden

The trends of shares of Swedish-born inventors and foreign-born inventors took part in the fields of education are quite different (see Figure 10 and Figure 11). They were quite stable for the group of Swedish-born over the period 1990-2007, however, they varied a lot for the group of foreign-born inventors in some fields such as science, mathematics.
and computing, engineering, manufacturing and construction as well as general programmes. At the beginning of 1990, for both of them, around 70% of the inventors took their education in the field of engineering, manufacturing and construction. However, their growing trends are on opposite. For the group of Swedish-born inventors, there was 10% decrease while for the group of foreign-born inventors, there was 5% increase at the end of 2007 comparing with 1990. Moreover, the share of inventors in the field of science, mathematics and computing for the group of foreign-born inventors increased from 12.5% in 1990 to 30.3% in 2007, while there was only 2% increase for the group of Swedish-born group. The decreased rate in the general programmes over the period was also higher for the foreign-born inventors than the Swedish-born ones (7.0% vs. 3.4%).

Figure 10. Share in different fields of education for Swedish-born inventors, 1990-2007
Source: Mona database, Statistics Sweden

Figure 11. Share in different fields for education for foreign-born inventors, 1990-2007

6. Inventions participated by Inventors resided in Sweden in different technology fields

Comparing with the big difference of shares of inventors in the fields of education that Swedish-born and foreign-born inventors took part in, their shares of inventions in different technology fields are not that uneven (see Figure 12). According to the codes of International Patent Classification (IPC) updated in 2008 by World Intellectual Property Organisation (WIPO) (Schmoch, 2008), we classified the technology fields of all inventions into five classes. The shares of their inventions in fields of electrical engineering, chemistry and mechanical engineering are all around 20% to 30% for both
Swedish-born and foreign-born inventors. In addition, for both of the groups, the shares of their inventions in the fields of instrument were around 18% and the other fields had the smallest share among all five technology classes. Of course, there is still a little bit difference between the different technology classes for the two groups. 29.5% of the inventions that Swedish-born inventors participated in belonged to mechanical engineering, followed by electrical engineering and chemistry, which were 25.7% and 20.1% respectively. While for the foreign-born inventors, they participated more in the field of electrical engineering inventions than the other two.

However, the distribution of the shares of inventions that the foreign-born inventors from different groups participated in still varies a lot among each other. For all of the groups from EU25, Europe, South America, Asia and Oceania, electrical engineering is the biggest field that their inventions belonging to. Especially for the group of Oceania, its share was even over 50%. However, half of the inventions participated by inventors from Africa were in the field of chemistry, 40.8% of the inventions participated by inventors from Former Soviet Union were the field of instruments and 31.8% of inventions participated by inventors from Nordic countries were in the field of mechanical engineering. The distribution of the shares of inventions participated by inventors from North America among the fields of electrical engineering, instrument and chemistry were quite even, which were around 27% to 28%. Chemistry is the second most popular field that most foreign-born inventors took part in, except for the ones from South America, who participate more inventions in the field of instruments.

Figure 12. Share of inventions in different technology fields participated by inventor resided in Sweden, 1985-2007
**Source:** Mona database, Statistics Sweden

**Note:**
1. Absolute number of inventions that the Inventors resided in Sweden participated in is used to calculate the shares of inventions.
2. When a patent is assigned to multiple IPC classes, then randomly one IPC class is selected in our data. 59.1% of the observations only have one IPC class, 30.8% of observations have two IPC classes, 8.0% of observations have three IPC classes, the left 2.0% of observations have four to six IPC classes and 0.1% of observations we do not know their IPC classes.

From Figure 13 and Figure 14, we can see that the main growing trends of the shares of inventions that Swedish-born inventors and foreign-born inventors participated in are quite similar with each other in different technology fields over the period of 1985-2007. The shares of inventions in the field of electrical engineering were increasing for both of the groups, which reached 24% and 28% respectively. Both of the groups reached their peaks of shares in the field of electrical engineering at the end of the 20\textsuperscript{th} century and had a small turn in 2003. On the contrary, the shares of inventions in the field of mechanical engineering decreased for both of the groups. The decreased trend for the group of foreign-born inventors was even faster than the group of Swedish-born inventors, which reached 22.8% and 14.1%, respectively. Meanwhile, the shares of chemistry and other fields were also decreasing for both groups, but the decreasing trends were not as obvious as the field of mechanical engineering.

![Figure 13. Share of inventions in different technology fields participated by Swedish-born inventor, 1985-2007](source)

![Figure 14. Share of inventions in different technology fields participated by foreign-born inventor, 1985-2007](source)

7. **Productivity description**
Patent citation counts have been extensively used as a patent valuation technique. Number and nature of forward and backward citations are widely used as indicators of patent value. According to the dominant theory, patents with higher forward citation counts have greater economic value relative to other patents (Breitzman and Thomas, 2002; Fleming 2003; Brinn, Fleming, Hannaka, Thomas and Beling, 2003), although there are dissenting views that the use of simple citation counts for patent valuation could be problematic as it does not take into account that citation lists are not always complete or valid (Brinn, Fleming, Hannaka, Thomas and Beling, 2003).

