Incentives and Careers in Academia: Theory and Empirical Analysis*

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Abstract

We study career concerns in Italian academia. We mould our empirical analysis on the standard model of contests, formalised in the multi-unit all-pay auction. The number of posts, the number of applicants, and the relative importance of the criteria for promotion determine academics' effort and output. In Italian universities incentives operate only through promotion, and all appointment panels are drawn from strictly separated and relatively narrow scientific sectors: thus the parameters affecting payoffs can be measured quite precisely, and we take the model to a newly constructed dataset which collects the journal publications of all Italian university professors. Our identification strategy is based on a reform introduced in 1999, parts of which affected different academics differently. We find that individual researchers respond to incentives in the manner described by the theoretical model: roughly, more capable researchers respond to increases in the importance of the publications for promotion and in the competitiveness of the scientific sector by exerting more effort; less able researchers are discouraged by competition and do the opposite.

JEL Numbers: D44, I23, I21, M51

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1 Introduction

Like other economic agents, academics operate under incentives: understanding how they respond to them, beside its independent interest, is indispensable background to any attempt to improve the behaviour and performance of the university sector. In this paper we show how the incentive provided by career concerns influenced the effort and the output of the academics working in Italian universities in the years between 1990 and 2011.

During this period, the Italian university sector followed a complex system of nationally mandated rules, designed to narrow the scope for cronyism by increasing transparency and minimising the room for discretion. While following the principle common to other university sectors that advancement decisions be based on peers' subjective judgement of a candidate's quality, these detailed rules distanced Italian academia from the standard theoretical framework of the academic labour market (e.g. Carmichael 1988, or Siow 1998). For example, appointment, tenure, and promotion decisions were minutely regulated, pay was fully determined by rank and seniority, teaching duties were uniform, there was no review of performance, promotions determined only a small non-negotiable pay rise, horizontal moves could not raise pay, dismissals for low productivity were non-existent in practice. The combined effect of these rules is to make the incentive scheme on the whole rather weak (Perotti 2008). But at the same time, the very meticulousness of the rules and their uniform scrupulous application across universities and subject areas ensure that academic conditions in Italy can be captured accurately and consistently, modelled formally, and measured empirically in a precise manner.

We model academic careers as contests in an uncertain environment, along the lines of Lazear and Rosen's (1981) model of progression in an organisation's hierarchy. The set of rules regulating the careers of Italian academics can be captured formally as an all-pay auction for multiple units (Barut et al 2002). In this model, bidders compete to be awarded one of K identical prizes, with all bidders, winners and losers alike, paying their bid, and the highest K bidders receiving one of the K prizes. Siegel's (2009) comprehensive review notes that the cost incurred by the participants can be monetary, as is the case for the expenditure on R&D where the prize is the award of a patent (Grossman and Shapiro 1986), or it can be a utility cost, given by the exertion of effort, as in Baye et al's (1993) and Anderson et al's (1998) models of lobbying and rent-seeking respectively. In the Italian academia, effort is exerted to carry out research, and the prizes are the promotions to positions in the next rung of the academic ladder, which are fixed in number.

The auction model at the basis of our analysis hinges on competitors knowing the relevant parameters affecting the competitive conditions: these are (i) the number of available posts, (ii) the number of potential competitors, (iii) the relative importance attributed by the appointment panel to the quality and quantity of the publications and to other academic activities, (iv) and the distribution of their competitors' characteristics. Because of the narrow channelling of the academic careers into a large numbers of separated paths, and of the very long temporal gap between appointment rounds recorded in practice (about four years), it is very plausible to assume that the professors in a given rank in a given scientific discipline were able to form a fairly precise measure of these parameters. The theoretical model of Section 2, therefore, assumes that academics choose their effort, which maps monotonically and deterministically into their output, on the basis of this information. It predicts that different individuals respond differently to changes in the competitive conditions: broadly speaking, more productive academics are encouraged by competition, less productive ones are discouraged. These conclusions are confirmed by our empirical analysis, which uses a newly constructed large dataset, that matches administrative data on all the individuals who have held a post in an Italian university at any time between 1990 and 2011, with all the articles they have authored in that period in journals listed in the Web of Knowledge dataset. Because there are three levels in academic hierarchy, we can run two separate regressions, one studying the assistant professors competing to become associate professors and the other the associate professors competing to become full professors. These obtain similar results, which moreover are robust to changes in the definitions the variables and in the specification of the model.

The analysis is conducted via a panel estimation with fixed effects for individual academics: because the competitive conditions – the importance of publications, the number of posts, the number of competitors, and an academic's position in the ranking of the people competing for these posts – change from period to period, we estimate the effort exerted by an academic relative to the effort of that same academic in different competitive conditions. The fixed effects estimation factors out the influence of the "type" posited in the theoretical analysis, which accounts for attitudes, skill, education and other idiosyncratic determinants of effort. One would expect these to remain relative constant across a person's lifetime, and, encouragingly, we find strong serial correlation in an academic's individual fixed effects (see the discussion Figure 10, at the end of Section 7). This is a confirmation of the soundness of our empirical strategy to assess the theoretical model.

Our identification strategy hinges on one important detail of the reform of appointments and promotions rules which came into force in 1999, right in the middle of the period we study, namely a cap on the number of applications a candidate could make in each year. This cap , as we show in Proposition 2, alters two of the parameters affecting the competitive conditions, the number of posts and the number of competitors, for some academics, but not for others, in a way that is likely unrelated to other unobservable characteristics determining their effort. Moreover, while the decentralisation of the appointment process could have been predicted in advance, and hence could have affected a person's early life choice of the narrow research area, the cap on the number of applications was unexpected, intended to reduce to workload of the panels. It was also blunt, it imposed a cap of five publications per year, and has therefore some of the features of a natural experiment. We show that this aspect of the reform does indeed affect academics in exactly the manner predicted by the theoretical model. In addition, we implement an instrumental variable strategy where the other relevant characteristic of the competitive environment, the importance of refereed publications, is linked to the homogeneity of the group of the full professors in the narrowly defined research area where competition takes place, who are the decision makers for these appointments. A small group of professors with similar records is more likely to agree on subjective criteria as a determinant of promotion, but it seems unlikely that their homogeneity should affect directly the individual effort of the associate and assistant professors competing for promotion.

