Decentralized academic selection mechanisms in Italy: opportunity or parochialism?

Stefano Verzillo

Università degli Studi di Milano, Department of Economics, Management and Quantitative Methods,

Via Conservatorio 7, 20122 Milano - email: stefano.verzillo@unimi.it

Abstract

The aim of this paper is to test the impact of decentralizing academic recruitment mechanisms in Italy on scientists' research productivity following a policy reform introduced in 1998 (Berlinguer's reform act). Is decentralization an opportunity to select higher quality researchers or is it a way that increase parochialism? To answer these questions we study the differences between individual research productivity measures of researchers being hired before and after this reform. We focus our analysis on differences in research trends and mid-term outcome levels (especially in terms of scientists' research impact, productivity and notoriety) six-years after being hired. From the web version of ISI Web of Knowledge we collect the publishing records of Italian academics over the last two decades (1991-2010) with their associated bibliometric indicators. We obtain -this way- a set of comparable standard measures of international research performances. Then in a "quasi-experimental" research framework we apply the Coarsened Exact Matching matching technique (Iacus et al., 2009) to select two balanced groups of researchers (one including the professors hired before and the second the left-overs) to measure the average impact of the policy change on individual research incentives. An overall general worsening effect of this reform is not clearly identified due to a big heterogeneity of our research measures within scientific disciplines. Restring the world to "hard sciences" only negative effects on research outcomes and trends are identified for researcher belonging to Math, Earth Sciences, Medicine and Veterinary disciplinary areas. We find both lower individual productivity (in terms of slope and six-year level) and lower impact associated with the decentralization reform.

Keywords: policy evaluation; coarsened exact matching; research outcomes

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1 Introduction

Has decentralization had a significant impact on the prevailing level of research productivity of newly hired academics in Italy? To what extent does the mechanism of recruitment provide incentives for researchers to reach better publication scores after selection?

The aim of this study is to determine whether local recruitment has an impact not only on the "level of quality" of selected researchers but also on their mid-term research outcomes (Fox, 1983 and Levin et al. 1991). We especially focus on the impact of the 1998 decentralization reform of the Italian university system on research outcomes for candidates publishing in international journals, bearing in mind that all other aspects of the system remained unchanged over the last two decades (salary benefits, university funding mechanisms etc…).

We investigate this issue using an *ad hoc* dataset on Italian academics between 1991 and 2011. Data from the web version of ISI-Web of Knowledge (WoK) were collected to obtain standard and comparable bibliometric indicators of Italian researchers, while administrative records regarding their affiliation, academic position and disciplinary area are given by the National Ministry of Education, University and Research (henceforth Miur)

Is it true that local recruiting performs poorly, and Italian academics hired under the decentralized system are less productive? Although it is potentially easier to increase the discretional influence of local professors over the recruitment process with decentralization, has this opportunity made it simpler to match better candidates with local departments or has it merely increased the opportunity to engage in nepotistic behaviours?

From a theoretical viewpoint, it is possible that decentralization of recruitment mechanisms can reduce the incentives for candidates to produce international research outcomes (conference papers, journal articles etc..) and/or to submit papers to higher-quality scientific journals (which usually implies longer publication times and lower acceptance rates).

More local recruitment management could generate the expectation that less stringent requirements will be applied. This consideration would be most crucial for applicants to assistant professorships and for associate professors applying for full professorships rather than for newly appointed assistant professors.

Our results document that decentralization, controlling for academic discipline, has a negative effect on ISI research outcomes (especially on measures of research impact) in mid-term performances of hired people.

2 The Italian Academic System

The Italian academic system is composed of 89 universities (28 private and 61 public) and 6 higher education institutions. The latter usually dispense only masters and PhD courses, being more research oriented than most of the other universities. Three out of the 61 public universities are polytechnics. Eleven out of the 28 private institutions are distance-learning universities. The university system is divided into 372 sectors of discipline (*settore scientifico-disciplinare*), grouped into fourteen research areas, as designated by the Italian National University Council (CUN)[1]. Sectors of discipline are categorized for homogeneity within each research area, and the selection of research candidates is conducted by recruitment commissions within each academic discipline in both national and local recruitment systems. Considering academic disciplines as our reference level of analysis ensures validity in accounting for heterogeneity of recruitment behaviours between disciplines.

The Italian university system is constrained by national regulations. Each professor working at an Italian university is categorized by a level of arrangement (full professor, associate professor and assistant professor) and by one out of 372 sectors of discipline. Each vacancy is coded in a standardized format, and each filled position becomes tenured after a review conducted three years after hiring. Each position is also associated to a school (*facoltà*) for teaching duties and to a department for research activity. Salaries in public universities are set by law and vary only by level of arrangement and seniority. Schools and departments are prevented from differentiating wages among professors, linking payment to research productivity and/or teaching loads. As a consequence, in addition to celebrity and funds attraction, the strongest incentive to scientific productivity for individuals working in academia derives from expected promotion (being hired as assistant professor, being promoted associated or full professor). Given the public nature of the employment contracts, university professors can only be hired through public competitions that should grant publicity of the vacancy, selection of the selecting committee based on objective criteria, transparency of the selection process. This may explain why it is crucial for the research productivity and quality to study the different incentives designed by different selection procedures.

A reform in 1998 changed these procedures with respect to several dimensions:

- *level of selection* (national or local, which mostly affects the number of competing applicants, but also the timing of the selection due to the heavier bureaucratic load associated with a nationwide competition);

[1] Mathematics and Computer Sciences, Physics, Chemistry, Natural Sciences, Biology, Medicine, Agriculture and Veterinary, Civil Engineering and Architecture, Industrial Engineering, Literature, History, Psychology, Law, Economics and Statistics, Social Sciences

- *selection of committees* (in accordance to the co-optation attitude of academia, for most of the period under analysis the committees were elected out of professors of the same sector of discipline, with element of randomness introduced at some stage);
- *number of eligible applicants* (each '*concorso*' declares a number of winners that are eligible to become professors, this number is usually equal to, but sometimes greater than, the number of available vacancies).

