The patenting performance of second-generation immigrants in Sweden: differentiated by parents' region of origin

Yannu Zheng (yannu.zheng@circle.lu.se)
Center for Innovation and Research and Competence in the Learning Economy (CIRCLE), Lund University, Sweden

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Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

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JEL classification J15, J24, N30, O31

Keywords: Native Swedes, Foreign-born, Innovation, Human capital, Selection

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Y. Zheng (✉)
Department of Economic History and Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University.
CIRCLE, P.O. Box 117, SE-22100, Lund, Sweden.
Tel. +46 46 222 3379
e-mail: yannu.zheng@circle.lu.se

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1 Introduction

Attracting highly skilled immigrants is a priority for many countries which aim to be competitive in the global market for talent. In recent years there has been increasing interest in the study of the contribution of immigrants to invention and innovation, to examine whether they help to promote their host country's innovation, productivity and economic development (Ozgen et al. 2013; Paserman 2013; Parrotta et al. 2014). Most extant studies compare the innovation performance of foreign-born (first-generation immigrants) with that of native-born (No and Walsh 2010; Hunt 2011; Zheng and Ejermo 2015) or different ethnic groups according to name-based approaches (Kerr 2008; Nathan 2014). However, no previous study has examined the differences that can exist between those native-born individuals with a different parental background. Arguably, such differences may be important driving forces for a country's long-term development and may have implications for the integration of immigrants in the host society.

This paper contributes to ongoing research by exploring whether differences in innovative performance exist between children of immigrants and children of native-born parents by comparing their patenting performance. The study is based on a unique and rich database that contains nearly all records of patent applications by Swedish residents to the European Patent Office (EPO) between 1985 and 2007 (Zheng and Ejermo 2015). I deconstruct the native-born population into three groups according to their biological parents' region of origin (data on country of origin for immigrants is not available in my database):

(a) native Swedes: Swedish-born with two Swedish-born parents.[1]

(b) mixed second-generation immigrants: Swedish-born with one Swedish-born and one foreign-born parent; and

(c) second-generation immigrants with two foreign-born (FB) parents.

For ease of reference, I term the groups of (b) and (c) mixed immigrants and immigrants with two FB parents, respectively. These two groups comprise members of second-generation immigrants. In total, the above three groups constitute 89% of

[1] It includes third- or later generations of immigrants, but their impact can be ignored because of their small number.

inventors in Sweden and are attributed with 88% (by fractional count[2]) of the total identified Swedish patent applications filed with the EPO by Swedish residents (see Table 1 and Zheng and Ejermo 2015).

Differences in innovation activity may exist between individuals who are born and raised in the same country with similar education systems. This is because of differences in ethnicity (and this may relate to discrimination), ethnic identity (degree of acculturation identity),[3] culture and other country-specific human capital, which can be driven by their parents' country of origin. These factors are believed to have important effects on an individual's human capital development and labour outcome (Fuligni 1997; Ermisch and Francesconi 2001; Black et al. 2005; Zimmermann et al. 2008; Nekby and Rödin 2010, Lundborg et al. 2014; Schüller 2015). For the second-generation, experiences and upbringing environment are usually more complicated and challenging than those of native Swedes. For example, they usually have ambiguous racial or ethnic identifications, have distinct culture, values or norms within or between their families and the host society, as well as are more likely to suffer discrimination or segregation (Kristen 2008). However, their growing environment may also help to push them become more ambitious than their native peers (Fuligni 1997) and make them become more open and flexible to different cultures and social networks. All these factors may affect an individual's innovative performance after reaching adulthood.

Zheng and Ejermo (2015) find that first-generation immigrants who migrated to Sweden as children (under the age of 18) perform worse in patenting compared with native-born individuals. This may be linked to negative selection towards their parents or themselves, as well as their lack of Sweden-specific human capital, such as a native social network. In this paper I compare second-generation immigrants' patenting performance with that of native Swedes. This study fits into many others which find

[2] Fractional count means that each co-patent is counted as a fraction, depending on how many inventors contributed to one patent. For instance, if one patent has three co-inventors, then each inventor is attributed one third of the patent.

[3] Ethnicity is assigned to an individual either by birth or by others on the basis of ethnic background or phenotype (Phinney and Ong 2007). Ethnic identity is defined as a part of social identity and can be chosen by individuals themselves (Tajfel 1981; Phinney and Ong 2007; Schüller 2015).

that children's ages at immigration significantly impact their assimilation, schooling and labour outcome performance in the host country (Schaafsma and Sweetman 2001; van Ours and Veenman 2006; Böhlmark 2008).[4] As compared with highly skilled first-generation immigrants, especially those who immigrated as teenagers or adults, who are usually highly mobile, second-generation immigrants are usually more likely to stay in the host country for the whole of their life and are a more reliable backbone force for the long-term development of the host country.

I also compare the patenting performance of mixed immigrants, immigrants with two FB parents, and native Swedes. As discussed above, the experiences of the second-generation immigrants may also be different, which may arise due to differences in parental background. Compared with those who have two FB parents, mixed immigrants should have an advantage in obtaining host-country specific human capital, as they have one native-born parent. In addition, I consider the effects of the parents' region of origin on the patenting performances of second-generation immigrants and native Swedes. The parents' country of origin captures difference in physical or cognitive (e.g. linguistic, cultural and institutional) proximity to Sweden and Swedish culture to some extent. This proximity may affect an individual's opportunity of integrating into the host society, interactive learning and innovative performance (Amin and Wilkinson 1999; Boschma 2005). Moreover, the selection mechanism from different regions of origin may not only impact on the human capital level of immigrants' themselves, but also on those of their children. This is because family background matters both children's cognitive and non-cognitive skills through intergeneration transmission (Ermisch and Francesconi 2001; Riphahn 2003; Lundborg et al. 2014). This could have impact on their innovative performance in the long term.

Sweden has seen a rise in immigration since the Second World War. Accompanying the increase in the size and diversity of the foreign-born population (1.6 million individuals, or 16.5% of the entire population) has been a rise in the number and

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[4] Studies find that immigrants who arrive at younger ages assimilate more quickly than those arrive in their teenage years (Gonzalez 2003; Bleakley and Chin 2004; Chiswick and DebBurman 2004; Beck et al. 2012). Child immigrants who arrive before age 7 are indicated to perform substantially better in school than those who migrate after age 7 (Böhlmark 2008).

share of mixed immigrants and immigrants with two FB parents, which reached 7.3% and 5.0% respectively of the entire Swedish population in 2014 (see Figure A1 in Appendix 2). Although second-generation immigrants now constitute a large part of the population in Sweden, to my knowledge this is the first study which considers their innovation contribution. Studying the inventive performance of children of immigrants with parents from different regions of origin may help to broaden the understanding of both intergeneration incorporation and the long-term effect of migration and migration policy on a host country's innovation and development.

Based on the unique database of inventors matched with the entire population in Sweden, I have been able to compare the patenting performance of the different groups of native-born by three indicators: (a) the probability of becoming an inventor among the entire corresponding population, (b) the total number of patents attributed to each inventor and (c) the number of forward citations (NFC) to their patents. Although patents have some shortcomings as an indicator of innovation output (for example, they relate only to certain types of inventions), it is still the most common measure of innovation output (Giuri et al. 2007).

The results show that, in terms of probability of becoming an inventor and NFC to their patents, second-generation immigrants with non-Nordic European backgrounds perform better than native Swedes. Their better performance is because they benefit from their positively selected parents and a certain distance of physical and cognitive proximity to Sweden through intergeneration transmission. However, second-generation immigrants with other Nordic backgrounds perform less well than native Swedes. This is mainly because of their lower education level, which is further related to their less positively selected FB parents. For mixed immigrants with non-European backgrounds, whose FB parents are most positively selected among all immigrant groups, the large distance of proximity of their FB parents' region of origin to Sweden seems to impede their patenting performance. The study indicates that there is a trade-off effect between the importance of proximity of parents' region of origin to Sweden and selection of parents on second-generation immigrants' innovative performance, which differs between groups. Although this is primarily a descriptive analysis and no causal effect has been explored of these factors on differences in patenting performance, this paper still provides an initial impression of the patenting contribution of different groups of native born and the impact of their parents' region of origin.

The paper is structured as follows. Section 2 summarizes previous studies about second-generation immigrants, as well as the difference between this and prior studies. Section 3 discusses the theoretical background. Section 3 presents the databases and descriptive statistics. Section 4 contains the methodology. Section 5 reports the results of the empirical analysis. The final section concludes the study, with a discussion of the results.

2 What do we know about second-generation immigrants?

The performance of second-generation immigrants has attracted considerable research interest from scholars across disciplines (Chiswick 1977; Carliner 1980; Chiswick and Miller 1985; Borjas 1993, 1994; Maani 1994; Gang and Zimmermann 2000; Nielsen et al. 2003; Riphahn 2003; van Ours and Veenman 2003). Earlier studies have focused largely on educational and labour market outcomes and find that differences exist between second-generation immigrants whose parents are from different countries or regions of origin (Fuligni 1997; Rooth and Ekberg 2003; Ramakrishnan 2004; Behrenz et al. 2007; Ekberg et al. 2010). However, the results of the different studies are varied. For example, Ramakrishnan (2004) indicates that, in the USA, mixed immigrants are more successful in educational attainment and income earnings than both third-generation immigrants with two native-born parents and second-generation immigrants with two FB parents. Fuligni (1997) also finds that, mixed second-generation adolescents receive higher grades in mathematics and English than their peers from native families. Moreover, he finds that students with East Asian parents receive significantly higher grades than those with European parents. Nevertheless, Riphahn (2003) reveals that the schooling success of German-born children of immigrants (with foreign citizenship) still lags behind that of native Germans (including second-generation children with German citizenship). He also finds that the worse educational attainment of second-generation immigrants in Germany is significantly related to their country of origin and differences exist between immigrants from different countries of origin. Dustmann and Theodoropoulos (2010) find that although British-born ethnic minorities are on average better educated, their employment probabilities are lower than their British- born white peers. Algan et al. (2010) also reveal that on average, labour market performance in terms of earnings and employment for most groups of second-generation immigrants in France, Germany and the UK is worse than that of the native population. However, substantial heterogeneity across different immigrant groups is found in both of the above two studies. Rooth and Ekberg (2003) indicate that, compared with native Swedes, second-generation immigrants with a Nordic or western or eastern European background have similar prospects in terms of earnings or being unemployed, while those with either a southern European or a non-European background fare much worse. The outcome is more favourable for those with one Swedish-born parent as compared with those whose parents were both born abroad. Behrenz et al. (2007) show that, compared with Swedish "twins" (i.e. people whose parents have the same age, gender, occupational status and county of residence as parents of immigrants), second-generation immigrants are significantly more disadvantaged in obtaining employment, and their performance in the Swedish labour market differs depending on their parents' regions of origin. Hammarstedt (2009) indicates that there is no significant difference in relative earnings between second-generation immigrants and native Swedes between the years 1980 and 1985. However, he finds a downward trend in immigrants' relative earnings across generations and his results indicate that ethnicity-based differences in earnings are likely to occur even after several generations spent in the host country; the problem of immigrant assimilation may last for several generations.

The causal reason as to why second-generation immigrants perform differently in educational achievement and labour market outcome is difficult to investigate. The selection of immigrants as a result of different migration policies (e.g. migration policy in the USA is more selective than those in Sweden and Germany) may be a reason for the performance of second-generation immigrants as compared with natives being different between countries (Christensen and Stanat 2007; Dustmann et al. 2012). In addition, many studies indicate that the different performance of native-born immigrants can be related to their ethnic background (Borjas 1992; Gang and Zimmermann 2000; Riphahn 2003), which may affect their accumulation of human capital, preference and ethnic identity (Gang and Zimmermann 2000; Nekby and Rödin 2010). These factors are indicated to have an impact on immigrant children's educational attainment and labour market outcome (Gang and Zimmermann 2000; Nekby and Rödin 2010; Schüller 2015). Borjas (1992) also indicates that "ethnic capital", which is the average quality of the ethnic group in the parents' generation, can work as an externality in the process of accumulating human capital and can be transmitted across generations. In the literature, ethnicity effects are usually indicated by country or region of origin (Gang and Zimmermann 2000; Riphahn 2003; Nekby and Rödin 2010).

However, it is not known whether the above applies to innovation behaviour between different groups of second-generation immigrants and natives. Compared with attainment of education, employment and income, patenting is a more knowledge-intensive and creative activity. The demand for skills in invention and the increasing dominance and propensity of highly educated individuals in invention imply that demand is increasing for high education and skills to be an inventor (Jung and Ejermo 2014). The development of children's human capital is achieved mainly through the education system and family, which is in turn highly determined by parental human capital and input (Borjas 1992; Haveman and Wolfe 1995; Rooth and Ekberg 2003). Therefore, for a person to become an inventor, significant demands may be made on that person's parents' human capital and input, as well as "ethnic capital", which can be very different between parents who are from different regions of origin (Gang and Zimmermann 2000). For example, the capability of obtainment of host country-specific human capital can be very different between groups whose parents are from different regions of origin. In addition, parents from some ethnic communities, such as those from China, Indochina, India and Central America, may put more emphasis on investing in their children's human capital and may put a higher value on "success" than others (Fuligni 1997; Ermisch and Francesconi 2001; Hammarstedt 2009). Moreover, the migration policy in Sweden differs a lot to immigrants from different regions of origin, which indeed can affect the selection and human capital level of immigrants from different regions (Zheng and Ejermo 2015). Studying the inventive performance of the children of immigrants can help us to better understand and predict the long-term impact of a selective migration policy on a country's future innovative performance, as ethnic differences and parents' human capital can be transmitted to succeeding generations (Borjas 1992), although potential cohort differences among immigrants, even those from the same country, may make the prediction very difficult (Borjas 1994).

3 Theoretical discussion

3.1 Positive and negative forces of second-generation immigrants and their impact on invention

The life environment of immigrants and their children is usually more complicated and challenging than that of native Swedes. One the one hand, their distinct appearance, their less proficient language and the distinct culture, values and norms between their family life and their school or society may put them at risk of discrimination, lower their self-confidence and affect their educational performance. These could all hamper their innovative performance in the long term. Moreover, foreign-born parents often retain their home language and culture, reside in areas that both are segregated from the native-born population and have a high concentration of immigrants with a similar ethnic background. They may also have problems in fully integrating into the host society (Bayer et al. 2004). These factors can all affect their children's school achievement (Åslund et al. 2011; Dustmann et al. 2012) and put their children at a disadvantage in obtaining host country-specific human capital (such as learning the Swedish language, accessing a native social network and getting familiar with the host country's culture and institutions), which is a very important factor in inventive performance (Agrawal et al. 2006; Kerr 2008). For example, Kristen (2008) indicates that Turkish children in Germany are more likely than children of a German background to enter a school which has a relatively large proportion of foreign nationals; this is a pattern that in the aggregate seems to contribute to an increasing ethnic separation at the school level, mainly due to their parents' unfamiliarity with the German elementary school system. However, the boundary between immigrants and natives can fade gradually over time and it is possible for immigrants over time to become highly assimilated in their host country (Borjas 1992; Alba and Nee 2009).

On the other hand, the environment that children of immigrants grow up in can also become an important source of motivation to push them to become more ambitious than their native peers. They may have stronger aspirations to study or work harder, and they may pay more attention on improving their knowledge and skills, believing that these are the most significant ways to improve their status in life. For example, Fuligni (1997) finds that, in the USA, the greater academic achievement of second-generation immigrants over their native peers is largely attributable to their parents' expectations and aspirations, as well as their own stronger academic attitudes. Second-generation immigrants are also more likely to be open and flexible to different cultures and social networks on account of their dynamic racial or ethnic identification. For example, they can co-invent with people from both home and host country with less communication cost. Moreover, their experience of mixed cultures, values and norms within or between family and host society also has the capacity to positively stimulate their creative capability and enable them to perform better in invention in the future.

It is difficult to have *a priori* expectations about the relative strengths of positive and negative forces on second-generation immigrants' innovative performance. This paper tries to investigate this issue by studying their patenting performance.

3.2 Differences between mixed immigrants and immigrants with two FB parents compared with native Swedes

Although the above two groups both comprise members of the second-generation, mixed immigrants can be distinct from those immigrants who have two FB parents, as well as from natives (Ramakrishnan 2004). First, compared with immigrants with two FB parents, mixed immigrants with one native-born parent can have certain advantages. They have an advantage in obtaining host country-specific human capital. Their link to the native-born population gives them a better chance of participating in social networks which include other native Swedes, and then they might have a higher probability of residential assimilation, greater Swedish-language proficiency and, overall, a better chance of integrating into the host society. All of these factors can have a positive effect on their ethnic self-identification as being natives, as well as on their future capability development (Ramakrishnan 2004; Nekby and Rödin 2010).

Second, the foreign-born parents of mixed immigrants are likely to have a higher level of education than parents of immigrants with two FB parents (and their education may even be better than parents of natives) (Ramakrishnan 2004).[5] Individuals with

[5] This is because educated immigrants are more likely both to move out of ethnic enclaves and to accept their prospective partners from different ethnic origins (Furtado and Theodoropoulos 2011; Furtado

better-educated parents, especially those with a more educated mother,[6] not only have a higher educational attainment, but also have better non-cognitive skills than those whose parents are less well educated (Ermisch and Francesconi 2001; Riphahn 2003; Lundborg et al. 2014). This is because more highly educated parents are more likely to provide a better cultural environment (e.g. they might have more books at home) and are more likely to invest in the development of their children's human capital (Ermisch and Francesconi 2001). All of these factors could help promote the creativity and development of their children.