The paper is organised as follows. Section 2 applies the standard all-pay multi-unit auction to the study of academics' career concerns. Our data is described in Section 3, with the details of how we construct the variables in Section 4. The empirical strategy and its econometric specification are explained in Sections 5 and 6, respectively. Section 7 presents our empirical results, and Section 8 concludes the paper.

2 Theoretical background

A simple extension of the multi-unit all-pay auction model developed by Barut et al (2002) serves well as a stylised model of competition and academic career progression in Italian universities. This is developed fully in Checchi et al (2014), and here we summarise the results relevant to the present analysis.

As we explain below, the Italian academic sector can be quite accurately described as a set of separate populations of academics. The N academics in the representative population all work in the same research area, and compete for promotion to the next rung of their career ladder by exerting costly effort to produce output. In a subsequent stage, K professorships across all the universities in Italy are advertised simultaneously, and the N candidates, labelled $i = 1, \ldots, N$, apply for the posts; they are then assessed by a centrally nominated panel, who appoints simultaneously all the new post holders (see Section 3 below and Appendix B for the details of the process). They incur their effort cost whether or not they are successful, hence our choice of the all-pay auction.

Compared to the set-up of an auction, there are two additional sources of uncertainty on the road from effort to promotion. First, academics exert effort well in advance of the opening of the relevant vacancies, and so, when they choose effort, they do not know for certain the criteria which will determine their likelihood of being appointed. A second layer of uncertainty is the stochastic nature of the link between effort and output: whether a given article is accepted in that prestigious journal, is, as we all know, partly due to luck. Checchi et al (2014) assume risk neutrality throughout, and simplify the model to a static deterministic set-up, where effort translates instantly and deterministically into output.[1]

Research output depends on effort. Candidates differ in their cost of effort: the model assumes that, prior to their choice of effort, each academic is assigned by nature a idiosyncratic parameter, her "type", $v_i \in [\underline{v}, 1]$, with $\underline{v} \in (0, 1)$, randomly drawn from a uniform distribution $F : [\underline{v}, 1] \to [0, 1]$, the same for all candidates. v_i may include innate ability, and variables determined before the beginning of the academic career, such as the place or field of study. It seems natural to assume that, within the research area, the draws for different individuals are not correlated, which makes their interaction a private value auction. The parameter v is private information, and therefore it is conveniently captured by the individual fixed effect in the empirical analysis.

If candidate i exerts effort $b_i \in \mathcal{B} \subseteq \mathbb{R}_+$, then she incurs a utility cost given by b_i / v_i. Being inversely related to the utility cost of effort, v_i is therefore a measure of individual i's *efficiency* in research, and we also refer to it as an individual's *productivity*. The benefit of being promoted is normalised to 1, and we assume that candidate i chooses b to maximise the difference between the expected benefit and the cost of effort. A

[1] They derive this from a dynamic model where risk-neutral academics have rational expectations about the future values of the relevant variables and the nature of the link between current effort and future output. With rational expectations, candidates are able, on average, correctly to anticipate the relevant characteristics of the competitions they will enter, and so evaluate the expected benefits of effort; with risk-neutrality expected and future benefits determine incentives and can be left implicit in the presentation.

strategy for candidate i is thus a function $B : [\underline{v}, 1] \to \mathcal{B}$, which associates the type v_i to the effort level exerted.

Effort may be directed towards a variety of academic activities, only one of which is publications in international refereed journals. A person's chance of promotion may depend also on more subjectively assessed activities, such as teaching, the influence of books published, administration, and perhaps also seeking out influential friends and networks, as it might cross the readers' mind who are familiar with Italian academia. The relative importance of international publications and these other activities, denoted by $x \in [0, 1]$, may vary from research area to research area. In general terms, it depends on the preferences and the relative clout of the members of the cohort of senior professors in the various research areas, among whom the panel will be chosen.[2] The competitive conditions faced by those vying for promotion also affect their behaviour. We capture them with the parameters K and N, defined above as the number of posts and the number of candidates.

The analysis in Checchi et al (2014) can be summarised in the following result.

Proposition 1. *The optimal strategy for candidate of type i is to exert effort level given by:*

$$B(v_i) = x \int_{\underline{v}}^{v_i} y Z'_{KN}(y)\, dy, \tag{1}$$

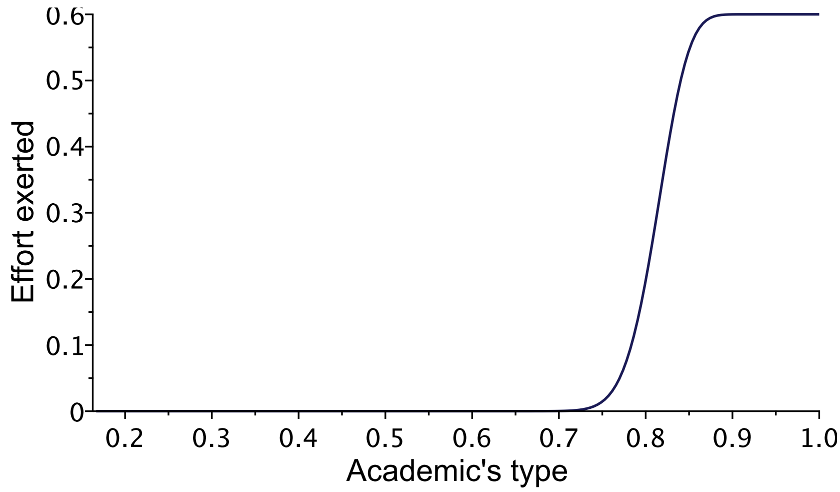
where

$$Z_{KN}(b) = \sum_{j=N-K}^{N-1} \frac{(N-1)!}{(N-j-1)!j!} F\big(V(b)\big)^j \Big(1 - F\big(V(b)\big)\Big)^{N-j-1}. \tag{2}$$

The proof is in Barut et al's (2002) and the online Appendix A details the changes to adapt it to the present set-up. In (2), $V(b)$ is the inverse of the function B, which associates bids to types. Existence of the inverse follows from monotonicity, the argument for which is standard. The above expression is a straightforward adaptation of Eq. (2) in Barut et al (2002, p 679). The function $Z_{KN}(b)$ is the probability that a candidate who exerts effort b is successful when there are N posts and K competitors, when all *other* candidates follow the bidding function $B(v_i)$ given in (1), and when the distribution of types is $F(v)$.

