STEM graduates, knowledge spillovers and entrepreneurship: evidence from Italian local labour market

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Abstract

The aim of this paper is to address the topic of the relation between knowledge spillovers and economic development, by examining to what extent the stock of STEM graduates at the local level in Italy affects the individual choice of being an entrepreneur and whether knowledge externalities related to the presence of this type of human capital stimulate entrepreneurial decision in Italy after the Great Recession (2009-2015). We exploit a unique data set, based on the Italian Labour Force Survey (ILFS), which contains detailed information on individual labour market outcomes and allows incorporating a measure of the stock of STEM graduates at the provincial level. Our empirical approach is consistent with a theoretical framework that aims to capture both supply- and demand-side factors, with a specific emphasis on the external effect of local STEM graduates on the probability of being an entrepreneur. Our findings seem to indicate the presence of potential external effects of STEM graduate in each local labour market on the entrepreneurial decision.

Keywords: entrepreneurship, STEM, knowledge externalities, local labour market

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1. Introduction

It has been widely acknowledged that technological change and knowledge spillovers can stimulate both entrepreneurship and innovation that, in turn, represent the main essential drivers of national and local long-term economic growth and mitigate the adverse effects imposed by the Great Recession during the last decade. In a complementary way, previous research has underlined how the local stock of human capital in an area can boost labour market outcomes through positive externalities (Lucas, 1998; Moretti, 2004; Shapiro, 2006) and improve innovation process (Carlino et al., 2007). Traditionally, the literature on human capital externalities has concentrated, not only on the evolution of labour demand, but also on how the stock of college graduates could strengthen the innovative capabilities of firms.

The debate on what types of skilled labour are most important for local economic development is still open (Florida, 2002; Glaeser 2005) and in particular, whether the heterogeneity in the types of human capital at the local level matters to uncover the geographical differences in the entrepreneurial rate.

On the one hand, there exist, conceptually, a great uncertainty about how to relate the alternative human capital measures. On the other hand, there is a widespread belief that the stock of STEM graduates available at the local level could dampen innovation in high-technology industries and, in turn, economic development. However, even if policymakers have mostly concentrated on the role of STEM workers as a drivers for stimulating innovation and growth, there is limited research that investigated the external effects of STEM graduates' diffusion at the local level (Winters, 2014).

In contrast to the majority of the literature on human capital externalities, this paper addresses this gap, by examining to what extent the stock of STEM (and non-STEM) graduates at the local level (i.e. in each province) affected the individual choice of being an entrepreneur and whether knowledge externalities related to the presence of this type of human capital stimulate entrepreneurial decision in Italy after the Great Recession (2009-2015).

In order to investigate this relevant issue, we exploit a unique data set, based on the Italian Labour Force Survey (ILFS), which contains detailed information on individual labour market outcomes and allows incorporating a measure of the stock of STEM graduates at the provincial level between 2009 and 2015. Our empirical approach is consistent with a theoretical framework that aims to capture both supply- and demand-side factors, with a specific emphasis on the external effect of local STEM (and non-STEM) graduates on the entrepreneurial rate at the local level. In doing so, we

complement the extant research that concentrates on the supply and demand factors that facilitate firms' creation (and innovation) at the local level and in turn, improve local economic conditions.

Empirically, we select only employed individuals and, among them, we calculate the share of entrepreneurs, aggregating data at the provincial level. In other words, we adopt pseudo-panel models, estimating for each cell defined at province-gender-year level the extent to which the local stock of STEM and non-STEM graduates influences the entrepreneurial rate.

Additionally, we deal with both the endogeneity in the stock of STEM (and non-STEM) graduate and the existence of potential spillover effects among provinces (i.e., the existence of spatial dependence). More precisely, we implement an IV approach, exploiting the gradual introduction of Bologna Process in each Italian university as an exogenous shock and using the lagged share of STEM and non-STEM degrees offered at the provincial level. Concerning spatial dependence, we test several models that capture the existence of interdependencies among provinces in the relation of interest. Moreover, we can disentangle the effect of knowledge externalities related to STEM graduates on the probability of being an entrepreneur by opportunity and by necessity. Indeed, we can separate our analysis by college and non-college graduates and therefore, minimise the ability-bias that has been shown to be important in this stream of literature (Poschke, 2008; Lazear, 2005; Di Addario and Vuri, 2010).