Since 1979, standardized competitions were held to hire assistants, associate and full professors, and until 1998, almost all academic recruitment was substantially centralized. Despite the legislative prescription of one '*concorso*' every two years, a three to four years interval occurred. National commissions of five members were chosen by lot within a pool of elected professors (from a pool of 15[2]) belonging to the same discipline. Commissioners declared which of the candidates had the qualifications to be promoted to associate/full professorship. Eligibility was given to a number of candidates greater then the available positions (usually 20% higher) for each discipline. Universities with opening positions drew by multilateral bargaining between them from the list of eligible applicants to fulfil their vacancies (Checchi, 1999, shows some evidences from a single national selection procedure for associate professorship). Starting in 1999, recruitment procedures became entirely local, and each university could hold its own selection procedure (both for assistants, associates and full professors). Local commissions were comprised of five members: one belonging to the institution itself -the '*internal commissioner'*- and the four others elected by the full set of Italian professors of that discipline. After 2005, a new reform act[3] established that the commission's members had to be drawn by lot in a pool of professors of three times the size of the local commission, elected by popular vote amongst the discipline's affiliates. The commissions initially declared three qualified candidates for each '*concorso*', but moved to two between 2007 until 2008, and only one thereafter. In the following years, universities with open vacancies could hire any candidate who had obtained a qualification. Professors hired under the new policy mechanism were engaged beginning in 2000, two years after the enactment of Berlinguer's reform[4]. Consequently, our empirical analysis marks the beginning of decentralization that year.

[2] d.l n° 31/1979 and dpr n° 382/1980
[3] Moratti reform, dl 230/2005
[4] dpr n° 390/1998 and dpr n° 117/2000

3 Theoretical incentives

The decentralization of academic recruitment could be considered as an exogenous shock to recruitment rules that potentially impacted the subsequent career of selected professors.

The majority of other factors that affecting research performance over this time has remained constant, setting the stage for a natural experiment for considering the effect of decentralization. Notwithstanding the hiring changes, university' funding mechanism remained totally disconnected from managerial behaviours.

No salary incentives (or penalties) were provided to incentivize (or prevent) virtuous behaviours of the commissioners in selecting high (or low) quality candidates; student evaluations of teaching performance for new hired professors usually had no impact on the professional life of professors (although including aspects of these evaluations become compulsory after 2000). Due to strict privacy rules, the results of evaluation exercises were in most of the cases known only by each professor until recently; no evaluation mechanisms were established to assess recruitment procedures at department (or university) level by the central administration;

Thus, over the time period we consider, there was *no private cost for opportunistic behaviour* for (part of) the selecting committee, as well as no impact on institutional funding mechanisms, except for lower scientific reputation.

In this context decentralizing academic recruitment could have mixed effects. On the one hand, decentralization could improve productivity and efficiency for at least three reasons; first, local recruitment usually induces speedier selection procedures (national "concorsi" were held every 4-6 years) while the multilateral bargaining between winners and hosting universities could last one or two years under national mechanisms, second, they guarantee more certainty of fulfilling available vacancies when needs arise (both for research and teaching necessities), and third decentralization could lead to more competition among universities in attracting candidates. The better candidate could also be the one that particularly fits with institutional needs (in terms of research competences and experiences).

Moreover decentralization means less compromise with "The Academia" when it is dominated by few national prevailing "Schools". The Italian academia is certainly not so unfamiliar with such corporatism (Durante et al. 2009; Allesina, 2011) and the existence of "schools" that could exert a direct influence on the selected candidates has to be considered as a possible problem.

On the other side, decentralized selections enable institution to favour individuals based on familiar, professional or political considerations, independent of their experience or qualifications. Local processes also may lead to less competition with respect to national procedures. In addition, it is important to analyse the extent to which influence of the selection procedures induces behaviours of the potential candidates. Before reforms, national *concorsi* were held less frequently and involved a larger number of interested applicants. This meant

more competitors. In most circumstances, a greater number of competitors encourage more effort on the part of the candidates, providing incentives for individuals to maximize their probability of winning through performance. Furthermore, the number of peers under central selections was stable in the Italian context, meaning that opportunities for advancement could be considered equal over time for each "*concorso"*. Decentralizing academic recruitment meant fewer competitors participate in "*concorsi"* both in the present, and future. Geographical constraints are also important because, with a local system, there is an incentive to participate in "*concorsi"* that are relatively close to the candidate's home area, rather than compete in all Italian "*concorsi"* for that year. If publishing more papers in impact journals increases an individual's probability of being selected (as should theoretically be the case), decentralizing academic procedures could provide fewer incentives for local candidates. Indeed the individual choice of putting less or more effort is not mainly driven only by the own candidate willingness to exert it but it could probably be given by also the selection year.

Then our research question is twofold: has decentralization of selection mechanisms improved (or worsened) mid-term research outcomes of winners? have local recruitment mechanisms incentivized (or discouraged) individual research careers?

4 Data

Data for this paper were collected from two primary sources: MIUR – Italian "Ministry of Education, University and Research" - and the "bibliographic" Web version of ISI WoK database (henceforth ISI). ISI, powered by the Institute for Scientific Information and distributed by Thomson Reuters, has been the standard in the bibliometric field for the past 30 years and indexes more than 8.700 journals in the fields of arts, humanities, sciences and social sciences. Scopus published by Elsevier (www.info.scopus.com), indexes a greater number of journals (12.850, including 500 open access journals) within the medicine, technical and social sciences. Alternative bibliometric sources are Scopus and Google Schoolar. Scopus (henceforth SCO) is significantly larger in size and covers more of the international literature, but it completely excludes the humanities (Klavan and Boyak, 2007). Google Scholar (henceforth GS) stands-today-as the main potential competitor of ISI and Scopus (particularly in light of the fact that it is the only one without commercial interests), but currently has outstanding information reliability problems. However the literature documents the presence of high correlations between and among bibliometric measures obtained by Scopus and ISI databases (Archambault et al., 2009). Thus, despite using a single source, we expected similar results of analysis using different bibliometric sources instead of ISI.

The main drawback we face concerns the disciplinary coverage specification of international research data with respect to the whole research domain. Researchers of some disciplines such as History and Literature in Italy usually publish on national journals only (usually with articles written in Italian). For these academics, little bibliometric information is available on ISI (and also on SCO or GS). Distortion of data due to higher 'ISI exposure' of some disciplines in comparison to others can only be managed by disaggregating the analysis by discipline, which is the approach we employ. Our data include around 1.000.000 ISI products over the last 20 years. After filtering duplicates and incomplete records were deleted obtaining a consistent database of 963.181 scientific publications with at least one Italian author over the period 1991-2010.