Third, mixed immigrants may also benefit from the mixed cultural and ethnic background of their families and communities as compared with native Swedes and immigrants with two FB parents. Cognitive distance and diversity between family members may have a positive impact on children's knowledge creation (Boschma 2005). A mixed ethnicity might also broaden their social network to include both foreign and native backgrounds. Native Swedes usually have an identical culture and ethnic background, and this may also be the case for immigrants with two FB parents, if their parents are from the same country of origin (Niedomysl et al. 2010). Cultural diversity has the capacity to improve idea generation and lead to innovation and creativity, since it involves variety in abilities and knowledge (Alesina and La Ferrara 2005; Niebuhr 2010; Nathan 2014). Some studies find that flows of knowledge, such as

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2012). Moreover, as there is a general assortative mating on education in the marriage market (see e.g. Mare 1991; Kalmijn 1998; Henz and Jonsson 2003; Niedomysl et al. 2010), better-educated immigrants are more likely to find partners who have an equal or similar education level and are willing to trade similarities in ethnicity for similarities in education (Dribe and Lundh 2008; Niedomysl et al. 2010; Furtado 2012). Parents of immigrants with two FB parents are possibly from the same country of origin since people simply seem to prefer a partner with the same ethnic background (positive assortative mating). Therefore there is no need to compensate culture distance with education level (Niedomysl et al. 2010). Table A1 in Appendix 1 also shows a positive association between parent's average years of school.

[6] This is because mothers usually put more time and effect on children's development than fathers. Better-educated mothers lead to substantially greater income and more "bargaining power" in the family, and they can also put more weight on the investment in children's human development (Ermisch and Francesconi 2001; Lundborg et al. 2014).

those that stem from patent citations, follow social networks (Agrawal et al. 2006; Kerr 2008), which may be partially channelled through ethnic networks (Agrawal et al. 2008). Thus, the diverse ethnicity and culture that mixed immigrants enjoy may broaden their social network and make a positive impact on their patenting performance (Owen-Smith and Powell 2003; Kerr 2008; Niebuhr 2010; Nathan 2014).

Based on the advantages discussed above for mixed immigrants, as compared with native Swedes and immigrants with two FB parents, I expect that mixed immigrants have a better patenting performance than native Swedes, which in turn have a better performance than immigrants with two FB parents.

3.3 Differences between second-generation immigrants with parents from different regions of origin

Parents' ethnic backgrounds have been found to affect their second-generation immigrant children's identity formation (Nekby and Rödin 2010), linguistic acculturation (Rooth and Ekberg 2003) and structural assimilation, since ethnic differences in skills can be transmitted across generations (Borjas 1992). Individuals' ethnic backgrounds can be classified to some extent by their countries of origin, since people from the same country usually share similar languages, cultures, values and institutions. They also usually even share economics and motivations for migration, which imply to some extent the human capital of immigrants (Scott 1999; Bengtsson et al. 2005; Helgertz 2010).

Individuals from countries with a closer physical distance are supposed to share a common or similar language, culture and habits. It can help reduce communication cost and uncertainty, facilitate interactive learning between individuals and promote their innovative performance. The more proximate the sending and receiving countries are, the easier it can be for those individuals' children to integrate into the host society, which can impact on their personal outcomes. For example, Nekby and Rödin (2010) find that, of those who immigrated to Sweden at a young age (before age 16) or who were born in Sweden with immigrant parents, those with non-Nordic European backgrounds show a higher likelihood of being separated and marginalized rather than assimilated (according to their self-perceived ethnic identity) from the majority Swedish society than the Finnish, but the likelihood is much higher for those with non-European backgrounds. Therefore, even among mixed immigrants and immigrants with two FB parents, differences can exist if their parents are from different regions of origin. Drawing from this, mixed immigrants with a foreign-born parent from regions with similar cognitive distance, such as the other Nordic countries, are more easily integrated into Swedish society and are easier to obtain Sweden-specific human capital than those whose non-Swedish parent is from a non-European country. The result is similar for immigrants with two FB parents; for example, individuals with two parents from other Nordic countries can expect to find it easier to accumulate Sweden-specific human capital than those with two parents from another region, such as southern Europe.

Moreover, experiences of discrimination against second-generation immigrants can vary depending on their parents' region of origin. The risk of being discriminated against based on ethnic background is expected to be low for second-generation immigrants with Nordic or western European backgrounds. However, the risk can be higher for those with southern European or non-European backgrounds. This may be driven by their different appearance (Rooth and Ekberg 2003). The context of the reception from the host society, which may be affected by an individual's parents' background, can affect that individual's self-confidence, educational performance and creative and innovative performance in the long term.

By considering the physical and cognitive proximity of foreign-born parents' regions of origin to Sweden, second-generation immigrants are divided into six groups. These are:

Mixed immigrants whose non-Swedish parent is from

(a) another Nordic country;

(b) the EU-15 (excluding Sweden, Denmark and Finland; for ease of reference I term these countries the EU-15);

(c) the rest of Europe (including the former Soviet Union); and

(d) a non-European country.

Immigrants with two FB parents, of whom

(e) at least one is from another Nordic country (among these inventors, 82% have both parents from other Nordic countries); and

(f) both are from non-Nordic European countries (i.e. EU-15 + the rest of Europe).

I exclude second-generation immigrants with two parents who are foreign-born and at least one of them has a non-European background in all regressions because of their small number of inventors.

However, the selection of parents to second-generation immigrants in Sweden, can differ by region of origin. This may also affect their children's human capital development through intergeneration transmission (Phalet and Schönpflug 2001; Bauer and Riphahn 2007). Compared with immigrants who are culturally more proximate to the host country, immigrants who are culturally distant to the host country are more likely to have a higher education to be able to intermarry natives, especially if the host country is a developed country (Dribe and Lundh 2008). This may be because culturally distant immigrants need to compensate with greater educational assets to be able to achieve a native-exogamous match on the marriage market (Dribe and Lundh 2008). Therefore, for mixed immigrants, their non-Swedish parents who are from a non-European country are more likely to be positively selected (i.e. better qualified than the average comparable natives), while those who are from the other Nordic countries are more likely to be negatively selected (i.e. lower qualified than their native counterparts). Moreover, among parents of adult second-generation immigrants from the other Nordic countries, a large number of them, especially those from Finland, came to Sweden as refugees during the Second World War (Westin 2000). Compared with labour migrants, refugee migrants are usually less educated and skilled (Scott 1999). In addition, the Swedish migration policy to immigrants from different regions of origin is very different. The agreement of free movement of citizens between Nordic countries since 1954 (Stalker 2002) may also have reduced the possibility of positive selection of immigrants from the other Nordic countries to Sweden. Therefore, parents of second-generation immigrants with other Nordic backgrounds are more likely to be negatively selected than those from other regions. However, the parents for adult second-generation immigrants in Sweden from non-Nordic regions are more likely to be positively selected following self-selection theory (Borjas 1987). As discussed in Section 3.2, parents' human capital can affect their children's development, I expect that those with more positively selected migrant parents are also more likely to have a better development in human capital, which can affect their innovative performance in the long term.

Considering both the advantage and disadvantage of the physical and coginitive proximity of the parents' region of origin to Sweden and its impact on the selection of immigrants, it becomes difficult to have a *priori* expectations about the innovative performance for each group. I will explore this issue by studying each group's patenting performance by comparing them with native Swedes.

4 Data and descriptive statistics

4.1 Summary of data

Based on the database as introduced in Zheng and Ejermo (2015) (for detailed introduction of the data, see Section 4 of that paper), which matches patent applications filed with the EPO by Swedish residents between 1985 to 2007 with demographic information, I add the further information relating to individuals' parental backgrounds. Two steps are required for this. Firstly, I match individuals' social security numbers (SSNs)[7] with their parents' SSNs, as provided by Statistics Sweden (SCB). Secondly, I add detailed demographic information (e.g. region of origin, education level, number of children and year of birth) for parents by using their SSNs. SCB has very detailed demographic information for all residents in Sweden from 1985 onwards. If an individual's parent died or left Sweden before 1985, then that parent's detailed demographic information cannot be matched. In total, I match 74.0% of mothers' SSNs of Swedish-born population, and 63.8% of their fathers'. The corresponding figures for inventors are 87.8% and 76.9%, respectively. However, SCB still provides basic information about whether his or her parent is Swedish-born or foreign-born. I consider an inventor to be a person who has patented at least once between 1985 and 2007.

Table 1 shows that, among the identified inventors in Sweden aged 25 to 64 (mean age: 43.9),[8] 6.25% (or 1,251 individuals) are mixed immigrants and 2.09% (or 419

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[7] The Swedish social security number is a unique identification number for each resident in Sweden, including foreigners with a valid residence permit for at least 1 year.

[8] I focus on inventors aged 25 to 64 as, at these ages, people are more likely to work and patent, which makes the sample more coherent. Inventors younger than 25 and older than 64 are excluded from my study because their contribution to patent applications is negligible. In total, 76.5% of the observations of patent–inventor combinations (see definition in footnote 11) are identified and their inventors are aged 25 to 64. The detailed discussion about unidentified inventors can be seen in Zheng and Ejermo (2015).

individuals) are immigrants with two FB parents. They are attributed with 6.39% and 1.93% of patent applications, respectively. On average, each first-generation immigrant inventor is attributed the highest number of patents (1.49 by fractional count), followed by each mixed immigrant inventor (1.43 patents) and native inventor (1.39 patents), while each immigrant inventor with two FB parents is attributed at the lowest rate (1.29 patents). However, when I consider the share of inventors relative to each group's entire population in Sweden, mixed immigrants enjoy the highest share at 0.36% (i.e. there are 36 inventors among 10,000 mixed immigrants), followed by immigrants with two FB parents (0.32%) and then by native Swedes (0.29%), while first-generation immigrants have the lowest share of inventors among their population (0.17%).

These results suggest that first- and second-generation immigrants display opposite results when considering the contribution of inventions among inventors and the share of inventors among the corresponding population. That is to say, compared with the first-generation, the second-generation contribute a lower number of patents per inventor but, by contrast, have a higher proportion of inventors among their population as a whole. Compared with native Swedes, both groups of the second-generation have a higher proportion of inventors among their populations, and mixed immigrant inventors also contribute on average a higher number of patents. Although the foreign-born parents of second-generation immigrants investigated in this paper are predominately refugees and unskilled manual labourers (especially those of immigrants with two FB parents[9]) who have lower human capital than parents of native Swedes (e.g., they have a lower education level and a lower skilled language proficiency), when compared with their population as a whole, their children are still more likely to become an inventor than native Swedes.

Insert Table 1 here

4.2 Growing trends for native-born inventors

[9] Respectively, 89% (85%) and 88% (73%) of the mothers and fathers of immigrants (inventors) with two FB parents have an education equal to or lower than secondary high school; the corresponding figures for native Swedes (inventors) are 86% (69%) and 83% (65%) and for the foreign-born mothers and fathers of mixed immigrants (inventors) are 85% (69%) and 80% (58%).

Figures 1 and 2 present the proportions of the three groups of native-born inventors against the proportions of their contributions to inventions and the shares of each population within the entire Swedish population aged 25 to 64. Figure 1 shows that, along with the stable decrease of the shares of native Swedes within the entire Swedish population, both the shares of native inventors and the shares of their contribution to invention decrease over the same period. Although both of the latter two shares are overrepresented compared to their population share, the proportion of inventions contributed to by native Swedes is lower than the share of inventors. By contrast to Figure 1, Figure 2 shows growing trends in all three share indicators for both groups of second-generation immigrants. The shares of inventions and inventors grow especially fast for mixed immigrants since 1997 onwards. This may be related to the recovery of Swedish economy, especially the high-tech sectors, where mixed immigrants are more likely to concentrate than other groups (Helgertz 2010). In general, the share of inventions contributed to by mixed immigrant inventors is higher than their share of inventors, which is in turn higher than their entire population share. The growing trends for immigrants with two FB parents are much slower and steadier than those for mixed immigrants.

Insert Fig. 1 and Fig. 2 here

The descriptive analyses suggest that, along with a surge of immigrants in Sweden since the Second Word War (see Figure A1 in Appendix 2), the proportion of immigrants' offspring who have made a contribution to invention in Sweden has been growing quickly. Contrasting with first-generation immigrants in Sweden, who are underrepresented in invention as compared with their population share in the entire workforce population (see Table 1 and Zheng and Ejermo 2015), second-generation immigrants (especially mixed immigrants) are overrepresented in invention (see Table 1 and Figure 2). This implies that, although first-generation immigrants may not contribute as much as they could to the host country's innovation when compared with their share of the population and they can be negatively selected and have an undeniable short-term impact on the host country's development (Rodríguez-Pose and

Von Berlepsch 2014; Zheng and Ejermo 2015), in the long run, their offspring are likely to contribute as much as or even more than native Swedes.

5 Methodology

I compare the patenting performance of second-generation immigrants and native Swedes by three indicators. First, I examine (a) the probability of becoming an inventor among the entire corresponding population from 1985 to 2007.[10] Each individual aged 25 to 64 only shows once in the data. Second, among the inventors, I investigate (b) the total number of patents attributed to each of them who patent at least once during 1985 and 2007. I use (a) and (b) as indicators of patenting productivity. Third, I use (c) the NFC to their patents to compare the quality of patents attributed to each group of native-born inventors. Studies have demonstrated that NFC has a significant and positive correlation with the value of a patent (e.g. Harhoff et al. 2003; Hall et al. 2005; Gambardella et al. 2008). It is used as the most common indicator and even considered the strongest predictor of patent value compared with other indicators (Lanjouw and Schankerman 1999). Moreover, it is considered a proxy for effective use or importance of a patent to new inventions (Sapsalis et al. 2006). Figure A2 also shows that patents received higher NFC are also more likely to be granted and more likely to receive opposition in my data, which are also used to indicate the value and quality of patents in literatures (Guellec and van Pottelsberghe de la Potterie 2000; Harhoff et al. 2003).

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[10] I have also tried to use the indicator of *the probability of patenting*, which is based on unbalanced panel data (as individuals can enter in different years, die or move out, or be out of age 64) for the entire Swedish-born population from 1985 to 2007 (the same indicator used in Zheng and Ejermo (2015)). This is because the control variables used in the regressions (see Table 3) for the same person such as age, education level, field of study and sector of work can vary across years. The dependent variable is set up as a dummy variable, coded as 1 if an individual has at least one patent application in year *t* and 0 otherwise. Random-effects probit regressions with observed information matrix (oim) standard errors are applied in this analysis. The results are similar as using the indictor of *the probability of becoming an inventor*. I report results of the above indicator instead of *the probability of patenting* as the marginal effects for the later indicator is very small. That is because in each year, only a small number of individuals patent among the entire population. For example, in 2000, only 2,180 individuals patent among 4.7 million population.

Table A3 presents the descriptive statistics of each dependent variable. The unit of analysis for indicator (a) and (b) is the individual, while for indicator (c) NFC is the unique patent–inventor combination,[11] since the NFC for different patents that filed by the same person can be different. Table 2 presents an overview of the estimation methods for each indicator and the reasons for using each method.

Insert Table 2 here

I mainly use three models to examine the patenting performance of second-generation immigrants. In model 1, all second-generation immigrants are combined together to be compared with native Swedes (the reference group in all regressions). I use this model to examine the positive and negative forces on second-generation immigrants' inventive performance, which is discussed in Section 3.1. In model 2, second-generation immigrants are divided into two groups, which are mixed immigrants and immigrants with two FB parents, and each is compared with that of native Swedes. This model is used to test discussion in Section 3.2. Similarly, in model 3, second-generation immigrants are further divided into six groups by their parents' region of origin, as described in Section 3.3.

Model 1 and model 2 have two specifications and model 3 has three specifications. In the first specification for each model, different groups of second-generation immigrants are compared with native Swedes without including any control variable. In the second specification for model 3, I control *highest education level* (at the time of the examined year) to examine its effect on patenting performance for each group. This is because it can vary widely across different immigrant groups and has especially strong effects on patenting performance (Dustmann and Theodoropoulos 2010; Hunt 2011). In the second specification for models 1 and 2 as well as the third specification for model 3, I control the following variables for each estimated dependent variable: *highest education level*; *field of study*; *age* and *age*^{2}; *birth cohort; gender*; *firm size*;

[11] Patent–inventor combination means that each inventor in a patent generate a unique observation. For example, if one patent has three inventors it will generate three unique observations. If an inventor contributes to four patents, then he or she will show four times and generate four unique observations.

sector of work (*high-tech industry of work* when only study high-tech sectors); *region of work*; *education level for mother/father*; *number of children for mother/father*. When study the probability of becoming an inventor, an individual's personal information, which can vary across different years, is randomly selected in year *t* between 1985 and 2007. I include *technology fields* when I examine the total number of patents for each inventor and the NFC for patents, which are likely to be influenced by the number of patents in different technology fields. When considering the NFC for patents, I also control *application year*, *total number of inventors in a patent*, and *number of co-inventors who are native Swedes/mixed immigrants/immigrants with two FB parents/first-generation inventors in a patent,* which are all related to patent quality. An overview of the reasons for including the control variables and their categorization can be seen in Table 3. I control the above variables in order to examine the extent to which these factors, in an individual's background and patent characteristics, could account for any observed differences for the different groups of native-born groups in patenting performance.