Finally, we discuss our findings that seem to indicate the presence of potential external effects of STEM (and non-STEM) graduate in each local labour market on the entrepreneurial dynamics and, in turn, we derive the implications for future search and local public policy, fostering innovation and firm creation decisions.

The remainder of the paper is organized as follows. Section 2 includes the related literature and theoretical background related to human capital spillovers and, in particular, the role of STEM graduates. Section 3 describes the empirical strategy, how we deal with endogeneity issue and the presence of spatial interdependencies in the relation of interest. In Section 4, we report data description and descriptive statistics, while Section 5 discusses the main empirical results. Finally, Section 6 summarizes and concludes.

2. Related literature and theoretical background

Economic literature has extensively addressed the topic of optimal level of college graduate supply in order to avoid losses for society and give an indication to policy makers about the public provision of higher education. Indeed, a long standing stream of research has recognized that a skilled

and educated workforce represents a critical factor for economic development both at national and local level ((Romer, 1987, 1996; Lucas, 1988; Mankiw et al., 1992; and Acemoglu and Pischke, 1998).

In this perspective, one stream of the literature has debated whether there are relevant external effects of the college share on individuals' wages even after controlling for individual educational attainment. Theoretically, human capital externalities are defined as the difference between the social and private return to education, (Lange and Topel, 2006; Moretti, 2004).[3] The majority of literature on human capital externalities focus on the effect on wages or wage growth at geographical level, even if recent studies has examined the impact also on employment and participation to the labour market (Winters, 2013).[4]

External effect of college share may affect wages for two reasons: first, according the standard neoclassical model, human capital externalities are due to the hypothesis of imperfect substitution between high educated and low educated workers in the production process. An increase in quantity of educated workers will increase the marginal productivity of low educated, and if they will be paid at their marginal products, imperfect substitution will cause the wage of high skill workers to fall with the rise in the share of high skilled workers (e.g. Moretti, 2004; Cicconi and Peri, 2006). The second source of spillovers is a sort of learning coming from interaction with high skilled workers (Glaser and Marè, 2001; Moretti 2004b). This kind of externalities is positive for all workers, but the effect may be different across type of workers.

For unskilled workers both two effects increase their wages, while the impact of an increase of supply of educated workers on their own wages is determined by two competing forces: standard supply effect makes the economy move along a downward sloping demand and spillovers that raise the productivity. Arguably, the final effect depends on how large are the spillovers.

The differences in the relative number of educated workers may be potentially driven by differences in the relative demand. There are some factors (advanced technologies or skill-biased technological change) that arise the productivity of educated workers and so their demand. Interestingly, workers move to occupation with higher wages and the average education raises. The wage of high educated worker is higher because of their higher productivity, while the wage of unskilled workers is higher because of complementarities (Acemoglu, 1996).

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[3] An alternative is offered by exploring the over-education problem that is the employment of college graduates in the so-called non-college occupation (McGuiness, 2006, Pryior and Schaffer, 1997; McGuiness and Bennett, 2007).

[4] Some evidence suggest that local level of human capital has positive effects on labour force participation of woman and reduce unemployment for both women and men. It has been claimed that the external effect is larger for unskilled worker (e.g. Winters, 2013).

However, the debate in the literature on local human capital externalities is still open. Indeed, the results are mixed and depend on both geographical level considered (state versus cities) and the measure of schooling (average years of schooling versus tertiary education level). A number of studies find that wages are affected by the share of educated individuals living in a particular geographical area, after controlling for individual education, experience and demographic characteristics. But whether there is some causality, it is less clear.

Methodologically, several studies have exploited IV technique to try to isolate the causal effect of an increase in average education levels. Moretti (2004b), for example, using US data on metropolitan areas finds that an increase of 1% share of college graduates raises individual wages in the range between 0.4% for college graduates and 1.9 for high-school graduates and high-school drop-outs. He use as instruments lagged city demographic structure and the presence of a land-grant college. Alternatively, Acemoglu and Angrist (2000) find small or not significant coefficients for external returns to education. They use Child Labour Law and compulsory attendance laws are used as instruments to point out the real social returns. The use of these instruments could be the reason why they find small size of spillovers. Indeed, these laws affect primarily the lower part of the distribution of educational attainments. At the same time they use State as geographical level and Rosenthal and Strange (2008) while providing positive evidence of externalities, show that the geographical effect of knowledge spillovers decreases beyond 5 miles. Dalmazzo and De Blasio (2007) on Italian data show that average human capital measured at local labour market area is positively correlated with wages. Their results range from 2-3 percent point. Recently researches show human capital externalities at firm levels on wages (see Cerejera da Silva, 2003, Moretti, 2004, Canton, 2009, Bratti and Leombruni, 2010).

