The Effects of Educational Mismatch on Inventor Productivity. Evidence from Sweden, 2003-2010

Ioana A. Igna

University of Perugia

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Premio Dottorale Prof. Fabio Gobbo

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State of the Art and Motivation

- Great of the attention paid to how imperfections in the functioning of product and labour markets affect firm-level performance and reverberate on macroeconomic outcomes (Bartelsman et al., 2015, Jones, 2011)
- Misallocation of knowledge workers in innovation activities: long understated but, potentially, can produce serious microeconomic effects

Research Question

- *Which are the effects of educational mismatch on inventor productivity?*

Educational mismatch is defined as the divergence between the inventor's level of education and the level *required* by his or her occupation

What we do

- We investigate the effects of the inventor's years of education in excess or in deficit compared to the *required* level on the inventor patenting productivity in Sweden over the period 2003-2010, controlling for the standard inventor characteristics

What we get

- Educational mismatch reduces significantly the inventive productivity with respect to the inventor full potential

Related literature

Education plays a key role in explaining the patent productivity of scientists and engineers (Jung and Ejermo, 2014):

- Strong positive causal effect of engineering education on the propensity to patent (Toivanen and Väänänen, 2016)
- Education maintains a prominent role in explaining patent productivity, even after controlling for other dimensions of human capital (e.g. problem-solving skills) (Zwick et al., 2017)
- Other studies find no evidence of the effects of education on the number of inventors' patents but rather on their quality (Schettino et al., 2013)

Job matching as result of job mobility

- Individuals in poor matches are willing to move in order to improve the quality of their match with the new employer (Jovanovic, 1979)
- Hoisl and De Rassenfosse (2017): first study to investigate the direct effects of job matching on the inventor productivity following a move

Estimation strategy

We conduct a cross-sectional analysis on a universe of Swedish inventors i using the ORU model:

$$y_i = \beta_0 + \beta_1 req_i + \beta_2 over_i + \beta_3 under_i + \beta_4 X_i + \epsilon_i$$

y_i is the row number or the quality-adjusted number of inventor's patent applications between 2003 and 2010

ORU variables: $over_i$ is a proxy for the number of years of over-education, req_i is is the required number of years of education and $under_i$ is the number of years of under-education (Duncan and Hoffman, 1981, Levels et al., 2014)

X_i represents a set of control variables: inventor's age and age^2, gender, nationality, patent portfolio, firm size, sector of work, technology field of the patents

ϵ_i represents the stochastic error term

We estimate the model by applying a negative binomial model (NBR) with standard errors robust to heteroskedasticity

Caveats

1. We conduct a cross-sectional analysis given the very low variability of the educational mismatch status of each inventor over the period
2. Two main types of bias may hamper the identification of the examined relationship:
    - ORU variables may be correlated with some omitted variables that may explain part of the variation of inventive productivity $\rightarrow$ control for several inventor characteristics
    - reverse causation: inventors may be allocated to a better job because they have a higher patent productivity. Therefore, the mismatch may be a reflection of unobservable inventive ability $\rightarrow$ control for high-school grade

Data Description

Data are taken from Statistics Sweden:

- Patent database (1978-2010) is based on EPO, extracted from the worldwide Patent Statistics (PATSTAT)
- Longitudinal integration database for health insurance and labour market studies (LISA) (1990-2012) provides information on individual and employer characteristics
- Swedish and Foreign background (1990-2014): foreign-born variable
- Secondary Schooling Registry: high school grade $\rightarrow$ available only for inventors graduated during the period 1973-1996

Only inventors who are "purely employed" (not self-employed or hold more than one job) are considered in this analysis. Information on the employment status is available as of 2003, thus our analysis covers the period 2003-2010

Measuring Educational Mismatch

Required education (*RE*) is calculated as the **mode** years of education for each year from 2003 to 2010 and within *21* and *31* occupations (Kiker et al., 1997)

$\Rightarrow$ Professionals and technicians employed in *Physical, mathematical and engineering* occupations. They are most likely to be involved in the creation of new inventions (Kaiser et al., 2015, OECD, 2015)

Table: **Descriptive statistics (2003-2010)**

Variables	Mean	SD	Min	Max
Total number of patents applications	2.73	4.08	1	88
Total number of forward citations	3.31	5.65	1	104
Years of education	15.86	2.81	7	21
Required education (years)	15.69	0.92	13	16
Over-education (years)	1.01	1.89	0	8
Under-education (years)	0.83	1.46	0	9
Observations	3,127			

Table: **Levels and Fields of Education**

Variables	Share
Levels of education	
Lower secondary level	0.01
Upper secondary level	0.10
Post secondary level (less than 2 years)	0.12
Post secondary level (up to three years)	0.15
Post secondary level (up to five years)	0.42
Postgraduate	0.20
Fields of education	
Science and Maths	0.10
Engineering	0.84
Other fields	0.06
Observations	3,127

Table: NBR on the total nr of patents per inventor (2003-10)

Req. edu	0.211***	0.208***	0.182***	0.167***	0.152***
	(0.0230)	(0.0308)	(0.0284)	(0.0284)	(0.0271)
Over-edu	0.0899***	0.0895***	0.0867***	0.0829***	0.0844***
	(0.0150)	(0.0178)	(0.0167)	(0.0161)	(0.0164)
Under-edu	-0.0613***	-0.0553**	-0.0488**	-0.0405*	-0.0358*
	(0.0144)	(0.0244)	(0.0226)	(0.0222)	(0.0215)
Gender			-0.335***	-0.343***	-0.342***
			(0.0724)	(0.0716)	(0.0692)
Age			6.121	6.215	5.405
			(5.397)	(5.257)	(5.210)
Age^2			-0.870	-0.882	-0.770
			(0.735)	(0.716)	(0.709)
			(0.153)	(0.155)	(0.148)
High-school grade		0.430**	0.456**	0.480***	0.468***
		(0.198)	(0.186)	(0.181)	(0.175)
					(0.0127)
				(0.0915)	
				(0.0814)	
Other cont. vars	no	no	yes	yes	yes
Observations	3,127	2,150	2,150	2,150	2,150

Robustness checks

Results do not change if:

- we include additional control variables such as: 1) the number of inventors for each geographical area, 2) the average productivity of inventors by geographical area and 3) by industry of work
- we include a measure of patent quality, i.e. the total number of *forward citations* received up to 5 years after publication date.
- we inspect whether the effect of educational mismatch changes between: 1) young and old inventors, 2) inventors working in metropolitan areas or urban and rural areas, 3) low-intensity and high-intensity R&D industries
- RE is computed for more occupations beyond *21* and *31* groups

Conclusions

This study is the first attempt to measure the effects of educational mismatch on inventor productivity. We have used original data on the universe of Swedish inventors from 2003 to 2010

The results suggest that approximately:

- the inventive productivity of over-educated associated to mismatch is half lower than perfectly matched inventors
- the inventive productivity of under-educated associated to mismatch is one quarter lower than perfectly matched inventors