[2]For example, if teaching is highly valued by the potential members of the panel, then rational candidates will "shift" their effort from research to teaching. De Philippis (2015) carries out an empirical analysis of the teaching research trade-off for professors at Bocconi University in Italy. Becker (1975) and (1979), or Mankiw (1998) among others have suggested that there might be complementarities in the individual "production function", that is that by doing research one becomes a better teacher and vice versa, generating a positive correlation between teaching and research. This correlation could alternatively be a spurious one, with an unobserved underlying variable "academic talent", which improves output in both activities (De Fraja and Valbonesi 2012).

Figure 1:
Equilibrium effort by ability type

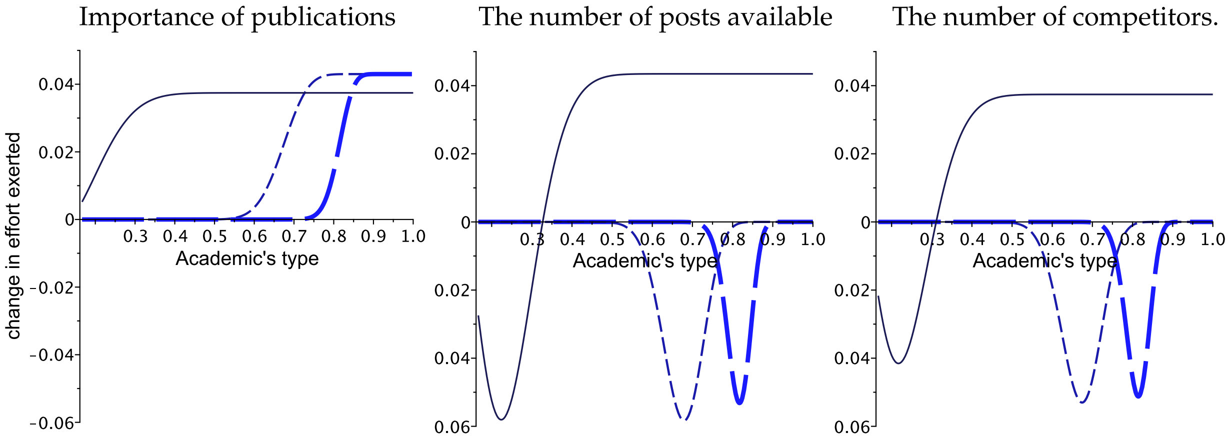


Note: The vertical axis measures the effort exerted by academics of different types, for the values of the parameters close to the average sample values: fixed $N = 150$, $K = 25$, and $x = 0.6$.

If $Z'_{KN}(b)$ did not vary with x, then the effort exerted by each candidate type would be proportional to a function of the competitive conditions. But because x appears in $V(b)$, then (1) and (2) determine an algebraically complex relationship between the effort b and the parameters x, K, and N. We compute this relationship for specific values of the parameter to understand how it changes in response to changes in exogenous conditions. We do so in Figure 1, which plots the equilibrium effort level (1), and in Figure 2, which shows how it changes following changes in x, K, and N. In both figures, which are drawn in the special case when the density is constant and so given by $\frac{1}{1-\underline{v}}$ for $z \in [\underline{v}, 1]$, the horizontal axis shows an academic's type $v \in [\underline{v}, 1]$, when $\underline{v} = 0.15$. In Figure 1, the vertical axis measures the effort exerted as a function of the academic's type, and the parameters are chosen to be close to their average values in the sample, given below in Table 3, $N = 150$, $K = 25$, $x = 0.6$ In Figure 2, the vertical axis shows the *change* in the effort exerted by a type v_i academic as a consequence of an exogenous change in one of the parameters, given in the caption to the Figure. The parameters are the same as in In Figure 1, with N increasing as the line becomes thicker from a very low $N = 33$ to $N = 80$, to the sample value shown as the thickest one at $N = 150$.

Note first of all the striking non-linearity of all the curves; academics of different types respond very differently to changes in exogenous conditions. In Section 6, we design our estimation strategy to capture these differences. The effect of changes of the

Figure 2:
Changes in the parameters



Note: Effect on effort of changes in the three exogenous variables. In each panel, the baseline values are $x = 0.6$, $K = 25$ and three values of N, which increases from 33 to 80 to 150 as the line gets thicker and the dash longer. The LHS panel shows how effort changes as the importance of publications increases by 0.043 from the baseline to 0.557. In the middle panel the number of posts decreases by 3%; and in the RHS panel the number of competitors increases by 4%.

importance of publications in the determination of the winners, given by an increase in x, is illustrated in the LHS panel of Figure 2. All types increase their effort, with the effect varying considerably according to the academic's type: productive types respond more strongly, and the range of types who respond strongly depends on the degree of competition. When competition is tough (high N, thick line, long dashes), the increase in effort is concentrated among the most productive types. As competition decreases, more academics increase their effort, though the increase flattens out for the most productive academics, so that the proportional increase in effort is highest for intermediate types. These are testable predictions.

In the other two panels, we show the effect of changes in the competitive conditions. In the middle panel, a decrease in the number of posts; and in the RHS panel an increase in the number of competitors. Not surprisingly, these two figures are similar. We can see that an increase in competition, a lower value of K or a higher values of N, decreases effort, except for productive academics when competition is relatively low to begin with, see the thin solid lines in the middle and the RHS figures. The effect, however, is not evenly distributed: there is a middle range of types who respond more strongly, by reducing more their effort in the face of stiffer competition. This middle range itself shifts towards more productive types when competition increases, compare the troughs as the line becomes thicker, indicating stiffer competition. Also note how, when competition is low enough, productive types *increase* their effort in response to an increase in competition, as the thinner curves show in the middle and the RHS panels.

