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The link between research quality and technology transfer in the Italian Evaluation of Research Quality VQR 2011-2014

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Research questions

- Research quality is **positively** or **negatively** associated with valorization of research in Italian universities? complementarity/substitution

- Does the link persist at individual level if we look at data on patents?

Complementarity

Several studies show that the relation between research quality and valorization has a positive sign

Complementarity

- Some of the most important inventions have taken origin from laboratories in top research-oriented universities
- Research quality works as a signaling device for firms
- A higher quality of research is associated to more intense technology transfer, invention and commercialization of academic patents third party funding, birth, survival and growth of startup firms and academic spinoff companies as well as IPO valuation

Complementarity

- Universities can benefit from the collaboration with the business sector: access to new funding channels, use of equipment and infrastructure, and opportunities of verification and refinement of theories, capacity to support research lines and to generate broader impact
- Close relations with firms may offer universities the opportunity to meet challenging operational problems, which in some cases may be of scientific interest

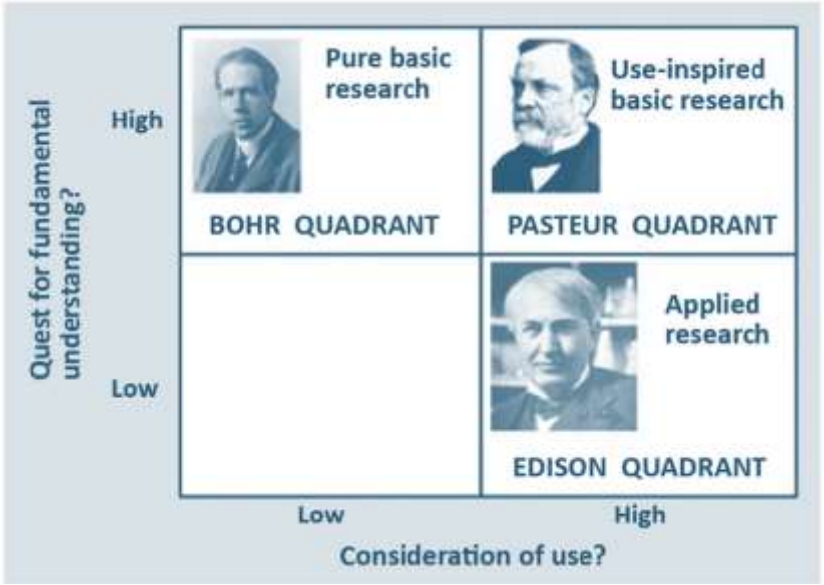
Substitution

Some authors have identified a negative or non significant relation between research quality and industry impact

Substitution

- Valorization of research takes time away from ‘blue-skies’: detrimental effects of ‘entrepreneurial science’ on the long-term production of scientific knowledge and academic freedom
- Researchers’ time and equipment may be diverted from fundamental and long term research
- Policies link the funding to publications and this creates a powerful incentive structure
- Top level researchers are mainly motivated to publish in good journals
- Firms often do not need rocket science, but rather ordinary and consolidated; low absorptive capacity needs proximity
- Patents can delay or even interrupt the disclosure of results, while knowledge production is based on openness

The discipline effect



Recent studies have emphasized the existence of disciplinary differences

The discipline effect

- Engineers are more active in industrial partnerships, while life scientists in commercialization of results since research in that field has a direct impact on technology development
- The impact of scientific output on the creation of new firms located close to universities is stronger in Engineering and Medicine, while it is negligible in Social Sciences and Humanities
- Disciplinary effects have also been found in those sectors where basic and applied research are more entrenched, mainly in the Transfer Sciences, such as biotechnology or informatics
- In those domains, due to the relatively low costs for translation from publications to patents, top scientists excel both as academic researchers and academic entrepreneurs

The regional context

Interaction is inevitably influenced by the regional context in which they are located

The regional context

- Large firms scan the global academic environment and try to select the best universities in terms of visibility and prestige; they also compete at the frontier and have interest in high level publication
- SMEs are more interested in geographical proximity and universities' capacity to support the whole innovation process and train high skilled workers
- Mechanical and civil Engineering firms are not necessarily interested in top quality scientific cooperation; machinery and communication equipment R&D is co-located with lower-quality rated research departments; pharmaceutical, chemistry and materials science R&D tends to be located close to star departments
- This issue is particularly prominent in the Italian context, due to the geographica the divide

Universities’ features

Institutional heterogeneity gives rise to different forms of strategy and organization of the knowledge valorization process

