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Foreign-born Inventors in Sweden

- Invention Performance by Origin of Region

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I. Background

- ❖ **Highly educated workers & diversity** - generate ideas and innovation -> by highly skilled immigrants
- ❖ **The US** - foreign-born talents, advancing technology and boosting innovation (e.g. No and Walsh, 2010; Hunt, 2011)
- ❖ **Sweden** - Limited local population resource, increasing immigrants. benefit from highly skilled immigrants, government makes great effects to attract - tax discount
- ❖ Until now, **know little** about the feature of highly skilled immigrants in Sweden.
- ❖ Foreign-born inventors as representatives, improve our understanding.



II. Motivation

Maybe because of differences in culture, national characteristics or edu. background, inventors from different regions could have different invention performance (e.g. Hunt, 2011)

Gap in prior studies:

- Only native-born inventors vs. overall of foreign-born inventors, without considering the origin and background differences of foreign-born inventors.
- Not clear foreign-born inventors from which places > native-born
- Studies mainly focus on the U.S.

Why?

- Hunt (2011) - immigrants' higher edu. level and field of study.
- Not clear foreign-born inventors in which edu level and from which field of study performed better than those US-born inventors

Purpose of the paper-show a clearer picture

- How foreign-born inventors vs. those Swedish-born on invention?
- Any difference by region?
- Effect of different edu levels and different fields of study on invention by regions.



III. Data

- ❖ **Foreign-born inventor:** who were born abroad without Swedish citizenship
- ❖ **Data:** Swedish patent applications filed by Swedish inventors (Swedish-born + foreign-born) to the EPO from 1985 to 2007 with demographic information
- ❖ **Matching way:**
 - Match Swedish inventors, identify Swedish social security number
 - Match demographic infor, by using Swedish social security number
- ❖ **Matching results:**
 - 1) total identified share of patent-inventor combinations: **79.3%** (58,173/73,356);
 - 2) used **77.4%** (age≤65)
 - 3) foreign-born inventors: **11.0%** (2,239)
 - 4) fractional count of identified applications: **11.6%** (3,308)
- ❖ **Sample selection problem:** does not exist when did sample test by name-matching for unidentified inventors



2. Growing trends of the foreign-born inventors from different regions

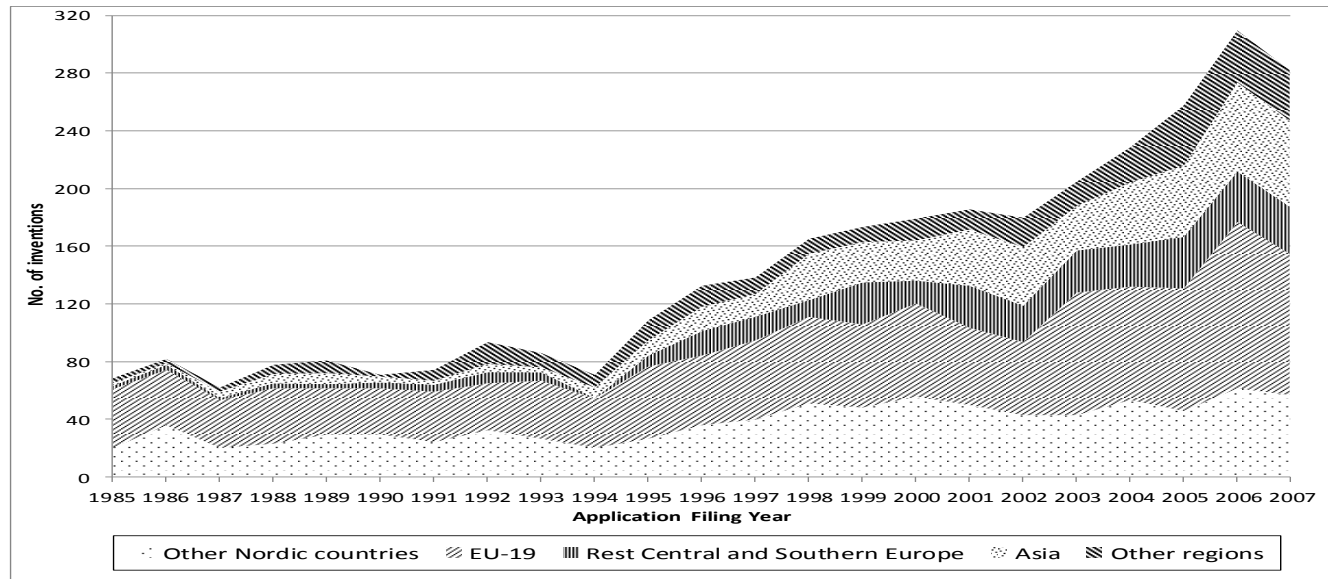


Figure 1. Number of inventions contributed by foreign-born inventors in each year, fractional count - by birth regions, 1985-2007