Information regarding academic positions, disciplinary areas, and university affiliation are available online from 2000 to 2011[5]. We obtained data on academic careers before 2000 from Cineca, a MIUR agency which collects administrative data on personnel as well as on competition for professorship in Italy. These data have several known problems, often relating to the uniqueness of identifying codes of individuals, and missing data on academic disciplines over the first five years (1990-1995). After we corrected for these issues to the best of our ability, we found a 1.5% degree of imbalance with respect to the last available official statistics published by Miur (reported in table 1). These differences are likely due to a few rare categories of professors, such as newly hired associate and full professors attracted from abroad, fixed-contract new researchers positions and so on. However, such a small difference is unlikely to seriously bias our results, or be the cause of distortionary effects in our estimation procedures.

Final Professors database					Official statistics*					Difference (%)
Year	Full Prof.	Associate Prof.	Assistant Prof.	Total	Year	Full Prof.	Associate Prof.	Assistant Prof.	Total	
1991	11750	14042	15642	41434	1991	***	***	***	45248	0,08%
1992	11804	16746	14964	43514	1992	***	***	***	***	***
1993	11876	17084	15739	44699	1993	***	***	***	47839	0,06%
1994	13288	15915	16694	45897	1994	***	***	***	47824°	0,04%
1995	14011	16313	18417	48741	1995	***	***	***	49098	0,0%
1996	13719	16093	19583	49395	1996	***	***	***	48560°	-0,01%
1997	13399	15675	20105	49179	1997	13402	15619	20167	49187	0,0%
1998	13098	18108	18748	49954	1998	13103	18108	18745	49956	0,0%
1999	12905	18069	19815	50789	1999	12899	17863	19949	50711	-0,2%
2000	14411	16615	19200	50226	2000	14676	16973	19542	51191	1,9%
2001	16901	17879	20255	55035	2001	16418	17572	20011	54001	-1,9%
2002	18148	18504	21055	57707	2002	17571	18100	20714	56385	-2,3%
2003	17997	18115	20577	56689	2003	17388	17783	20371	55542	-2,1%
2004	18062	18094	21341	57497	2004	17469	17633	21149	56251	-2,2%
2005	19296	18982	22186	60464	2005	19147	18849	21904	59900	-0,9%
2006	19843	19084	23355	62282	2006	19676	18966	23099	61741	-0,9%
2007	19640	18776	23793	62209	2007	19623	18739	23560	61922	-0,5%

[5] www.cercauniversita.it

2008	18929	18253	25923	63105	2008	18932	18261	25569	62762	-0,5%
2009	17980	17630	25911	61521	2009	17878	17567	25434	60879	-1,1%
2010	15949	16967	25590	58506	2010	15834	16745	24784	57363	-2,0%

Table 1 - Official 1998-2010 data reported in 11° Rapporto CNVSU (tab.5.8 pp.154), in "° Rapporto CNVSU (tab 1 pp.2), and in °Dalia Cineca

Individual and research output information refers to the period 1990-2011. Italian academics' publication records were downloaded using specific institution and publication year as key query parameters.

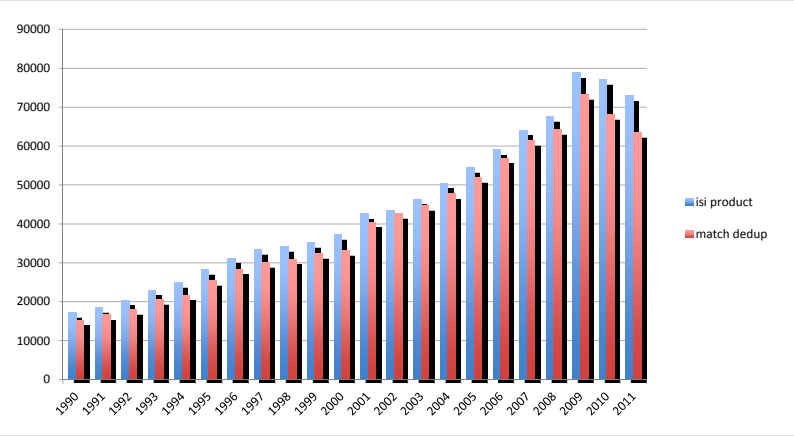


Figure 1 -Share of ISI products with at least a 1:1 matching on author's identifying code

We employ a multi-step matching procedure to assign the corresponding author identifying codes to each research product in the bibliometric dataset. At the end we obtain a 91% of matched records (figure 1). Indeed a 9% percent of ISI products is plausibly stored in the database reporting an Italian affiliation but with an author who is not included in the official faculty list provided by Miur, which may be plausible due to the presence of post-doctoral students, PhD candidates and individual researchers not included in Miur's research and teaching faculty list.

Year	At least one ISI paper		Total
	No	*Yes*	
1991	86,03	13,97	100
1992	83,14	16,86	100
1993	80,94	19,06	100
1994	78,87	21,13	100
1995	76,35	23,65	100
1996	74,35	25,65	100
1997	72,51	27,49	100
1998	70,12	29,88	100
1999	68,15	31,85	100
2000	65,71	34,29	100
2001	62,24	37,76	100
2002	59,06	40,94	100
2003	57,19	42,81	100
2004	55,14	44,86	100
2005	52,07	47,93	100
2006	49,12	50,88	100

2007	46,84	53,16	100
2008	44,21	55,79	100
2009	42,32	57,68	100
2010	40,52	59,48	100
2011	38,25	61,75	100
Total	62,05	37,95	100

Table 2 - Percentage of professors with at least one paper on ISI by year

The overall percentage of academics with at least one paper on ISI over the entire period is higher for full professors with respect both to associate and assistant professors (50%).

Academic Position	At least one ISI paper (1991-2011)		
	No	*Yes*	Total
Assistant Professor	50,98	49,02	100
Associate Professor	45,17	54,83	100
Full Professor	41,41	58,59	100
Total	46,32	53,68	100

Table 3 - Percentage of professors with at least one paper on ISI by Academic Position

Our data show different numbers of individuals over time, the panel for each academic professor is unbalanced due to varying entry points into the administrative archives of Miur. Data vary depending on the year of selection, the year of the first published international paper, the persistence rate of publication on ISI of the own discipline. Discontinuities are also possible (and several are identified in our analysis), due to such considerations as working abroad, or that the individual enters unusually one year and ceases publishing after that point. These issues could have significant effects on the distribution of bibliometric indicators over time, and the challenges are more pronounced in some disciplines than in others.