Universities' features

- Differences across universities in research quality have lower magnitude than within-university differences
- Non-state universities in principle may have a stronger incentive to produce commercially valuable outputs but in the Italian context, the disciplinary background (mainly SSH, Medicine and Agriculture) is not particularly favorable to the production of patents and spin-off companies
- Generalist universities may enjoy better conditions for valorization for disciplinary diversification and contamination, e.g. business schools might contribute to the creation of spinoff companies
- Graduate-only schools and Polytechnics may enjoy better conditions for research valorization, mainly for their size

Funding

A positive relation between the volume of research funding (including third party funding) and scientific production is largely confirmed

Funding

- Increased funding is associated not only to increased volume of production, but also to increased productivity
- Keeping the academic quality of researchers constant, a marginal increase in funding makes it possible to invest more in research equipment and/or junior research positions: the Principal Investigator ‘draws away from the bench’ and coordinate a larger research team with a better division of academic labour
- Researchers will allocate their time budget in order to achieve a better balance between various and potentially conflicting objectives
- Within a larger team there will also be junior researchers that choose to create spin-off companies instead of pursuing an academic career. These spin-off companies will maintain, however, close linkages with the academic background
- Scientific disciplines greatly differ with respect to their ability to attract third party funding

Technology Transfer Office

The role of the internal organization of universities for the design and implementation of valorization as well as the creation of a dedicated professional layer of technology transfer brokers

Technology Transfer Office

- The impact of University-Level Support Mechanisms, such as Technology Transfer Offices and dedicated administrative staff) and Local-Context Support Mechanisms, such as incubators, technology parks, or specialized intermediaries to the effectiveness and efficiency of the knowledge transfer process is a matter of debate
- The tension between research quality and industrial impact are mitigated through professionalization

Hypoteses and empirical findings

Construct	Operationalization	H	Expected sign	Dependent variable and results		
				Number of patents per capita	Number of spin-offs per capita	Number of patents
Quality of research	R normalized by Area	H1(a)+(b)	+/-	n.s. (^)	n.s. (^)	+
Disciplinary differences	SSN	H2	+ (Engineering)	Not applicable	Not applicable	+
Regional context	South	H3	-	-	n.s.	-
University governance	State university	H4(a)	+	n.s.	+	-
University type	Polytechnic and School for Advanced Studies	H4(b)	+	n.s.	n.s.	+
University specialization	Heterogeneity index	H4(c)	+ (generalist)	n.s.	n.s.	+
Funding	Revenues from commercial activity	H5	+	n.s.	+	Not applicable
	Funding from competitive calls		+	+	+	Not applicable
	Log per capita funding		+	Not applicable	Not applicable	+
TTO		H6	+	n.s.	n.s.	Not applicable

Data

- Patents
- Spin-off companies
- Third-party funding
- Research quality
- Other control variables

Building up the database

- Integration of two databases containing respectively:
  - data on research quality of italian academic researchers' outputs and institutional and individual characteristics;
  - data on technological transfer (patents, spin off, third party research)

- Unique dataset related to years 2011-2014 that covers:
  - all Italian Universities (except on-line Universities)
  - all Italian academic researchers working in STEM and LS fields (almost 33k)

Research quality

- drawn from database of Italian Evaluation of research quality VQR 2011-2014
- VQR 11-14: two research outputs for each academic researcher assessed using informed peer review
- we computed measures of research quality aggregated at individual and institutional level:
  - for each academic researcher we computed the mean of the scores of the two outputs submitted;
  - for each institution we computed normalized and standardized indicators:
    - Normalized indicators: we normalized the institutional average score by scientific field or scientific sector averages (narrower definition in the field) to account for different evaluation parameters in different areas and aggregated them weighting for the quota of outputs in the field/sector (R Area and R SSD in the following)
    - Standardized indicator: we compute standardized scores at individual level with respect to the mean and the variance and sum up the standardized scores at institutional level (ISA)

University’s and individual features

- VQR database contains also data on:
  - researchers’ individual characteristics (gender, age, academic position)
  - institutional funding from competitive calls

Technological transfer: patents

- Data on academic patents are taken from the European Patent Office (Worldwide Patent Statistical Database) and subsequently validated and integrated by researchers in the submission phase of the VQR
- Academic patents are defined as those signed by at least one professor-inventor regardless of their ownership
- Data on patents are available at individual level
- Cash receipt registered per year from patents' license, sale and option have been collected during the assessment procedure

Technological transfer: spin-off

- Data on spin off companies have been collected from Chamber of Commerce database and subsequently validated and integrated by Universities
- A spin-off company is based on the research results produced by the university and it has ability to maintain regular research collaboration relationships with it
- Data on spin off companies were collected at University level
- Also data on revenues of spin-off companies have been collected (large number of missing data)