Source: Statistics Sweden and Circle data on inventors

Note: others includes Former Soviet Union, Africa, North America, South America, Oceania and unknown

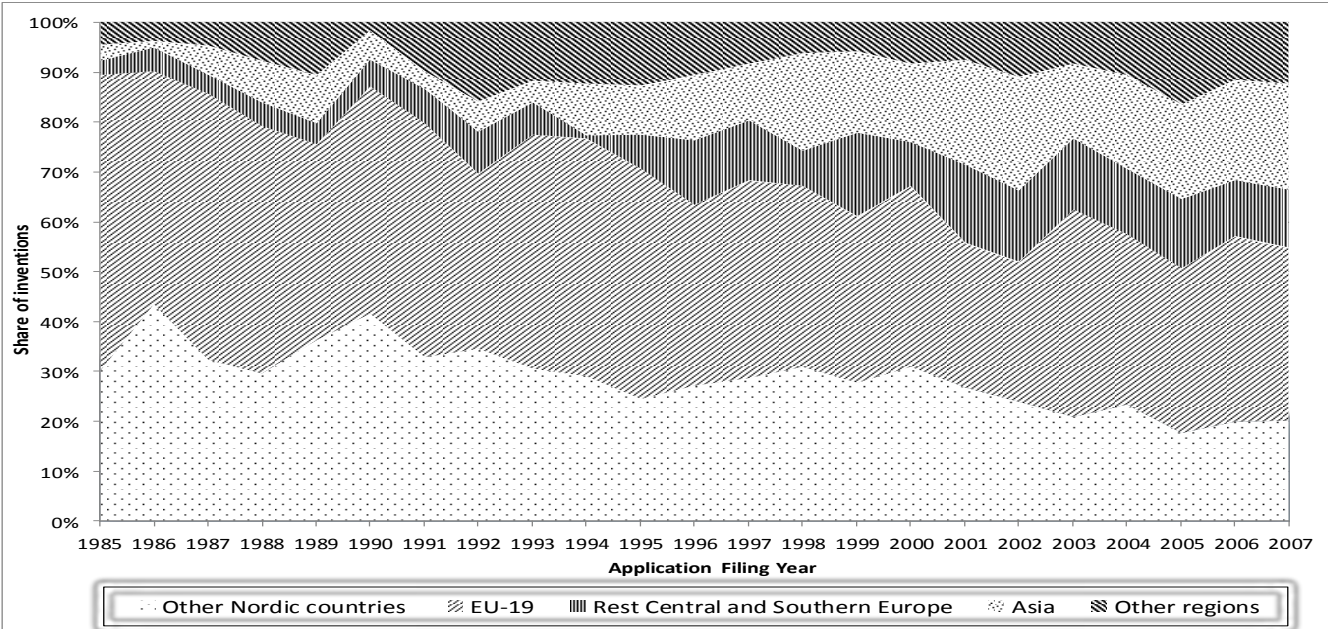


Figure 2. Share of inventions contributed by foreign-born inventors in each year, fractional count - by birth regions, 1985-2007



V. Methodology

1. *Listwise deletion* - missing values, 91%, 1985-2007

2. *Dependent variable*

Number of forward citations (NFC) -number of patents citing, within five years after filing

NFC

- most popular indicator, the strongest predictor of patent value (Lanjouw and Schankerman, 1999; Sapsalis, et al, 2006).
- as a proxy of effective use or the importance of a patent to new inventions (Sapsalis, et al, 2006). Inventions with higher economic value estimate, more likely to be cited (Harhoff et al, 1999).



3. Independent variable (1/2)

1). Birth region: *main variable of interest*

- Swedish-born (omitted) vs. Each group of foreign-born: (6 dummies)

2). Highest edu level at the time of filing (3 dummies)

3). Field of study for the highest edu level at the time of filing (4 dummies)

4). Edu_SE (dummy)

could be related to the education quality, could further affect the quality of inventors and patents

5). Age and age square

productivity varies with age of inventors (Jones, 2010). Creativity is a curvilinear (inverted U) function of age (Simonton, 2000).