Another stream of literature has investigated the presence of human capital externalities at the firm level in order to understand the potential effects on productivity growth and innovative capabilities. For instance, Bratti and Leombruni (2014) explore local level human capital in each firm in Manufacturing at provincial level. They show a positive correlation between wages and local human capital especially to white collars. They use also IV technique with lagged change in university supply of manufacturing related courses and its interactions with 20 years lagged demographic structure.

However, while there is a wide consensus about the relevance of human capital, the debate is still open on what type of human capital is most important for economic growth and innovation. In this perspective, Florida (2002) sustains that workers in creative occupations represent the key factor for local development. Alternatively, a recent stream of research concentrates on the role of STEM

graduates considered as one of major drivers of innovation and, in turn, long-run productivity growth (Winters, 2014; Deming, 2018), even if the number of studies is few. Moreover, policy makers and scholars argue that there is a shortage of STEM workers and, therefore there is a need for policies that stimulate the production of STEM graduates at the local level.

An additional branch of literature that is related to our work concerns the effects of agglomeration economies and knowledge spillovers on entrepreneurship. Recent studies (e.g. Di Addario and Vuri, 2010) have shown how population density at the local level could increase the probability of being an entrepreneur among college workers and emphasize the heterogeneity in the returns to entrepreneurship. In a similar perspective, Audretsch and Lehmann (2005) argued that in the local contexts the knowledge stock positively influences the entrepreneurial dynamism and, in turn, innovation and economic growth.

In sum, our work contributes to several streams of research concerning the potential externalities of human capital at the local level, addressing the relevance of STEM and non-STEM graduates as a key factor in stimulating entrepreneurial dynamism among employed individuals, controlling for several structural and cyclical determinants that influence the performance of local labour markets.

3. Empirical strategy

To investigate the relationship between the local stock of STEM (and non-STEM) graduates and the entrepreneurial dynamism at the provincial level, we estimate the following equation:

$$share\_entrepreneur_{pgt} = \alpha + \gamma l(STEM)_{pgt} + \delta l(nonSTEM)_{pgt} + \beta X_{pgt} + \rho X_{pt} + \mu_p + \mu_t + \varepsilon_{pgt}$$

where the dependent variable $share\_entrepreneur_{pgt}$ denotes the share of entrepreneurs in each cell defined at the province-gender-year level, p is the province subscript, g is the gender subscript (female or male) and t is the time subscript for the period 2009-2015. As main explanatory variables, $l(STEM)_{pgt}$ and $l(nonSTEM)_{pgt}$ identify respectively the (log) of the stock of STEM and non-STEM graduate at the province-gender level for each year. The vectors X_{pgt} includes a wide set of control variables that capture labour market composition for each cell, such as the age cohort composition, part-time and temporary jobs and the sector of employment. Analogously, X_{pt} includes a set of variables that vary only at the provincial time over time such as the territorial density, the number of local banks, the unemployment rate, the number of foreign residents and the number of

patents registered. These factors measure the incidence of regulation concerning credit markets and innovation as well as other potential local confounding factors. We also add a set of province and time fixed effects to capture potential unobserved heterogeneity across provinces and years. Finally, ε_{pgt} is an idiosyncratic error term clustered at the provincial level.

In order to recover a causal interpretation of the results, we tackled the endogeneity in the STEM (and non-STEM) local stock of graduates, by employing an IV strategy. As commonly proposed in the literature on human capital externalities, we exploit the gradual introduction of Bologna process in the Italian university system and calculate the lagged change in the number of STEM and non-STEM college course at the provincial level. We expect this instrument is uncorrelated with the unobservables related to the share of entrepreneurs at the local level nowadays but correlated with the stock of STEM and non-STEM graduates.

