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Papers in Innovation Studies

Paper no. 2014/15

How Important are Local Inventive Milieus: The role of Birthplace, High School and University Education

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This is a pre-print version of a paper that has been accepted in its final version in *Geoforum*. Please cite the original journal article.

This version: September 2014

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JEL codes: I21; J24; O18; O31; O33; R12; Y91

Keywords: Inventor; time-space; regional unevenness; context; local milieu

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1 Introduction

To what extent do local milieus influence individuals' abilities to become an inventor? Marshall (1920) famously observed that closely related industries tended to locate in the same district, and he noted several advantages as being critical to their success. One of these was that knowledge was as if in the 'air'. The question raised in this paper is whether different 'airs' or socio-cultural relations are 'contagious' in the sense that they have a positive impact on an individual's probability of becoming an inventor. We study this by measuring the volume and density of co-located inventors at various stages and estimate whether such socio-cultural imprints are lasting. Moreover, we investigate their relative strength during upbringing and later on through education.

Existing literature on the role of place for inventive activity looks mainly at regional characteristics at the time when the creative act takes place, leaving the background of individuals largely unaccounted for. Even when historical perspectives are brought into the analysis it is usually the region itself that receives attention and not the individuals' backgrounds, i.e. if they migrated from one location to another along with other information on background. By contrast, rather than writing another "history of locations of inventive ideas" in this study we examine "the location history of inventors" and focus on an individual's probability to become an inventor herself by studying the eventual impact from the level and density of other nearby future inventors over time. We use the entire population born in 1955-1977 which can be observed in 2007 and study how the probability of being listed on a patent as inventor is influenced by the density of other future inventors residing in the same region. We focus on three such densities: a) future inventors in the municipality around the time of birth, b) future inventors around the time of graduation from high school and c) future inventors at graduation from higher education. We have two objectives. First, we want to get a qualitative understanding of whether certain birth and educational milieus matter more as experiences are accumulated over time. Second, we want to estimate the relative impact of exposure to other inventors on the probability that individuals themselves become inventors. For this purpose, we employ probit regressions to estimate the extent to which each density impacts on the probability of becoming inventor.

Our main finding is that a local milieu measured as high density of future inventors at an individual's birth place or place of higher education indeed has a significant positive effect on the probability that this individual becomes an inventor him- or herself. However, effects from high school are less consistent with such an interpretation. This suggests that the local inventive milieu within a birth region or during higher education is the most promising candidate to dig further into for future study of the relation between geography and inventiveness.

The paper is structured as follows. In Section 2, we review the literature examining the location of inventive and innovative activity. In Section 3, we describe the data and method used to examine the inventors and describe the distribution of future inventors found at different locations. In Section 4, descriptive analysis of the distribution of future inventors is made followed by a regression model investigating the effects of birthplace, high school and university on future inventors. Section 5 concludes.

2 Literature review

An abundant selection of literature examines the location of activities related to knowledge creation at the time of its occurrence. Economic geographers and other scholars with interest in regional studies have a long tradition of explaining innovative activity and regional economic development partly as an outcome of socio-cultural variables. The learning region debate in the 1990's (Asheim, 1996; Maskell and Malmberg, 1999; Morgan, 1997) stresses this relation by arguing that on the local level embedded institutions and both strong and weak relations between economic actors can shape a strong innovative environment. Such environments can turn out to be stable over time and provide long periods with continuously innovative active that helps regions to stay competitive. These regions can be based on high-tech and research, e.g. Silicon Valley and Grenoble region, or more low-tech production like furniture production in northern Jutland in Denmark. The level of technological input is not necessarily decisive in explaining whether an environment turns out to be an innovative and competitive milieu, rather than the local institutional setup. But, the local institutional setup does not do the job alone, global 'pipelines' are also essential to access and exchange knowledge generated in the greater surroundings (Bathelt et al., 2004).

Shefer and Frenkel (1998) state that innovative milieus should be defined by the rate of innovation in a specific locality in combination with the degree of socio-economic interaction among firms closely located. This is basically what this paper aims to sketch out using register based data on an individual level: The probability to become an inventor if you are brought up or educated in a specific milieu.