6). Gender (dummy)

gender difference in patenting performance as differences in personal characteristics, structural positions, organizational reasons and marital status (e.g. Whittington and Smith-Doerr, 2005).



3. Independent variable (2/2)

7). Interaction variables

to test the additive effect of birth region on patent quality

birth region *

- i) highest education level
- ii) field of education
- iii) gender

8). Control variables

- Application year: 23 dummies, 1985 (omitted)
- Number of inventors
- Technology classes (4 dummies)
- Firm size (3 dummies)



4. Negative binomial model

Reason:

- a) NFC: count data & overdispersed: 50.3% of observations: zero citation
- b) standard deviation (=2.87) > mean value (=1.46).

with cluster-robust standard errors - control for intra-inventor correlation
46% of inventors - more than one patent application



Table 3. Statistics on dependent and independent variables used in the regressions

Birth region	No. of forward citations			Highest education level (%)			Field of study ¹ (%)					Edu_SE (Yes, %)	Age	Gender (%) ²		Total No. of obs. used in reg. ³	% of data used in reg. ⁴
	Mean	S.D.	Max	<= Short post-2nd	Long post-2nd	PhD	E,M&C	S,M&C	H&W	Oth	F			M			
Total Swedish inventors	1.47	2.88	60	30.6	41.5	27.8	74.0	11.8	6.6	7.6	95.3	43.8	6.8	93.2	51,606	90.9%	
<i>Swedish-born</i>	1.47	2.90	60	31.7	42.6	25.7	75.9	10.0	6.5	7.6	100	43.6	6.6	93.4	46,127	91.9%	
<i>Foreign-born</i>	1.43	2.70	48	21.5	32.8	45.7	58.1	27.0	7.3	7.6	56.0	45.1	8.5	91.6	5,479	83.3%	
Other Nordic countries	1.35	2.43	31	34.2	30.5	35.4	61.4	20.9	7.4	10.3	59.9	46.3	6.9	93.1	1,385	82.4%	
EU-19	1.41	2.45	24	19.7	33.4	46.9	61.6	28.5	4.8	5.2	45.4	45.1	7.0	93.0	2,039	81.0%	
Rest C & S Europe	1.63	3.19	22	30.3	34.2	35.5	46.1	26.7	13.3	14.0	58.8	46.0	7.5	92.5	558	85.8%	
Asia	1.43	2.93	44	6.0	26.8	67.2	61.0	27.0	10.6	1.5	69.4	43.7	13.7	86.3	898	89.0%	
Others	1.51	3.24	48	13.2	44.2	42.6	45.6	36.1	5.5	12.9	60.0	43.5	10.0	90.0	599	84.0%	

Source: Statistics Sweden and CIRCLE data on inventors

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

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

3. ¹ “E, M&C” = Engineering, Manufacturing and Construction; “S, M&C” = Science, Mathematics and Computing; “H&W” = Health and Welfare; “Oth” = other fields.

4. ² “F” = Female; “M” = Male.

5. ⁴ = ³ / total No. of obs. in database for each group.



V. Result Analysis

Interaction variables:

1). **Different birth regions***same edu level/ field of study/ gender.

E.g.

Swedish-born*short post-2nd edu (omitted)

Other Nordic countries*short post-2nd edu

EU-19*short post-2nd edu

Rest Central and Southern Europe*short post-2nd edu

Asia*short post-2nd edu

Other regions*short post-2nd edu

2). **Same birth region*** different edu level/ field of study/ gender.

E.g.

Asia*short post-2nd edu

Asia*long post-2nd edu (omitted)

Asia*Ph.D.



Table 4: Determinants of NFC: Swedish-born vs. foreign-born inventors, by same education level, field of study and gender, 1985-2007