We arbitrarily decide a threshold in order to exclude disciplines with lower level of individuals with at least one product on ISI. Heterogeneity within academic research areas is highly effective in ISI studies, and the following figure 2give us the idea of which of the standard disciplines overcome the 50% cut-off level of individuals with at least one record. We consider in this study especially the scientific area where this percentage is greater than 50% with respect to the different historical and individual nature of each discipline. Bibliometric indicators could be theoretically considered for all the scientific areas but a rate greater than 50% guarantee a degree of reliability in our research exercise. A high sensitivity level among academic fields and aggregation levels is common in bibliometric studies. Thus we reduce the area on less heterogeneous disciplines this way and build the dataset longitudinally, considering year-of-selection as the (moving) starting point for all individuals considered.

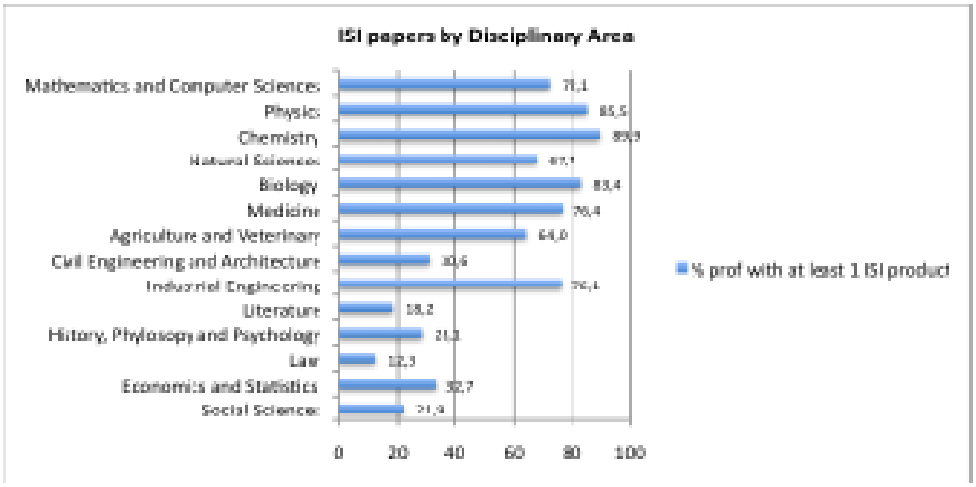


Figure 2 –Percentage of Professors with at least one ISI paper

Bibliometric indicators

Three simple bibliometric measures are introduced in this work. Firstly, as quantity of published research we calculate the individual cumulative frequency of ISI items extracted from the database at each year. This measure gives an idea of the quantity of papers on international journals published by the considered researcher up to each considered year. Secondly, we calculate the cumulative average impact factor[6] of each academic professor at each of the considered years. This measure could be considered as an individual "expected measure of impact". This second measure is open to criticism. On one hand, one could argue that it is not correct to use journal impact factors to evaluate individual productivity and, on the other hand, that the impact factor could not be considered as a proper measure of "quality". Indeed, impact factors are by definition the arithmetic average of citations of the journal papers in a given period. Referring the average impact factor to each article means that the underlying distribution of citations is assumed to be uniform. But this is empirically unproven, and in some respects refuted by observation. The literature documents that the underlying distribution is strongly asymmetric to the right; few articles receive many citations, and most receive few (Seglen, 1997; Adler, 2009). It is certainly the case however that the impact factor of a journal provides *a priori* information about the "expected number of citations" of a published article. In the absence of acceptable citations indexes, we consider the average impact factor of the journals were a researcher has published as a measure of the "expected impact" in terms of citations the researcher will obtain. Secondly, it is also true that papers published in top journals with high reputation (high impact factor) have already been peer-reviewed by rigorous referees; this

[6] to obtain this measure we matched our bibliometric dataset with the Journal Citation Report 2010 (reporting information on the average five-years impact factor of ISI scientific journals over the period 2005-2010)

process should guarantee high quality standards of the published research. There is thus justification for thinking that a strong correlation exists between journal impact factors and research quality of its published papers.

Then a measure of network extent was extracted using the total number of citations. The significance of the network rate measure has to be widely discussed in literature because of its strong relationship with time. The greater is the number of years an article has been published, the higher is the number of citations due to time exposure on ISI. ISI citations are by definition updated to download time (April, 2012) and they could not be considered comparable measures across years without accounting for their time of exposure.

A quick overview of the descriptive statistics for assistant professors at year of selection evidences the wide differences of bibliometric indicators within academic disciplines. “Hard sciences” professors in Physics or Chemical Sciences at time of their selection had an average of 24 ISI papers, with 2.5 average impact factor, 15 average citations per paper, and more than 400 cumulative citations. On the other end of the spectrum, Arts and Humanities academics have on average less than 1 paper on ISI, with 0.33 impact factor, 1.7 average citations per paper, and 7 cumulative citations in their research careers. We take log-transformations of research outcomes (impact factor and n° of papers on ISI) in our analysis to guarantee the normality of both variable distributions. In order to maintain the maximum number of observations, we input zero values for all the individuals with missing values over these variables.