The innovative milieu concept partly has its origin in the GREMI (the European Research Group into Innovative Milieus) research program, which was underpinned by analyses of factors that made some regions or locations more dynamic than others with respect to innovation. According to Crevoisier (2004) innovative milieus are "a synthetic analytical tool for analysing and understanding current economic change" (p. 369) and consists of three important axes: technological dynamics, change in territories and organizational change. The argument put forward by Crevoisier (2004) is that over time a milieu stays innovative by "mobilizing the resources constituted by the past that are then adapted to new techniques and markets and are incorporated within new products" (p. 373). Accordingly, to understand innovation, and thus also inventiveness, time and space relations become essential.
Also, time-space geography takes into account that creative people, at least partly, are formed by their experiences in the past and opens for such an attempt to analyse the relation between the past and the present. According to Törnqvist (2011), a majority of Nobel Prize winners in economics and physics have been attending Princeton University, Harvard University and University of Chicago at some point in their careers either as students, visiting researcher or in more permanent positions. Based hereon, Törnqvist argues that some places – or milieus - provide more creative or stimulating settings than others. This is an excellent example of the hypothesis that some institutions and organisations that materialise in place have a more dominant role in generating knowledge, creative thinking, etc., compared to others. This view on connecting time, space and human activity demonstrates that prior experiences may give valuable insights to understanding present creativity of individuals. Thus, in the light of the theoretical and empirical work that has been developed within time-space geography, we argue that milieus such as place of birth (childhood), high schools and universities may provide valuable insights to explaining creative and thus inventive behaviour of individual human beings.

Other literature examines to what extent innovation is concentrated in certain regions and to what extent research and development (R&D) and education facilities can be linked to inventive outcomes, such as patents (Ejermo and Gråsjö, 2011; Jaffe, 1989). This literature invariably finds that, irrespective of which traditional innovation indicator is used (Acs et al., 2002), innovative activity is geographically concentrated, even after controlling for population size (Ejermo, 2009). Supplementary literature has examined whether knowledge spillovers, typically using patent citations as a proxy, is bounded by geographical space. Jaffe et al. (1993) found strong evidence for geographical boundedness while later contributions moderated the spillover interpretation but improved the understanding towards which mechanisms could explain these patterns. These studies focused on labour mobility (Almeida and Kogut, 1999; Møen, 2005; Zucker et al., 1998) and social networks (Singh, 2005). The social networks literature suggests that geography matters for spillovers when inventors are not bound together by prior social links (Agrawal et al., 2006), but also that social networks to some extent can substitute geographical interaction and thus become important for the distribution of knowledge.

This is also one of the major points stressed by Saxenian's (1994) famous study on the IT industry. She argues that some of the more successful examples of knowledge circulation across regions can be linked to the mobility of creative, innovative and entrepreneurial individuals and are largely dependent on the social relations these individuals engage in. This suggests that entrepreneurial or inventive behaviour may be a part of the socio-cultural setting that is inherited through the experiences obtained in one region and then transferred through individual mobility to other regions.

Entrepreneurship studies address the location of creative acts through the study of new firms. This literature highlights other aspects than those obtained by innovation indicators. While new firms are undoubtedly concentrated, similar to innovations, they are not always found in urban centres. For instance, based on studies from the small Gnosjö region, Sweden, Johannisson (1986) argues that some regions have a socio-cultural milieu that facilitates entrepreneurship in a way not found in surrounding regions. This demonstrates that the contextual setting of a place can be of great importance for the regions' ability to prosper and also for how individuals act. By the same token, Vogelius and Sørensen (1987) study uneven geographies of entrepreneurship and labour culture in Denmark, revealing that areas dominated by large enterprises tend to develop a worker-based culture that lacks entrepreneurial spirit, whereas regions based on small firms and agriculture tend to have a larger proportion of people willing to engage in entrepreneurial activities such as own start-ups.

In the same line of thinking, Fritsch and Wyrwich (2012) find that regions characterised by a high level of new firm formation in 1925 were also entrepreneurial in 2005, despite the interruption of World War II and shifts between capitalist and communist regimes in Eastern Germany. Thus according to Fritsch and Wyrwich, socio-cultural institutions and traits towards entrepreneurial activity are so strongly embedded in the socio-cultural milieus of certain regions that it can survive beyond formal institutions provided by society. This focus on the local institutional setting stresses the path dependent nature of economic development; i.e. whether it results in a positive or less positive reproduction of place specific characteristics such as socio-cultural milieus that influence the learning process and the ability to develop and utilize accumulated knowledge as highlighted by Markussen (1996), Storper (1997) and Gertler (2004). Thus, local milieu may be stimulating knowledge creation, whether through invention, innovative activity or entrepreneurship, and can be expected to influence individuals' behaviour, whether consciously or not.

Well aware that measuring local milieus' effects on regional inventiveness is a very difficult task, this study suggests that the number and density of future inventors in space and across time can be used as a proxy for the inventive milieu of a certain place. Therefore, and based upon the above theoretical discussion, this paper sets out to study whether local inventive milieus, understood as the level and density of inventors present in the region of birth, at high school and at higher education affect the likelihood that an individual becomes an inventor in the future.