Indep. var.	1	2	3	4	5	6	7	8	9	10	11	12	13
	BR	Edu	BR*E1	BR*E2	E Field	BR*F1	BR*F2	BR*F3	BR*F4	BR*F all	Age	BR*Fem	BR*Male
BR (omit: Swedish-born)													
Nordic	-0.035 (0.077)	-0.033 (0.075)	-0.044 (0.101)	-0.022 (0.080)	-0.053 (0.115)	0.087 (0.118)	-0.198 (0.123)	-0.082 (0.127)	-0.052 (0.116)	-0.246 (0.252)	-0.236 (0.252)	-0.223 (0.249)	-0.728** (0.338)
EU-19	-0.038 (0.058)	-0.070 (0.056)	-0.026 (0.064)	-0.130** (0.065)	-0.095 (0.083)	-0.165* (0.085)	-0.062 (0.109)	-0.099 (0.090)	-0.094 (0.084)	-0.704** (0.348)	-0.725** (0.343)	-0.723** (0.345)	-0.767** (0.352)
Rest C & S Europe	0.254 (0.285)	0.248 (0.254)	0.246 (0.358)	0.079 (0.124)	-0.135 (0.161)	0.021 (0.165)	0.241 (0.176)	-0.232 (0.168)	-0.136 (0.161)	1.636*** (0.353)	1.700*** (0.364)	1.661*** (0.361)	1.095** (0.446)
Asia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other regions	-0.042 (0.092)	-0.071 (0.091)	-0.044 (0.098)	-0.201** (0.098)	-0.219** (0.110)	-0.126 (0.116)	-0.412*** (0.151)	-0.158 (0.113)	-0.230** (0.110)	0.048 (0.336)	0.005 (0.328)	0.014 (0.328)	-0.157 (0.386)
Edu level (omit: long post-2nd)													
Short post-2nd		-0.262 *** (0.030)	-0.255 *** (0.029)	-0.249 *** (0.029)	-0.240 *** (0.029)	-0.238 *** (0.029)	-0.240 *** (0.029)	-0.240 *** (0.029)	-0.235 *** (0.029)	-0.235 *** (0.029)	-0.196 *** (0.030)	-0.195 *** (0.030)	-0.195 *** (0.030)
Ph.D.		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*each edu level (omit: Swedish-born*each edu level)													
Each BR*short post-2nd													
Nordic/Asia/Others*short		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
EU-19*short		-0.254** (0.119)	-0.254** (0.119)	-0.180 (0.131)	-0.251* (0.148)	-0.211 (0.146)	-0.176 (0.135)	-0.143 (0.129)	-0.184 (0.154)	-0.144 (0.153)	-0.144 (0.153)	-0.144 (0.153)	-0.144 (0.153)
Rest C & S EU*short		0.006 (0.394)	0.006 (0.394)	0.370 (0.233)	0.834*** (0.288)	-0.003 (0.241)	0.411* (0.229)	0.255 (0.258)	0.234 (0.217)	0.226 (0.211)	0.237 (0.209)	0.237 (0.209)	0.237 (0.209)
Each BR*long post-2nd													
Nordic/EU-19/Asia/*long				Yes (0.547)	Yes (0.564)	Yes (0.474)	Yes (0.432)	Yes (0.566)	Yes (0.207)	Yes (0.191)	Yes (0.195)	Yes (0.197)	Yes (0.197)
Rest C & S EU*long				0.266 (0.172)	0.244 (0.174)	0.320* (0.171)	0.335** (0.159)	0.184 (0.175)	0.195 (0.175)	0.234 (0.168)	0.247 (0.175)	0.255 (0.177)	0.255 (0.177)
Others*long													
Field of study (omit: E, M & C)													
S, M & C					0.184*** (0.040)	0.170*** (0.042)	0.183*** (0.044)	0.184*** (0.040)	0.189*** (0.040)	0.179*** (0.044)	0.186*** (0.044)	0.181*** (0.044)	0.181*** (0.044)
H & W					0.151*** (0.040)	0.134*** (0.042)	0.147*** (0.040)	0.134*** (0.043)	0.154*** (0.040)	0.130*** (0.043)	0.161*** (0.043)	0.156*** (0.044)	0.156*** (0.044)
Other fields					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR* each field of study (omit: Swedish-born*each field of study)													
Each BR*E, M & C													
Nordic*E, M & C						-0.322** (0.138)				-0.038 (0.219)	-0.017 (0.218)	-0.024 (0.216)	-0.024 (0.216)
EU-19*E, M & C						0.154 (0.124)				0.656** (0.334)	0.685** (0.328)	0.683** (0.328)	0.683** (0.328)
Rest C & S EU*E, M & C						-0.813*** (0.294)				-1.816*** (0.335)	-1.905*** (0.349)	-1.867*** (0.344)	-1.867*** (0.344)
Asia*E, M & C						Yes				Yes	Yes	Yes	Yes
Others*E, M & C						-0.337* (0.176)				-0.446 (0.323)	-0.377 (0.313)	-0.362 (0.313)	-0.682 (0.313)
Each BR* S, M & C													
Nordic*S, M & C							0.372** (0.180)			0.413 (0.279)	0.424 (0.281)	0.471* (0.279)	0.471* (0.278)