Upon reflection, these comparative statics effects are intuitive. There are N competitors for K posts. For all types, an increase in effort increases the likelihood of gaining a position in the order. But the change in the cost-benefit balance of a decrease in competition is different for different types, and this generates different responses to change in the exogenous conditions. The reason is the only gain that matters is being K-th instead of $(K+1)$-th: in any other position in the ranking, the higher likelihood of climbing in the ranking – whether above or below the threshold – is wasted effort. The incentive of an extra post is highest for those who are more likely to be at the $(K+1)$-th position: since productive types are very likely to end up high up in the ranking, they will be around the threshold position only if many of their competitors have also drawn a very productive type, the chance of which is low, and so they do not change effort much. By the same token, the least productive academics exert very little effort to begin with and so are quite below the $(K+1)$-th position, and the encouragement effect of the higher chance of winning is very small. Middle types are instead quite likely to be around the "borderline" position, where gaining one place in the ranking is the difference between being appointed and not being appointed, making their effort more likely to be useful and so increasing it in equilibrium as competition becomes softer.[3]

We end this section by collecting the results illustrated in this discussion of Figures 1 and 2 into a formally stated conjecture, which constitutes the basis for our econometric strategy.

Conjecture 1. *(i) An increase in the importance of publications increases effort; the strength of the effect increases for more productive academics, but at a decreasing rate for very productive academics. (ii) An increase in competition decreases effort for less productive academics. (iii) This effect is strongest for academics with an intermediate value of the productivity parameter, and this intermediate range of types is shifted to the left when competition is weaker (iv) Productive academics exert more effort as a consequence of an increase in competition, unless competition is high.*

[3]The situation is reminiscent of the discouragement effect of the follower in patent races, noted by Fudenberg et al (1983), whereby the follower, less likely to win the race, reduces its R&D investment. Our empirical analysis does suggest that this discouragement effect is present in our data, see below, section 7, in particular Figure 7.

3 Data

The theoretical analysis gives a number of predictions on the effort exerted by candidates to improve performance in a given dimension as a function of a number of observable variables: the importance of the observable dimension of output for promotion, which is given by the variable x, the competitiveness of the sector, determined by the variables K and N, the legal environment which shapes the incentive mechanism, and the distribution of types of the potential applicants for promotion.

Proposition 1 above shows that the effort exerted by academics is a strictly increasing function of their type, given by the parameter measuring their utility cost of effort. However, neither type nor effort are observable directly in the data we have. We use the immediate consequence of Proposition 1 that in turn output is a strictly increasing function of effort, and the lack of an independent measure of effort, to posit the normalisation that one "unit" of effort produces precisely one unit of output.[4] That is we proxy effort with output, and we use this proxy for effort as the dependent variable in our econometric strategy. This will therefore be based on the following equation:

$$o_{its} = \alpha_0 + \alpha_x x_{ts} + \alpha_K K_{ts} + \alpha_N N_{ts} + \gamma_C C_{ts} + f_i + \xi_t + \sigma_s + \zeta_u + \varepsilon_{its}, \qquad (3)$$

where o_{ist} is the output of academic i, who, in period t, is in scientific sector s. x_{ts}, K_{ts}, and N_{ts} are (functions) of the importance of publications, the number of posts, and the number of competitors in scientific sector s in period t. C_{ts} is a vector of time varying controls, which include the share of women, the average age of the competitors, the share of the appointments from outside Italian academia, and two homonymy dummies defined below in Section 4.4. The fixed effects included in (3) account for unobserved differences among individuals, f_i, periods, ξ_t, scientific sectors, σ_s, and universities, ζ_u.

We describe in detail our data in the rest of this section, and in Section 4 below we explain how we constructed these variables from the data.

Our data comes from three sources, one collecting individuals, one their journal publications, and the third the outlets where these appear. Information on individu-

[4]One potential pitfall of this normalisation is that the ranking of type and output is not robust at the lower end of the type distributions, as shown in Figure 1, which shows that, for the typical parameters of the sample, the effort and output of types below the median is similar. In our set-up this is not a problem: many individuals in the lower half of the distribution have identical outputs, and so they are assigned the same rank, that is the same type. Secondly, the regressions we report in the Tables group together all individuals ranked below the median in their scientific sector.

Table 1:
Number of professors by rank: 1990 and 2011.

	1990			2011		
	Assistant	Associate	Full	Assistant	Associate	Full
Number	15,158	14,542	12,006	24,596	16,618	15,244
Average age	39.62	47.85	52.68	44.93	52.55	58.64
	5.55	6.69	7.79	8.32	8.13	7.20
Share females	0.41	0.25	0.10	0.45	0.34	0.19
Share WoK	0.59	0.62	0.59	0.68	0.61	0.69

Note: Standard deviation of age under the corresponding average. Share WoK is the proportion of professors with at least one publication in the WoK dataset.

als is the administrative data from the Italian Ministry of Education, University and Research (MIUR). The data contains information on everyone who held an academic position in Italian universities, public or private,[5] 81,399 individuals in total. For every year from 1990 to 2011, it reports everyone's age and sex, their scientific sector, their university affiliation, and their academic rank. With a handful of exceptions, every person in the dataset has one of three ranks: assistant professor (*ricercatore*), associate professor, and full professor (*professore di seconda* and *di prima fascia*, respectively). A change in a person's rank from one year to the next implies a promotion in the intervening year. Table 1 presents two snapshots of the aggregate faculty in Italian universities, at the beginning and at the end of the period we study. Table A4 in the appendix breaks down this aggregate picture by broad disciplinary area, and throughout the period.

Once appointed, academics are tenured after a brief probation period. Some individuals exit the system before then; if they do so to pursue outside work opportunities, such as a career in a foreign university, then they may face different incentives from those provided by the promotion process considered here, embodied in the three variables K, N, and x. However, as we explained in detail in Section C.4 in the Appendix, early exit is a rare event for assistants and associate professors, whose effort we aim to explain.