3 Data and research design

This study uses Swedish municipalities as the units under which we gauge the local milieu effects from other inventors around the time of birth, high school and higher education. There are 290 municipalities in Sweden with slight changes over time. Considerable efforts were invested into standardising municipality codes from old systems, where tables of old municipality coding systems were manually coded and converted into the present system. About 99% of the birth locations of Swedish-born could be delineated through this new system. Although employing larger regions such as functional regions based on travel to work patterns would have been possible, we argue that since this study focuses on upbringing milieu, high school and university, the smaller municipality level is the right unit for this type of analysis since, differently from adults that frequently commute across municipal borders, the strongest socio-cultural effects arguably incur to young people in the same municipality where they are born or are educated. For instance, when considering effects from upbringing, the affected individuals are yet to become inventors and are less likely to draw inspiration from individuals in nearby municipalities.

Time trends and associated trends in location of inventive activity may disturb the study of regional influences on individuals' careers towards becoming an inventor. For instance, Ejermo and Kander (2011) has documented a rise in patent activity for Sweden over the period 1985-1998, and Ejermo and Andersson (2013) shows that this trend continues, also after considering that R&D has risen over time. These trends in patenting are linked to both institutional changes related to intellectual property (Sanyal and Jaffe, 2005) and firm strategies. For instance, it is well documented that patents are used as bargaining chips in negotiations between major ICT firms (The Economist, 2005). With respect to inventive activity over space, Ejermo (2009) shows that inventive activity has tended to become geographically more concentrated towards the larger regions Stockholm, Gothenburg and Malmoe over time, which in turn of course is a function of the patent profiles of different firms and their associated strategies in those regions.

We draw on a rich database of inventors gathered, encompassing 23,000 or 80% of Swedish inventors listed on European Patent Office applications over the period 1978-2007.[1] Our inventors are linked to

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[1] Certainly, there are inventors that for instance i) never file patents, ii) only go through the Swedish patent office (PRV), or iii) only go through the American patent office (USPTO). Group i) is for obvious reasons unknown but probably quite small, though there are indications that secrecy or moving down the learning curve are more efficient ways of protecting innovations which are sector-specific, see e.g. Levin, R.C., Klevorick, A.K., Nelson, R.R., Winter, S.G., 1987. Appropriating the Returns from Industrial Research and Development. Brookings Papers on Economic Activity 1987 (3), 783-820. Inventors that only file with ii) is a small and shrinking group whose inventions most likely are less valuable. Using iii) would as well capture more valuable inventions in theory, but such inventors are more difficult to identify because their addresses are less clearly specified. Also, inventions that make it to the EPO would in most cases make it to the USPTO, making this distinction less important in practice.

directories of the entire Swedish population as observed in 2007, or slightly more than 7 million individuals aged 16 or more.

We select the subset of inventors who patented during 2002-2007 (and possibly also before), who can be observed in 2007. To be able to observe municipal characteristics and average grades (to proxy for ability) for virtually all individuals, we only include individuals aged 33-52 years at the end of 2007, i.e. those born 1955-1974. This restriction was put because almost all individuals graduate from high school within a few years after their 18th birthday and we only have information on high school graduation and associated grades under the same unified standard for the period 1973-1996. We also control for age in our regressions, because of the high dependence of inventive activity on age. Jung and Ejermo (2014) show that the average Swedish inventor is in his/her 40s, with women inventors being slightly younger at the time of patenting.

We include all individuals born in Sweden, because we want to be able to study the role of the birth region. We exclude individuals with employment in the public sector, because their inventive opportunities are likely to be constrained by their employer. An important set of control variables use variants based on parents' education, from both the biological mother and father, which to some extent weeds out family background. These may otherwise disturb some of the interpretation of local milieu, especially from young age (i.e. birth region). Nevertheless, our analysis does not give rise to a causal interpretation. For instance, it may very well be that individuals self-select into higher education, a force that coincides with any peer effect. Also, our inclusion of parental education variables do not for instance distinguish or sort out any pre-birth self-selection of parents to reside in a particular region. The ambition of our analyses is therefore mainly to sort and through regressions make a descriptive (but advanced) set of correlation analyses that condition the likelihood to observe that someone is inventive based on place-specific covariates. In order to capture the local milieu effect of inventiveness, we use probit regressions to estimate the probability of becoming an inventor by taking future inventors present in the same municipality into consideration. Thus we examine the sum of other future inventors located in the same municipality as our focal person *around* (but not on) the exact same time of birth, high school degree and higher education. The reason for excluding the same year is that we would otherwise enter into a circular causation problem, because the share of inventors from a specific region in a specific year is a function of the number of inventors and therefore this share drives the probability to observe someone to be an inventor from that region (see 4.6 in Angrist and Pischke, 2009 for a discussion)

Below, we present the variables that are used in the regression model in more detail. It should be noted that when we speak of e.g. inventor density in the birth municipality and similarly for high school and higher education variables, it is not the current density of invention at the time of birth, but the density of *future* inventors that we refer to. For birth variables we thus refer to inventors that are eventually going to end up as inventors that happen to be born at the same time and same place as the focal inventor. We examine the strength of three types of effects from being geographically proximate to other future inventors. One effect emanates from having many future inventors in the approximate same birth cohort, the second from those that were around at the time of high school and the third from higher education attendees. Attendance at high school is not mandatory in Sweden, but the vast majority of inventors has a high school degree.