EU-19/Asia*S, M & C						Yes				Yes	Yes	Yes	Yes
Rest C & S EU*						-0.655**				-1.921***	-1.996***	-1.894***	-1.894***
S, M & C						(0.288)				(0.351)	(0.364)	(0.368)	(0.368)
Others*S, M & C						0.314*				-0.109	-0.080	-0.070	-0.070
						(0.167)				(0.335)	(0.325)	(0.323)	(0.323)
Each BR* H & W													
Nordic/Asia*H & W							Yes			Yes	Yes	Yes	Yes
EU-19*H & W						0.022				0.625*	0.655*	0.657*	0.657*
						(0.153)				(0.368)	(0.362)	(0.362)	(0.362)
Rest C & S EU*H & W						0.367				-1.408***	-1.423***	-1.343***	-1.343***
						(0.233)				(0.385)	(0.399)	(0.393)	(0.393)
Others*H & W						-0.657***				-0.861**	-0.804**	-0.786**	-0.786**
						(0.211)				(0.380)	(0.370)	(0.368)	(0.368)
Each BR*other fields													
Nordic/Asia/Others*other fields							Yes						
EU-19*other fields							-0.637*						
							(0.334)						
Rest C & S EU* other fields							1.829***						
							(0.332)						
Edu SE²													
Age										Yes	Yes	Yes	
										-0.037***	-0.037***	-0.037***	
										(0.011)	(0.011)	(0.011)	
Age_sqr										0.000***	0.000**	0.000**	
										(0.000)	(0.000)	(0.000)	
Female (omit: male)³													
Each BR*female (omit: Swedish-born*female)													
Nordic*female												-0.506**	
												(0.216)	
EU-19/Asia/Others* female												Yes	
												(0.124)	
Rest C & S EU* female												-0.565*	
												(0.314)	
Each BR*male (omit: Swedish-born*male)													
Nordic*male													0.506**
													(0.216)
EU-19/Asia/Others*male													Yes
Rest C & S EU*male													0.565*
													(0.314)
No. of inventors	0.098***	0.094***	0.094***	0.094***	0.092***	0.092***	0.092***	0.092***	0.092***	0.092***	0.088***	0.088***	0.088***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Firm size (omit: medium firms (100-499 employees))													
Small firms (<100 employees)	0.112***	0.119***	0.119***	0.117***	0.106***	0.105***	0.105***	0.108***	0.101***	0.101***	0.104***	0.106***	0.106***
	(0.031)	(0.031)	(0.031)	(0.030)	(0.031)	(0.031)	(0.031)	(0.031)	(0.030)	(0.030)	(0.031)	(0.031)	(0.031)
Large firms (>=500 employees)	0.168***	0.140***	0.140***	0.140***	0.131***	0.130***	0.128***	0.132***	0.130***	0.128***	0.134***	0.133***	0.133***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.029)	(0.029)	(0.029)
Constant	-0.248***	-0.158*	-0.156*	-0.163*	-0.157*	-0.154*	-0.156*	-0.154*	-0.150	-0.146	0.818***	0.809***	0.809***
	(0.094)	(0.093)	(0.093)	(0.093)	(0.092)	(0.093)	(0.092)	(0.092)	(0.092)	(0.092)	(0.273)	(0.274)	(0.274)
Chi-square	2,943	2,960	3,008	2,996	3,099	3,166	3,155	3,123	3,153	3,238	3,251	3,254	3,256
Log likelihood	-80,794	-80,658	-80,654	-80,648	-80,609	-80,583	-80,591	-80,603	-80,563	-80,543	-80,442	-80,432	-80,432

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

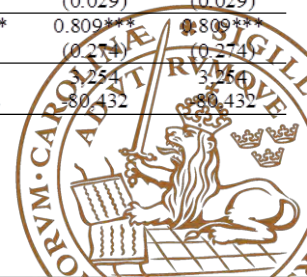
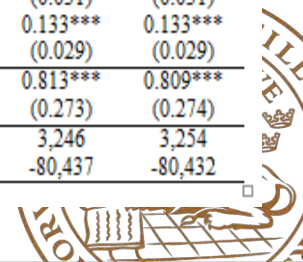