At any given moment, each academic is allocated to one – and only one – of 371 "scientific sectors" (*settore scientifico disciplinare*), strictly separated from each other and created at central level. There was no requirement that all members of a faculty or of a department had to belong to the same scientific sector, and it was not uncommon for a professor in a scientific sector to be in a faculty not closely related to his/her research

[5]At the end of 2012, the sector comprised 96 institutions (cercauniversita.cineca.it/index.php) collectively enrolling 1,751,186 students (statistica.miur.it/ustat/Statistiche/IU_home.asp) and employing 54,931 academics and 56,653 non-teaching staff. Public funding exceeds €7bn. The overall cost of tertiary education (including private expenses) is estimated at €14.8bn, 1% of GDP in 2010 (OECD 2013, Table B2.1).

interests. These sectors are very important for career progression, as appointments, promotions, and all other evaluations are carried out within each scientific sector. For example, if it is decided that a professor in sector SECS/P02 should be appointed at the University of Bologna, then the appointment panel for this post will be composed exclusively of professors from the same sector.[6] These scientific sectors are fairly small, their average number of full professors is 43, the standard deviation is 46, and the size distribution is skewed, see Figure A1 in the Appendix.[7] They are very stable in composition: in the period we consider, only 1,504 assistant professor and 930 associate professors, respectively 3% and 2.4% of the total, change scientific sector either before or upon promotion, more detailed data is in Table A4 in the Appendix. Their small size and the stability of their composition make each scientific sector a "small world" where everyone knows everyone else, and suggests that our assumption is not far-fetched that candidates are able to form an accurate assessment of the preferences of the likely membership of the promotion and appointment panels.

Even though universities were given in the 1990s some managerial and financial autonomy, university professors maintained their status of public employees: pay scales[8] and career progress were uniform across the country, mechanically determined on the basis of seniority and age, and no merit pay was possible.

Academics had to be hired through public "competitions", with rigid and uniform rules. All new posts for full and associate professors were authorised by the government, and advertised simultaneously in all subject areas for all universities (assistant professor positions were filled with a local interview process analogous to the US and UK). Up to the end of the 90s, academics seeking to be promoted made a single application, valid for all posts; this rule changed at the end of the century, as we explain below, in Section 5.3. These national calls happened at approximately four yearly intervals, as illustrated by Table 2. In theory, anybody could apply, though in

[6]With the exception of very small scientific sectors, where there might not be enough qualified professors: professors from similar scientific sectors would be seconded in this case. Some of the panel members may be associate professors (only in the associate professor appointments), some may be in post at the University of Bologna some in post elsewhere, depending on the rules in force at the time the vacancy opens.

[7]To fix ideas, practically all Italian economists are in SECS/P01 "Economics", which comprised 341 full professors in 2007, SECS/P02 "Economic policy" (149 full professor in 2007), SECS/P03 "Public economics" (107), SECS/P04 "History of economic thought" (20), SECS/P05 "Econometrics" (32), SECS/P06 "Applied Economics" (63), SECS/P07 "Accounting" (229), SECS/P08 "Management" (176), SECS/P09 "Finance" (24), SECS/P10 "Human resources" (41), SECS/P11"Banking" (105), SECS/P12 "Economic history" (66), SECS/P13 "Commodity economics" (48 full professors).

[8]The salary scales were (and are) overlapping: the lower rungs of the full professor scale being well below the upper rungs of the associate professor's scale, although promotions maintained length of service so that did not imply a pay-cut.

practice potential applicants were academics in the lower rank in the same scientific sector, plus some from similar scientific sectors, and people from outside the Italian university system. Horizontal moves were not possible.

The government also appointed the selection committees for these posts, one each for the 371 scientific sectors. Selection committees choose all the appointees in their scientific sector,[9] in number equal to the number of posts. They did not, however, specify which academic would go to which institution: this was left to subsequent negotiations between "winners" and institutions.[10] These panels had considerable discretion in establishing criteria for promotion, in the spirit of the self-regulating academia, including the relative importance of outputs and activities such as teaching and contribution to the wider society.

In the set-up of the model, it is important to note that there were no "internal" promotions. Someone who had been in post as associate professor in a university had to wait for a full professor post to be advertised, and then apply to the national competition like everyone else. Universities simply did not have the legal authority to sanction a change of rank. This changed at the end of 2010, when another major reform (Law n. 240) introduced, among other changes, internal promotion, and made our model less applicable: for this reason, our analysis of career progress ends then.

The second data source is the record of research publications by Italian academics. We have obtained it from the web-version of the Thomson Reuters Web of Knowledge (formerly ISI, WoK hereafter).[11] This proprietary dataset indexes more than 12,000 journals in the fields of arts, humanities, sciences and social sciences.[12] For each article, the dataset reports the title, each author's surname and first initial, their affiliations, the journal where it appears, and the number of times it is cited by a WoK indexed publication. From this dataset, we have downloaded every article published in the

[9]These selection committees were formed using a combination of election (by peers) and random draw all full professors (for full professor posts) and all the full and associate professors (for associate professor posts), all *within each scientific sector*. Thus, for example, funding for 44 new associate professorships in economics was provided in 1996. The 44 holders of these posts were appointed by a nine person panel which worked in 1997/98. See Checchi (1999) for a detailed account of this process.

[10]Importantly, these negotiations did not affect pay in any way, as institutions had no freedom whatsoever to alter a person's salary, or teaching load, both being determined by law, pay according to the years of service. Institutions could not even refund moving costs.

[11]The main alternative bibliometric sources are Scopus and Google Scholar. Scopus has a less full coverage of the sciences (Klavans and Boyak, 2007). At the time of writing, Google Scholar has some reliability problems (López-Cózar et al 2014). At any rate, the literature comparing the Scopus and WoK databases (Archambault et al 2009) documents high correlations among the bibliometric measures derived from these different sources.

[12]Most of the analyses we have come across are carried out by economists on economists (Bosquet and Combes (2013) a recent contribution); among the exceptions, Kelchtermans and Veugelers (2011), and Dietza (2005).