Birth variables

With respect to the birth cohort, we considered that both the absolute value of a given number of future inventors or the number of future inventors as a share could impact on the likelihood that an individual becomes an inventor. Although it may seem natural to use a relative measure to control for population size, it is not self-evident that it is a relative share that matters most for a specific individual if selection of these individuals bring them to specific locations. For instance Stockholm municipality (Sweden’s largest in terms of inhabitants), may see a large number of future inventors take a specific high school exam. A relative share may underestimate their joint importance of local inventive milieu that we try to proxy for. Ideally, we would therefore like both absolute and relative measures to contribute positively, if our theory of a positive local milieu effect on inventive capability is correct.

Our measures capture inventors *around* the time of birth. Such measures have the advantage of smoothing out high and random year-by-year fluctuation. We construct the following candidate variables:

Inventors around at birth. If the focal individual was born in *t,* this variable counts the number of inventors born in the same municipality in a five-year interval around this person, i.e. in *t-2,t-1, t+1, t+2*.

Inventors share around time of birth. This variable uses the same basis as the above and divides by population*,* i.e. it sums the number of inventors born in *t-2, t-1, t+1, t+2,* and divides by the population born *t-2, t-1, t+1, t+2*.

High school variables

Out of 1,276,519 persons in our sample, 886,323 persons (69%) are recorded for a high school degree. Among inventors, almost everyone has a high school degree: 6,836 out of 7,341 or 93%. High school programs are nowadays almost invariably three years starting at age 16-17 and ending at 18-19 years of age.[2] Data include information on specific high school programmes that individuals have attended. Although there is a large variation in terms of programs that individuals have attended, the 3-year technical program accounts for 51% of the degrees for inventors and the 3-year natural sciences program accounts for an additional 25%. The corresponding share among the whole population (restricted to our age groups and sectors) in our sample is just 13% and 7%.

High school variables are constructed very similarly to birth variables; we either count the number of future inventors graduating or use shares in five-year intervals:

Inventors around high school. This variable counts the number of inventors graduating in a five-year interval around the focal individual's graduation year.

[2] In the past there has been a division between two-year, practically oriented programs and three-year theoretical programs.

Inventor share around high school. Takes the share of persons that graduate and later become inventors in a five-year interval around the focal individual.

Higher education (university) variables

Ejermo (2012a) and Jung and Ejermo (2013) have shown that Swedish inventors have high and rising levels of education despite the fact that inventors tend to get younger in Sweden. Similarly, high levels of education among inventors have been recorded for other European countries (Giuri et al., 2007; Toivanen and Väänänen, 2011) Japan (Nagaoka and Walsh, 2009) and the US (Nagaoka and Walsh, 2009). Toivanen and Väänänen (2011) study the causal effect of accessibility to higher education using distance to the closest engineering school as an instrumental variable for the choice of attending those schools, exploiting the start of new education facilities in the 1950s and 60s. They found that the number of Finnish inventors rose, stimulated by the establishment of education facilities, and therefore led to increased patenting and probably innovativeness as well. Therefore, for more than one reason, other inventors taking higher education may potentially be a strong influence on an individual's choice of pursuing an inventor career.

The following measures are used in the analysis:

Inventor share around HE measures the number of inventors taking a higher education degree in a municipality in a five-year interval around the focal individual in relation to everyone taking a degree.

Inventors around HE counts all inventors in a five-year interval around the focal person taking *any* program.