Id	Disciplinary Area	Freq	N° paper ISI	Impact factor	Avg citations	Avg citations cum
0	Missing (1991-1995)	279	3,31	0,94	5,50	63,05
1	Mathematics and Computer Sciences	1.282	7,75	1,18	7,07	65,46
2	Physics	1.887	24,04	2,62	15,30	402,27
3	Chemistry	1.139	24,04	2,99	17,96	500,21
4	Natural Sciences	1.644	6,14	1,70	13,75	105,36
5	Biology	1.268	16,09	3,43	19,40	344,71
6	Medicine	948	19,47	3,73	14,81	361,47
7	Agriculture and Veterinary	376	6,33	1,38	9,98	90,35
8	Civil Engineering and Architecture	1.777	2,21	0,68	4,23	24,64
9	Industrial Engineering	563	10,73	1,43	8,68	107,67
10	Literature	1.471	0,70	0,33	1,82	8,89
11	History, Philosophy and Psychology	964	1,49	0,72	3,74	23,24
12	Law	2.205	0,43	0,39	1,75	7,41
13	Economics and Statistics	558	1,24	0,66	4,08	14,96
14	Social Sciences	1.578	0,62	0,50	1,76	7,79

Table 7 - Descriptive statistics of bibliometrics indicator by disciplinary area; Associate Professors at year of selection only

5 Empirical Strategy

The methodological approach we employ to evaluate the impact of different selection mechanisms caters to the specific research question we ask: "*Is there a causal effect of local (vs. national) recruitment programs on the subsequent research productivity levels of selected academics?*"

We focus on evaluating the effects of a shift to decentralized selection mechanisms in terms of subsequent research productivity average level of the outcome and its time trend. The treatment status can be considered as the exposure of an individual to local selections instead of national ones. The problem is that we can observe almost one of these *states* for each individual of interest. Indeed individuals who are exposed to local selection programs are by definition (due to a specific time constraint: they were selected after 2000) different from those who are exposed to national recruitment programs. These differences may invalidate the causal comparison of the impact of decentralization on future research productivity outcomes.

Recent studies in the econometric literature of program evaluation (Imbens, Wooldridge, 2008) and methodological research on causal inference (Rosenbaum and Rubin, 1983) from observational studies (where investigators have no control over the treatment assignment) suggests the use of parametric methods, such as propensity score, or non-parametric strategies (as CEM) to accommodate general heterogeneity between two groups of individuals in estimating the treatment effects and to increase precision of the estimates. The treated (in our empirical application all the researchers selected with local mechanisms) and control (the selected with national mechanisms) groups may have significant differences in their observed covariates (scientific discipline and research productivity outcomes) that could lead to biased estimates of the selected effect.

Our analysis implements a recent non-parametric method to obtain balanced treated and controls groups: the Coarsened Exact Matching (CEM) technique. (Iacus et al. 2009)

Coarsened Exact Matching

Coarsened exact matching is a matching method recently introduced by Iacus, King and Porro (2009) to improve causal inference controlling for the confounding influence of covariates in observational studies. The time-dependent nature of our study, and the flexibility of CEM in estimating non-parametrically two balanced distributions of treated (locally selected professors) and controls (centrally selected) units, allows us to obtain desired counterfactuals for estimating the decentralization effect. Balanced groups avoids having the researcher control for the heterogeneity while specifying the model, meaning that simple differences in means are good estimates of the causal effect. But usually finding a matching solution in empirical propensity applications does not guarantee good balance to all the selected covariates. Improving balance

on most of them could leave the remainders imbalanced, often introducing more bias with respect to the initial distribution (Iacus S. et al., 2009).
In addition to this, propensity score matching (and Mahalanobis distance methods) has the drawback of violating the congruence principle, which requires congruencies between data and analysis spaces metrics (the own metric of the two spaces is different). Parametric methods usually force covariates of the original data from a multi-dimensional original space in a new space defined by the propensity itself. Mielke and Berry (2007) show how violating this principle produces less robust inferences. In comparison, coarsened exact matching meets the principle of not reducing the original data space, operating in the multidimensional variable space itself.

Applying CEM to our study means firstly to set variable-by-variable the non-overlapping intervals to coarsen original data about winners of selection procedures (before and after the reform) at the year of their selection. Then we match one-to-one each stratum treated and controls units after removing all the individuals (treated and controls) owning to zero controls strata[7].Available covariates regarding bibliometric indicators and disciplinary area are coarsened according to reasonable assumptions: a 0.3 impact factor intervals, a one-to-one n° of ISI publications and a 10 pages interval of cumulative number of pages written by the authors are settled as coarsening rules. Missing data are treated as *'missing as zeros'* due to the particular nature of our data. Indeed, missing values of bibliometric indicators (impact factor, n° of paper ISI, citations, sum of pages etc…) reflect the absence of the author in the data and absence on ISI is equal to 0 international papers published, with 0 pages written, 0 citations received and 0 average impact factor. A real drawback of missing replaced with zeros could be represented by the equal 'treatment' of an author with few ISI publications with zero impact factor and 0 citations and an author without ISI records. However, equal treatment of zero ISI publications or few records with no impact factor and no citations at the associate professorship level in our restricted word (hard sciences only) could be considered, without a significant loss of information, acceptable. The desirable output of this procedure is a sample of balanced treated and controls. For this case, we found 3.181 treated professors with one-to-one coarsened exactly matched controls over 5.292 potentially possible 1:1 couples.

Groups		frequencies	Sample
Treated	total	12.646	3.181
	zero controls strata	6.096	
Untreated	total	5.292	3.181
	zero controls strata	1.727	
		matched	*6.362*

Table 5 - Frequencies of Treated and Untreated units by CEM groups

[7] We wrote a SAS macro procedure to do that.

The selected sample population is now composed of comparable sub-groups of individuals (selected before and after the reform) with similar levels of bibliometric indicators (according to the coarsened intervals settled as before) and operating their research effort in the same disciplinary areas.

Balancing

The following table shows statistics for three of the four selected variables, impact factor, number of paper ISI and cumulative sum of written pages. Frequencies and descriptive statistics reported underline the differences between the two sub-populations (most of the difference is plausibly due to the different time horizon at which the two populations refer to).

treat=0					
Variable	*N*	*Min*	*Mean*	*Max*	*StdDev*
Impact factor	5.292	0	1,289	25,285	1,954
N° of paper Isi	5.292	0	5,002	133	10,156
Sum of written pages	5.292	0	35,726	923	67,93
treat=1					
Variable	*N*	*Min*	*Mean*	*Max*	*StdDev*
Impact factor	12.647	0	1,656	53,48	2,245
N° of paper Isi	12.647	0	9,559	231	16,334
Sum of written pages	12.647	0	253,151	923	5581

Table 6 - Descriptive statistics by treated and controls

Table 7 provides first evidence (univariate absolute difference in means) of balancing between CEM selected treatment and control groups in the overall sample. Mean and standard deviations of the two, equal-size, samples of units are relatively close from one to the next. Before and after reform associate professors have an average number of 1.2 papers published on ISI journals with an average impact factor of 0.45 and a n° of pages close to 10.