Table 5: Determinants of NFC: Swedish-born vs. foreign-born inventors, compare within same region by different education level, field of study and gender, 1985-2007

<u>Indep. var.</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>
	<u>EU19_E</u>	<u>All_Edu</u>	<u>E_Field</u>	<u>SE_F</u>	<u>Nor_F</u>	<u>EU19_F</u>	<u>R_EU_F</u>	<u>Other_F</u>	<u>All_F</u>	<u>Age</u>	<u>Nor_Fe</u>	<u>R_EU_Fe</u>	<u>All_Fe</u>
BR (omit: Swedish-born)													
Nordic	-0.034 (0.076)	-0.064 (0.165)	-0.123 (0.144)	-0.162 (0.139)	-0.307*** (0.106)	-0.125 (0.143)	-0.125 (0.143)	-0.122 (0.145)	-0.308*** (0.106)	-0.286*** (0.108)	-0.264** (0.107)	-0.287*** (0.108)	-0.264** (0.107)
EU-19/Asia/Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rest C & S Europe	0.247 (0.254)	0.539 (0.533)	0.524 (0.541)	0.338 (0.425)	0.525 (0.539)	0.515 (0.538)	-0.479*** (0.149)	0.528 (0.541)	-0.479*** (0.149)	-0.465*** (0.157)	-0.466*** (0.157)	-0.422*** (0.157)	-0.419*** (0.157)
Edu level (omit: long post-2nd)													
Short post-2nd	-0.254 *** (0.030)	-0.248 *** (0.029)	-0.240 *** (0.029)	-0.237 *** (0.029)	-0.242 *** (0.029)	-0.242 *** (0.029)	-0.234 *** (0.029)	-0.240 *** (0.029)	-0.235 *** (0.029)	-0.196 *** (0.030)	-0.195 *** (0.030)	-0.195 *** (0.030)	-0.195 *** (0.030)
Ph.D.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Each BR*each edu level (omit: each BR*long post-2nd)¹													
Nordic*each edu level													
Nordic*short		0.054 (0.190)	0.115 (0.172)	0.083 (0.172)	0.289** (0.146)	0.116 (0.172)	0.118 (0.171)	0.113 (0.173)	0.284* (0.146)	0.293** (0.146)	0.282* (0.144)	0.292** (0.147)	0.282* (0.144)
Nordic*Ph.D.		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
EU-19*each edu level													
EU-19*short	-0.314** (0.142)	-0.319** (0.142)	-0.288** (0.142)	-0.282* (0.146)	-0.291** (0.142)	-0.306** (0.142)	-0.292** (0.142)	-0.290** (0.142)	-0.311** (0.142)	-0.299** (0.145)	-0.300** (0.145)	-0.300** (0.145)	-0.301** (0.145)
EU-19*Ph.D.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rest C & S Europe*each edu level													
Rest C & S Europe * short		-0.288 (0.559)	-0.289 (0.565)	-0.158 (0.465)	-0.289 (0.563)	-0.279 (0.562)	0.533** (0.260)	-0.294 (0.565)	0.534** (0.260)	0.486* (0.256)	0.490* (0.256)	0.451* (0.254)	0.451* (0.254)
Rest C & S Europe* Ph.D.		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Asia*each edu level													
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Others*each edu level													
Others*short		-0.368* (0.221)	-0.322 (0.219)	-0.359* (0.207)	-0.327 (0.219)	-0.321 (0.218)	-0.319 (0.222)	-0.291 (0.217)	-0.293 (0.217)	-0.294 (0.217)	-0.302 (0.219)	-0.302 (0.219)	-0.289 (0.215)
Others*Ph.D.		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field of study (omit: E, M & C)													
S, M & C			0.184*** (0.040)	0.226** (0.091)	0.164*** (0.041)	0.191*** (0.042)	0.191*** (0.040)	0.176*** (0.041)	0.179*** (0.044)	0.186*** (0.044)	0.182*** (0.044)	0.183*** (0.044)	0.181*** (0.044)
H & W			0.151*** (0.040)	0.303*** (0.100)	0.138*** (0.041)	0.154*** (0.041)	0.145*** (0.041)	0.154*** (0.040)	0.130*** (0.043)	0.161*** (0.043)	0.156*** (0.044)	0.157*** (0.044)	0.156*** (0.044)
Other fields			0.011 (0.042)	0.288* (0.170)	0.012 (0.043)	0.026 (0.042)	-0.019 (0.042)	0.004 (0.042)	-0.014 (0.043)	0.004 (0.043)	0.003 (0.043)	0.003 (0.043)	0.003 (0.043)
Each BR+ each field of study (omit: each BR*E, M & C)													
Swedish-born*each field of study													
Swedish-bom*S, M & C/H & W				Yes									
Swedish-bom* other fields				-0.304* (0.177)									
Nordic*each field of study													