Other variables

A number of control variables are included in the regressions for our individuals. First, we include basic demographic controls. These include a dummy for *female, age* and *age*^{2}. Earlier studies show that most inventors tend to be male (e.g. Frietsch et al., 2009), even though Swedish data suggest that this tendency that male dominance is slowly declining (Jung and Ejermo, 2014). Gender thus captures to some extent, socially inherited effects. Moreover, the fact that the median inventor is in his 40s, motivates the inclusion of age-variables that capture life-cycle effects, well documented in science and to some extent also among inventors (Jung and Ejermo, 2014; Levin and Stephan, 1991). We also include variables measuring whether having children in the family, as well as their numbers, impose trade-offs that negatively affect the possibilities for inventive activity because of tighter time-constraints. It is not certain, however, that having children show a negative sign. First of all, men and women may be affected differently. Men may not see the same time-constraints as women when trying to balance work and personal life. Moreover, having children may also induce individuals to reduce their work time by working harder or more concentrated when in office. Possibly, this effect may be somewhat stronger for men considering they may be the most important bread-winner in the family. A completely opposite effect could, however, be expected if children are indicative of underlying productivity. For these reasons, and in order to potentially control for different effects for men and women, we include four interaction variables based on a dummy for gender multiplied with respectively a dummy for if the family has at least one child and, alternatively the gender dummy multiplied by the number of children and then the corresponding variables for women. We also include a dummy for whether an inventor residing in a metro region (Stockholm, Gothenburg, Malmoe) because we know that inventive activity is highly concentrated to large Swedish regions (Ejermo, 2009), and residing in any of these regions is expected to have a positive effect on the probability to observe that someone is an inventor. When using the absolute level of our main variables of interest (i.e. without dividing by population size), we exclude the metro dummy because of the strong collinearity between it and the absolute number of inventors in a region. For similar reasons that motivated the inclusion of the metro variable we include (but do not report) 2-digit dummies for the industry in which the inventor works to control for inherent sectoral patent intensity (Breschi et al., 2000). Concerning education, we include dummies for broad *education types*: education in natural sciences (N), technical sciences (T) and in medicine (M). We also control for each of the biological parents' education with dummies for orientation (N/T/M) and length, where we distinguish between short higher education (< 3 years), long higher education (3 or more years) and education on the PhD level.

4 Empirical analysis

In the following, we analyse the geography of inventiveness and its relation to indicators of inventive local milieu, namely place of birth, high school and university. We start by a descriptive analysis of geographical patterns of inventors' background and end by employing a probit regression model looking at the effects of surrounding inventors at birthplace, high school and university for future inventors.

Descriptive analysis

Figure 1 shows the location of birth (left panel) and density (right) of future inventors at time of birth in Sweden's present 290 municipalities. The top 10 municipalities by birth municipality of inventors are given in Table 1 in terms of both absolute numbers and density. Note that the table and the maps include all inventors without restriction on age or sector. Not surprisingly, the highest number of inventors at time of birth is found in Stockholm municipality, followed by Gothenburg, Malmoe and Uppsala (ranked 1, 2, 3 and 4 in population size). Then follows Lund (ranked 14th by population size) which hosts the largest university in Sweden. This suggests that local characteristics indeed are important. Looking at density, only one of the municipalities that ranked among the top 10 in absolute numbers, Lund, is also on the high-density list. The data show that a person being born in a top 10 density municipality has a 2-3 times stronger chance of becoming an inventor on average than a person born in any other municipality. Four municipalities can be characterised as within-commuting distance to Malmö (Lund, Burlöv, Staffanstorp and Lomma), two are in the Stockholm region (Täby, Solna) and only one (Vårgårda) is in the vicinity (65 km) from Gothenburg. Vårgårda is a small municipality but some well-known inventors were born there.[3] Also on the list are Gnosjö and Gislaved located in the famous Gnosjö region, well known for its high level of entrepreneurship (Wigren, 2003). These examples suggest that inventive cultures, possibly with both entrepreneurial and/or academic traits, may be formative for the career paths of Swedish inventors.

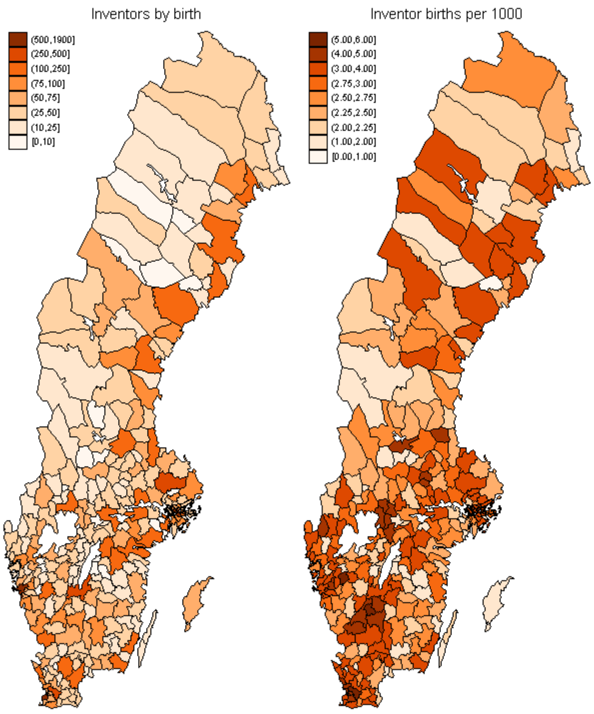

Figure 1. Counts of inventors and density of future inventors in birth municipalities.

Table 1. Top 10 inventor municipalities in absolute numbers and by future inventor density at birth.