Insert Table 3 here

Patenting activity can vary across different sectors. High-tech sectors can be more active in patenting than other sectors and they can work as key drivers of innovation and economic growth for a country (Helmers and Rogers 2011). In order to reduce unobserved heterogeneity in the underlying patenting activity of various sectors, I also try to restrict my sample to a cohort of individuals who work in high-tech sectors.[12] High-tech sectors in this paper include medium high-tech manufacturing and high-tech knowledge-intensive service (KIS) sectors. This is because these sectors are the ones

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[12] The classification of high-tech sectors is according to Eurostat's statistics. The list of detailed code and name of each sector, which follow the Swedish Standard Industrial Classification (SNI92), is shown in 3.1, Appendix 3. I combine the different high-tech sectors together but do not examine each sub-sector separately in order to retain enough observations for each group of second-generation immigrants when I divide them into six groups and to make the statistics analysis meaningful.

most likely to face the chance of patenting (that is, in principle all their inventions should be patentable) (Arundel and Kabla 1998; Helmers and Rogers 2011). In total, 70.6% of the inventors in Sweden work in these high-tech sectors at the year of patenting. Moreover, for further exploration and to compare those who work in high-tech sectors, I investigate the other sectors (see 3.2 in Appendix 3) for the six subgroups of immigrants after adding control variables as well (model 4 in Tables A4 and A5, model 6 in Table A6). As immigrants from different regions of origin can be concentrated in and good at different technology fields (Kerr 2010), when studying NFC for patents in high-tech sectors, I also compare the six subgroups of immigrants with native Swedes in different technology fields. Among the investigated inventors, 39% of them patent in electrical engineering, which is the most important patenting technology field for Swedish companies like Ericsson (WIPO 2011). Therefore, first, I compare the NFC for patents for those who patent in electrical engineering (model 4 in Table A6), and then I compare those who patent in other technology fields as a whole (model 5 in Table A6). Technology fields are classified according to International Patent Classification (IPC) codes (Schmoch 2008). Patent with multiple technology fields are randomly assigned to one field.[13]

Only people with an education level equal to or higher than secondary school, and who were employed, are included in the regressions, as the data on explanatory variables of "field of study" in Sweden and "sector of work" are only available for this group.[14]

6 Empirical results

6.1 Do second-generation immigrants perform as well as native Swedes in patenting?

6.1.1 Probability of becoming an inventor

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[13] Among the patents, 61% only belong to one technology field and 30% belong to two fields. Among the patents which are classified as electrical engineering, 64% of them are only categorized as electrical engineering, and 29% of them belong to two fields. Therefore, it seems unlikely that there is any large issue with respect to the classification of technology field if a patent belongs to multiple fields.

[14] Among all the identified inventors, only 3.8% have an education at only primary school level and 3.6% are unemployed.

Table 4 shows that second-generation immigrants, both of mixed immigrants and immigrants with two FB parents, are significantly more likely to become an inventor than native Swedes, although the difference is small (models 1 and 2). The marginal effect of becoming an inventor is a little higher for immigrants with two FB parents than that of mixed immigrants. However, there is no significant difference between the above two groups (*p*>0.1 by T-test, model 2). The better performance for mixed immigrants is mainly attributed to those whose non-Swedish parent is from the EU-15 or a non-European country, while for immigrants with two FB parents is mainly because of those with both parents from non-Nordic European countries (model 3.1). Compared with native Swedes, immigrants with other Nordic backgrounds are less likely to become an inventor, although the result is not significant for those with at least one parent from other Nordic countries (model 3.1). Compared with native Swedes, either the better or worse performance of mixed immigrants with non-European backgrounds and immigrants with other Nordic backgrounds can be explained by their higher or lower education level (model 3.2). The better performance of mixed immigrants whose non-Swedish parent is from the EU-15 and immigrants with two FB parents from non-Nordic European countries persist even when holding all other variables constant (model 3.3). This indicates that they have advantage in some unobservable characteristics than native Swedes, such as higher non-cognitive skills and ability.

Insert Table 4 here

For individuals who work in high-tech sectors (Table A4 in Appendix 1), second-generation immigrants, both of the two groups, are as likely to become an inventor as native Swedes (models 1 and 2). However, when I investigate the six subgroups of immigrants, the results are similar as discussed above (model 3, Table 4). The main differences are: (a) the negative difference between native Swedes and immigrants with at least one FB parent from other Nordic countries becomes significant (*p*<0.1, model 3.1); (b) education level explains more for the better performance of mixed immigrants whose non-Swedish parent is from the EU-15 (model 3.2); (c) the better performance of immigrants with both FB parents from non-Nordic European countries does not persist when holding all control variables constant (model 3.3). However, the above group's better performance than native Swedes still persist in other sectors, which is the same for mixed immigrants whose non-Swedish parent is from the EU-15 (model 4).

6.1.2 Total number of patents per inventor

There is no significant difference between all groups of Swedish-born inventors when considering the total number of patents attributed to each inventor, no matter investigate them as a whole (Table 5) or in different sectors (Table A5 in Appendix 1). This shows that, regardless of their parents' region of origin, second-generation immigrant inventors are as productive in patenting as native Swedes in terms of the total number of patents per inventor attributed. This result indicates that there is a trade-off effect between the positive and negative forces for each group of second-generation immigrant inventors which are discussed in Section 3. It suggests that second-generation immigrant inventors, most of whom can be considered and defined as a subgroup of highly skilled individuals, are all well-integrated into the host society and are similar active in patenting.

Insert Table 5 here

6.1.3 NFC to patents per inventor

In general, patents filed by second-generation immigrant inventors receive a significantly higher NFC than those of native inventors ($p<0.05$, model 1, Table 6). It is mainly because of mixed immigrant inventors (model 2), especially those whose non-Swedish parent is from the EU-15 or the rest of Europe (i.e. non-Nordic European countries) (model 3). Only a small proportion of the differences in NFC for patents between the above groups and native inventors is explained by our observable variables; their main differences can be attributed to some unobservable characteristics. The NFC for patents filed by immigrant inventors with two FB parents is similar to that filed by their native counterparts, both when the population as a whole is considered and when their parents' region of origin is explored (models 2 and 3).

Insert Table 6 here

The above results also hold when I only study those who work in high-tech sectors (models 1–3, Table A6 in Appendix 1). The only difference is that the negative difference between native Swedes and immigrant inventors with at least one FB parent from other Nordic countries becomes significant (p<0.1, model 3.1). This can be mainly attributed to the latter group's lower education level (model 3.2). Among this immigrant group, 40% of them have only a short education (coef: –0.34, p<0.01), which twice the proportion than is seen in the other groups. The better performance of mixed immigrants with non-Nordic European background than native Swedes is attributed to those who patent in high-tech electrical engineering (model 4). The patents filed by the former group are more likely to be cited maybe because of their higher quality as they are field by the "best and brightest" inventors who patent in electrical engineering (they have the greatest average high school GPA among all groups, see Table A7). Compared with individuals who have lower grades, those have higher grades are more likely to be creative, knowledgeable and capable (Zheng and Ejermo 2015) and produce high quality of patents (high school GPA has significantly positive effect on NFC, p<0.01, see note [b] in Table 2). However, it is an opposite result for immigrant inventors with at least one FB parent from other Nordic countries. No significant difference is found between each second-generation immigrant group and native Swedes when investigate in other technology fields as a whole (model 5). Table A7 shows that all of the "best and brightest" individuals among native Swedes and mixed immigrants whose FB parent is from European countries patent in electrical engineering. This can be because it is the most important and promising technology field in Sweden and individuals are easy to be attracted by famous multinational companies like Ericsson. The better Swedish background for the above groups can help them easier to find job in this technology field than those with larger distance of proximity to Sweden. Compared with the "best and brightest" native Swedes, the "best and brightest" mixed immigrants with non-Nordic European backgrounds are even better. This can be because the latter group have the possibility of benefiting from their positively selected parents and a certain distance of proximity to Sweden (see detailed discussion in paragraph 3, Section 6.1.4). The “best and brightest” individuals with larger distance of proximity to Sweden may be “crowed out” by the former groups and choose to work in other technology fields which have less competition and less requirement of Sweden-specific human capital. The better performance of mixed immigrants with non-Nordic European backgrounds is mainly driven by those who work in high-tech sectors, but not by those who work in other sectors (model 6).

6.1.4 Discussion

In terms of the indicators of the probability of becoming an inventor and NFC to patents (the discussion below are all based on this two indicators), the results in model 1 indicate that, in general, positive forces on second-generation immigrants discussed in Section 3.1 overcome negative forces. When investigate the patenting performance of mixed immigrants and immigrants with two FB parents, the results in model 2 strongly support part of expectation in Section 3.2, which is mixed immigrants has a better performance than native Swedes. However, the immigrants with two FB parents are more likely to patent than native Swedes and their patents receive as high NFC as those of native Swedes. Therefore, part of expectation in Section 3.2 is rejected. Moreover, no significant difference is found between the above two groups of second-generation immigrants. This indicates that in contrast to my expectation, immigrants with two FB parents in Sweden are capable to overcome their disadvantages, to be well integrated into Swedish society and perform as well as or even better than their native counterparts in patenting. This maybe because that the distance of proximity between Sweden and other European countries is small, which help them easy to integrate into Swedish society.

The results in model 3 indicate that there is a trade-off effect between the importance of proximity of parents’ region of origin to Sweden and selection of parents on second-generation immigrants’ patenting performance, which differs between groups. The study shows that the worse patenting performance for second-generation immigrants with other Nordic backgrounds than native Swedes is mainly attributed to their lower education level (models 3.2 in Tables 4, A4 and A6, high school GPA in Table A7). It is further related to their negatively selected parents, who have the lowest education level among all immigrant groups. Tables A1 and A2 show that children's educational performance is positively correlated with their parents'. The negatively selected parents from other Nordic countries seems negatively affect their children's human capital development through intergeneration transmission, which in turn hamper their innovative performance.

In general, second-generation immigrants with non-Nordic European backgrounds, especially those mixed immigrants whose non-Swedish parent is from the EU-15, perform better in patenting than native Swedes. This is because they have the probability of benefiting from their positively selected FB parents and a certain distance of their proximity to Sweden. Compared with native Swedes, the above group who have positively selected parents also have better educational performance (Tables A1 and A2), which explains part of their better patenting performance, especially for those who work in high-tech sectors. Moreover, it is also reasonable to suspect that a higher education level on the part of parents can positively affect their children's non-cognitive skills (Ermisch and Francesconi 2001), which can be important for innovative performance. In addition, compared with native Swedes, who may experience too much cognitive proximity in family, society and work, second-generation immigrants with non-Nordic European backgrounds may benefit from a certain distance of proximity to Sweden. Studies indicates that too much proximity between actors could be detrimental to their interactive learning and knowledge creation because of the problem of lock-in (Boschma 2005; Fornahl et al. 2011). If actors' knowledge bases are too similar (for example, as between co-inventors, who can often be native Swedes),[15] the likelihood of an innovative recombination is

[15] 77, 78 and 84% of the patent applications used in the regressions attributed to mixed immigrant inventors whose non-Swedish parent is from another Nordic country, the EU-15 and the rest of Europe,

lower than if dissimilar knowledge bases are merged (McEvily and Zaheer 1999; Fornahl et al. 2011). By contrast, a certain distance of proximity (not too much or too little) between actors can help to increase the diversity of culture and knowledge (Boschma 2005), to stimulate new ideas through recombination and to promote the novelty of their patents.

However, for mixed immigrants whose non-Swedish parent is from a non-European country, the large distance of proximity of parents' region of origin to Sweden seems impede their patenting performance. Consistent with their most positively selected parents among all groups (Table A1), the above group has the best educational performance as well (see Tables A1 and A2). However, they still do not perform better than native Swedes, especially after controlling their education level. This implies that they can be disadvantaged in some unobserved human capital, such as lacking of social networks or having large distance of proximity to other actors (e.g. family members or co-inventors), which may hamper their patenting performance. This is because that too little cognitive proximity between actors can also harm an individual's interactive learning with others, which in turn affect his or her innovation performance by generating communication problems. A certain degree of proximity is also necessary for actors to have a sufficient absorptive capacity to identify, interpret and exploit the knowledge of other actors (Fornahl et al. 2011). Therefore, the complicated upbringing experience with large distance of proximity between family members and social society could induce the above group suffer more discrimination, narrower social networks and more problems in integrating into the host society than those with European backgrounds. This may be driven by their different appearance and ambiguous ethnic identity.

6.2 Control variables

The control variables largely confirm my expectations (see detailed results in Supplementary material). Education level mainly has a significantly positive effect on patenting performance: the higher a person's education level, the more productive he or

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respectively, are with at least two inventors. As native Swedes are the main component of the population of inventors in Sweden, it is reasonable to suspect that they can mainly co-patent with native Swedes.

she is in patenting and the greater the NFC received for a patent that he or she files. However, the NFC for patents filed by inventors with a PhD education is similar as for those with a long education.

Individuals who have studied in different fields perform differently in invention. Those who studied engineering, manufacturing and construction are significantly more likely to patent. However, the patents of those who studied in the fields of science, mathematics and computing or health and welfare are more likely to be cited than those who studied engineering, manufacturing and construction.

As I expected, a curvilinear relationship is found for age and age squared, but this differs when comparing different indicators. The higher the age of an individual, the higher his or her cumulative number of patents. However, the higher the age of an individual, the lower the probability of becoming an inventor and the lower the NFC to his or her patents.

Individuals of different birth cohort perform differently in patenting activity. In general, the younger the birth cohort is, the better their patenting performance is, both in terms of their patenting productivity and NFC. The only exception is that the marginal effect of becoming an inventor for those born between 1966 and 1982 is smaller than that of those born between 1946 and 1965. This maybe because the former individuals are still too young to become inventors.

Women are significantly less productive in patenting than men. However, no significant difference is found when I investigate their NFC.

Generally, individuals working in larger firms are more productive in patenting than those working in smaller firms. Nevertheless, the patents of inventors from both small and large firms receive a higher NFC than the patents of inventors from medium-sized firms.

Individuals who work in non-industry sectors are significantly less likely to become inventors than those who work in industry sectors. With regard to the number of patents per inventor and NFC for patents, individuals who work in the public service sector perform worse than those who work in the industrial sector. However, no significant difference is found when compared with those who work in agriculture, hunting, forestry and fishing, as well as in private service sectors.

Compared with those who work in rural regions, inventors who work in metro regions perform better in patenting activity, both in terms of productivity and NFC. Individuals who work in urban regions are also more likely to become inventors and their patents have a higher NFC, but the advantage is not as large as for those who work in metro regions. However, they have no advantage in the number of patents per inventor.

Both parents' education level have significantly positive effect on their children's patenting performance. The higher the parents' education level is, the more productive their children is in patenting, especially if the parents have equal or higher than three years of post-secondary high education. Patents filed by inventors with mothers who have at least three years of post-secondary high education also receive a higher NFC than those with mothers who have secondary high school education. However, no significant effect is found for fathers' education level on NFC for patents filed by their children. In general, mothers' education level has a more significant and important effect than fathers'.

In general, the number of children born to mother or father has no significant effect on either a person's patenting productivity or NFC, except that the number of children born to mother has a negative effect on an individual's probability of becoming an inventor. This may be because there is an offset between its positive and negative effects.

The total number of inventors in a patent has a significantly positive effect on NFC.

The number of co-inventors who are native Swedes has a significantly negative effect on NFC (coef. –0.046, $p<0.01$), which is contrasted with the number of co-inventors who are first-generation immigrant inventors (coef. 0.067, $p<0.05$). This may be because the cognitive proximity between native Swedes in the same group hampers the generation of new ideas and high-quality patents (Hong and Page 2004; Boschma 2005). First-generation immigrant inventors, who usually have larger cognitive distance from native-born inventors, and who may have been "pre-selected" on the basis of their skill, especially if they migrated as adults, may help to bring greater cultural diversity in the group (Nathan 2014; Zheng and Ejermo 2015). This may in turn help to improve patent quality, as well as help to extend international social networks for patent citation flows by the co-ethnicity effect (Agrawal et al. 2008; Parrotta et al. 2014). Number of co-inventors who are in any group of second-generation immigrants has no significant effect on NFC.

7 Conclusion

The paper shows that in terms of probability of becoming an inventor and NFC for patents, second-generation immigrants in general perform better than native Swedes. Both groups of mixed immigrants and immigrants with two FB parents have higher probability of becoming an inventor than native Swedes. It is mainly attributed to those whose non-Swedish parent from the EU-15 and those with both FB parents from non-Nordic European countries, respectively. The patents filed by mixed immigrants also receive higher NFC than those of native Swedes. This is mainly on account of those with non-Nordic European backgrounds who patent in high-tech electrical engineering. Their patents may have higher quality and are more likely to be cited than those of native Swedes as they are filed by the "best and brightest" immigrants from that group, who are also the "best" among all groups patent in this field. However, second-generation immigrant inventors contribute a similar total number of patents per inventor as those of native inventors, no matter where their parents came from. Moreover, no significant difference is found between mixed immigrants and immigrants with two FB parents in terms of all three indicators. This may be because of the small distance of proximity between Sweden and other European countries, which makes it easier for immigrants with two FB parents to integrate into Swedish society. The above results also hold, in the main, when studying only individuals who work in high-tech sectors.