Additionally, most empirical analyses that seek to identify human capital spillovers at the provincial level consider each province as an isolated economies. However, a large stream of research emphasizes how local labour markets (provinces and/or regions) are neither homogeneous nor independent. Then, if we ignore the influence of location on the relation of interest, our findings could be, in a some way, biased and any conclusions, therefore, misleading. For this reason, we have chosen to expand equation (1) to include the interaction between provinces. Recent studies adopting a similar approach incorporate substantive spatial dependence, which means that spatial effects are propagated to neighbouring labour markets by means of endogenous as well as exogenous variables. More precisely, equation (1) is augmented with spatially lagged main independent variables related to the STEM and non-STEM local stocks of graduate that enable us to identify the existence of geographical spillovers among the provinces under consideration.

4. Data description and descriptive statistics

The primary data for the empirical analysis is the Italian Labour Force Survey (LFS), which represents a household survey conducted by ISTAT and the principal source about the Italian labour market. Indeed, among the survey currently available, ILFS offers the most detailed and rich information concerning the demographic characteristics of a large sample representative of the Italian population (e.g. Ceccarelli, 2007), their employment status and a precise set of variables related to the job description. In the same perspective, the survey also collects information on the province of residence and of work, enabling us to unveil the impact of human capital on the entrepreneurial rate at the local level.

The survey is conducted quarterly through a two-stage sample design with stratification: indeed, about 1300 municipalities are sampled at the first stage and about 70.000 households at the second one. The ILFS follows a rotating scheme according to which each household is interviewed for two successive quarters and then, again for two other consecutive waves after two quarters of interruption.[5]

Table 1: Descriptive statistics

Variable	Description	Mean	Std. Dev.	Min	Max
Entrepreneur	1 if Entrepreneur (strict definition)	0,06	0,24	0,00	1,00
Entrepreneur2	1 if Entrepreneur (broad definition)	0,20	0,40	0,00	1,00
female	1 if female	0,43	0,50	0,00	1,00
cohort 2530	1 if cohort 25-30 years old	0,15	0,36	0,00	1,00
cohort 3035	1 if cohort 30-35 years old	0,21	0,41	0,00	1,00
cohort 3540	1 if cohort 35-40 years old	0,27	0,45	0,00	1,00
cohort 4045	1 if cohort 40-45 years old	0,37	0,49	0,00	1,00
highschool	1 if has high school degree	0,49	0,50	0,00	1,00
localhce	graduate density	0,12	0,03	0,06	0,22
localhce_stem	STEM graduate density	0,04	0,01	0,01	0,08
localhce_nostem	Non-STEM graduate density	0,08	0,02	0,03	0,14
distancedegree	Distance from degree	278,63	438,78	0,00	1018,00
temporary	1 if temporary worker	0,11	0,32	0,00	1,00
partime	1 if part-time worker	0,18	0,38	0,00	1,00
sec1	1 if Agriculture, hunting, forestry	0,04	0,19	0,00	1,00
sec2	1 if Manufacturing	0,15	0,35	0,00	1,00
sec3	1 if Construction	0,12	0,33	0,00	1,00
sec4	1 if Wholesale	0,13	0,34	0,00	1,00
sec5	1 if Hotels and restaurants	0,09	0,29	0,00	1,00
sec6	1 if Transport, storage and communication	0,05	0,21	0,00	1,00
sec7	1 if Information an Comunications servicies	0,03	0,18	0,00	1,00

[5] Practically, for each year the survey collects information on at least 300,000 households, which represent around 800,000 individuals (1.4% of total national population) distributed over 1,351 municipalities (out of 8,000). Explicitly, the 50 per cent of the sample is kept constant between two consecutive rounds. In other words, the LFS has a natural longitudinal dimension with people followed up to fifteen months, but the linkage of individual records across surveys can be problematic, because of the lack of an individual-specific identifier and because of reporting errors in the household identifier.

sec8	1 if Financial intermediation; insurance	0,03	0,17	0,00	1,00
sec9	1 if Real estate; renting	0,11	0,32	0,00	1,00
sec10	1 if Public admin,national defence; compulsory social security	0,05	0,22	0,00	1,00
sec11	1 if Education	0,13	0,33	0,00	1,00
sec12	1 if Other community, social and personal service activities	0,07	0,26	0,00	1,00
tenure	tenure	101,15	80,18	0,00	420,00
chieftown	1 if province chief town	0,39	0,49	0,00	1,00
TOM	1 if historical autonomous province	0,43	0,50	0,00	1,00
density	territorial density	353,34	528,82	30,91	2652,73
bcc	number of local banks: "Banche di credito cooperativo"	70,14	80,20	1,00	337,00
popBanks	number of local banks: "Banche popolari"	82,77	113,45	1,00	613,00
unempRate	Unemployment rate	9,59	4,98	2,09	31,46
forRes	Foreign residents	69667,93	104753,80	602,00	523957,00
patents	Number of patents	1081,34	3106,90	1,00	14772,00