Absolute values			Density	
Rank #	Municipality	# inventors born (%)	Municipality	Inventors/1000 persons
1	Stockholm	1,870 (10%)	Burlöv	6.20
2	Gothenburg	1,170 (6%)	Gnosjö	5.77
3	Malmö	580 (3%)	Täby	5.19
4	Uppsala	406 (2%)	Lund	5.16
5	Lund	297 (2%)	Solna	5.05

[3] Vårgårda was the birth location of the inventor of the wrench, Johan Petter Johansson (1853-1943). It now hosts the company Autoliv, a world leader and pioneer in auto safety equipment with many early inventions on safety belts by brothers Lennart and Stig Lindblad.

6	Solna	289 (2%)	Vårgårda	5.05
7	Jönköping	265 (1%)	Staffanstorp	4.94
8	Västerås	250 (1%)	Laxå	4.87
9	Linköping	244 (1%)	Lomma	4.84
10	Skellefteå	222 (1%)	Gislaved	4.79
SUM 1-10		5,593 (30%)	SUM 1-10	5.11
Other municipalities		12,890 (70%)		1.76
Inventors born in Sweden		18,483 (100%)		2.46
Unknown*	-	2,991	-	-
Total		21,474	-	-

* This group consists mostly of immigrants.

Examining high school locations, we find in terms of absolute values that major cities again appear on top (Figure 2 and Table 2). Lund again ranks higher than is only explained by population size, as it is also ranked number three in terms of density. Arjeplog, Norberg and Storfors are very small municipalities (less than 6,000 inhabitants each), thus their high rankings may partially be due to a larger variability among smaller municipalities.

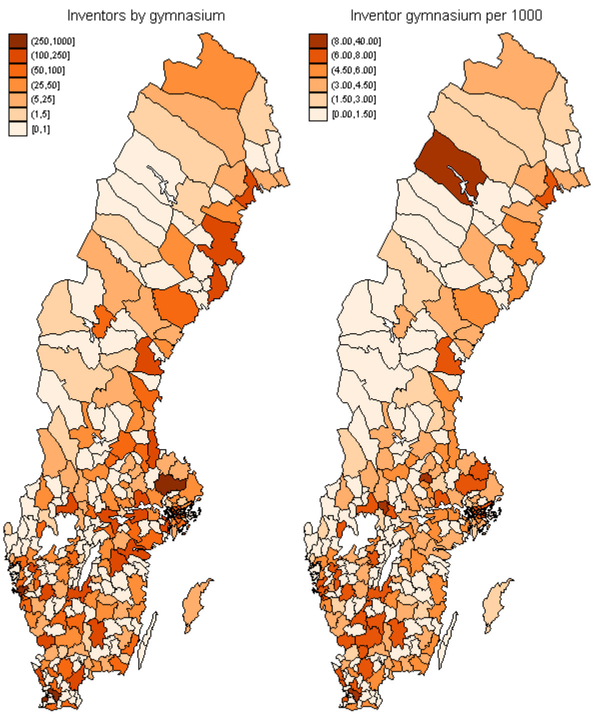

Figure 2. Counts of inventors and density of future inventors based on high school degree in municipalities.

Table 2. Top 10 municipalities in absolute numbers and by density of future high school graduation location.*

Absolute values			Density	
Rank #	Municipality	# graduating future inventors	Municipality	Future inventors/persons graduating
1	Stockholm	831	Arjeplog	35.7
2	Gothenburg	737	Norberg	12.4
3	Malmö	351	Lund	9.9
4	Lund	269	Storfors	8.4
5	Uppsala	256	Eslöv	7.8
6	Helsingborg	229	Gislaved	7.7
7	Jönköping	228	Kungälv	7.6
8	Linköping	212	Alingsås	7.5
9	Västerås	211	Helsingborg	7.5
10	Karlstad	198	Gothenburg	7.4

* Not all municipalities host high schools and therefore individuals that later turn into inventors would tend to commute to such schools in nearby municipalities.

Turning to the location of higher education (Figure 3), the concentration of inventors' education locations is very pronounced, mainly towards the larger regions. Inventors most often graduate from Lund, the Royal institute of Technology in Stockholm, Chalmers university in Gothenburg and the universities in Uppsala or Linköping (Ejermo, 2012b).

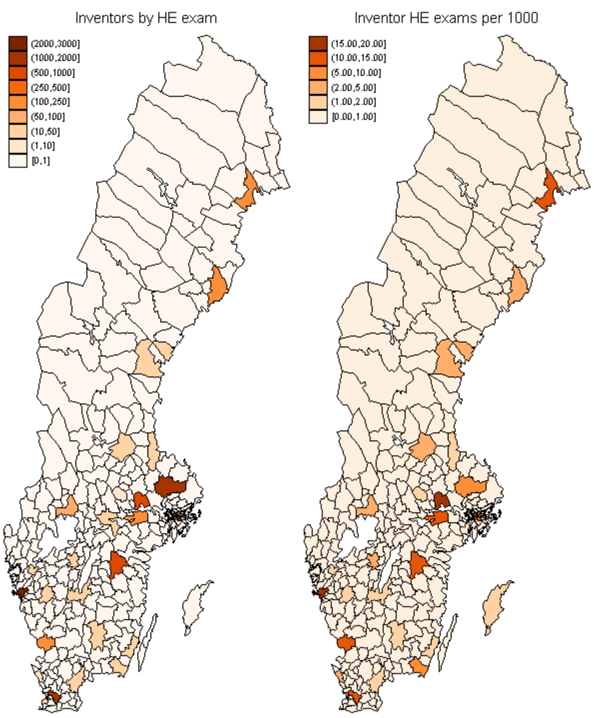

Figure 3. Counts of inventors and density of future inventors based on higher education degrees.