The study indicates that there is a trade-off effect between the importance of proximity of parents' region of origin to Sweden and selection of parents on second-generation immigrants' innovative performance, which differs between groups. The reasons for why second-generation immigrants with non-Nordic European backgrounds perform better in patenting can be because first, the positive selection of their parents positively impacts on their human capital development through intergeneration transmission; second, a certain distance of their physical and cognitive proximity to Sweden not only help them have good opportunities to integrate into Sweden, but also help to increase their diversity of culture and knowledge, which promote their innovative performance. However, for second-generation immigrants with other Nordic backgrounds, although they have close proximity to Sweden, they perform less well than native Swedes. This is attributed to their lower education level, which is further related to their less positively selected parents. While for mixed immigrants with non-European backgrounds, although their FB parents are most positively selected and they themselves also have the best educational performance among all groups, their large distance of proximity to Sweden seems to impede their performance.

This study also suggests that it is important to consider the long-term impact of immigrants. Contrary to the findings by Zheng and Ejermo (2015), which reveal that generally first-generation immigrants are underrepresented compared with their corresponding proportions in the working population, this study shows that second-generation immigrants are overrepresented. The better performance of the second-generation immigrants with non-Nordic European backgrounds than native Swedes also suggests that ethnic and cultural diversity can stimulate an individual's innovative performance, which in turn can help promote the innovative performance of a country. Therefore, even though first-generation immigrants do not have as much human capital as native Swedes (e.g. lower education level for parents of second-generation immigrants; see footnote 9) and cannot contribute as much as native Swedes to Sweden's innovation and development, they may leave some positive innovative legacy that may be revealed in the future (e.g., they may have outstanding offspring). Therefore, for those who worry about the cost of immigration to the host country (Ekberg 1999; Storesletten 2003; Rowthorn 2008), it is important for them and the government to have a long-term perspective on the impact of immigrants. However, as discussed above, the study indicates that it is very important to select immigrants positively as children of immigrants' human capital development and innovative performance can be strongly related to their parents' human capital through intergeneration transmission. The empirical results show that parents' education level, especially university education or higher, has a significantly positive effect on the patenting performance of their children. This effect is more significant for mothers than fathers. Moreover, the proximity of immigrants' region of origin to Sweden is also very important. For immigrants, even those second-generation, who are with large distance of proximity to the host country, it is important to improve their host country-specific human capital, e.g. offering better integration policy to decrease discrimination and improve their social network. Therefore, both the selection of immigrants and their proximity to the host country will not only impact on the innovative performance of immigrants themselves, but also that of their offspring in the long term, which can influence a country's future innovation performance and international competitiveness.

This study certainly makes contributions to the literature, but there are some limitations which need to be explored further. Firstly, although I have tried to explore the reasons for the difference in patenting performance between different groups of native-born, the results are mainly descriptive. Secondly, the data on country of origin for immigrants are not available in our database, which is detrimental to the study of ethnic effects. Proximity to Sweden can vary across immigrants who may come from the same region but from different countries within that region. Thirdly, despite the richness of the data, I cannot track the growing environment for individuals, as individual data are only available from 1985 onwards. For example, I do not have data on individuals' parents' work status or income condition (although the free education in Sweden can weaken the effect of parents' income on their children's availability of education), age of immigration for foreign-born parent(s) (which indicates to some extent the level of integration), ethnic identity, language skills (Nekby and Rödin 2010; Schüller 2015), attitude and expectation to the achievement of both their parents and themselves (Fuligni 1997) or their growing place (Nielsen et al. 2003; Åslund et al. 2011). All of these factors may have an impact on individuals' obtainment of human capital and future innovative performance. Fourthly, the detailed collaboration patterns between different native-born groups (e.g. whether mixed immigrant inventors whose non-Swedish parent is from another Nordic country are more likely to co-invent with inventors with the same parental background), which may influence their patenting performance, are not studied in this paper. Fifthly, I cannot determine who cited the patents, and so cannot examine any ethic effect on citation. For example, the preference of self-citation by different groups of inventors may affect the results of NFC for patents, although I cannot find any literature to show that such difference in preference exists. Finally, I do not compare the changes of patenting performance over time because of space limitation and small number of inventors for each specific immigrant group if dividing into several periods. I plan to explore these dimensions in future research.

Tables

Table 1 Number and share (%) of different groups of identified inventors in Sweden aged 25–64 and patent applications that they contributed to, 1985–2007

Different groups of residents in Sweden	Native Swedes	Mixed immigrants	Immigrants with two FB parents	First-generation immigrants	Total
No. of identified inventors	16,169	1,251	419	2,176	20,015
Share of all identified inventors	80.78%	6.25%	2.09%	10.87%	100%
No. of population	5,546,209	347,990	131,001	1,274,029	7,299,229
Share of inventors in the population	0.29%	0.36%	0.32%	0.17%	0.27%
No. of identified applications (fractional count)	22,513	1,797	542	3,254	28,106
Share of all identified applications	80.10%	6.39%	1.93%	11.58%	100%
Average no. of patents attributed to	1.39	1.44	1.29	1.49	1.40

Sources: Statistics Sweden and CIRCLE data on inventors. It is the same for all tables and figures below.

Table 2 Dependent variables and estimation methods

Dependent variable	Estimation method[a]	Rationale of estimation method
(a) Probability of becoming inventors	Probit regressions with observed information matrix (oim) standard errors	1. Dummy variable: coded as 1 if an individual has at least one patent application during 1985 to 2007 and 0 otherwise.
(b) Total number of patents attributed to each inventor	Negative binomial models with robust standard errors.	1. Count data 2. Widely overdispersed: more than half (51.5%) of the inventors have only one patent application, and the standard deviation (4.4) of the dependent variable is larger than its mean value (2.9).
(c) NFC received by each inventor's patent	Negative binomial models with clustered robust standard errors.	1. Count data. It is calculated within a five-year interval after filing the original patent or one of its family members. 2. Highly overdispersed (zero citations: 49.3%, standard deviation: 3.0, mean: 1.5). 3. As 48.5% of inventors have filed more than one patent, I control for intra-inventor correlation by clustered robust standard errors on inventors.[b]

Notes: [a] I have compared between probit and logit models for indicator (a) and negative binomial, Poisson and zero inflow models for indicators (b) and (c). I find that the models used here have the higher log pseudolikelihood, a smaller Akaike's information criterion (AIC) and Schwarz's Bayesian information criterion (BIC) than their corresponding models.

[b] As 60% of patents have more than one inventor and a patent with *N* inventors can show *N* times in patent–inventor combinations, I also try to run regressions on clustered robust standard errors on patents, i.e. vce(cluster patent_ID). The results are similar as run regressions on clustered robust standard errors on inventors, i.e. vce(cluster inventor_ID), which are reported in Tables 6 and A6.

Table 3 Control variables: rationale for inclusion and categorization

Control variable[a, b]	Rationale	Categories
Highest education level at the time of the examined year	Studies indicate education level has positive effect on patenting performance (Hunt and Gauthier-Loiselle 2010; No and Walsh 2010; Hunt 2011).	Three education levels: (a) Secondary or <3 years of post-secondary education (short education); (b) ≥3 years of post-secondary education but below PhD level (long education, reference); (c) Any PhD education (also unfinished).
Field of study[c]	Patenting activity can vary across individuals who study in different fields of study (Hunt and Gauthier-Loiselle 2010; Hunt 2011), e.g. those study in science and engineering (S&E) are more likely to patent than those study in business.	Four categories: (a) Engineering, manufacturing, and construction (reference); (b) Science, mathematics, and computing; (c) Health and welfare; (d) Other fields.
Age and age^2	Inventive productivity varies with the age of individuals and has a curvilinear relationship (Simonton 2000; Jones 2010; Jung and Ejermo 2014).	Discrete data.
Birth cohort	Individuals who were born at different periods can have different upbringing and social environment, which can affect their integration and further inventive activity (Riphahn 2003).	Four categories by birth year: (a) 1921–1945 (reference); (b) 1946–1955; (c) 1956–1965; (d) 1966–1982.
Gender	Gender differences exists in patenting performance (e.g. Ding et al. 2006; Azoulay et al. 2007). Women are less likely to patent than men (Azoulay et al. 2007) but patents filed by women have equal or better citation rates as those by men (Whittington and Smith-Doerr 2005)	Dummy variable: (a) Male (reference); (b) Female.
Firm size	Small firms may be more constrained in their propensity to patent and thus might focus only on the most valuable inventions (No and Walsh 2010). Large firms are more likely to patent and can also be expected to produce higher-quality patents, as they usually have more ample resources for invention and can afford to hire employees with greater innovation skills.	Three categories: (a) Small firms, coded 1 for 1–99 employees, 0 otherwise; (b) Medium firms, coded 1 for 100–499 employees, 0 otherwise (reference); (c) Large firms, coded 1 for 500 employees or more, 0 otherwise.
Sector of work	Inventive activity can vary across different sectors. For instance, it can be higher in manufacturing sectors than agriculture and service sectors (Nathan 2014). Employees in the public service sector may perform more poorly than those in other sectors as their work rarely involves competing for	Four categories following SNI92: (a) Agriculture, hunting, forestry and fishing; (b) Industry (reference); (c) Private service; (d) Public service.

Control variable[a, b]	Rationale	Categories
	technology in markets.	
High-tech industry of work	Inventive activity can also vary across specific high-tech industries (Helmers and Rogers 2011) (see share distribution of inventors in each industry in 3.1, Appendix 3). To account for unobserved sector-specific effects, I include industry fixed effects when run regressions on *high-tech* sectors.	12 categories following SNI92: See the detailed name of each category in 3.1, Appendix 3. 32 Manufacture of radio, television and communication equipment and apparatus (reference).
Region of work	Larger cities often offer agglomeration economies, which leads to more developed markets, resources and greater opportunities for innovation, than smaller cities (Orlando and Verba 2005).	Three categories: (a) Metro regions; (b) Urban areas; (c) Rural regions (reference).
Education level for mother/father	Parents' education level, especially mothers', is indicated to have positive effect on their children's outcome (Ermisch and Francesconi 2001; Riphahn 2003; Dustmann et al. 2012; Lundborg et al. 2014), not only on education attainment, but also on non-cognitive skills (Ermisch and Francesconi 2001; Lundborg et al. 2014), which may impact on their children's innovative performance.	Four categories: (a) ≤Primary education; (b) Secondary high school education (reference); (c) <3 years of post-secondary high education; (d) ≥3 years of post-secondary high education.
Number of children for mother/father	Having more siblings may have negative effect on a child's outcome because of resource dilution (both money and time) (Ermisch and Francesconi 2001; Black et al. 2005) or positive effect because can know better how to compete or cooperate with others.	Discrete data.
Technology fields	In some technology fields, inventions are more likely to be applied for as patents (No and Walsh 2010). Moreover, technologies with many patents are likely to have a higher NFC than those with fewer patents (No and Walsh 2010; Ejermo and Kander 2011).	Five categories (Schmoch 2008)[a]: (a) Electrical engineering (reference); (b) Instruments; (c) Chemistry; (d) Mechanical engineering; (e) Other fields.
Application year	Used to control for differences in citation behaviour over time and possible differences in the accumulation of citations over time (Sapsalis et al. 2006), although this is largely dealt with by counting citations within 5 years after application.	23 time dummy variables.
Total number of inventors in a patent	Used to control for the level of resources devoted to the research project leading up to a patent, which should therefore affect the quality of a patent (Sapsalis et al. 2006).	Discrete data.
Number of co-inventors who are native Swedes/mixed immigrants/ immigrants with two FB parents	Used to measure the cognitive diversity of inventors in a patent, which may benefit group members if it brings a richer mix of ideas and perspectives and in turn help members problem-solve, generate ideas and improve the quality of patent as well (Nathan 2014).	Discrete data.

Control variable[a, b]	Rationale	Categories
/first-generation inventors in a patent[d]	Ethnic or cultural mix may be a good proxy for cognitive diversity (Hong and Page 2004).	

Notes: [a] For the indicator (b) *the total number of patents per inventor*, if an inventor has more than one patent, then I use his/her personal and patent information when the last time he/she applied for a patent.
[b] I have also tried to control for *individuals' secondary high school GPA* (results not reported). This was used as a proxy for unobserved ability, which may correlate with inventive performance. However, these data are only complete between 1973 and 1996 but unobserved before 1973 and not comparable with earlier years from 1997 onwards. Therefore, it deducts quite a lot from the observations. I found that the regression results do not change much compared with leaving high school GPA out, although it has positively significant effect on patenting performance. Thus, in order to retain enough observations for each sub-group of second-generation immigrants and make the statistics analysis more meaningful, the main regressions reported here exclude this variable.
[c] I have also run regressions by adding mothers' and fathers' fields of study and found no substantial differences from the reported results.
[d] Only identified inventors in a patent are calculated here. Zheng and Ejermo (2015) indicate that it seems unlikely that there is any large sample selection issue in the data for unidentified inventors.

Table 4 Probit regressions on the probability of becoming an inventor for second-generation immigrants among the *entire* population aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation immigrants	1.1	1.2	2.1	2.2	3.1	3.2	3.3
(omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.0004***	0.0004***					
	(0.0001)	(0.0001)					
Mixed immigrants (1)			0.0004**	0.0003**			
			(0.0002)	(0.0001)			
Immigrants with two FB parents (2)			0.0006**	0.0007***			
			(0.0003)	(0.0003)			
Mixed immigrants							
−1 parent from another Nordic country					−0.0004**	0.0000	0.0001
					(0.0002)	(0.0002)	(0.0002)
−1 parent from the EU-15					0.0020***	0.0013***	0.0013***
					(0.0004)	(0.0003)	(0.0003)
−1 parent from the rest of Europe					0.0006	0.0001	−0.0001
					(0.0004)	(0.0004)	(0.0003)
−1 parent from a non-European country					0.0014**	0.0001	0.0002
					(0.0006)	(0.0005)	(0.0005)
Immigrants with two FB parents							
−≥1 parent(s) from other Nordic countries					−0.0002	0.0005	0.0004
					(0.0003)	(0.0003)	(0.0003)
−2 parents from non-Nordic European countries					0.0024***	0.0018***	0.0012***
					(0.0006)	(0.0005)	(0.0005)
Education level	No	Yes	No	Yes	No	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes
No. of observations	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159
Wald χ^2	10	47,754	10	47,756	70	15,134	47,773
Log likelihood	−68,276	−44,404	−68,276	−44,403	−68,246	−60,714	−44,395
Pseudo R^2	0.000	0.350	0.000	0.350	0.001	0.111	0.350
T-test (1)=(2) (p-value)			0.458	0.178			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Marginal effects are reported.

(2) The results for control variables are omitted here to save space but can be seen in Supplementary material. These are the same for Tables 5–6 and A4–A6.

(3) The other control variables included here are: four dummies of field of study; age, age^2; three dummies of birth cohort; gender; three dummies for firm size; four dummies for sector of work; three dummies for region of work; four dummies of education level for mother/father and number of children for mother/father.

Table 5 Negative binomial regressions on total number of patents per inventor aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation immigrant inventors	1.1	1.2	2.1	2.2	3.1	3.2	3.3
(omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.006	0.007					
	(0.048)	(0.040)					
Mixed immigrants (1)			0.031	0.023			
			(0.056)	(0.047)			
Immigrants with two FB parents (2)			−0.080	−0.046			
			(0.079)	(0.067)			
Mixed immigrants							
−1 parent from another Nordic country					0.038	0.075	0.051
					(0.079)	(0.080)	(0.066)
−1 parent from the EU-15					−0.055	−0.067	−0.034
					(0.110)	(0.107)	(0.093)
−1 parent from the rest of Europe					0.131	0.108	0.046
					(0.129)	(0.129)	(0.105)
−1 parent from a non-European country					0.085	0.063	−0.008
					(0.169)	(0.178)	(0.151)
Immigrants with two FB parents							
−≥1 parent(s) from other Nordic countries					−0.122	−0.075	−0.039
					(0.104)	(0.104)	(0.094)
−2 parents from non-Nordic European countries					−0.030	−0.063	−0.055
					(0.118)	(0.108)	(0.094)
Education level	No	Yes	No	Yes	No	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes
Constant	1.079***	−2.641***	1.079***	−2.637***	1.079***	1.064***	−2.634***
	(0.015)	(0.296)	(0.015)	(0.295)	(0.015)	(0.021)	(0.295)
No. of observations	10,464	10,464	10,464	10,464	10,464	10,464	10,464
Wald χ^2	0	1,687	1	1,689	3	231	1,702
Log pseudolikelihood	−23,050	−21,805	−23,049	−21,804	−23,047	−22,801	−21,804
Pseudo R^2	0.000	0.054	0.000	0.054	0.000	0.011	0.054
T-test (1)=(2) (p-value)			0.236	0.392			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1
Notes: (1) Coefficient results are reported.
(2) In addition to the control variables in Table 4, here I also include five dummies of technology field.
(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).