Technological transfer: third party funding

- Data on third party contracts are derived from universities' balance sheets
- Data are the sum of the third party funding of the university (registered at central level) and of its departments. In particular, third party funding are the sum of:
  - commercial activity revenues (including research and teaching activities carried out on behalf of third parties and other revenues deriving from commercial activities)
  - income from business (private and public enterprises)
  - income from institutional relations

Correlations

We first look at simple pairwise correlations between our variables of interest (tech transfer variables and research quality indicators):

$\rho_{Rarea,patents}$=0.29 ***

$\rho_{Rarea,spinoff}$=0.32 *

$\rho_{Rarea,3rdpartyrevenues}$=0.36***

$\rho_{RSSD,patents}$=0.28**

$\rho_{RSSD,spinoff}$=0.38**

$\rho_{RSSD,3rdpartyrevenues}$=0.33***

$\rho_{ISA,patents}$=0.22*

$\rho_{ISA,spinoff}$=0.10

$\rho_{ISA,3rdpartyrevenues}$=0.18

Correlation between average revenues per patent (or spin-off) and research quality turned out not statistically significant

Regression model at Institutional level

$$Y_u = \alpha + \beta VQR_u + X_u'\gamma + \varepsilon_u$$

- dependent variable: per capita n. of patents, n. of spin-off
- Independent variable of interest: research quality indicators
- X' vector of control variables regarding University characteristics:
  - geographical location
  - type of institution (Polytechnic/School for Advanced Studies)
  - legal status (state/non state)
  - disciplinary specialization
  - presence of a Technological Transfer Office
  - funding attractiveness (from competitive research calls and revenues from commercial activities –third parties)

Regression model

- We do not want to detect any causal relations, but rather the existence of a correlation controlling for inventors' characteristics and institutions' characteristics
- Endogeneity problem in the relation between research quality and valorization of research due to reverse causality

Estimation results (dep var: nr. of patents)

	(1)	*(2)*	*(3)*
R normalized by Area	0.208***	0.0387	0.0416
	(0.0741)	(0.0998)	(0.0888)
South		-0.0823*	-0.0889**
		(0.0452)	(0.0409)
Polytechnics and School for Advanced Studies		0.0430	
		(0.0930)	
State university		-0.0738	
		(0.0624)	
Heterogeneity index		0.273	
		(0.220)	
Revenues from commercial activity per capita		0.000209	
		(0.000383)	
Funding from competitive calls per capita		0.132***	0.134***
		(0.0438)	(0.0322)
Presence of Technology Transfer Office		0.0537	
		(0.0572)	
Constant	-0.0905	-0.216	0.0201
	(0.0737)	(0.203)	(0.0833)
Observations	88	83	83
R^2	0.084	0.295	0.265

Estimation results (dep var: nr. of spin-off)

	(1)	*(2)*	*(3)*
R normalized by Area	0.169**	-0.126	-0.0829
	(0.0654)	(0.0778)	(0.0661)
South		-0.0166	
		(0.0190)	
Polytechnics and School for Advanced Studies		-0.0380	
		(0.0508)	
State university		0.278***	0.248***
		(0.0992)	(0.0838)
Heterogeneity index		0.0959	
		(0.131)	
Revenues from commercial activity per capita		0.00133***	
		(0.000411)	0.00116***
Funding from competitive calls per capita		0.000861***	(0.000307)
		(0.000192)	0.000641***
Presence of Technology Transfer Office		-0.0319	(0.000144)
		(0.0424)	
Constant	-0.116*	-0.237	-0.183*
	(0.0664)	(0.146)	(0.0979)
Observations	61	61	61
R^2	0.102	0.510	0.477

Regression model using microdata (STEM and LS Italian academics)

- dependent variable: n. of patents
- Independent variable of interest: research quality indicators
- vector of control variables:

University characteristics	Individual characteristics
- geographical location - type of institution - legal status - disciplinary specialization - funding attractiveness	- gender - age - University role - research field