According to our data, we find that all of the numbers of citations for the focal patent both by foreign-born and Swedish-born inventors are quite similar with each other (See Table 5). It is the same for the number of forward citations before or after focal patent and the number of patents they filed before or after the focal patent. In some sense, these imply that the average productivity and the value of the inventions by foreign-born and Swedish-born inventors are quite similar. In addition, the Swedish-born invention stars are much bigger bulls than the foreign-born ones.

However, if we dig into the every detailed information for the productivity and the value of the inventions by these two groups, there is still a little bit difference among different indicators. The forward citation counts were a little bit higher for filed or published patent families in the International Patent Documentation Center (IPADOC) within 3 or 5 years by the Swedish-born inventors than the ones by the foreign-born inventors. It is the same for the number of backward citations. Meanwhile, the number of the forward citation for the published patents within 3 (5) years is around 50% (17%) higher than the filed ones for both of the groups. However, if looking at the number of non-patent literature citations for the focal patents, the number is around 55% higher for the focal patents by foreign-born inventors than the ones by the Swedish-born inventors. This may be because of the cluster effect of the technology area that Swedish-born inventors are better known in the cluster than the foreign-born ones. These imply that the inventions by Swedish-born are better known or valuable in the patent area while the ones by foreign-born inventors are better known or valuable outside the patent area. Moreover, the values
of different inventions by Swedish-born inventors vary more than the ones by foreign-born ones according to the higher standard deviations of the forward citations for the ones by Swedish-born inventors.

By looking at the number of patents filed by inventors before or after focal patent, we find that the output of patents by foreign-born inventors was a little bit higher than the ones by the Swedish-born inventors. Meanwhile, the number of patents filed by inventors within the same time after the focal patent is a little bit higher than before the focal patent for both groups. This means that their output of inventions is increasing by the time. However, the average number of granted patents filed by the inventors before the focal patent by the Swedish-born inventors is a little bit higher than the ones by foreign-born ones. Combining together with the number of forward and backward citations for the focal patents, we can find that the value of the patent by the Swedish-born inventors is a little bit higher than the ones by the foreign-born inventors, while the output of the patent is a little bit higher by the foreign-born ones.
### Table 5. Productivity descriptive statistics: inventions by foreign-born vs. Swedish-born inventors, 1985-2007

<table>
<thead>
<tr>
<th>Number of citations for focal patent</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>S</td>
<td>F</td>
<td>S</td>
</tr>
<tr>
<td>No. of FC for IPADOC family filed within 3 years</td>
<td>0.87</td>
<td>0.88</td>
<td>1.80</td>
<td>1.95</td>
</tr>
<tr>
<td>No. of FC for IPADOC family filed within 5 years</td>
<td>1.39</td>
<td>1.41</td>
<td>2.64</td>
<td>2.84</td>
</tr>
<tr>
<td>No. of FC for IPADOC family published within 3 years</td>
<td>1.29</td>
<td>1.33</td>
<td>2.65</td>
<td>3.07</td>
</tr>
<tr>
<td>No. of FC for IPADOC family published within 5 years</td>
<td>1.62</td>
<td>1.66</td>
<td>3.10</td>
<td>3.51</td>
</tr>
<tr>
<td>No. of backward citations focal patent</td>
<td>3.88</td>
<td>3.92</td>
<td>2.83</td>
<td>2.92</td>
</tr>
<tr>
<td>No. of non-patent literature citations for focal patent</td>
<td>1.02</td>
<td>0.66</td>
<td>3.10</td>
<td>2.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of FC before or after focal patent</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average No. of FC received by the patents filed before the focal patent</td>
<td>0.71</td>
<td>0.70</td>
<td>1.22</td>
<td>1.43</td>
</tr>
<tr>
<td>Average No. of FC received by the patents filed after the focal patent</td>
<td>0.51</td>
<td>0.49</td>
<td>0.95</td>
<td>0.97</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of patents filed by inventors before or after focal patent</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patent filed by the inventor before the focal patent</td>
<td>4.29</td>
<td>3.93</td>
<td>7.05</td>
<td>7.12</td>
</tr>
<tr>
<td>No. of granted patents filed by the inventor before the focal patent</td>
<td>2.49</td>
<td>2.52</td>
<td>4.36</td>
<td>4.65</td>
</tr>
<tr>
<td>No. of patents filed by the inventor within 3 years before the focal patent</td>
<td>2.36</td>
<td>1.92</td>
<td>4.23</td>
<td>4.23</td>
</tr>
<tr>
<td>No. of patents filed by the inventor within 5 years before the focal patent</td>
<td>3.07</td>
<td>2.59</td>
<td>5.24</td>
<td>5.13</td>
</tr>
<tr>
<td>No. of patents filed by the inventor within 3 years after the focal patent</td>
<td>2.47</td>
<td>1.98</td>
<td>4.36</td>
<td>4.27</td>
</tr>
<tr>
<td>No. of patents filed by the inventor within 5 years after the focal patent</td>
<td>3.22</td>
<td>2.66</td>
<td>5.45</td>
<td>5.25</td>
</tr>
</tbody>
</table>