In our empirical analysis, we use data relative to the period 2009-2015. We select a sample of employed individuals aged between 25 and 45 who are not currently full time students. Specifically, we exclude employed over the age of 45 in order to capture the initial entrepreneurial choice in the local labour market. Moreover, those individuals with missing variables on relevant variables concerning employment status have been excluded from the sample.

We complement our data with other information at the provincial level drawn from alternative sources. More precisely, we exploit several administrative datasets, provided by ISTAT, Bank of Italy and the Italian Minister of Economic Development. These data represents a rich source of information at the level of each single province, reporting, respectively, the unemployment rate, the percentage of foreign residents, the number of local banks (“Banche di credito cooperativo” and “Banche popolari”) and the number of patents. We inserted also an indicator of tradition of political autonomy, as calculated by Isl, University of Parma. Specifically, we are able to build several province characteristics, which we consider as exogenous.

Then, we aggregate our variable at the province-year level, in order to investigate how the variation in the stock of (STEM) graduates at the local level affect the entrepreneurial activity among those

entered in the labour market. The summary statistics of the main variables used in the paper are reported in table 1.

Our dependent variable is the local entrepreneurial rate, defined according to the working activity sampled by the National Statistical Office (Istat). Audretsch and Fritsch (1994) warns that the choice of the dependent variable is not neutral in the firm creation context, and they identified two alternative approaches: the ecological approach and the labour market approach. The ecological approach standardizes figures on new firm creation by using the stock of existing firms, while the labour market approach uses employment levels. We adopt this last approach and use the count of entrepreneurs in each province (Entrepreneur) as the dependent variable. We classify as entrepreneur any self-employed who works as *entrepreneur* or *freelance*. In order to alleviate potential biased we defined also a second dependent variable (Entrepreneur2) that adopts a broader definition, adding also *own-account workers*.

Figure 1 provides an illustration of the entrepreneurial rate in Italy, in 2015.

Our main explanatory variable is the stock of human capital at the occupational level. Explicitly, we compute the graduate density as the share of graduate employees in each Italian province, defining the following index:

$$graduate\_share = graduate_o / (graduate_o + nongraduate_o)$$

Where $graduate_o$ is the number of college workers in each province and $nongraduate_o$ is the number of non college workers in each province. Practically, the measure of graduate density varies from 0 to 1. In order to uncover the extent to which the stock of STEM graduates affects the entrepreneur rate, we also calculate the graduate density for STEM graduates and the rest of graduates (no_stem graduates). Figure 2 provides an illustration of the graduate density in Italy, in 2015 (STEM graduates on the left; NO STEM graduates on the right).