Table 6 Negative binomial regressions on number of forward citations for second-generation immigrant inventors aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.3
immigrant inventors (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.118**	0.098**					
	(0.055)	(0.045)					
Mixed immigrants (1)			0.146**	0.121**			
			(0.062)	(0.050)			
Immigrants with two FB parents (2)			0.010	0.013			
			(0.093)	(0.095)			
Mixed immigrants							
−1 parent from another Nordic country					0.081	0.111	0.098
					(0.100)	(0.099)	(0.072)
−1 parent from the EU-15					0.243**	0.229**	0.178**
					(0.099)	(0.096)	(0.089)
−1 parent from the rest of Europe					0.322***	0.292**	0.195**
					(0.117)	(0.117)	(0.093)
−1 parent from a non-European country					−0.159	−0.163	−0.079
					(0.144)	(0.166)	(0.198)
Immigrants with two FB parents							
−≥1 parent(s) from other Nordic countries					−0.085	−0.023	−0.076
					(0.106)	(0.103)	(0.104)
−2 parents from non-Nordic European countries					0.107	0.067	0.103
					(0.142)	(0.139)	(0.151)
Education level	No	Yes	No	Yes	No	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes
Constant	0.399***	1.179***	0.399***	1.177***	0.399***	0.440***	1.196***
	(0.021)	(0.409)	(0.021)	(0.409)	(0.021)	(0.030)	(0.407)
No. of observations	31,002	31,002	31,002	31,002	31,002	31,002	31,002
No of inventors	10,576	10,576	10,576	10,576	10,576	10,576	10,576
Wald $\chi 2$	5	2703	6	2,710	16		2,745
Log pseudolikelihood	−50,829	−48,495	−50,828	−48,494	−50,818	−50,659	−48,490
Pseudo R^2	0.000	0.046	0.000	0.046	0.000	0.004	0.046
T-test (1)=(2) (p-value)			0.207	0.306			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results of clustered robust standard errors on inventors are reported.

(2) In addition to the control variables in Table 5, here I also control the total number of inventors in a patent, number of co-inventors who are native Swedes/mixed immigrants/immigrants with two FB parents/first-generation inventors in a patent and 23 dummies for application years.

(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).
(4) The results for different groups of second-generation immigrant inventors are robust if using data from 1985 to 2004, 1985 to 2005 and 1985 to 2006. The only exception is model 3.3, where mixed immigrants with one parent from another Nordic country becomes positively significant as well.

Figures

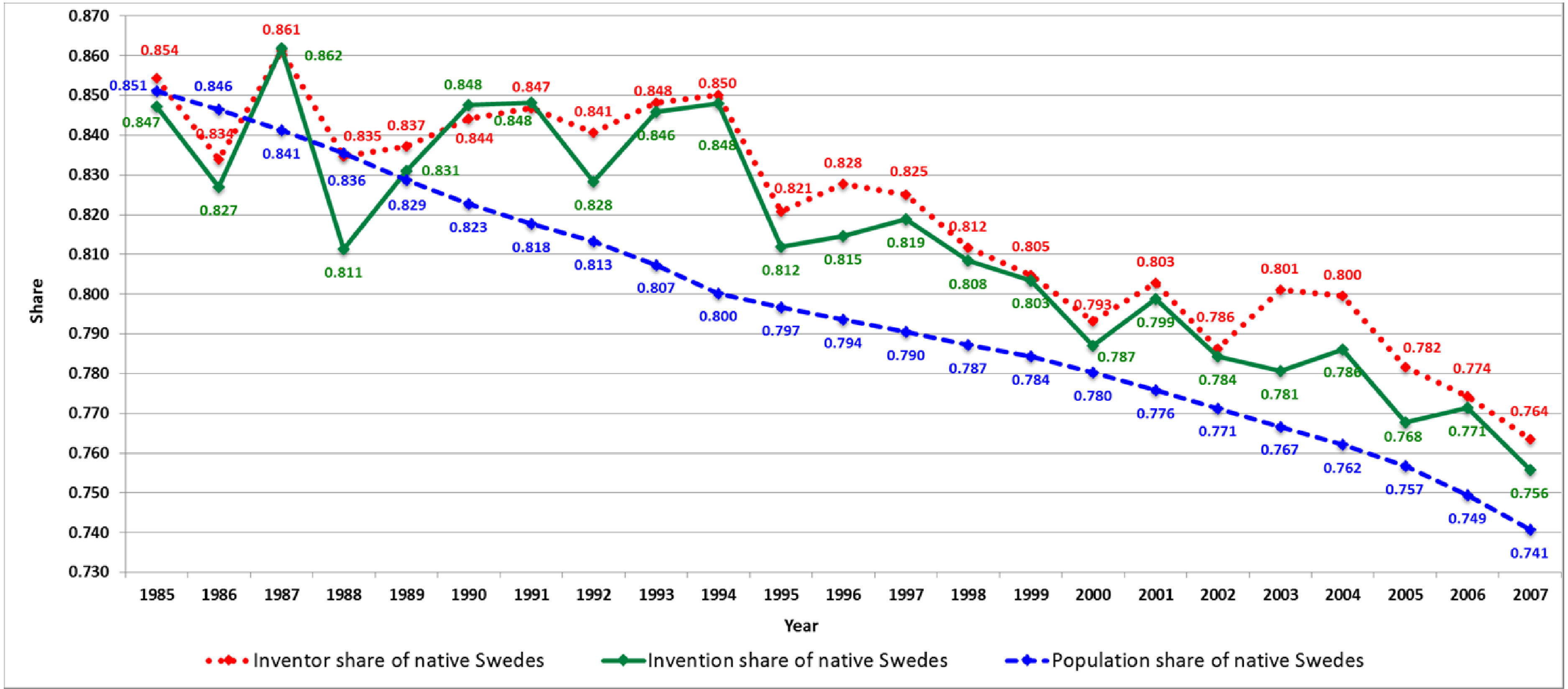

Fig. 1 Share of native inventors in the entire inventors in Sweden, their contribution of inventions (fractional count) and their population share in the entire Swedish population aged 25–64, for each year 1985–2007

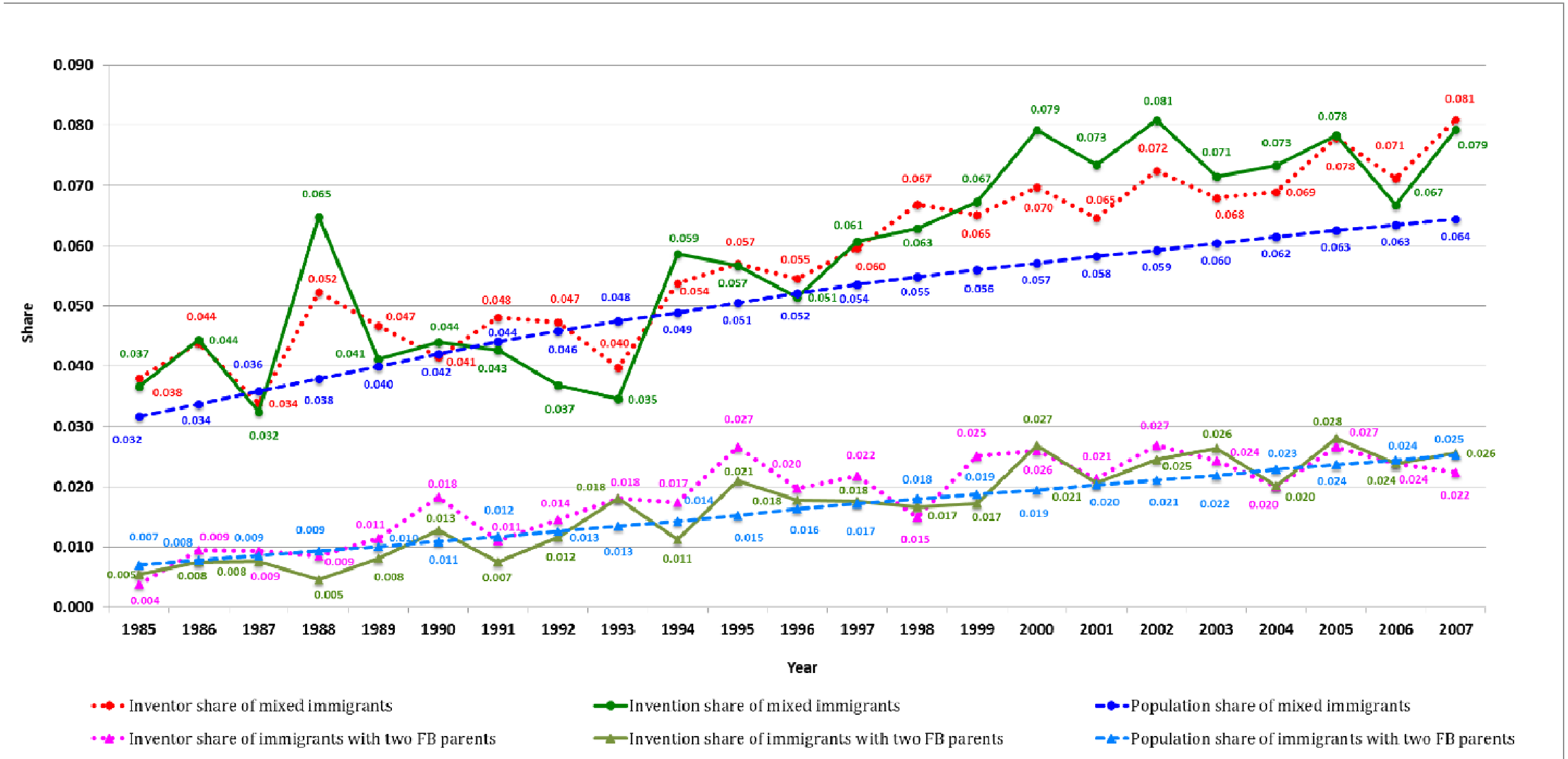

Fig. 2 Share of mixed immigrants and immigrants with two FB parents in the entire inventors in Sweden, their contribution of inventions (fractional count) and their population in the entire Swedish population aged 25–64, for each year 1985–2007

Appendices

Appendix 1

Table A1 Descriptive statistics of parents' average years of schooling, secondary high school GPAs for each group of Swedish-born population/inventors who graduated between 1973 and 1996 and aged 25–64, 1985–2007

	Population					Inventors				
	Average years of schooling[a]		High school GPAs for population	No. of obs.	Share (%)	Average years of schooling[b]		High school GPAs for inventors	No. of obs.	Share (%)
Different groups of Swedish-born	Mother	Father				Mother	Father			
All native Swedes	10.6	10.8	326	1,381,569	89.4	11.7	12.5	376	6,842	88.4
All second-generation	10.5	11.0	323	163,447	10.6	11.5	12.6	371	900	11.6
Mixed immigrants	10.7	11.2	325	122,175	7.9	11.8	13.0	372	689	8.9
−1 parent from other Nordic country	10.4	10.6	321	69,991	4.5	11.3	12.2	367	332	4.3
−1 parent from the EU-15	11.3	11.8	331	27,643	1.8	12.2	13.3	374	209	2.7
−1 parent from the rest of Europe	11.0	11.6	328	16,849	1.1	12.0	13.9	374	94	1.2
−1 parent from a non-European country	11.9	12.7	339	7,692	0.5	13.2	15.1	393	54	0.7
Immigrants with two FB parents	10.0	10.4	319	41,272	2.7	10.5	11.6	369	211	2.7
−≥1 parent(s) from other Nordic countries	9.7	9.9	317	28,137	1.8	10.3	11.4	366	127	1.6
−2 parents from non-Nordic European countries	10.5	11.2	322	13,135	0.9	10.7	11.9	373	84	1.1
All Swedish-born	10.6	10.8	326	1,545,016	100	11.7	12.5	375	7,742	100

Notes: (1) [a,b] It is similar results for average years of schooling for parents when investigate the total number of observations used in regressions of Table 4 (2,634,159) and Table 5 (10,464).
(2) I use average years of schooling instead of education level for patents is for the easy comparison with high school GPAs.

Table A2 Descriptive statistics of education level for each group of Swedish-born population/inventors (data used in regressions) aged 25–64, 1985–2007

Different groups of Swedish-born	Population: Short education (%)	Population: Long education (%)	Population: Any PhD (%)	Population: Total (%)	Population: No. of obs.	Inventors: Short education (%)	Inventors: Long education (%)	Inventors: Any PhD (%)	Inventors: Total (%)	Inventors: No. of obs.
All native Swedes	77.2	22.1	0.7	100	2,379,152	26.2	46.9	26.9	100	27,739
All second-generation	78.4	20.8	0.8	100	255,007	26.0	52.2	21.7	100	3,263
Mixed immigrants	77.4	21.8	0.8	100	195,754	25.3	53.6	21.1	100	2,537
−1 parent from other Nordic country	80.6	18.8	0.6	100	116,389	31.0	53.3	15.7	100	1,262
−1 parent from the EU-15	73.6	25.3	1.1	100	39,453	23.7	47.7	28.6	100	646
−1 parent from the rest of Europe	74.2	24.9	1.0	100	25,923	13.6	63.2	23.2	100	397
−1 parent from a non-European country	67.9	30.8	1.3	100	13,989	19.0	54.7	26.3	100	232
Immigrants with two FB parents	81.7	17.5	0.7	100	59,253	28.7	47.5	23.8	100	726
−≥1 parent(s) from other Nordic countries	84.3	15.2	0.5	100	40,394	38.6	46.5	14.9	100	383
−2 parents from non-Nordic European countries	76.3	22.6	1.1	100	18,859	17.5	48.7	33.8	100	343
All Swedish-born	77.3	21.9	0.7	100	2,634,159	26.1	47.5	26.4	100	31,002

Table A3 Descriptive statistics of dependent variables: probability of becoming an inventor, total number of patents per inventor and NFC for patents, 1985–2007

Different groups of Swedish-born	Probability of becoming an inventor					Total no. of patents per inventor					NFC				
	Mean	SD	Max	No. of obs.	Share (%)	Mean	SD	Max	No. of obs.	Share (%)	Mean	SD	Max	No. of obs.	Share (%)
All native Swedes	0.0039	0.0626	1	2,379,152	90.3	2.94	4.37	116	9,353	89.4	1.49	2.97	60	27,739	89.5
All second-generation	0.0043	0.0658	1	255,007	9.7	2.96	4.46	51	1,111	10.6	1.68	3.14	46	3,263	10.5
Mixed immigrants	0.0043	0.0654	1	195,754	7.4	3.04	4.77	51	843	8.1	1.73	3.25	46	2,537	8.2
−1 parent from other Nordic country	0.0036	0.0596	1	116,389	4.4	3.06	4.83	46	417	4.0	1.62	2.94	46	1,262	4.1
−1 parent from the EU-15	0.0059	0.0768	1	39,453	1.5	2.79	4.63	51	233	2.2	1.90	3.73	44	646	2.1
−1 parent from the rest of Europe	0.0045	0.0670	1	25,923	1.0	3.35	4.69	30	119	1.1	2.06	3.71	31	397	1.3
−1 parent from a non-European country	0.0053	0.0725	1	13,989	0.5	3.20	4.66	25	74	0.7	1.27	2.40	16	232	0.7
Immigrants with two FB parents	0.0045	0.0671	1	59,253	2.2	2.72	3.44	26	268	2.6	1.51	2.73	25	726	2.3
−≥1 parent(s) from other Nordic countries	0.0037	0.0606	1	40,394	1.5	2.60	3.26	24	149	1.4	1.37	2.56	24	383	1.2
−2 parents from non-Nordic European countries	0.0063	0.0792	1	18,859	0.7	2.86	3.65	26	119	1.1	1.66	2.91	25	343	1.1
All Swedish-born	0.0040	0.0629	1	2,634,159	100	2.94	4.38	116	10,464	100	1.51	2.99	60	31,002	100

Note: Minimum values for indicators of probability of becoming an inventor and NFC is 0, for indicator of total no. of patents per inventor is 1.

Table A4 Probit regressions on the probability of becoming an inventor for second-generation immigrants among the *entire* population who work in high-tech and other sectors aged 25–64, 1985–2007

	High-tech							Other
	1		2		3			4
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4
immigrants (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g_other
All second-generation	−0.0001	0.0003						
	(0.0008)	(0.0008)						
Mixed immigrants (1)			−0.0002	−0.0001				
			(0.0009)	(0.0009)				
Immigrants with two FB parents (2)			0.0001	0.0016				
			(0.0016)	(0.0016)				
Mixed immigrants								
−1 parent from another Nordic country					−0.0040***	−0.0019	−0.0015	0.0002
					(0.0011)	(0.0012)	(0.0011)	(0.0001)
−1 parent from the EU-15					0.0065***	0.0036*	0.0033*	0.0009***
					(0.0023)	(0.0020)	(0.0019)	(0.0003)
−1 parent from the rest of Europe					0.0021	0.0001	0.0001	−0.0002
					(0.0025)	(0.0023)	(0.0022)	(0.0002)
−1 parent from a non-European country					0.0069*	0.0015	−0.0007	0.0002
					(0.0040)	(0.0032)	(0.0029)	(0.0003)
Immigrants with two FB parents								
−≥1 parent(s) from other Nordic countries					−0.0034*	0.0009	0.0002	0.0002
					(0.0018)	(0.0021)	(0.0019)	(0.0002)
−2 parents from non-Nordic European countries					0.0070**	0.0060**	0.0039	0.0006*
					(0.0032)	(0.0030)	(0.0026)	(0.0003)
Education level	No	Yes	No	Yes	No	Yes	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes	Yes
No. of observations	321,669	321,669	321,669	321,669	321,669	321,669	321,669	2,312,490
LR χ^2	0	20,690	0	20,691	35	6,988	20,697	14,937
Log likelihood	−33,018	−22,673	−33,018	−22,672	−33,000	−29,523	−22,669	−19,694
Pseudo R^2	0.000	0.313	0.000	0.313	0.001	0.106	0.313	0.275
T-test (1)=(2) (p-value)			0.886	0.329				

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Marginal effects are reported.