Source: Mona database, Statistics Sweden

Note: The observations for “F” is 6768 and for “S” is 51405

“F” refers to inventions by foreign-born inventors

“S” refers to inventions by Swedish-born inventors

“FC” refers to forward citations

“IPADOC” refers to International Patent Documentation Center

### V. Policy implication and Conclusion

This paper used a newly compiled dataset with plentiful of demographic data and patent information over the period of 1985 to 2007, which allow us to do the detailed study on the demographic characteristics and invention performance of the foreign-born inventors and compares them with the Swedish-born ones as well as the foreign-born ones themselves according to their birth regions. The paper indicates that there are 11.0% of
the Inventors resided in Sweden born abroad and they contributed 11.7% of the Swedish patent applications filed in EPO over the period of 1985-2007. Sweden seems like an attractive country for the foreign-born inventors as there were many more foreign-born inventors immigrating into Sweden than the ones emigrating out every year between 1968 and 2006. Work, family ties and study are the top three reasons for the foreign-born inventors to settle down in Sweden, but with some difference between different time periods and groups. The distribution of number of inventors and their performance in invention within and between different groups are quite uneven, which was the same for the distribution of inventors by gender and their salary treatment. The shares of the number of Swedish female inventors, the inventions they participated in, their average age and salary were all much lower than the Swedish male inventors. Moreover, all the above factors except the average salary were higher for the foreign-born inventors than the Swedish-born ones.

For both Swedish-born and foreign-born inventors, around 80% of them have received education equal or higher than post-secondary education levels. However, the distributions of education levels between these two groups were quite uneven. The shares of inventors who got Ph.D. education were much higher for the foreign-born inventors than the Swedish-born ones (42.8% vs. 24.9%). However, it is on opposite for these two groups for the ones who got post-secondary education at least for 3 years (32.8% vs. 41.2%). It is the same for the non-Swedish groups. Moreover, the trends of the shares of foreign-born and Swedish-born inventors in different education levels were similar to each other, with the increasing shares of inventors owing education level higher than the secondary education level.

For both Swedish-born and foreign-born inventors, around 85% of the inventors took their highest education degrees in the fields of science, mathematics and computing or engineering, manufacturing and construction, with opposite shares in these two fields for the two different groups. The trends of shares of inventions took by Swedish-born inventors were quite stable over the period 1990-2007. Nevertheless, they varied a lot for the group of foreign-born inventors in some fields.
The shares of inventions in different technology fields where the foreign-born and Swedish-born inventors participated in are not that uneven. The shares of their inventions in fields of electrical engineering, chemistry and mechanical engineering are all around 20% to 30% for both groups. Additionally, in some sense, the average productivity and the value of the inventions by foreign-born and Swedish-born inventors are quite similar as well. However, the value of the patent by the Swedish-born inventors is a little bit higher than the ones by the foreign-bone inventors, while the output of the patent is a little bit higher by the foreign-born ones.

According the above study results, we can see that the foreign-born inventors performs as well as the Swedish-born ones and they also contributed a lot to the invention progress and technology development in Sweden. They even over-performed in some fields such as chemistry. However, in recent years, the pessimistic opinion about the immigrants is extending as they thought the large number of immigrants has become a big burden for the public sector. Meanwhile, more and more Swedish people are abominated and against the increasing immigrants as well as the government have more and more restraints on the visas because of the large pressure on public finance and the strong against of the local people. However, when the Swedish government tighten up the visa on immigrants, it is better for them to distinguish the different types of immigrants. The ones apply visa for work, family ties and study seem to have better invention ability than the others. It is the same for the ones with high education levels such as post-secondary at least for 3 years or Ph.D. It is also important for the government to pay attention to the immigrants as it usually cost them sometime to enter into the labour market and contribute to the society. This can be told from the inventors who immigrated in Sweden since 1961 but contributed to the invention progress after 1985. The government also should try to attract the ones who received education such as post-secondary at least for 3 years or Ph.D. in Sweden to settle down in this country as these people are usually quite talented. It is also important for the government to gain what have spent on them back and try to lead them make contribution to the Sweden population.
Reference


Stephan, P., Grant B. and Shiferaw G. (2005). *The Role of Foreign-born Graduate Students in University Patenting*. Atlanta, GA: Georgia State University manuscript.