Figure 1: Entrepreneur rate, Italy, 2015

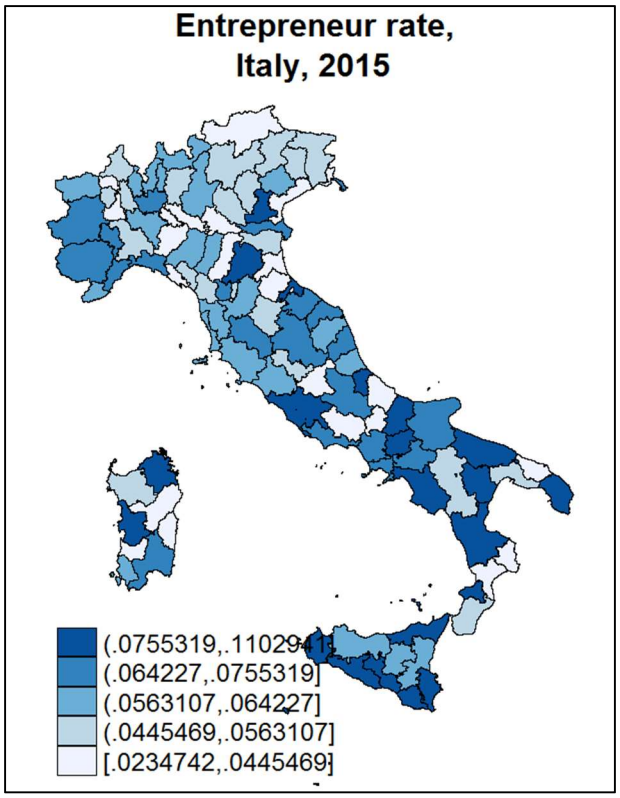
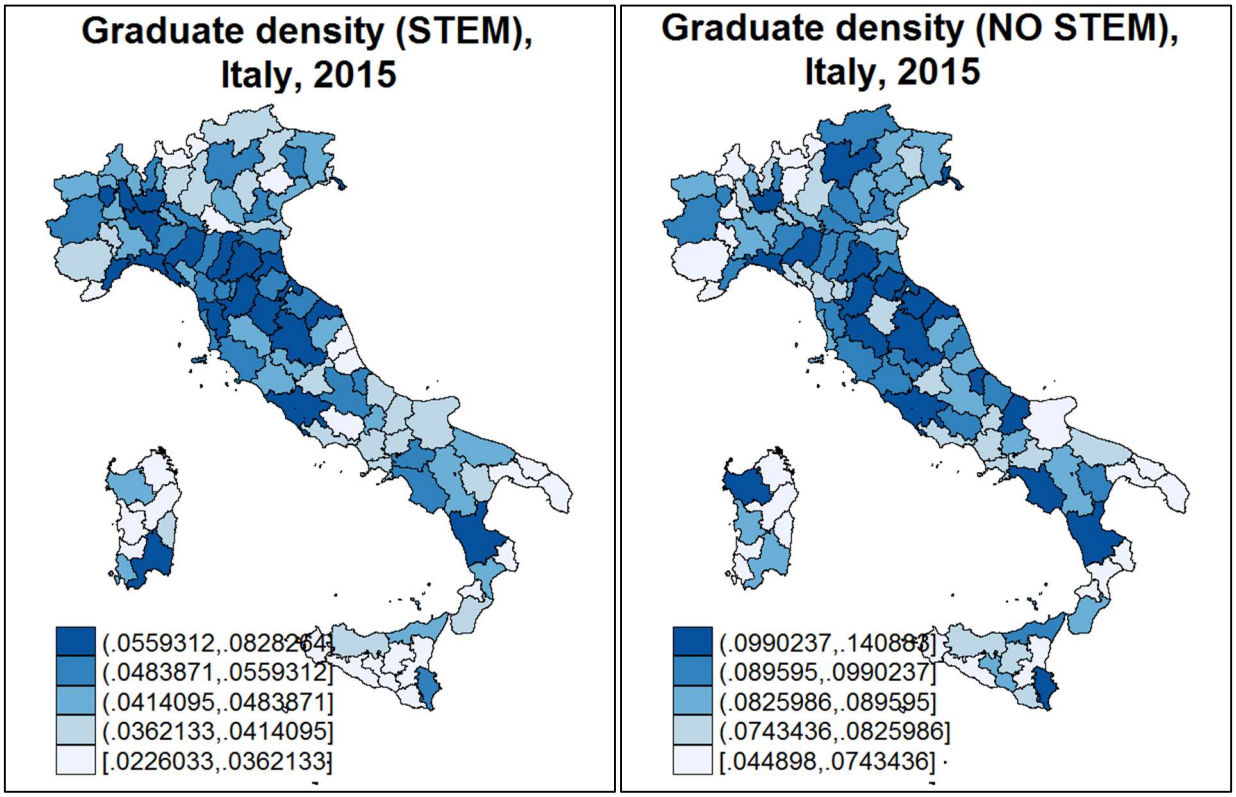


Figure 2: Graduate density, Italy, 2015



5. Main results

In this section, we describes our main findings concerning the relationship between the local stock of STEM and non-STEM graduates and the entrepreneurial rate at the provincial level. Firstly, we start by discussing our baseline OLS specification, both for all sample and distinguishing between high-school and college workers. Secondly, in order to recover a causal interpretation and to correct potential endogeneity in the local availability of STEM and non-STEM graduates, we rely on an IV approach based on the gradual introduction of the Bologna Process at the local level in Italy. Finally, we account for potential spatial dependence in the relation of interest, by estimating spatial models in which we include spatially lagged main independent variables related to different types of human capital.