(2) The other control variables included here are the same as those of Table 4. However, instead of four dummies of sector of work in Table 4, models 1.2, 2.2 and 3.3 here include 12 dummies for high-tech industry of work.

(3) For individuals who work in other sectors, it is similar results as model 4 when only run on immigrants without including any control variable or if only control their education level. The main difference is that, for those second-generation immigrants whose FB parents are both from the non-Nordic European countries, it is significant at 1% if without including any control variable and at 5% if only controlling education level.

Table A5 Negative binomial regressions on total number of patents per inventor who work in high-tech and other sectors aged 25–64, 1985–2007

	High-tech							Other
	1		2		3			4
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4
immigrant inventors (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g_other
All second-generation	–0.006	–0.016						
	(0.061)	(0.051)						
Mixed immigrants (1)			0.029	0.008				
			(0.072)	(0.060)				
Immigrants with two FB parents (2)			–0.118	–0.094				
			(0.102)	(0.086)				
Mixed immigrants								
–1 parent from another Nordic country					0.054	0.095	0.048	0.052
					(0.099)	(0.099)	(0.080)	(0.102)
–1 parent from the EU-15					–0.112	–0.103	–0.079	0.089
					(0.154)	(0.155)	(0.142)	(0.104)
–1 parent from the rest of Europe					0.104	0.096	0.001	0.112
					(0.157)	(0.157)	(0.117)	(0.202)
–1 parent from a non-European country					0.147	0.166	0.053	–0.130
					(0.211)	(0.225)	(0.197)	(0.138)
Immigrants with two FB parents								
–≥1 parent(s) from other Nordic countries					–0.166	–0.121	–0.118	0.097
					(0.129)	(0.128)	(0.114)	(0.153)
–2 parents from non-Nordic European countries					–0.060	–0.078	–0.065	–0.021
					(0.158)	(0.141)	(0.127)	(0.126)
Education level	No	Yes	No	Yes	No	Yes	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes	Yes
Constant	1.154***	–2.681***	1.154***	–2.678***	1.154***	1.115***	–2.674***	–2.100***
	(0.020)	(0.361)	(0.020)	(0.361)	(0.020)	(0.025)	(0.360)	(0.472)
No. of observations	6,777	6,777	6,777	6,777	6,777	6,777	6,777	3,687
Wald χ2	0	1,288	2	1,287	4	170	1,294	606
Log pseudolikelihood	–15,416	–14,523	–15,414	–14,522	–15,412	–15,226	–14,521	–7,156
Pseudo R^2	0.000	0.058	0.000	0.058	0.000	0.012	0.058	0.051
T-test (1)=(2) (p-value)			0.226	0.325				

Robust standard errors in parentheses. ***$p<0.01$; **$p<0.05$; *$p<0.1$
Notes: (1) Coefficient results are reported.
(2) The other control variables included here are the same as those of Table 5. However, instead of four dummies of sector of work in Table 5, models 1.2, 2.2 and 3.3 here include 12 dummies for high-tech industry of work.
(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant−only model).

Table A6 Negative binomial regressions on number of forward citations for second-generation immigrant inventors who work in high-tech and other sectors aged 25–64, 1985–2007

Different groups of second-generation immigrant inventors (omit: native Swedes)	High-tech									Other
	1		2		3			4	5	6
	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4	5	6
	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g _co_ee	6g_ co_ot	6g_other
All second-generation	0.117*	0.103*								
	(0.069)	(0.054)								
Mixed immigrants (1)			0.160**	0.127**						
			(0.077)	(0.059)						
Immigrants with two FB parents (2)			−0.054	0.008						
			(0.126)	(0.122)						
Mixed immigrants										
−1 parent from another Nordic country					0.072	0.080	0.061	0.023	0.088	0.126
					(0.130)	(0.124)	(0.089)	(0.136)	(0.091)	(0.098)
−1 parent from the EU-15					0.301**	0.274**	0.246**	0.331*	0.121	0.102
					(0.128)	(0.124)	(0.108)	(0.186)	(0.116)	(0.102)
−1 parent from the rest of Europe					0.323***	0.300**	0.188*	0.248*	0.121	0.116
					(0.120)	(0.121)	(0.103)	(0.129)	(0.143)	(0.185)
−1 parent from a non-European country					−0.180	−0.153	−0.007	−0.278	0.222	−0.319*
					(0.181)	(0.209)	(0.225)	(0.223)	(0.293)	(0.178)
Immigrants with two FB parents										
−≥1 parent(s) from other Nordic countries					−0.238*	−0.160	−0.190	−1.113***	0.074	0.243**
					(0.144)	(0.141)	(0.137)	(0.260)	(0.127)	(0.122)
−2 parents from non-Nordic European countries					0.125	0.096	0.205	0.315	0.058	−0.101
					(0.181)	(0.176)	(0.177)	(0.335)	(0.181)	(0.137)
Education level	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Other control variables	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes
Constant	0.469***	1.175**	0.469***	1.171**	0.469***	0.510***	1.200***	−0.094	−0.823*	1.101*
	(0.026)	(0.457)	(0.026)	(0.457)	(0.026)	(0.035)	(0.454)	(1.863)	(0.481)	(0.584)
No. of observations	21,875	21,875	21,875	21,875	21,875	21,875	21,875	8,614	13,261	9,127
No. of inventors	7230	7230	7230	7230	7230	7230	7230	2595	5095	4,092
Wald χ2	2.903	2560	4.637	2558	17.35	66.12	2604	2992	1679	997
Log pseudolikelihood	−36750	−34723	−36747	−34722	−36737	−36643	−34715	−14292	−20106	−13,393
Pseudo R2	0.000	0.055	0.000	0.055	0.000	0.003	0.056	0.068	0.054	0.040
T-test (1)=(2) (p-value)			0.136	0.379						

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results of clustered robust standard errors on inventors are reported.

(2) The other control variables included here are the same as those of Table 6. However, instead of four dummies of sector of work in Table 6, models 1.2, 2.2, 3.2, 4 and 5 here include 12 dummies for high-tech industry of work. In model 5, I use instrument as reference for the control variable of technology field.

It is similar results for models 4−6 when only run on immigrants without including any control variable. The main difference is the significance levels in models 4 and 6. In model 4, for mixed immigrants with one parent from the EU-15 and the rest of Europe, the significance levels are at 1% and 5%, respectively. In model 6,

there is no significance difference for group of mixed immigrants with one parent from a non-European country if without including any control variable.
(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model)

Table A7 Average high school GPA for different groups of inventors who patent in different high-tech technology fields

Different groups of Swedish-born inventors	Electrical engineering		All other four fields		*Instruments*		*Chemistry*		*Mechanical engineering*		*Other fields*	
	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.
Native Swedes	403	6,849	379	8,644	390	2,358	388	2,313	368	3,619	371	354
Second-generation immigrant inventors												
−1 parent from other Nordic country	405	288	364	415	369	107	373	124	356	171	343	13
−1 parent from the EU-15	422	183	381	246	378	53	382	68	381	118	373	7
−1 parent from the rest of Europe	409	152	350	128	331	33	363	45	352	34	349	16
−1 parent from a non-European country	403	64	416	61	413	18	449	18	392	24	433	1
−≥1 parent(s) from other Nordic countries	367	71	372	182	350	39	407	65	362	69	300	9
−2 parents from non-Nordic European countries	393	70	383	126	400	27	388	52	371	43	326	4

Note: Mean= Mean high school GPA; No.=Number of patent–inventor combinations

Appendix 2

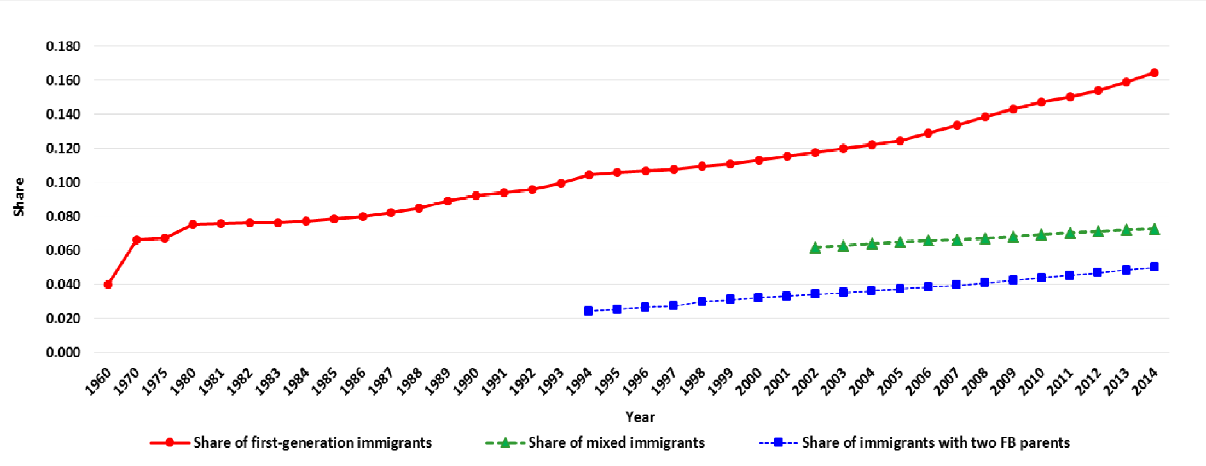

Fig A1. Population shares of first-generation immigrants, mixed immigrants and immigrants with two FB parents in the entire Swedish population at all ages, for each year 1960–2014
Source: Statistics Sweden (2015)

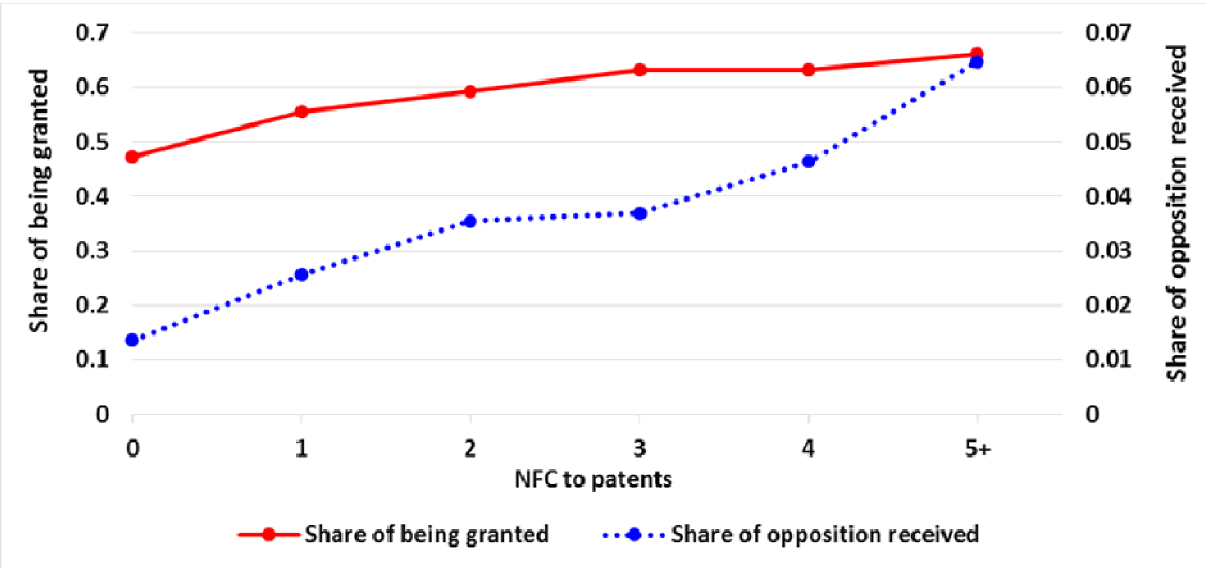

Fig A2. Relationship of NFC for patents, share of being granted and share of opposition received.
Source: CIRCLE data on inventors

Appendix 3

3.1 Codes and names (SNI92) of high-tech sectors classified by Eurostat's statistics and the share of inventors among the entire inventors in Sweden for each sector

3.1.1 High-tech and medium high-tech manufacturing sectors (51.76%)
23 exclude 231 Manufacture of refined petroleum products and nuclear fuel 0.24%
24 Manufacture of chemicals and chemical products 6.81%
29 Manufacture of machinery and equipment n.e.c. 10.49%
30 Manufacture of office machinery and computers 0.86%
31 Manufacture of electrical machinery and apparatus n.e.c. 4.03%
32 Manufacture of radio, television and communication equipment and apparatus 14.24%
33 Manufacture of medical, precision and optical instruments, watches and clocks 7.02%
34 Manufacture of motor vehicles, trailers and semi-trailers 6.73%
35 exclude 351 Manufacture of other transport equipment 1.36%

3.1.2 High-tech KIS sector (18.80%)
64 Post and telecommunications 1.34%
72 Computer and related activities 5.26%
73 Research and development 12.19%

3.2 Other sectors include:
(a) Primary sectors and low-tech, medium low-tech manufacturing sectors 11.25%
(b) KIS market and other sectors 13.35%
(c) Low KIS market and other sectors 4.84%

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Supplementary material

Detailed regression results for the probability of becoming an inventor, total number of patents per inventor and NFC for patents

Table 4 Probit regressions on the probability of becoming an inventor for second-generation immigrants among the entire population aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation immigrants	1.1	1.2	2.1	2.2	3.1	3.2	3.3
(omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.0004***	0.0004***					
	(0.0001)	(0.0001)					
Mixed immigrants (1)			0.0004**	0.0003**			
			(0.0002)	(0.0001)			
Immigrants with two FB parents (2)			0.0006**	0.0007***			
			(0.0003)	(0.0003)			
Mixed immigrants							
−1 parent from another Nordic country					−0.0004**	0.0000	0.0001
					(0.0002)	(0.0002)	(0.0002)
−1 parent from the EU-15					0.0020***	0.0013***	0.0013***
					(0.0004)	(0.0003)	(0.0003)
−1 parent from the rest of Europe					0.0006	0.0001	−0.0001
					(0.0004)	(0.0004)	(0.0003)
−1 parent from a non-European country					0.0014**	0.0001	0.0002
					(0.0006)	(0.0005)	(0.0005)
Immigrants with two FB parents							
−≥1 parent(s) from other Nordic countries					−0.0002	0.0005	0.0004
					(0.0003)	(0.0003)	(0.0003)
−2 parents from non-Nordic European countries					0.0024***	0.0018***	0.0012***
					(0.0006)	(0.0005)	(0.0005)
Education level (omit: long education)							
Short education		−0.0081***		−0.0081***		−0.0070***	−0.0081***
		(0.0002)		(0.0002)		(0.0001)	(0.0002)
PhD		0.0442***		0.0442***		0.0934***	0.0442***
		(0.0014)		(0.0014)		(0.0022)	(0.0014)
Field of study (omit: engineering, manufacturing and construction)							
Science, mathematics and computing		−0.0026***		−0.0026***			−0.0026***

	(0.0002)	(0.0002)	(0.0002)
Health and welfare	–0.0038***	–0.0038***	–0.0038***
	(0.0002)	(0.0002)	(0.0002)
Other fields	–0.0052***	–0.0052***	–0.0052***
	(0.0001)	(0.0001)	(0.0001)
Age	–0.0007***	–0.0007***	–0.0007***
	(0.0000)	(0.0000)	(0.0000)
Age^2	0.0000***	0.0000***	0.0000***
	(0.0000)	(0.0000)	(0.0000)
Birth cohort (omit: 1921–1945) (omit: 1921–1945)			
1946–1955	0.0020***	0.0020***	0.0020***
	(0.0001)	(0.0001)	(0.0001)
1956–1965	0.0043***	0.0043***	0.0043***
	(0.0001)	(0.0001)	(0.0001)
1966–1982	0.0017***	0.0017***	0.0017***
	(0.0001)	(0.0001)	(0.0001)
Gender (omit: male)	–0.0043***	–0.0043***	–0.0043***
	(0.0001)	(0.0001)	(0.0001)
Firm size (omit: medium (100–499 employees))			
Small (1–99 employees)	–0.0022***	–0.0022***	–0.0022***
	(0.0001)	(0.0001)	(0.0001)
Large (500+ employees)	0.0042***	0.0042***	0.0042***
	(0.0002)	(0.0002)	(0.0002)
Sector of work (omit: industry)			
Agriculture, hunting, forestry and fishing	–0.0048***	–0.0048***	–0.0048***
	(0.0004)	(0.0004)	(0.0004)
Private service	–0.0039***	–0.0039***	–0.0039***
	(0.0001)	(0.0001)	(0.0001)
Public service	–0.0070***	–0.0070***	–0.0070***
	(0.0001)	(0.0001)	(0.0001)
Region of work (omit: rural regions)			
Metro regions	0.0017***	0.0017***	0.0017***
	(0.0001)	(0.0001)	(0.0001)
Urban areas	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)
Education level for mother (omit: secondary high school education)			
≤primary education	–0.0002**	–0.0002**	–0.0002**
	(0.0001)	(0.0001)	(0.0001)
<3 years of post-secondary high education	0.0004***	0.0004***	0.0004***
	(0.0001)	(0.0001)	(0.0001)

≥3 years of post-secondary high education		0.0009***		0.0009***			0.0009***
		(0.0001)		(0.0001)			(0.0001)
Education level for father (omit: secondary high school education)							
≤primary education		–0.0010***		–0.0010***			–0.0010***
		(0.0001)		(0.0001)			(0.0001)
<3 years of post-secondary high education		0.0001		0.0001			0.0001
		(0.0002)		(0.0002)			(0.0002)
≥3 years of post-secondary high education		0.0008***		0.0008***			0.0008***
		(0.0001)		(0.0001)			(0.0001)
No. of children for mother		–0.0001**		–0.0001**			–0.0001**
		(0.0001)		(0.0001)			(0.0001)
No. of children for father		–0.0000		–0.0000			–0.0000
		(0.0001)		(0.0001)			(0.0001)
No. of observations	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159	2,634,159
Wald χ^2	10	47,754	10	47,756	70	15,134	47,773
Log likelihood	–68,276	–44,404	–68,276	–44,403	–68,246	–60,714	–44,395
Pseudo R^2	0.000	0.350	0.000	0.350	0.001	0.111	0.350
T-test (1)=(2) (p-value)			0.458	0.178			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1
Sources: Statistics Sweden and CIRCLE data on inventors. It is the same sources for tables below.
Note: Marginal effects are reported.