treat=0					
Variable	*N*	*Min*	*Mean*	*Max*	*StdDev*
Impact factor	3.181	0	0,459	10,61	0,998
N° of paper Isi	3.181	0	1,201	41	3,247
Sum of written pages	3.181	0	9,492	249	24,793
treat=1					
Variable	*N*	*Min*	*Mean*	*Max*	*StdDev*
Impact factor	3.181	0	0,457	10,55	0,995
N° of paper Isi	3.181	0	1,222	49	3,365
Sum of written pages	3.181	0	9,801	255	27,496

Table 7 - Descriptive statistics of matched units by treated and controls

By construction, covariate descriptive statistics over the entire sample are almost equal to descriptive statistics of units in each of the selected disciplinary areas. However, despite being commonly use in observational studies (especially in propensity score studies), univariate distributions of means do not guarantee the absence of bias in estimating the treatment effect.

Recent studies (Iacus et al, 2011) looking at the multidimensional histograms of the two samples (for treated and controls) introduce methods to check for multivariate balancing of their empirical distributions. They propose a measure of imbalance (L_1) that is the semi-sum of the

absolute differences between relative frequencies of treated and controls for each identified strata in our case. L_1 for the entire population is close to 1 (highly unbalanced distribution of treated and controls). This means that a substantial number of cells in the multidimensional matrix have zero controls (or treated). Comparing the L_1 of the matched population with the previous one provides evidence of the unbalanced reduction due to CEM. L_1 is equal to 0.19 after CEM, this means high rate of balancing between the populations of treated and controls (table 8).

L_1 – matched	L_1 - population
0,19	0.92

Table 8 - L1 matched and original population multivariate balance measures

We then plot parallel coordinates plot as a visualization method for detecting patterns of matched and unmatched units in a multivariate setting. Looking at the subsequent graphs (3a and 3b), it appears that the full professor matching individuals are relatively well distributed between the considered dimensions; they belong to all the academic disciplines, produce a number of papers, with average citations and impact factor on ISI in the first bottom half of the distribution.

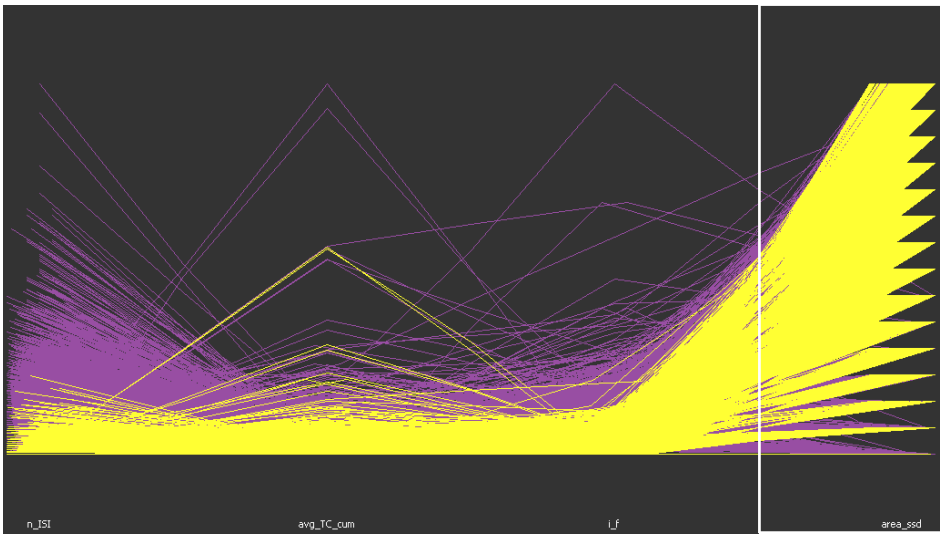


Figure 3a - Full Professors parallel coordinates plot across included covariates[8]

[8] Thanks to the open source software GGobi

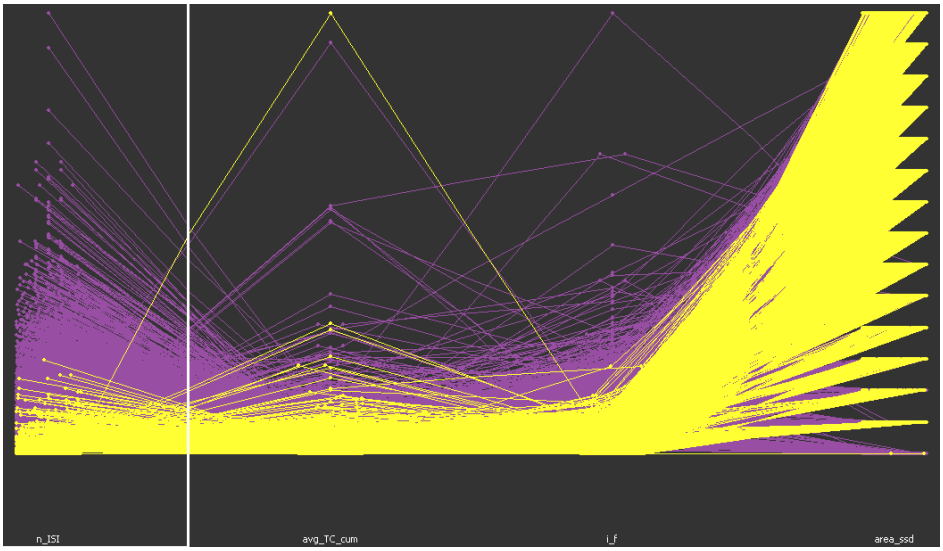


Figure 3b - Associates Professors parallel coordinates plot across included covariates[9]

On the other side of the story matched assistant professors are distributed as well in the first bottom half of the distribution between these dimensions.

We then fit both a standard treatment model and a growth longitudinal model (Overall et al. 1999; Howell et al., 2008) through the individual careers of treated and controls that allow us to identify a negative effect of decentralization on research slopes (impact and quantity) of selected individuals, for both associate and full professors.