Table 2:
Promotions and Appointments

Period	from Assist. to Assoc.	from Assoc. to Full	from Assist. to Full	from Outside to Assoc.	from Outside to Full
1990-1994	2,539	1,619	83	1,034	116
1995-1998	2,441	301	46	492	61
1999-2002	7,064	6,462	198	1,475	203
2003-2006	4,879	3,639	50	1,180	122
2007-2011	2,252	1,448	22	397	82
Total	19,175	13,469	399	4,578	584

Note: Number of promotions to associate and full professor in each period, according to the academic's previous rank.

period 1990-2011 where at least one author listed an Italian institution among their affiliations. This harvest yielded almost two million publications, which required a considerable amount of "cleaning" work, described in greater detail in Verzillo (2013). It seems plausible that in some scientific sectors publications in journals not included in the WoK, for example Italian journals, might be important from a career viewpoint. For these scientific sectors, publications in non-WoK journals are implicitly included in a person's other academic activities.

We have linked this dataset to the Journal Citation Report, also from Thomson Reuters, our third source of data. This allowed us to attach to every journal the impact factor over the years between 2008 and 2012, as well as the research areas where each journal belongs. Details of the procedure we followed are in Section C.5 in the Appendix. After cleaning the dataset, we are left with 1,142,971 papers.

The focus of our paper is on promotions: these are accurately determined as a change in rank in the administrative database described in Section 4.2. Table 2 summarises the number of promotions and appointments recorded in our dataset. Some individuals became associate or full professors without having previously held a lower rank post, see the last two columns in Table 2, which Table A3 in the Appendix breaks down by broad research areas. These were individuals working outside the Italian university system, in Italy or abroad. We exclude them from the estimations, because the incentives under which they operate prior to their appointment may differ from those operating in the Italian university system. We also exclude them from our sample individuals who change sector on promotion (as we mention, they are between 2% and 3% of our sample), as they may differ systematically from the rest of the population. So, to sum up, we run two separate regressions of (various versions of) equation (3), one for assistant professors trying to become associate, the other for associate professors trying to become full professor. In each of these two regressions, an academic is in the regression sample in period t if they are in the corresponding rank in period t, or if they are in the rank for the first time, and they were in a lower rank in period $t-1$. Section C.1 in the Appendix illustrates some examples.

4 Constructing the variables

4.1 Individual effort in a period

As explained, effort is proxied by output, and, we measure output as the count of the publications in WoK journals published by a given professor in a given period, weighted with a function of the number of authors. We follow Checchi's (1999) weighting, $\frac{1}{1+\frac{N-1}{2}}$, where N is the number of authors. This implies that having two papers with one co-author is a higher output than having one single-authored paper, and reflects the practice of forming a first impression of someone's vita by looking at its "length". Using the perhaps more straightforward weighting given by $\frac{1}{N}$ makes no qualitative difference to any of the results.[13] An alternative to a simple count is to weight publications with their importance, measured by the impact factor *ranking* of the journal. In view of the large differences of this measure in different research areas, a coarsely defined ranking seems preferable. Thus we assign a weight of 4 to a paper appearing in a journal in the top quartile in the impact factor ranking of all the journals in the 30 or so subdisciplines (defined by the Journal Citation Report as explained in Section C.5 in the Appendix), a weight of 2 to a paper in a journal in the third quartile, and a weight of 1 to a paper in a journal below the median, or with no reported impact factor.[14] The correlation between these two measures is 0.856, and hence it is not surprising that regressions run with either give very similar results, as shown by the comparison between columns 3 and 4 with 7 and 8 in Table 5.

Different disciplines have widely different standards regarding the quantity and type of publications, as anyone is aware who has sat in a university-wide promotion committee; Abramo et al's (2014) empirical evidence confirms that this is the case in Italy as well. For this reason we normalise each person's output with the average output of the full professors in the same scientific sector in the same period. Formally,

[13]Abramo et al (2014) suggest weighting differently the first and the last authors in science publications: we have calculated output with this weighting pattern for sciences, and obtained a correlation of 0.926 with our chosen measure of output, suggesting that our results would not change qualitatively with the Abramo et al weighting pattern.

[14]The correlation of our chosen weighting with other plausible ones is consistently well above 0.9. Taking a position in the ranking rather than the measure of the impact factor reduces the influence of differences in the impact factors of journals in different disciplines, documented among others in Althouse et al (2009). At any rate, we have also run our analysis weighting papers with the natural log of (1 plus) the journal impact factor, with no noticeable changes.

define o_{its} the output of person i in scientific sector s in period t. Let $\mathcal{P}_{it}$ be the set of publications by person i in period t; let $\mathcal{F}_{st}$ be the set of full professors in scientific sector s in period t. Finally, let w_p be the weight, by number of authors or by impact factor, of publication p. We measure o_{its} by

$$o_{its} = \frac{\sum_{p \in \mathcal{P}_{it}} w_p}{\frac{\sum_{f \in \mathcal{F}_{st}} \sum_{p \in \mathcal{P}_{ft}} w_p}{\# \mathcal{F}_{st}}}. \tag{4}$$

In (4), the numerator is person i's weighted number of publications. At the denominator, $\sum_{p \in \mathcal{P}_{ft}} w_p$ is the weighted number of publications written in period t by full professor f; this is averaged over all the full professors $f \in \mathcal{F}_s$ in the scientific sector s at the end of period t; recall that $\#\mathcal{F}_{st}$ denotes the number of elements in the set $\mathcal{F}_{st}$.

4.2 The number of posts, K_{ts}, and of competitors, N_{ts}

Since the determination of the index x uses the values of K and N, we describe these first. K_{ts} is the number of new positions available in period t in scientific sector s: this is given by the number of individuals who are promoted to a professorship in the period, or appointed from outside the scientific sector. Given that, during the period we consider, there was no separate channel for internal promotions, academics who changed rank without changing university were in fact competing with all those who held the same rank in the same scientific sector in different universities or outside the system. We do not observe the appointment process, and we derive K from the data simply as the number of all "new entries" into that rank.[15]

We do not have information on who applied for the available positions, and therefore we define N as the number of *potential* applicants, information which can be inferred from our dataset.[16] Recall that N matters because it affects the beliefs academics hold about the extent of the competition they face, not as the actual number of applicants: our assumption, therefore, amounts to each academic viewing all potential applicants as competitors. In detail, for the associate professorships, we calculate N_{ts} as the sum of three groups: (i) the assistant professors who are in scientific sector s during any year in the period, (ii) those that are assistant professors in the last year of

[15]Measuring the number of posts in this way would underestimate K if someone appointed in February leaves her post before December. This however is a very rare event, and so counting the number of new professors in a given rank is an appropriate proxy for K.