Baseline results

Table 2 reports OLS estimates about the effect of (STEM) graduates at the local level on entrepreneurs. We provide several specification controlling for personal and local characteristics.

Column (1) in Table 2 reports the results of the baseline model, which only takes into consideration time and regional fixed-effects. As expected, the graduate density has a positive and significant effect on the entrepreneurial number at the local level. Column (2) adds, as control variables, age cohorts: the cohorts for 25-30 years old shows a negative and significant coefficient, showing that young graduates are less likely of becoming entrepreneurs.

If all the control variables are considered, as in Column 3, the value of the graduate density maintains its positive value.

Column (3) (4) and (6) in Table 2 reports the results obtained after extending the model to include the replacement of the general graduate density with the (STEM) and the (Non-STEM)graduate density.

The positive and significant coefficient of the (Non-STEM) graduate density in columns (4) (5) and (6) shows that only the graduate stock in non-scientific faculties stimulate increase opportunities for knowledge-based entrepreneurship.

As previously mentioned, all the estimations include region and time fixed effects.

Table 2: OLS estimates for entrepreneurial rate

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
llocalhce	0.015**	0.014**	0.016*			
	[0.007]	[0.007]	[0.009]			
llocalhce_stem				-0.005	-0.005	-0.006
				[0.005]	[0.005]	[0.006]
llocalhce_nostem				0.019***	0.018***	0.020**
				[0.007]	[0.007]	[0.008]
cohort2530		-0.084*	-0.063		-0.084*	-0.068
		[0.050]	[0.052]		[0.048]	[0.051]
cohort3035		-0.054	-0.035		-0.058	-0.044
		[0.042]	[0.042]		[0.040]	[0.041]
cohort3540		-0.016	-0.021		-0.018	-0.027
		[0.037]	[0.038]		[0.036]	[0.037]
cohort4045		-0.018	-0.016		-0.021	-0.022
		[0.036]	[0.038]		[0.035]	[0.038]
chieftown			0.009			0.006
			[0.021]			[0.022]
TOM			0.011			0.008
			[0.013]			[0.013]
density			-0.000			-0.000
			[0.000]			[0.000]
bcc			0.000			0.000
			[0.000]			[0.000]
popBanks			-0.000			-0.000
			[0.000]			[0.000]
unempRate			0.001*			0.001*
			[0.000]			[0.000]
forRes			0.000			0.000
			[0.000]			[0.000]
patents			0.000			0.000
			[0.000]			[0.000]
Region dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Constant	0.096***	0.132***	0.107**	0.097***	0.136***	0.112**
	[0.016]	[0.043]	[0.045]	[0.020]	[0.045]	[0.047]
Observations	1,498	1,498	1,292	1,498	1,498	1,292
R-squared	0.351	0.357	0.347	0.355	0.361	0.351

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 3 and 4 reports OLS estimates about the effect of (STEM) graduates at the local level on entrepreneurs, by distinguishing between high-school and college graduates. As in Table 2 we provide several specification controlling for personal and local characteristics. Column (3) (4) and (6) in Table

3 reports the results obtained after extending the model to include the replacement of the general graduate density with the (STEM) and the (Non-STEM) graduate density.

Table 3: OLS estimates for entrepreneurial rate, high-school graduates

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
llocalhce	-0.013	-0.011	-0.014			
	[0.011]	[0.012]	[0.014]			
llocalhce_stem				-0.010*	-0.012*	-0.014**
				[0.006]	[0.006]	[0.007]
llocalhce_nostem				-0.003	-0.000	-0.001
				[0.009]	[0.009]	[0.012]
cohort2530		0.023	0.037		0.023	0.036
		[0.041]	[0.044]		[0.041]	[0.044]
cohort3035		0.007	0.026		0.005	0.023
		[0.038]	[0.042]		[0.037]	[0.042]
cohort3540		0.002	0.012		0.002	0.011
		[0.032]	[0.034]		[0.032]	[0.034]
cohort4045		-0.056*	-0.076**		-0.059*	-0.078**
		[0.031]	[0.033]		[0.031]	[0.033]
chieftown			0.008			0.004
			[0.034]			[0.034]
TOM			0.006			0.004
			[0.015]			[0.015]
density			0.000			0.000
			[0.000]			[0.000]
bcc			0.000			0.000
			[0.000]			[0.000]
popBanks			-0.000			-0.000
			[0.000]			[0.000]
unempRate			-0.000			-0.000
			[0.001]			[0.001]
forRes			0.000			0.000
			[0.000]			[0.000]
patents			-0.000			-0.000
			[0.000]			[0.000]
Region dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Constant	0.025	0.042	0.005	0.010	0.029	-0.012
	[0.024]	[0.037]	[0.046]	[0.031]	[0.042]	[0.052]
Observations	1,498	1,498	1,292	1,498	1,498	1,292
R-squared	0.173	0.188	0.209	0.174	0.190	0.211