Summarising the descriptive results, we find that the largest regions in Sweden are also the regions that host most inventors. Relating absolute values to the number of inhabitants, high school and especially university graduates results in a more concentrated pattern than for birth region. A few municipalities stand out as places that give birth to a disproportionally large part of future inventors by providing them with the socio-cultural fabric which is believed to influence their probability of becoming an inventor in the future.

Regression analysis

With the descriptive results in mind, we turn to a regression analysis investigating the effect of respectively birthplace, high school and university as proxies for different inventive local milieus. All regressions using shares are shown in Table 3, whereas absolute value results are only reported. The first column (model 1) shows the regression with merely control variables. Age has no significant effect because our examined data consist of people in their most patent-productive age. In order to conserve space and due to the stability of most estimates, we choose to report only the qualitative results of these. Females are found to be less likely to invent, consistent with many earlier studies and our expectations. It can be noted that this tendency remains even after controlling for an individual's education, which means that it is not only the result of e.g. less technical education attainment among women. Concerning the role of having children, the dummy turns out to be positive for both men and women. This goes against the idea that children may necessarily entail a lower productivity at work, but rather suggest that children reflect productivity. However the *number* of children is not significantly different from zero. Since the coefficient is more positive for men, it suggests that some trade-off effect with regard to time-constraints may still be present, though the net effect is positive, but give rise to a less positive probability effect for women. Residing in one of the larger regions, as expected, quite clearly influences the likelihood of becoming an inventor. Dummies for sectors and education were controlled for, but coefficients are not reported. As expected, a technical or medical education makes it much more likely that a person becomes an inventor, compared to other types of education. With respect to sector of work in 2007, the strongest effect on the likelihood to become an inventor shows for persons who work in extraction of crude petroleum and natural gas and ancillary services, in pharma and chemicals, in electronics, in computer and related activities or in R&D. Finally, introducing parental education to control for family background adds about 2% of explanatory value to the regressions (measured as pseudo-R^2). Most parental education variables have a significant and positive effect on the probability to observe that someone is an inventor. Clearly, this effect grows stronger with the level of education, for both mothers and fathers. These coefficients are larger for fathers with PhDs and long education, but smaller for short higher education. With respect to the type of education, the strongest effect is obtained from fathers with natural science and fathers with technical education, whereas medical education is usually insignificant. For mothers, the strongest effect comes from technical education, whereas natural science education is insignificant and medical education frequently has a negative significant effect. Clearly, the father's education has a stronger effect, not surprising given that they may be more formative towards inventors which are frequently men. Also, the formative influence is stronger from expected, more patent-oriented subjects. All these control variables are very stable in all our regressions and will therefore not be discussed further.

Turning to our birth variables, our empirical estimations show that the likelihood of becoming an inventor is positively affected by future inventors born in the municipality, whether measured as absolute numbers (not reported) or as a share of the population. This effect remains also when including the other shares. Thus, there seems to be a persistence in this effect that stays on throughout growing up and onto working life.

Table 3. Probit regressions on the likelihood to be an inventor.

	(1)	(2)	(3)	(4)	(5)	(5b)
Age	0.00658	0.00307	0.00562	0.0476***	0.0436**	-0.000297
	(0.0153)	(0.0155)	(0.0164)	(0.0158)	(0.0170)	(0.000291)
Age^2	0.000205	0.000236	0.000296	-0.000274	-0.000162	8.88e-06**
	(0.000180)	(0.000182)	(0.000193)	(0.000186)	(0.000201)	(3.47e-06)
Dum metro	0.263***	0.258***	0.286***	0.216***	0.233***	0.00286***
	(0.0118)	(0.0120)	(0.0130)	(0.0122)	(0.0135)	(0.000216)
Inventor share around time of birth		7.001***			11.04***	0.168***

		(2.609)			(2.923)	(0.0510)
Inventors share, around secondary school			-16.21***		-19.05***	-0.375***
			(2.413)		(2.543)	(0.0438)
Inventors share, around HE				30.10***	29.29***	1.505***
				(0.548)	(0.569)	(0.0172)
Children and gender dummies	YES	YES	YES	YES	YES	YES
Parental education dummies	YES	YES	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES	YES	YES
Education dummies	YES	YES	YES	YES	YES	YES
Observations	1,085,362	1,077,018	775,342	1,085,361	769,947	773,604
Pseudo r-squared	0.238	0.238	0.233	0.273	0.268	0.038