[16]This is unlike Bosquet et al (2013), and so our analysis should be seen as a reduced form of a two-stage model where individuals first choose whether to apply and, if they do, are chosen for appointment. Unlike Zinovyeva and Bagues (2015) and Zinovyeva et al (2017), we cannot control for the identities of the members of the appointment panel.

the previous period, and were appointed as associate professor in the initial year of the period, (iii) and the assistant professors who become associate professors in scientific sector s from being assistant professor in a different scientific sector. Likewise for full professor appointments: N_{ts} is the number of associate professor in scientific sector s, in any year in the period or in the last year of the previous period, plus the number of new full professors in scientific sector s who were not in scientific sector s, but excluding those who were appointed from outside the system. There are very few such appointments, and so excluding them does not alter our measure of N by much. Since the reason N matters is that it affects the effort of the other competitors, excluding these outside competitors implies that academics in a given scientific sector did not expect, at the time they choose their effort, these "outsiders" to be among their competitors. As a robustness test, we run the regression including them, with almost identical results, as shown in the last two columns in Table A7. For analogous reasons, we do not include as competitors for full professorships the assistant professors in the same scientific sector. This implies that the associate professors in a given scientific sector did not consider assistant professors as credible applicants for full professorships. This is plausible given the low number of direct promotions from assistant to full professor (see the last column of Table 2).

4.3 The importance of publications in refereed journals, x_{ts}

There does not exist an obvious measure for the importance of refereed international publications in an academic appointment process.

When the panel appoint K new professors from a pool of N applicants, they are performing a selection of K elements from a set of N elements. These elements, the candidates, can be ordered according to various measures of performance. We take as the measure of the importance of publications the "closeness" of the selection to the ordering determined by that which would be determined on the basis of a synthetic measure of their publication output. In the present context, for this to make sense, it is necessary to have a tool which can compare selections of different sizes from sets of different sizes. We develop elsewhere (Checchi et al 2018) precisely this tool, an "orderliness" index of arbitrary selections from arbitrary ordered sets, and in this paper we take this index as the measure of the importance of international publications. This index, constructed to satisfy a number of natural axioms, assigns to any selection from any set, a number between 0 and 1, in such a way that, given any two selections from any two ordered sets, if one selection is "closer" than the other to the selection that

Table 3:
Summary statistics for the variables used in the regressions.

		Assistant		Associate		Full	
		Mean	sd	Mean	sd	Mean	sd
Output		0.269	0.521	0.355	0.673	1.00	0.497
Output weighted with IF		0.391	1.122	0.514	2.047	1.00	4.160
Orderliness index		0.605	0.127	0.607	0.128		
Number of posts K		28.1	29.4	20.0	21.4		
Number of competitors N		164.8	141.2	145.1	120.6		
Average age in the sector		43.8	4.2	50.8	4.1	56.9	3.4
Share of women in the sector		0.418	0.186	0.299	0.177	0.162	0.139
Broad homonymy dummy		0.277		0.276		0.288	
Narrow homonymy dummy		0.007		0.006		0.007	
Sector:	Science	0.251		0.249		0.251	
	Medicine	0.129		0.130		0.126	
	Engineering	0.177		0.176		0.177	
	Arts, Hum. & Law	0.352		0.354		0.354	
	Social Sciences	0.091		0.091		0.091	
Region:	North East	0.228		0.216		0.220	
	North West	0.195		0.219		0.208	
	Centre	0.279		0.273		0.298	
	South and Islands	0.298		0.293		0.275	
Observations		127,078		107,939		89,757	

Note: "Mean" and "sd" are the values computed over the individual-period sample. Output for full professors is the reference value for the scientific sector, and so has mean identically 1. IF is the impact factor. The number of observations is professors times periods.

would be made if only the highest ranked elements had been selected, then the value of the index assigned to the first selection is higher than the value assigned to the second selection. The axioms specified in Checchi et al (2018) specify formally the meaning of "closer" and identify this index uniquely as:

$$x_{ts} = \frac{r_{ts,\max} - r_{ts}}{r_{ts,\max} - r_{ts,\min}}. \tag{5}$$

In (5), r_{ts} is the sum of the ranks of the candidates appointed in period t in scientific sector s, and $r_{ts,\max}$ and $r_{ts,\min}$ are the maximum and the minimum possible values that the sum of the ranks of the winners could take, which occur, respectively, when the K worst and the K best candidates are selected. Thus x_{ts} would be 0 in a scientific sector where all the appointees in a period have lower output (and so higher rank) than all the non-appointees ($r_{ts} = r_{ts,\max}$), and vice versa x_{ts} would take value 1 if all the winners had higher output than all the non-winners ($r_{ts} = r_{ts,\min}$).[17]

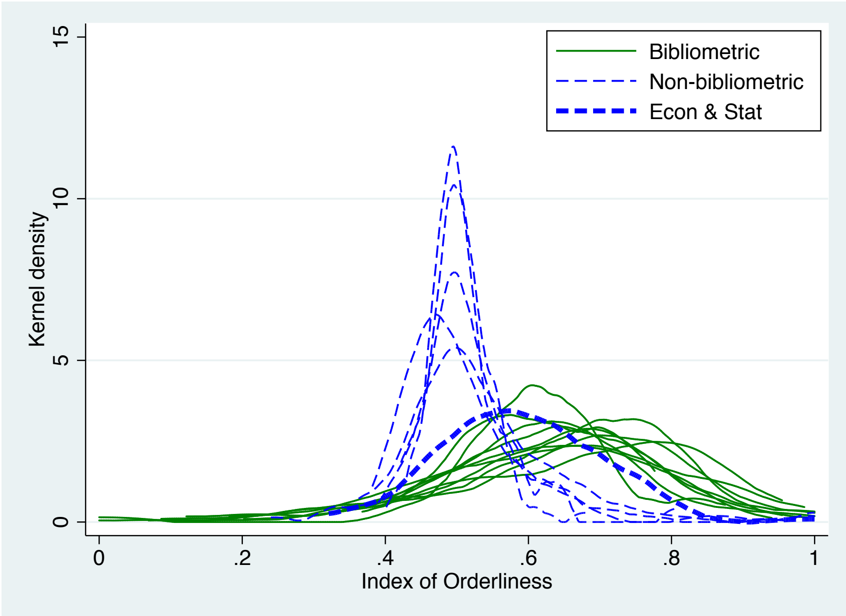
[17] Ties in ordering cause a problem when only some of the tied candidates are selected. When this happens, we simply rank the tied candidates randomly, and calculate the value of the index x for that sector for that period as the average calculated values for a large number of repetitions.