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

The main results indicate that for college graduates the effect of the graduate density is negligible, and only considering the (STEM) graduate density, a negative effect can be noticed. Result are confirmed also for college graduates, where the negative effect is stronger.

Table 4: OLS estimates for entrepreneurial rate, college graduates

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
llocalhce	-0.036	-0.049	-0.057*			
	[0.028]	[0.030]	[0.031]			
llocalhce_stem				-0.052***	-0.046***	-0.049***
				[0.016]	[0.016]	[0.017]
llocalhce_nostem				0.013	-0.005	-0.009
				[0.025]	[0.025]	[0.027]
cohort2530		-0.189*	-0.157		-0.187*	-0.155
		[0.099]	[0.125]		[0.099]	[0.125]
cohort3035		0.005	0.015		0.004	0.013
		[0.096]	[0.114]		[0.097]	[0.115]
cohort3540		0.104	0.089		0.098	0.080
		[0.078]	[0.087]		[0.078]	[0.088]
cohort4045		0.125	0.196**		0.126	0.197**
		[0.081]	[0.093]		[0.081]	[0.093]
chieftown			0.008			-0.005
			[0.078]			[0.079]
TOM			0.004			-0.004
			[0.043]			[0.043]
density			-0.000			-0.000
			[0.000]			[0.000]
bcc			0.000			0.000
			[0.000]			[0.000]
popBanks			0.000			0.000
			[0.000]			[0.000]
unempRate			0.002			0.002
			[0.002]			[0.002]
forRes			-0.000			-0.000
			[0.000]			[0.000]
patents			0.000*			0.000*
			[0.000]			[0.000]
Region dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Constant	0.098	0.034	-0.059	0.046	-0.015	-0.116
	[0.060]	[0.121]	[0.154]	[0.073]	[0.132]	[0.163]
Observations	1,498	1,498	1,292	1,498	1,498	1,292
R-squared	0.233	0.277	0.307	0.236	0.279	0.309

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Endogeneity issue and Spatial analysis

TBC

Conclusion

Human capital theory indicates that a higher graduate density might imply a positive spillover effect on productivity and innovation.

The goal of this paper is a first attempt to estimate whether the human capital at the local level (i.e. in each province) affects the individual choice of being an entrepreneur and whether knowledge externalities related to the presence of this type of human capital stimulate entrepreneurial decision in Italy. Practically, we investigate this topic by calculating the effect of the share of STEM and non-STEM college workers on the entrepreneurial rate for each province, using Italian LFS for the period 2009-2015.

The OLS estimates clearly indicate that an increase in the graduate density within a province has a positive effect on individuals' decision concerning entrepreneurship. Indeed, we found that the entrepreneurship gain associated with human capital externalities is 0.015. The results are robust to the inclusion of possible confounding factors into the base equation.

Considering the graduate density of (STEM) graduates and (Non STEM) graduates, we found that only the graduate stock in non-scientific faculties increase opportunities for knowledge-based entrepreneurship.

We also replicate the analysis for different education group and, as expected, the positive effect is larger for less educated workers.

However, our measure of graduate density across local labour markets might suffer from a possible endogeneity bias. In order to recover a causal interpretation and to isolate the exogenous effect of human capital externalities, we employ both an IV approach and spatial models. The first approach exploits as instrument the gradual introduction of the Bologna Process and, in turn, the variation at the local level in the supply of STEM and non-STEM degrees. In a complementary way, spatial models allow to correct for potential spatial dependence in the relation of interest across provinces that could bias our baseline findings.

Summarizing, our results endorse the relevant presence of positive human capital externalities at local level, suggesting that policies aimed at expanding higher education in Italy could significantly

improve labour market prospects both for graduates and non-graduates workers and represent an important source to exit from the current recession. Moreover, the investment in higher education may further strengthen the role of occupational-specific human capital, reinforcing the demand for college skills in the labour market.

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