Constant included. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
(5b) is the linear probability model version of (5). Inventor variables refer to density of individuals that will become inventors in the *future.*

When examining high school effects only, *Inventors around high school* and *Inventor share around high school* show conflicting signs. The first variable shows a highly significant negative effect in model 3 while the latter shows a strong significant positive effect (not reported). The latter has slightly stronger predictive power, but in conclusion high school effects are not consistent with a positive inventive milieu effect. Possibly, the reason for this result may be because of the imprecision of the high school density variable, where a lot of different types of students attend the same school, where most of them never become inventors.

In model 4, investigating the regressions on higher education variables, we find that the share of inventors around the year of the focal person is positive and significant. This is also the case when considering absolute numbers (not reported). There is a distinct possibility, however, that the number of other inventors captures job location *after* higher education graduation and is therefore indicative of job opportunities of inventors, although this should be mitigated to some extent by the inclusion of sector, metro and education dummies for the 2007 characteristics of individuals as controls.

A combined evaluation

Model 5 puts together birth, high school and higher education variables into one combined regression, as before using shares for our variables of interest. Clearly, they remain strong and strongly significant, with the same sign as in the other models. Also, the size estimates of the coefficients do not change dramatically suggesting some stability in the effects. Note, however, our earlier finding of an opposite to expected sign for high school effects.

Finally, marginal effects are investigated in column (5b) through a simple linear probability model. The absolute strongest effect comes from higher education share. It should be noted, that as was previously discussed, higher education effects reflect both the combination of a conscious choice to go into higher education. Interestingly, despite the fact that individuals who want to become inventors strongly self-select into environments where there are other inventors, there still exist a socio-cultural effect from birth region where no self-selection effect exists. This suggests that of all effects of inventive local milieu found, birth region effects persist the longest for an individual.

5 Interpretation of findings and conclusions

In this paper, we have examined the impact of early years' local milieu of inventors by analysing the effects of birthplace, high school and higher education. We find that having many other future inventors around in the municipality of birth and place of higher education has a significant positive effect on a person's possibility of becoming an inventor him or herself. It is notable that birthplace seems to have such a persistent role, given the lack of self-selection. By comparison, the fact that higher education is positive is not so surprising but that result must be interpreted more conservatively since it reflects the combination of self-selection into higher education and local milieu effects. Nevertheless, studying this topic leaves us with the impression that the institutional fabric of the early childhood milieu can have a critical effect on whether an individual becomes an inventor or not in the future. Our findings correspond to those of entrepreneurial studies where e.g. Johannisson (1986) points to the socio-cultural context of regions to be critical for the entrepreneurial spirit. In addition to upbringing in entrepreneurial milieus, we find that upbringing in an academic milieu or close by, also has a positive influence on being an inventor.

However, we must also stress the lack of a causal interpretation of our findings. The results indicate that local milieu is important in order to shape future inventors, but the study does not capture the very essence of what these local inventive milieus are based on. For this we would need to go further into the specifics of each stage. Instead, we offer a first step of looking at the location history of inventors to identify common patterns. In further research we will use more qualitative research techniques to generate a better picture of the essence of local milieus from the inventors' point of view. Interviewing inventors will give insights on how to develop indicators of different types of inventive milieus that can also be used in more quantitative analysis.

With respect to birthplace effects, we have already shown that educational background of parents play an important role too for the probability of becoming an inventor and that by controlling for parents' level of education strengthens the argument that early childhood years are critical. The parental effect could be further investigated by looking at formative role of upbringing that may stem from parents' preferences about occupations, education or could be inherited (Dustmann, 2004). For instance, a recent study based on adoption and associated data on biological and adopting parents' occupations finds that entrepreneurial traits are both inherited (nature) and obtained (nurtured) from adopting parents (Lindquist et al., 2013).

This study further highlights the need to sort out, not only the role of self-selection vs. education type, but also to address the role of peers (Vardardottir, 2013). By going into specific mechanisms, we may be able to address causal mechanisms through instrumental variable or matched sample techniques. Some of these matching techniques could exploit whether different patterns of inventors can be identified when dividing between inventors with or without a university degree; and to look into the location history, and thus differences in exposure to local milieus, between more and less successful inventors and mobile and non-mobile inventors.

Summing up, this study suggests that we can expect local milieu to have a notable effect on the probability of becoming an inventor. Distinguishing between effects from different local milieus, birthplace, high school and university, we find that only birthplace and place of higher education have a positive effect. Thus, we can expect characteristics of the local milieu to partly explain why both individuals and regions become inventive and creative – or why they do not.

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