Our motivation for using also a growth model is firstly because it is specifically designed for exploring longitudinal structure of the data. Moreover, in commonly specified generalized linear models, estimations are carried out forcing the pattern of covariances (or correlations) to be constant across time. This means that we require that all subjects in each group to change in the same way over time. This is an unrealistic assumption especially thinking of the heterogeneity of research patterns across individuals. The second reason to propose also a mixed model is that it allows for different lengths of measurements for different subjects. Thus inference is based on all available measures included in the data. Time can also be continuous, rather than a fixed set of points.

First, let us consider a model of the changes in logarithmic transformation of research output y_i across time as a function of treatment group, time and the interaction of treatment and time:

$$ln\_y_{it}=\beta_0+\beta_1*time_{it}+\beta_2*treat_i+\beta_3(treat_i*time_{it})+v_{0i}+v_{1i}time_{it}+\varepsilon_{it}$$

where ln_y_{it} is the log-transformation of research output (impact factor, n° of paper on ISI etc). β_0 is the mean of the dependent variable of all the selected individuals at time zero (sixth year). The term $time_{it}$ is a time variable with values from -5 (at time of selection) to 0 (at the sixth year

[9] Thanks to the open source software GGobi

after selection) for each individual *i*. So, in terms of its representation, this model could be divided into a within-subject model:

$$ln\_y_{it}=b_{0i}+b_{1i}*time_{it}+\varepsilon_{it}$$

and the between-subjects model:

$$b_{0i}=\beta_0+\beta_2*treat_i+v_{0i}$$

$$b_{1i}=\beta_1+\beta_3*treat_i+v_{1i}$$

With this econometric characterization of treatment and time effects, we can interpret the parameters as follows: β_0 is the average of log-yi at time 0 (sixth year after selection) for the untreated group (nationally selected individuals, where treat=0); β_1 is the average trend across time for the untreated group (treat=0); β_2 is the average difference in log-yi at the sixth-year after selection between centrally and nationally selected professors; β_3 represents the average difference in trend lines between treated and untreated. Furthermore this regression model allows each individual to deviate from the owning group trend line in terms of final intercept (v_{0i}) and time-trend across time (v_{1i}).

6 Empirical Results

Significant negative effects regarding local selections on both final outcomes level (β_2) and slope differences (β_3) are estimated for impact factor outcomes in both career steps. Local selection negative effects are statistically significant only for slope differences with the quantity measure of international research.

		Growth model		***Pre94 vs. After2000 growth model***	
Parameter	**treat**	***log impact factor***	***log n°of ISI products***	***log impact factor***	***log n°of ISI products***
intercept		0,302*** [0,035]	2,197***[0,066]	0,552*** [0,044]	1,98***[0,072]
time		-0,026** [0,010]	0,126*** [0,020]	-0,011[0,016]	0,21*** [0,026]
treat	**0**	0,077*** [0,017]	-0,051 [0,034]	0,137*** [0,027]	-0,201*** [0,043]
treat	**1**	.	.	.	.
time(treat)	**0**	0,081** [0,011]	0,0199*** [0,020]	0,008[0,027]	0,035 [0,043]
time(treat)	**1**	.	.	.	.
treat a vs b intercept		-0,077*** [0,0017]	0,051 [0,034]	-0,137*** [0,027]	0,201*** [0,043]
treat a vs b slope		-0,081*** [0,011]	-0,0199*** [0,020]	-0,008 [0,027]	-0,035 [0,043]
Pr > ChiQuadr		<.0001	<.0001	<.0001	<.0001
Obs.		6.362	6.362	5.111	5.111

Table 9 - *significant at 10%; ** significant at 5%; *** significant at 1%, standard errors in brackets, Associate Professors model with region and scientific discipline controls included

Table 10 provides evidence of a treatment effect on the careers of full professors (sixth year after selection). Both final research impact and impact slopes are statistically significant and

negative. Newly hired associate professors have fewer incentives to produce high quality papers in the subsequent years. The "number of papers" outcome highlights a negative difference in slopes (better for untreated) and no significant difference in the final quantity level.

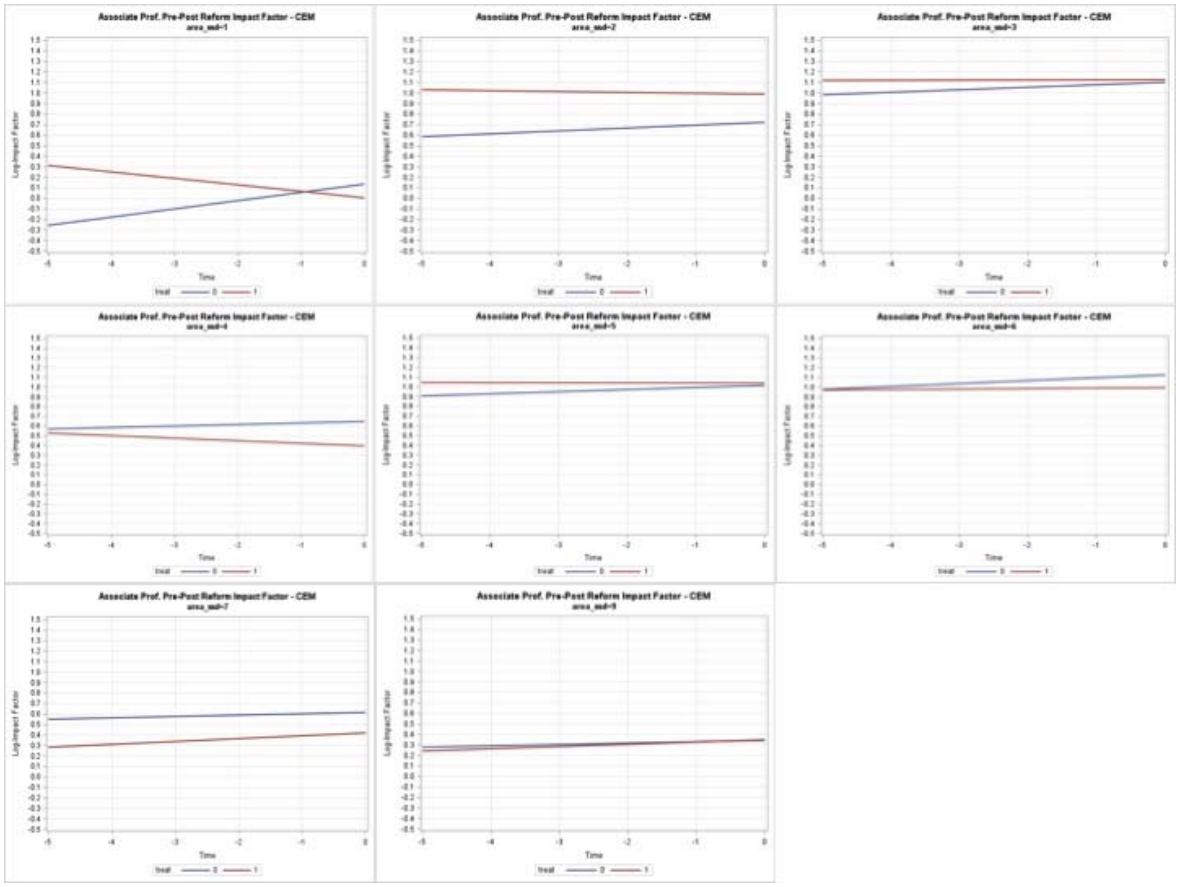
Parameter	treat	*log impact factor*	*log n°of ISI products*
time		0,014*** [0,0044]	0,159*** [0,0066]
treat	**0**	0,129*** [0,0465]	0,014 [0,087]
treat	**1**	.	.
time(treat)	**0**	0,014** [0,0063]	0,051*** [0,0094]
time(treat)	**1**	.	.
treat a vs b intercept		-0,129*** [0,0465]	-0,014 [0,087]
treat a vs b slope		-0,014** [0,0063]	-0,051*** [0,0094]
Pr > ChiQuadr		<.0001	<.0001
Obs.		3.090	2.763