Table 5 Negative binomial regressions on total number of patents per inventor aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation immigrant inventors	1.1	1.2	2.1	2.2	3.1	3.2	3.3
(omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.006	0.007					
	(0.048)	(0.040)					
Mixed immigrants (1)			0.031	0.023			
			(0.056)	(0.047)			
Immigrants with two FB parents (2)			−0.080	−0.046			
			(0.079)	(0.067)			
Mixed immigrants							
−1 parent from another Nordic country					0.038	0.075	0.051
					(0.079)	(0.080)	(0.066)
−1 parent from the EU-15					−0.055	−0.067	−0.034
					(0.110)	(0.107)	(0.093)
−1 parent from the rest of Europe					0.131	0.108	0.046
					(0.129)	(0.129)	(0.105)
−1 parent from a non-European country					0.085	0.063	−0.008
					(0.169)	(0.178)	(0.151)
Immigrants with two FB parents							
−≥1 parent(s) from other Nordic countries					−0.122	−0.075	−0.039
					(0.104)	(0.104)	(0.094)
−2 parents from non-Nordic European countries					−0.030	−0.063	−0.055
					(0.118)	(0.108)	(0.094)
Education level (omit: long education)							
Short education		−0.218***		−0.218***		−0.234***	−0.218***
		(0.029)		(0.029)		(0.030)	(0.029)
PhD		0.272***		0.273***		0.355***	0.273***
		(0.038)		(0.038)		(0.039)	(0.038)
Field of study (omit: engineering, manufacturing and construction)							
Science, mathematics and computing		−0.124***		−0.125***			−0.125***
		(0.046)		(0.046)			(0.046)
Health and welfare		−0.180***		−0.180***			−0.180***
		(0.052)		(0.052)			(0.052)
Other fields		−0.231***		−0.231***			−0.231***
		(0.041)		(0.041)			(0.041)
Age		0.064***		0.064***			0.064***
		(0.013)		(0.013)			(0.013)
Age^2		0.000		0.000			0.000

	(0.000)	(0.000)	(0.000)
Birth cohort (omit: 1921–1945)			
1946–1955	0.370***	0.370***	0.370***
	(0.058)	(0.058)	(0.058)
1956–1965	0.862***	0.862***	0.863***
	(0.069)	(0.069)	(0.069)
1966–1982	1.248***	1.248***	1.248***
	(0.076)	(0.076)	(0.076)
Gender (omit: male)	−0.205***	−0.205***	−0.206***
	(0.036)	(0.036)	(0.036)
Firm size (omit: medium (100–499 employees))			
Small (1–99 employees)	−0.026	−0.027	−0.027
	(0.037)	(0.037)	(0.037)
Large (500+ employees)	0.111***	0.110***	0.110***
	(0.032)	(0.032)	(0.032)
Sector of work (omit: industry)			
	0.023	0.022	0.022
Agriculture, hunting, forestry and fishing	(0.144)	(0.144)	(0.144)
Private service	−0.027	−0.027	−0.026
	(0.032)	(0.032)	(0.032)
Public service	−0.447***	−0.447***	−0.447***
	(0.050)	(0.050)	(0.050)
Region of work (omit: rural regions)			
Metro regions	0.170***	0.170***	0.170***
	(0.032)	(0.032)	(0.032)
Urban areas	0.024	0.024	0.024
	(0.035)	(0.035)	(0.035)
Technology field (omit: electrical engineering)			
Instrument	−0.125***	−0.124***	−0.125***
	(0.039)	(0.039)	(0.039)
Chemistry	−0.116***	−0.116***	−0.115***
	(0.038)	(0.038)	(0.038)
Mechanical engineering	−0.263***	−0.264***	−0.263***
	(0.034)	(0.034)	(0.034)
Other fields	−0.240***	−0.240***	−0.239***
	(0.050)	(0.050)	(0.049)
Education level for mother (omit: secondary high school education)			
≤primary education	0.021	0.021	0.020
	(0.029)	(0.029)	(0.028)
<3 years of post-secondary high education	0.045	0.044	0.044

		(0.040)		(0.040)			(0.040)
		0.072**		0.070**			0.070**
≥3 years of post-secondary high education		(0.035)		(0.035)			(0.035)
Education level for father (omit: secondary high school education)							
≤primary education		0.002		0.002			0.002
		(0.030)		(0.030)			(0.030)
		0.023		0.022			0.022
<3 years of post-secondary high education		(0.042)		(0.042)			(0.042)
		0.064**		0.064**			0.064**
≥3 years of post-secondary high education		(0.032)		(0.032)			(0.032)
No of children for mother		−0.012		−0.012			−0.012
		(0.021)		(0.021)			(0.021)
No of children for father		0.021		0.021			0.020
		(0.020)		(0.020)			(0.020)
Constant	1.079***	−2.641***	1.079***	−2.637***	1.079***	1.064***	−2.634***
	(0.015)	(0.296)	(0.015)	(0.295)	(0.015)	(0.021)	(0.295)
No. of observations	10,464	10,464	10,464	10,464	10,464	10,464	10,464
Wald χ^2	0	1,687	1	1,689	3	231	1,702
Log pseudolikelihood	−23,050	−21,805	−23,049	−21,804	−23,047	-22,801	−21,804
Pseudo R^2	0.000	0.054	0.000	0.054	0.000	0.011	0.054
T-test (1)=(2) (p-value)			0.236	0.392			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results are reported.

(2) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).

Table 6 Negative binomial regressions on number of forward citations for second-generation immigrant inventors aged 25–64, 1985–2007

	1		2		3		
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.3
immigrant inventors (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con
All second-generation	0.118**	0.098**					
	(0.055)	(0.045)					
Mixed immigrants (1)			0.146**	0.121**			
			(0.062)	(0.050)			
Immigrants with two FB parents (2)			0.010	0.013			
			(0.093)	(0.095)			
Mixed immigrants							
–1 parent from another Nordic country					0.081	0.111	0.098
					(0.100)	(0.099)	(0.072)
–1 parent from the EU-15					0.243**	0.229**	0.178**
					(0.099)	(0.096)	(0.089)
–1 parent from the rest of Europe					0.322***	0.292**	0.195**
					(0.117)	(0.117)	(0.093)
–1 parent from a non-European country					–0.159	–0.163	–0.079
					(0.144)	(0.166)	(0.198)
Immigrants with two FB parents							
–≥1 parent(s) from other Nordic countries					–0.085	–0.023	–0.076
					(0.106)	(0.103)	(0.104)
–2 parents from non-Nordic European countries					0.107	0.067	0.103
					(0.142)	(0.139)	(0.151)
Education level (omit: long education)							
Short education		–0.139***		–0.139***		–0.336***	–0.137***
		(0.037)		(0.037)		(0.045)	(0.037)
PhD		0.034		0.035		0.119***	0.033
		(0.040)		(0.040)		(0.043)	(0.040)
Field of study (omit: engineering, manufacturing and construction)							
Science, mathematics and computing		0.157***		0.156***			0.156***
		(0.052)		(0.052)			(0.052)
Health and welfare		0.166**		0.166***			0.166***
		(0.064)		(0.064)			(0.064)
Other fields		–0.036		–0.036			–0.039
		(0.062)		(0.062)			(0.062)
Age		–0.081***		–0.081***			–0.082***
		(0.017)		(0.017)			(0.017)
Age^2		0.001***		0.001***			0.001***

	(0.000)	(0.000)	(0.000)
Birth cohort (omit: 1921–1945)			
1946–1955	0.273***	0.273***	0.276***
	(0.093)	(0.093)	(0.093)
1956–1965	0.306**	0.307**	0.307**
	(0.126)	(0.126)	(0.126)
1966–1982	0.312*	0.312*	0.311*
	(0.160)	(0.161)	(0.160)
Gender (omit: male)	0.087	0.085	0.086
	(0.055)	(0.054)	(0.055)
Firm size (omit: medium (100–499 employees))			
Small (1–99 employees)	0.076**	0.076**	0.075**
	(0.038)	(0.038)	(0.038)
Large (500+ employees)	0.074*	0.074*	0.076**
	(0.038)	(0.038)	(0.038)
Sector of work (omit: industry)			
	–0.169	–0.170	–0.170
Agriculture, hunting, forestry and fishing	(0.170)	(0.170)	(0.170)
Private service	–0.009	–0.009	–0.008
	(0.039)	(0.039)	(0.039)
Public service	–0.113**	–0.113**	–0.112**
	(0.055)	(0.055)	(0.055)
Region of work (omit: rural regions)			
Metro regions	0.251***	0.251***	0.249***
	(0.044)	(0.044)	(0.044)
Urban areas	0.137***	0.137***	0.136***
	(0.047)	(0.047)	(0.047)
Technology field (omit: electrical engineering)			
Instrument	–0.233***	–0.232***	–0.231***
	(0.040)	(0.040)	(0.040)
Chemistry	0.081*	0.082*	0.084*
	(0.044)	(0.044)	(0.044)
Mechanical engineering	–0.319***	–0.318***	–0.318***
	(0.038)	(0.038)	(0.038)
Other fields	–0.242***	–0.241***	–0.241***
	(0.075)	(0.075)	(0.075)
Education level for mother (omit: secondary high school education)			
≤primary education	0.011	0.011	0.011
	(0.036)	(0.036)	(0.036)
<3 years of post-secondary high education	0.025	0.023	0.022

		(0.047)		(0.047)			(0.047)
		0.091**		0.089*			0.089*
≥3 years of post-secondary high education		(0.046)		(0.047)			(0.046)
Education level for father (omit: secondary high school education)							
≤primary education		0.021		0.021			0.023
		(0.036)		(0.036)			(0.036)
		−0.077		−0.079			−0.079
<3 years of post-secondary high education		(0.050)		(0.050)			(0.050)
		0.021		0.021			0.025
≥3 years of post-secondary high education		(0.041)		(0.041)			(0.041)
No. of children for mother		−0.016		−0.016			−0.016
		(0.030)		(0.030)			(0.031)
No. of children for father		0.020		0.020			0.019
		(0.030)		(0.030)			(0.030)
No. of inventors		0.093***		0.093***			0.093***
		(0.009)		(0.009)			(0.009)
No. of co-inventors who are							
Native Swedes		−0.046***		−0.046***			−0.047***
		(0.012)		(0.012)			(0.012)
Mixed immigrants		0.047		0.048			0.048
		(0.032)		(0.032)			(0.032)
Immigrants with two FB parents		0.053		0.055			0.057
		(0.056)		(0.056)			(0.057)
First-generation inventors		0.067**		0.067**			0.066**
		(0.032)		(0.032)			(0.032)
Constant	0.399***	1.179***	0.399***	1.177***	0.399***	0.440***	1.196***
	(0.021)	(0.409)	(0.021)	(0.409)	(0.021)	(0.030)	(0.407)
No. of observations	31,002	31,002	31,002	31,002	31,002	31,002	31,002
No of inventors	10,576	10,576	10,576	10,576	10,576	10,576	10,576
Wald χ2	5	2703	6	2,710	16		2,745
Log pseudolikelihood	−50,829	−48,495	−50,828	−48,494	−50,818	−50,659	−48,490
Pseudo R^2	0.000	0.046	0.000	0.046	0.000	0.004	0.046
T-test (1)=(2) (p-value)			0.207	0.306			

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results of clustered robust standard errors on inventors are reported.

(2) Models 1.2, 2.2 and 3.3 also include 23 dummies for application years.

(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).

(4) The results for different groups of second-generation immigrant inventors are robust if using data from 1985 to 2004, 1985 to 2005 and 1985 to 2006. The only exception is model 3.3, where mixed immigrants with one parent from another Nordic country becomes positively significant as well.

Table A4 Probit regressions on the probability of becoming an inventor for second-generation immigrants among the *entire* population who worked in high-tech and other sectors aged 25–64, 1985–2007

	High-tech							Other
	1		2		3			4
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.2	4
immigrants (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g_other
All second-generation	–0.0001	0.0003						
	(0.0008)	(0.0008)						
Mixed immigrants (1)			–0.0002	–0.0001				
			(0.0009)	(0.0009)				
Immigrants with two FB parents (2)			0.0001	0.0016				
			(0.0016)	(0.0016)				
Mixed immigrants								
−1 parent from another Nordic country					–0.0040***	–0.0019	–0.0015	0.0002
					(0.0011)	(0.0012)	(0.0011)	(0.0001)
−1 parent from the EU-15					0.0065***	0.0036*	0.0033*	0.0009***
					(0.0023)	(0.0020)	(0.0019)	(0.0003)
−1 parent from the rest of Europe					0.0021	0.0001	0.0001	–0.0002
					(0.0025)	(0.0023)	(0.0022)	(0.0002)
−1 parent from a non-European country					0.0069*	0.0015	–0.0007	0.0002
					(0.0040)	(0.0032)	(0.0029)	(0.0003)
Immigrants with two FB parents								
–≥1 parent(s) from other Nordic countries					–0.0034*	0.0009	0.0002	0.0002
					(0.0018)	(0.0021)	(0.0019)	(0.0002)
–2 parents from non-Nordic European countries					0.0070**	0.0060**	0.0039	0.0006*
					(0.0032)	(0.0030)	(0.0026)	(0.0003)
Education level (omit: long education)								
Short education		–0.0294***		–0.0294***		–0.0340***	–0.0294***	–0.0032***
		(0.0008)		(0.0008)		(0.0007)	(0.0008)	(0.0001)
PhD		0.0594***		0.0594***		0.1386***	0.0594***	0.0326***
		(0.0033)		(0.0033)		(0.0047)	(0.0033)	(0.0016)
Field of study (omit: engineering, manufacturing and construction)								
Science, mathematics and computing		–0.0112***		–0.0112***			–0.0112***	–0.0017***
		(0.0008)		(0.0008)			(0.0008)	(0.0001)
Health and welfare		–0.0119***		–0.0119***			–0.0119***	–0.0022***
		(0.0011)		(0.0011)			(0.0011)	(0.0001)
Other fields		–0.0199***		–0.0199***			–0.0199***	–0.0027***
		(0.0005)		(0.0005)			(0.0005)	(0.0001)
Age		–0.0027***		–0.0027***			–0.0027***	–0.0003***

	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Age^2	0.0001***	0.0001***	0.0001***	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Birth cohort (omit: 1921–1945)				
1946–1955	0.0098***	0.0098***	0.0098***	0.0009***
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
1956–1965	0.0241***	0.0241***	0.0241***	0.0015***
	(0.0007)	(0.0007)	(0.0007)	(0.0001)
1966–1982	0.0157***	0.0157***	0.0157***	0.0003***
	(0.0008)	(0.0008)	(0.0008)	(0.0001)
Gender (omit: male)	−0.0195***	−0.0195***	−0.0195***	−0.0020***
	(0.0008)	(0.0008)	(0.0008)	(0.0001)
Firm size (omit: medium (100–499 employees))				
Small (1–99 employees)	−0.0068***	−0.0068***	−0.0068***	−0.0011***
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
Large (500+ employees)	0.0184***	0.0184***	0.0184***	0.0010***
	(0.0008)	(0.0008)	(0.0008)	(0.0001)
Sector of work (omit: industry)				
Agriculture, hunting, forestry and fishing				−0.0011***
				(0.0002)
Private service				−0.0005***
				(0.0001)
Public service				−0.0019***
				(0.0001)
Region of work (omit: rural regions)				
Metro regions	0.0091***	0.0091***	0.0091***	0.0001
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
Urban areas	0.0025***	0.0025***	0.0025***	−0.0004***
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
Education level for mother (omit: secondary high school education)				
≤primary education	−0.0004	−0.0004	−0.0004	−0.0001**
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
<3 years of post-secondary high education	0.0013	0.0013	0.0013	0.0002*
	(0.0009)	(0.0009)	(0.0009)	(0.0001)
≥3 years of post-secondary high education	0.0031***	0.0032***	0.0031***	0.0004***
	(0.0008)	(0.0008)	(0.0008)	(0.0001)
Education level for father (omit: secondary high school education)				
≤primary education	−0.0037***	−0.0037***	−0.0036***	−0.0005***
	(0.0006)	(0.0006)	(0.0006)	(0.0001)
<3 years of post-secondary high	−0.0002	−0.0001	−0.0001	0.0001

education		(0.0009)		(0.0009)			(0.0009)	(0.0001)
≥3 years of post-secondary high		0.0022***		0.0022***			0.0022***	0.0005***
education		(0.0008)		(0.0008)			(0.0008)	(0.0001)
No. of children for mother		−0.0005		−0.0005			−0.0004	−0.0000
		(0.0004)		(0.0004)			(0.0004)	(0.0000)
No. of children for father		−0.0001		−0.0001			−0.0001	−0.0000
		(0.0004)		(0.0004)			(0.0004)	(0.0000)
No. of observations	321,669	321,669	321,669	321,669	321,669	321,669	321,669	2,312,490
LR χ^2	0	20,690	0	20,691	35	6,988	20,697	14,937
Log likelihood	−33,018	−22,673	−33,018	−22,672	−33,000	−29,523	−22,669	−19,694
Pseudo R^2	0.000	0.313	0.000	0.313	0.001	0.106	0.313	0.275
T-test (1)=(2) (p-value)			0.886	0.329				

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Marginal effects are reported.