Nordic*S, M & C					0.465** (0.186)					0.451** (0.187)	0.441** (0.188)	0.495*** (0.188)	0.437** (0.189)	0.495*** (0.188)
Nordic*H & W					0.377** (0.163)					0.386** (0.164)	0.373** (0.164)	0.438*** (0.169)	0.371** (0.165)	0.438*** (0.169)
Nordic*other fields					Yes					Yes	Yes	Yes	Yes	Yes
<i>EU-19*each field of study</i>														
EU-19*S, M & C/H & W					Yes					Yes	Yes	Yes	Yes	Yes
EU-19*other fields					-0.697** (0.333)					-0.656** (0.334)	-0.685** (0.328)	-0.682** (0.329)	-0.683** (0.328)	-0.683** (0.328)
<i>Rest C & S Europe*each field of study</i>														
Rest C & S Europe*S, M & C					Yes					Yes	Yes	Yes	Yes	Yes
Rest C & S Europe*					0.395** (0.198)					0.408** (0.199)	0.481** (0.198)	0.481** (0.199)	0.522*** (0.193)	0.523*** (0.193)
H & W					1.821*** (0.335)					1.816*** (0.335)	1.905*** (0.349)	1.908*** (0.349)	1.867*** (0.344)	1.867*** (0.344)
Rest C & S Europe* other fields														
<i>Asia*each field of study²</i>										Yes	Yes	Yes	Yes	Yes
<i>Others*each field of study</i>										(0.501)	(0.488)	(0.490)	(0.490)	(0.496)
Others*S, M & C						0.341* (0.180)				0.338* (0.181)	0.296 (0.187)	0.294 (0.188)	0.294 (0.189)	0.313 (0.190)
Others*H & W						-0.439* (0.248)				-0.415* (0.248)	-0.427* (0.249)	-0.435* (0.249)	-0.436* (0.249)	-0.403 (0.255)
Others*other fields						Yes				Yes	Yes	Yes	Yes	Yes
<i>Edu_SE³</i>											Yes	Yes	Yes	Yes
Age											-0.037*** (0.011)	-0.037*** (0.011)	-0.037*** (0.011)	-0.037*** (0.011)
Age_sqrt											0.000*** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)
Female (omit: male) ⁴												0.075* (0.045)	0.069 (0.045)	0.078 (0.048)
<i>Each BR*female (omit: each BR*male)⁵</i>														
Nordic*female													-0.503** (0.215)	-0.506** (0.216)
EU-19/Asia/Others*female														Yes
Rest C & S Europe*female													-0.556* (0.313)	-0.565* (0.314)
No. of inventors	0.098*** (0.005)	0.094*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.092*** (0.005)	0.088*** (0.005)	0.088*** (0.005)	0.088*** (0.005)	0.088*** (0.005)
Firm size (omit: medium firms (100-499 employees))														
Small firms (<100 employees)	0.112*** (0.031)	0.118*** (0.030)	0.106*** (0.031)	0.107*** (0.031)	0.105*** (0.031)	0.105*** (0.030)	0.102*** (0.031)	0.108*** (0.030)	0.101*** (0.030)	0.104*** (0.031)	0.106*** (0.031)	0.106*** (0.031)	0.106*** (0.031)	0.106*** (0.031)
Large firms (≥500 employees)	0.168*** (0.030)	0.140*** (0.030)	0.131*** (0.030)	0.132*** (0.030)	0.129*** (0.030)	0.131*** (0.030)	0.131*** (0.030)	0.132*** (0.030)	0.128*** (0.030)	0.134*** (0.029)	0.133*** (0.029)	0.133*** (0.029)	0.133*** (0.029)	0.133*** (0.029)
Constant	-0.159* (0.093)	-0.160* (0.093)	-0.157* (0.092)	-0.152 (0.093)	-0.153* (0.092)	-0.159* (0.092)	-0.150 (0.092)	-0.154* (0.093)	-0.146 (0.092)	0.818*** (0.273)	0.806*** (0.273)	0.813*** (0.273)	0.813*** (0.273)	0.809*** (0.274)
Chi-square	2,980	3,028	3,099	3,126	3,115	3,106	3,150	3,149	3,238	3,251	3,247	3,246	3,246	3,254
Log likelihood	-80,654	-80,644	-80,609	-80,602	-80,600	-80,602	-80,567	-80,603	-80,543	-80,442	-80,435	-80,437	-80,437	-80,432



Result conclusions (1/3)

Quality of patents:

1). in general, **similar** for different groups

2). **different**, when inventors from different regions with different background on education level, field of study and gender.