Table 10 - *significant at 10%; ** significant at 5%; *** significant at 1%, standard errors in brackets, Full Professors model with region and scientific discipline controls included

The effects are robust on pre-1994 vs. after-2000 professors (used as controls of the incentive schema due to the possibility of mixed incentives for people selected as associates after 1994 but before 2000 with national procedures, and applying as full professors with the local mechanism. The model results by each of the selected disciplines (table 11) shows the negative effects of local recruitment process over Math and Computer Science, Earth Sciences, Medicine and Agricultural and Veterinary in terms of final impact factor level (sixth year after selection) of associate professors. The slope is negative and significant only in the Match and Computer Science area. Both estimates of the standard regression model and growth model are basically consistent.

Academic Discipline		**Regression model**			**Growth model**		
		Estimate	*Std.Errors*	*Obs.*	*Estimate*	*Std.Errors*	*Obs.*
Math and Computer Sciences	treat	-0,13***	0,042	537	-0,15***	0,034	537
	time(treat)	-0,013	0,014		-0,014***	0,015	
Physics	treat	0,22	0,133	151	0,31	0,17	151
	time(treat)	-0,057	0,042		-0,036	0,12	
Chemistry	treat	0,03	0,035	348	0,021	0,049	348
	time(treat)	-0,0039	0,011		-0,024	0,042	
Earth Sciences	treat	-0,22***	0,099	270	-0,17***	0,11	270
	time(treat)	-0,049	0,035		-0,038	0,09	
Biology	treat	0,04	0,014	620	0,085	0,071	620
	time(treat)	-0,015	0,061		-0,024	0,068	
Medicine	treat	-0,11***	0,044	1703	-0,12***	0,045	1703
	time(treat)	-0,015	0,015		-0,025	0,043	
Agricultural and Veterinary	treat	-0,19**	0,013	1371	-0,20**	0,051	1371
	time(treat)	-0,037***	0,051		0,0143	0,05	
Industrial and Information Engineering	treat	-0,028	0,029	2728	-0,011	0,029	2728
	time(treat)	0,003	0,011		0,007	0,028	

Table 11 - * significant at 10%; ** significant at 5%; *** significant at 1%, standard errors in brackets, Log of impact factor Associate Professors model by discipline with region controls included.



Log of impact factor Associate Professors growth lines by academic discipline with region controls included.

7. Conclusions

Heterogeneity is endemic in the Italian University system and it is not a surprise to obtain different results across academic disciplines; heterogeneity within scientific areas makes not possible to generalize the results to the entire Italian Academia. To account for these considerations, as well as data availability issues for international oriented research outcomes, we focus our analysis on the "hard sciences" only. We find shrinking individual research productivity (both in terms of slopes and six-year levels) due to local selection mechanisms (with respect to national ones). Lower incentives for publishing on international top-level journals are associated with the decentralization reform.

In sum, the main results are the following:

- we found negative effects of decentralization on both final outputs levels and slopes for impact factors of both associates and full professors. The results were statistically significant and negative only for slopes the N° of paper on ISI (both for associates and full professors)*;

- Differentiating by research areas, the negative incentives of local selections six years after selection research levels are statistically significant in the: Math, Earth sciences, Medicine, Veterinary and Agricultural Sciences;
- Differentiating by research areas, the negative incentives of local selections on slopes are significant only in Math and Agricultural and Veterinary areas ;
- Effects are robust on pre-1994 vs. after-2000 professors (used as controls of the incentive schema due to the possibility of mixed incentives for people selected as associates after 1994 but before 2000 with national procedures, and applying as full professors with the local mechanism);

However credible results are available for "hard sciences" only, due to the higher exposition of these disciplines onto the international research area (collected in ISI). Arts and Humanities and Social Sciences could not be tested due to the inconsistence of available data;

We also have no data on the relative importance of teaching and research as the two main dimensions of academic recruitment (this is one research objective we expect to investigate in the future). The effort of candidates is usually divided on both these activities in the years before each *concorso,* and it is likely the case that most universities in the last decade judged candidates with respect of both their level of research outcomes (quantity and impact) and teaching. The shrinking incentives in the research dimension due to decentralization are certain, yet we know very little about teaching incentives.

These identified problems probably arise from the scarcity of competition between universities in Italy. An insufficient mobility rate of professors within the country (typical of local mechanisms), the predominance of institutional needs (both in research and teaching), and the preeminence of a small number of academic "schools" with respect to others, all have had a negative impact on research growth paths of local recruited researchers. No penalties were associated with collusive behaviors, and the lack of competitiveness between institutions is endemic in the Italian university system. This is probably due to the "false-autonomy" of universities where salary levels and teaching loads are centrally regulated (by MIUR).

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