(2) Models 1.2, 2.2 and 3.3 also include 12 dummies for high-tech industry of work.

(3) For individuals who worked in other sectors, it is similar results as model 4 when only run on immigrants without including any control variable or if only control their education level. The main difference is that, for those second-generation immigrants whose FB parents are both from the non-Nordic European countries, it is significant at 1% if without including any control variable and 5% if only controlling education level.

Table A5 Negative binomial regressions on total number of patents per inventor who worked in high-tech and other sectors aged 25–64, 1985–2007

	High-tech							Other
	1		2		3			4
Different groups of second-generation	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4
immigrant inventors (omit: native Swedes)	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g_other
All second-generation	–0.006	–0.016						
	(0.061)	(0.051)						
Mixed immigrants (1)			0.029	0.008				
			(0.072)	(0.060)				
Immigrants with two FB parents (2)			–0.118	–0.094				
			(0.102)	(0.086)				
Mixed immigrants								
–1 parent from another Nordic country					0.054	0.095	0.048	0.052
					(0.099)	(0.099)	(0.080)	(0.102)
–1 parent from the EU-15					–0.112	–0.103	–0.079	0.089
					(0.154)	(0.155)	(0.142)	(0.104)
–1 parent from the rest of Europe					0.104	0.096	0.001	0.112
					(0.157)	(0.157)	(0.117)	(0.202)
–1 parent from a non-European country					0.147	0.166	0.053	–0.130
					(0.211)	(0.225)	(0.197)	(0.138)
Immigrants with two FB parents								
–≥1 parent(s) from other Nordic countries					–0.166	–0.121	–0.118	0.097
					(0.129)	(0.128)	(0.114)	(0.153)
–2 parents from non-Nordic European countries					–0.060	–0.078	–0.065	–0.021
					(0.158)	(0.141)	(0.127)	(0.126)
Education level (omit: long education)								
Short education		–0.218***		–0.218***		–0.230***	–0.217***	–0.198***
		(0.034)		(0.034)		(0.038)	(0.034)	(0.047)
PhD		0.267***		0.268***		0.431***	0.269***	0.224***
		(0.045)		(0.045)		(0.049)	(0.045)	(0.062)
Field of study (omit: engineering, manufacturing and construction)								
Science, mathematics and computing		–0.173***		–0.175***			–0.175***	–0.066
		(0.055)		(0.055)			(0.055)	(0.092)
Health and welfare		–0.156**		–0.157**			–0.157**	–0.248***
		(0.075)		(0.075)			(0.075)	(0.073)

Other fields	–0.237***	–0.236***	–0.236***	–0.232***
	(0.060)	(0.060)	(0.060)	(0.055)
Age	0.062***	0.062***	0.062***	0.048**
	(0.017)	(0.017)	(0.017)	(0.021)
Age^2	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Birth cohort (omit: 1921–1945)				
1946–1955	0.467***	0.467***	0.466***	0.263***
	(0.081)	(0.081)	(0.080)	(0.082)
1956–1965	1.022***	1.022***	1.023***	0.643***
	(0.093)	(0.093)	(0.093)	(0.094)
1966–1982	1.463***	1.462***	1.461***	0.967***
	(0.101)	(0.101)	(0.100)	(0.111)
Gender (omit: male)	–0.310***	–0.311***	–0.311***	–0.110*
	(0.043)	(0.043)	(0.043)	(0.058)
Firm size (omit: medium (100–499 employees))				
Small (1–99 employees)	–0.033	–0.033	–0.035	0.017
	(0.049)	(0.049)	(0.049)	(0.050)
Large (500+ employees)	0.043	0.042	0.042	0.265***
	(0.040)	(0.040)	(0.040)	(0.055)
Sector of work (omit: industry)				
Agriculture, hunting, forestry and fishing				0.049
				(0.166)
Private service				–0.059
				(0.047)
Public service				–0.438***
				(0.069)
Region of work (omit: rural regions)				
Metro regions	0.179***	0.180***	0.181***	0.161***
	(0.045)	(0.045)	(0.045)	(0.054)
Urban areas	0.085*	0.086*	0.086*	–0.060
	(0.047)	(0.047)	(0.047)	(0.052)
Technology field (omit: electrical engineering)				
Instrument	–0.050	–0.050	–0.050	–0.032
	(0.049)	(0.049)	(0.049)	(0.069)
Chemistry	–0.000	0.001	0.003	–0.053

		(0.054)		(0.054)			(0.054)	(0.070)
Mechanical engineering		−0.085*		−0.085*			−0.085*	−0.105
		(0.051)		(0.051)			(0.051)	(0.066)
Other fields		−0.098		−0.097			−0.096	−0.105
		(0.078)		(0.078)			(0.078)	(0.076)
Education level for mother (omit: secondary high school education)								
≤primary education		0.037		0.038			0.037	−0.028
		(0.035)		(0.035)			(0.034)	(0.046)
<3 years of post-secondary high education		0.017		0.017			0.018	0.067
		(0.051)		(0.051)			(0.051)	(0.061)
≥3 years of post-secondary education		0.080*		0.078*			0.078*	0.058
		(0.044)		(0.044)			(0.044)	(0.053)
Education level for father (omit: secondary high school education)								
≤primary education		−0.034		−0.034			−0.035	0.060
		(0.036)		(0.036)			(0.036)	(0.048)
<3 years of post-secondary high education		0.007		0.007			0.006	0.072
		(0.051)		(0.051)			(0.051)	(0.071)
≥3 years of post-secondary high education		0.039		0.039			0.038	0.110**
		(0.039)		(0.039)			(0.039)	(0.051)
No. of children for mother		−0.028		−0.028			−0.029	0.022
		(0.024)		(0.024)			(0.024)	(0.039)
No. of children for father		0.028		0.029			0.029	−0.001
		(0.023)		(0.023)			(0.023)	(0.037)
Constant	1.154***	−2.681***	1.154***	−2.678***	1.154***	1.115***	−2.674***	−2.100***
	(0.020)	(0.361)	(0.020)	(0.361)	(0.020)	(0.025)	(0.360)	(0.472)
No. of observations	6,777	6,777	6,777	6,777	6,777	6,777	6,777	3,687
Wald χ2	0	1,288	2	1,287	4	170	1,294	606
Log pseudolikelihood	−15,416	−14,523	−15,414	−14,522	−15,412	−15,226	−14,521	−7,156
Pseudo R^2	0.000	0.058	0.000	0.058	0.000	0.012	0.058	0.051
T-test (1)=(2) (p-value)			0.226	0.325				

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results are reported.

(2) Models 1.2, 2.2 and 3.3 also include 12 dummies for high-tech industry of work.

(3) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).

Table A6 Negative binomial regressions on number of forward citations for second-generation immigrant inventors who worked in high-tech and other sectors aged 25–64, 1985–2007

Different groups of second-generation immigrant inventors (omit: native Swedes)	High-tech									Other
	1		2		3			4	5	6
	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4	5	6
	1g_sim	1g_con	2g_sim	2g_con	6g_sim	6g_edu	6g_con	6g _co_ee	6g_ co_ot	6g_other
All second-generation	0.117*	0.103*								
	(0.069)	(0.054)								
Mixed immigrants (1)			0.160**	0.127**						
			(0.077)	(0.059)						
Immigrants with two FB parents (2)			–0.054	0.008						
			(0.126)	(0.122)						
Mixed immigrants										
–1 parent from another Nordic country					0.072	0.080	0.061	0.023	0.088	0.126
					(0.130)	(0.124)	(0.089)	(0.136)	(0.091)	(0.098)
–1 parent from the EU-15					0.301**	0.274**	0.246**	0.331*	0.121	0.102
					(0.128)	(0.124)	(0.108)	(0.186)	(0.116)	(0.102)
–1 parent from the rest of Europe					0.323***	0.300**	0.188*	0.248*	0.121	0.116
					(0.120)	(0.121)	(0.103)	(0.129)	(0.143)	(0.185)
–1 parent from a non-European country					–0.180	–0.153	–0.007	–0.278	0.222	–0.319*
					(0.181)	(0.209)	(0.225)	(0.223)	(0.293)	(0.178)
Immigrants with two FB parents										
–≥1 parent(s) from other Nordic countries					–0.238*	–0.160	–0.190	–1.113***	0.074	0.243**
					(0.144)	(0.141)	(0.137)	(0.260)	(0.127)	(0.122)
–2 parents from non-Nordic European countries					0.125	0.096	0.205	0.315	0.058	–0.101
					(0.181)	(0.176)	(0.177)	(0.335)	(0.181)	(0.137)
Education level (omit: long education)										
Short education		–0.157***		–0.156***		–0.341***	–0.151***	–0.229***	–0.095**	–0.069
		(0.041)		(0.041)		(0.057)	(0.041)	(0.078)	(0.042)	(0.053)
PhD		–0.015		–0.014		0.095*	–0.016	–0.050	0.050	0.159***
		(0.044)		(0.044)		(0.053)	(0.043)	(0.070)	(0.048)	(0.058)
Field of study (omit: engineering, manufacturing and construction)										
Science, mathematics and computing		0.107**		0.107**			0.109**	0.030	0.152***	0.094
		(0.051)		(0.051)			(0.051)	(0.084)	(0.057)	(0.071)
Health and welfare		0.210**		0.210**			0.207**	–0.209	0.218***	–0.052
		(0.083)		(0.083)			(0.083)	(0.650)	(0.079)	(0.081)
Other fields		0.036		0.036			0.030	0.112	–0.045	–0.128
		(0.083)		(0.082)			(0.083)	(0.162)	(0.084)	(0.081)
Age		–0.074***		–0.074***			–0.076***	–0.073*	–0.021	–0.064***
		(0.020)		(0.020)			(0.020)	(0.042)	(0.020)	(0.023)
Age^2		0.001***		0.001***			0.001***	0.001	0.000	0.001**

	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Birth cohort (omit: 1921–1945)						
1946–1955	0.283**	0.284**	0.288**	0.224	0.170	0.157
	(0.124)	(0.124)	(0.124)	(0.295)	(0.104)	(0.102)
1956–1965	0.334**	0.336**	0.333**	0.284	0.136	0.098
	(0.162)	(0.162)	(0.162)	(0.352)	(0.146)	(0.155)
1966–1982	0.381*	0.383*	0.376*	0.399	0.172	0.035
	(0.197)	(0.197)	(0.197)	(0.402)	(0.191)	(0.210)
Gender (omit: male)	0.059	0.058	0.059	0.263*	0.021	0.043
	(0.068)	(0.068)	(0.069)	(0.154)	(0.071)	(0.070)
Firm size (omit: medium (100–499 employees))						
Small (1–99 employees)	0.224***	0.224***	0.223***	0.266***	0.176***	–0.207***
	(0.043)	(0.043)	(0.043)	(0.084)	(0.049)	(0.069)
Large (500+ employees)	0.109***	0.108***	0.112***	0.124*	0.080*	–0.083
	(0.039)	(0.039)	(0.040)	(0.076)	(0.043)	(0.064)
Sector of work (omit: industry)						
Agriculture, hunting,						–0.034
forestry and fishing						(0.148)
Private service						0.077
						(0.063)
Public service						0.036
						(0.075)
Region of work (omit: rural regions)						
Metro regions	0.168***	0.168***	0.164***	–0.056	0.180***	0.157**
	(0.056)	(0.056)	(0.056)	(0.133)	(0.060)	(0.065)
Urban areas	0.189***	0.189***	0.188***	0.103	0.157**	0.046
	(0.059)	(0.059)	(0.059)	(0.133)	(0.064)	(0.071)
Technology field (omit: electrical engineering)						
Instrument	–0.073	–0.071	–0.067		Reference	0.054
	(0.050)	(0.050)	(0.050)			(0.069)
Chemistry	0.196***	0.199***	0.203***		0.197***	0.145**
	(0.059)	(0.059)	(0.059)		(0.048)	(0.068)
Mechanical engineering	–0.037	–0.036	–0.034		0.005	–0.144**
	(0.056)	(0.056)	(0.056)		(0.047)	(0.066)
Other fields	–0.117	–0.115	–0.113		–0.037	0.028
	(0.098)	(0.099)	(0.099)		(0.093)	(0.107)
Education level for mother (omit: secondary high school education)						
≤primary education	0.031	0.031	0.033	0.055	0.036	–0.062
	(0.042)	(0.042)	(0.042)	(0.074)	(0.044)	(0.054)
<3 years of post-secondary	–0.010	–0.011	–0.011	0.050	–0.080	0.033
high education	(0.053)	(0.053)	(0.053)	(0.084)	(0.057)	(0.078)
≥3 years of post-secondary	0.095*	0.093*	0.091*	0.073	0.098*	0.033

high education		(0.050)		(0.050)			(0.050)	(0.079)	(0.054)	(0.061)
Education level for father (omit: secondary high school education)										
≤primary education		−0.043		−0.044			−0.041	0.008	−0.055	0.146***
		(0.041)		(0.041)			(0.041)	(0.074)	(0.044)	(0.057)
<3 years of post-secondary high education		−0.072 (0.058)		−0.075 (0.058)			−0.074 (0.057)	−0.142 (0.094)	−0.027 (0.063)	−0.044 (0.078)
≥3 years of post-secondary high education		−0.017 (0.045)		−0.017 (0.045)			−0.010 (0.045)	−0.003 (0.071)	−0.005 (0.047)	0.092 (0.061)
No. of children for mother		−0.009		−0.010			−0.011	0.004	−0.011	0.009
		(0.028)		(0.029)			(0.029)	(0.039)	(0.035)	(0.035)
No. of children for father		0.013		0.015			0.016	−0.018	0.023	−0.023
		(0.027)		(0.028)			(0.028)	(0.037)	(0.034)	(0.032)
No. of inventors		0.090***		0.090***			0.090***	0.071***	0.101***	0.075***
		(0.010)		(0.010)			(0.010)	(0.015)	(0.012)	(0.013)
No. of co-inventors who are										
Native Swedes		−0.056***		−0.056***			−0.056***	−0.084***	−0.032*	0.001
		(0.014)		(0.014)			(0.014)	(0.020)	(0.016)	(0.019)
Mixed immigrants		0.044		0.045			0.046	0.033	0.006	0.080
		(0.038)		(0.038)			(0.038)	(0.057)	(0.046)	(0.055)
Immigrants with two FB parents		0.089 (0.067)		0.091 (0.068)			0.094 (0.068)	−0.066 (0.177)	0.133** (0.064)	0.010 (0.068)
First-generation inventors		0.073**		0.073**			0.072**	0.218***	0.009	0.093
		(0.033)		(0.033)			(0.033)	(0.066)	(0.035)	(0.058)
Constant	0.469***	1.175**	0.469***	1.171**	0.469***	0.510***	1.200***	−0.094	−0.823*	1.101*
	(0.026)	(0.457)	(0.026)	(0.457)	(0.026)	(0.035)	(0.454)	(1.863)	(0.481)	(0.584)
No. of observations	21,875	21,875	21,875	21,875	21,875	21,875	21,875	8,614	13,261	9,127
No. of inventors	7230	7230	7230	7230	7230	7230	7230	2595	5095	4,092
Wald χ2	2.903	2560	4.637	2558	17.35	66.12	2604	2992	1679	997
Log pseudolikelihood	−36750	−34723	−36747	−34722	−36737	−36643	−34715	−14292	−20106	−13,393
Pseudo R2	0.000	0.055	0.000	0.055	0.000	0.003	0.056	0.068	0.054	0.040
T-test (1)=(2) (p-value)			0.136	0.379						

Robust standard errors in parentheses. ***p<0.01; **p<0.05; *p<0.1

Notes: (1) Coefficient results of clustered robust standard errors on inventors are reported.

(2) Models 1.2, 2.2, 3.2, 4, 5 and 6 also include 23 dummies for application years. Models 1.2, 2.2, 3.2, 4 and 5 also include 12 dummies for high-tech industry of work. In model 5, I use instrument as reference for the control variable of technology field.

(3) It is similar results for models 4–6 when only run on immigrants without including any control variable. The main difference is the significance levels in models 4 and 6. In model 4, for mixed immigrants with one parent from another EU-15 or the rest of Europe, the significance levels are at 1% and 5%, respectively. In model 6, there is no significance difference for mixed immigrants with one parent from a non-European country if without including any control variable.

(4) Pseudo R^2 =1−log pseudolikelihood (full model)/log pseudolikelihood (constant-only model).