Specifically:

i) Edu level

a) **a negative relation**: NFC & \leq short post-2nd edu,
both overall (26% lower) and EU-19*(\leq short post-2nd edu) (25% lower).

b) EU-19 (13%, $p < 0.05$) and “other regions” (20%, $p < 0.05$) (for those without long post-2nd edu, mainly those with short post-2nd) < Swedish-born
after adding each birth region* long post-2nd edu - themselves insignificant.



Result conclusion (2/3)

ii) Field of study

a) overall, S, M & C (18%, $p < 0.01$) and H & W (15%, $p < 0.01$) > E, M & C

b) it differs for inventors who are from different regions.

① **Swedish-born**: “other fields” (30%, $p < 0.1$) < E, M & C

E, M & C: other Nordic countries (32%, $p < 0.05$) < Swedish-born

rest C & S Europe (81%, $p < 0.01$) < Swedish-born

other regions (34%, $p < 0.1$) < Swedish-born

② **other Nordic countries**:

➤ S, M & C (47%, $p < 0.05$) and H & W (38%, $p < 0.05$) > E, M & C.

after controlling, other Nordic (for those studied in E, M & C) (31%, $p < 0.01$) < Swedish-born

➤ S, M & C: other Nordic (37%, $p < 0.05$) > Swedish-born

③ **EU-19**: those who did not studied in E, M & C (17%, $p < 0.01$) < Swedish-born.

Because its badly performed inventors who studied in “other fields”

➤ EU-19: “other fields” (70%, $p < 0.05$) < E, M & C

➤ “other fields”: EU-19 (64%, $p < 0.1$) < Swedish-born



Result conclusion (3/3)

④ rest C & S Europe:

- H & W (40%, $p < 0.05$) and “other fields” (182%, $p < 0.01$) $>$ E, M & C.
after controlling, rest C & S Europe (those studied in E, M & C) (48%, $p < 0.01$) $<$ Swedish-born.
- “other fields”: rest C & S Europe (183%, $p < 0.01$) $>$ Swedish-born.

⑤ “other regions”:

- S, M & C (34%, $p < 0.1$) $>$ E, M & C
H & W (44%, $p < 0.1$) $<$ E, M & C
- S, M & C: “other regions” (31%, $p < 0.1$) $>$ Swedish-born,
after controlling, “other regions” (those did not study in S, M & C) (41%, $p < 0.01$) $<$ Swedish-born, mainly because those badly performed inventors studied in E, M & C & H & W, especially H & W



VI. Discussion and Conclusion

1. Conclusion of study results

1). **productivity of patents** (quantity and quality):

foreign-born (each group) \approx Swedish-born

Reason:

- **EU-19:** those with long post-2nd edu, those studied in E, M & C
- **Other Nordic countries:** those studied in S, M & C and H & W
- **Rest C & S Europe:** those studied in H & W and "other fields"
- **Other regions:** those with long post-2nd edu, those studied in S, M & C

2. Foreign-born inventors in Sweden vs. the US

The US:

Foreign-born $>$ native born

- one of the most attractive place for the best talents in the world
- average quality of US-born individuals choosing to get doctorates in S&E has declined
- less limitation e.g. language and culture for foreign-born in the US

Sweden:

Foreign-born \approx native born

- major component of highly skilled immigrants - asylum seekers or under family reunification when they arrived (Gaillard, 2002), similar for foreign-born inventors
- major native born PhDs still choose to study in the S&E field



3. Contribution

- **First detailed study:** research on the foreign-born inventors in Sweden.
- **Prior studies:** overall of foreign-born inventors vs. native born
This paper: foreign-born from different regions vs. Swedish-born, with detailed exploration in their study background.

4. Limitations of study

- Need more sound theories
- only based on patent data - only represent part of contribution by highly skilled immigrants
- do not consider about commercialization of patents and other innovative activities



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The end
Thank you!

Questions and Suggestions?