Sample statistics

	N	mean	sd	p10	p25	p50	p75	p90	p95	min	max
Number of patents per capita	32,616	0.120	0.567	0	0	0	0	0	1	0	21
Quality of research score	32,616	1.861	1.038	0.165	1.152	1.867	2.695	3.182	3.291	0	3.351
Female	32,616	0.329	0.470	0	0	0	1	1	1	0	1
Age	32,616	52.551	8.958	40	45	53	60	65	67	28	76
Full Professor	32,616	0.217	0.412	0	0	0	0	1	1	0	1
Associate Professor	32,616	0.358	0.479	0	0	0	1	1	1	0	1
Assistant Professor	32,616	0.357	0.479	0	0	0	1	1	1	0	1
Mathematics and Computer Science	32,616	0.101	0.301	0	0	0	0	1	1	0	1
Physics	32,616	0.065	0.246	0	0	0	0	0	1	0	1
Chemistry	32,616	0.085	0.280	0	0	0	0	0	1	0	1
Earth Science	32,616	0.031	0.174	0	0	0	0	0	0	0	1
Biology	32,616	0.143	0.350	0	0	0	0	1	1	0	1
Medicine	32,616	0.284	0.451	0	0	0	1	1	1	0	1
Agricultural and Veterinary Science	32,616	0.090	0.286	0	0	0	0	0	1	0	1
Civil Engineering	32,616	0.046	0.209	0	0	0	0	0	0	0	1
Engineering	32,616	0.155	0.362	0	0	0	0	1	1	0	1
heterogeneity index	32,616	0.931	0.069	0.849	0.921	0.955	0.974	0.978	0.982	0.363	0.982
North	32,616	0.434	0.496	0	0	0	1	1	1	0	1
Center	32,616	0.249	0.432	0	0	0	0	1	1	0	1
South	32,616	0.313	0.464	0	0	0	1	1	1	0	1
Online	32,616	0.005	0.068	0	0	0	0	0	0	0	1
Log per capita founding	32,557	10.744	0.551	10.133	10.478	10.841	11.044	11.188	11.636	5.8226	12.742
Polytechnic/School for Advenced Studies	32,616	0.060	0.238	0	0	0	0	0	1	0	1
State University	32,616	0.962	0.192	1	1	1	1	1	1	0	1

Sample statistics on research quality and individual and institutional characteristics, 2011-2014

	(1)	*(2)*	*(3)*	*(4)*
Normalized score	0.0485***	0.0369***	0.0347***	0.0898***
	(0.00301)	(0.00313)	(0.00315)	(0.0342)
Female		-0.0393***	-0.0391***	-0.0713
		(0.00686)	(0.00686)	(0.0698)
Age		-0.00166***	-0.00168***	0.00121
		(0.000413)	(0.000415)	(0.00400)
Full professor		0.0945***	0.0948***	0.296***
		(0.00883)	(0.00885)	(0.0741)
Mathematics and Computer Science		-0.281***	-0.267***	-0.437*
		(0.0125)	(0.0127)	(0.228)
Physics		-0.203***	-0.191***	-0.435***
		(0.0144)	(0.0146)	(0.121)
Chemistry		-6.76e-05	0.0199	-0.0517
		(0.0132)	(0.0136)	(0.0833)
Earth Science		-0.272***	-0.249***	-0.651**
		(0.0191)	(0.0193)	(0.303)
Biology		-0.183***	-0.162***	-0.391***
		(0.0116)	(0.0120)	(0.0940)

Medicine		-0.241***	-0.220***	-0.480***
		(0.0101)	(0.0106)	(0.0964)
Agricultural and Veterinary Science		-0.234***	-0.212***	-0.510***
		(0.0130)	(0.0134)	(0.126)
Civil Engineering		-0.212***	-0.203***	-0.0776
		(0.0163)	(0.0164)	(0.165)
Heterogeneity index			0.137*	2.022***
			(0.0784)	(0.690)
South			-0.0319***	-0.118*
			(0.00683)	(0.0665)
Log per capita funding			0.0353***	0.208***
			(0.00615)	(0.0574)
Polytechnics/School for Advanced Studies			0.0911***	0.663***
			(0.0222)	(0.179)
State university			-0.0725***	-0.990***
			(0.0196)	(0.217)
Constant	0.0295***	0.306***	-0.137	-1.692**
	(0.00642)	(0.0232)	(0.0931)	(0.849)
Observations	32,616	32,616	32,557	2,359

Main results

- Positive correlation between quality of research and inventive capacity at individual level that persists with controls linked to university and individual characteristics
- We find strong evidence of disciplinary differences with respect to the baseline Engineering discipline
- Universities located in the South show a weaker relation between research quality and valorization outputs
- Patenting activity is lower for affiliates to State Universities and higher for affiliates to Polytechnics and School for Advanced Studies
- Strong support for the role of funding as an intermediate variable: we find a positive impact of funding attractiveness on research valorization

Future research

- Explore more in depht the differences in research fileds
- Add in the analysis measures of the teaching activity of professors

Thanks for your attention!