To calculate the index x_{ts} according to (5), we need to determine the ordering of the candidates in each scientific sector and each period. We do not construct this ranking using the measure of output developed in Section 4.1, which considers only the publications in the given period. This is because the appointment panels typically evaluate the contribution of candidates over their entire career, and also have discretion to judge the influence and importance of an applicants' work. We therefore combine information of past output with information on the importance of this output. In practice, to determine a person's ranking in scientific sector s in period t, we take the first factor of a principal component extraction of two measures: a candidate's *cumulative* output up to period t, and her *real* h-index[18] in the last year of period t, and so it is affected by productivity, seniority and influence. The cumulative output we use to determine a person's ranking among those competing for promotion in her given scientific sector in a given period is in general different from the measure of her output in the same period .We note here that the orderliness x of a scientific sector varies considerably from promotion to associate to promotion to full professor: the correlation between the two indices is 0.263.

So, to sum up, the importance of refereed international publications in scientific sector s in period t, x_{ts}, is calculated by first ranking all the N potential applicants in period t in scientific sector s, then by adding up the ranks of the K appointed candidates, the determination of K and N given in Section 4.2 above, and finally by applying the formula in (5). The variable x thus takes the same value for all academics in each scientific sector, and of course it varies from period to period; if it were calculated on the basis of the same information as the *individual* output on the LHS, it would be loosely analogous to the peer effect. It still differs from it in that it is calculated on the lifetime publication and citation record, whereas the individual output is determined only by the current period publications only. Table 3 reports the summary statistics for this index, but it is worth delving more into its distribution. In general, one would expect considerable differences in the value of this index for different scientific sectors, given that in some broad research areas publication in Italian language outlets may matter as much or more than international ones. It is therefore perhaps surprising that this remains the case *within* each broad research areas, as Figure 3 illustrates: this

[18]Recall that an author has index h if h of her N_p papers have at least h citations each, and the other $(N_p - h)$ papers have no more than h citations each (Hirsch 2005). The *real* h-index, a refinement proposed by Guns and Rousseau (2009, p 67, expression (6)), is the intersection of the 45° line in the Cartesian diagram with the number of papers ranked by number of citations on the horizontal axis, and the number of citations on the vertical axis and the line segment joining the least cited paper above the diagonal and the most cited paper below it. Further details can be found in the appendix.

Figure 3:
Kernel density of the index of orderliness by scientific sector.



Note: Kernel density of the index of orderliness in the scientific sectors within each of 29 broad research areas. The bibliometric vs non-bibliometric split reflects the classification made by the Italian government for the purpose of a later evaluation exercise.

could be due to correlation between overall quality of publications and quality of the international publications.

4.4 Dealing with homonymy

There are people with the same surname and initial. This creates two distinct problems. Firstly, there are professors who hold a post at an Italian university and who share surname and initial with an individual who appears in a paper with an affiliation in the same university without holding in that year a post of professor: typically PhD students, or post-docs, or medical doctors working in a university hospital. Secondly, there are individuals who share their name and first initial with another academic employed in the same year by the same university. Unlike the first group, we can quantify this second: there are 4969 such individuals (6.1% of the total), and, of these, 846 (1.04% of the total) also share the same broad research area.[19] We address the

[19]Two hypothetical examples illustrate the problems: suppose first that Ernesto Maserati is employed by the faculty of engineering of the university of Bologna, where there are no other E. Maserati, but someone called Ettore Maserati has published an article whilst working at a hospital affiliated with the university of Bologna; this article would be attributed by our download procedure to Ernesto. The second problem would happen if the university of Modena employs in a given year Enzo Ferrari in the faculty of medicine and Emilia Ferrari in the economics faculty.

problems caused by homonymy with a heuristic disambiguation strategy, described in detail in the appendix, and similar in spirit to the one used in D'Angelo et al (2011), which also has an extensive bibliography on the topic.

The first type of misattribution of publications due to homonymy is a measurement error which does not introduce bias: there is no reason to think that an art historian should be more likely to have a WoK publishing homonym than an engineer, and therefore homonymy is not correlated with characteristics of interest, such as the competitiveness of the scientific sector, or the importance of WoK publications for promotion. The disambiguation strategy simply improves the efficiency of the estimations. The second cause of homonymy could however be due to "nepotism", the appointment to professorships of undeserving individuals thanks to the influence of their relations.[20]

If nepotism is unevenly distributed across disciplines (differences in geographical areas, such as those pointed out by Durante et al (2011) should be accounted for by the university fixed effects), it may have a separate effect from the index x, and so controlling for it reduces the omitted variable bias. We therefore include additional controls to account for the possibility of nepotism, in the shape of two dummies which measure low and high probability of nepotism. We exploit the idea, suggested by the literature mentioned above, that whilst family members are more likely than two unrelated individuals to share the surname, they are not more likely to share the same initial. The dummy indicating low probability takes value 1 if individual i has a colleague with the same surname, though not necessarily the same initial, in the databases, in the same year working outside their university and outside their scientific discipline. The second dummy denotes high probability of a homonym being a relation by taking value 1 if the individual i has a colleague with the same surname, again possibly a different initial, working in the same year in the same university and the same scientific sector. Notice that while a person's surname does not change, the value of the dummies can change from period to period with changes in the composition of the rest of the professoriate. Of course we cannot identify situations where a person is promoted because their output is artificially inflated by their relation's unethical practices.[21]

[20]Because relations are more likely to bear the same surname, evidence that the concentration of homonymy is higher among university colleagues than it would be in a random sample of the population is interpreted as evidence of nepotism (Durante et al 2011; see also Allesina 2011, Moss 2012, Perotti 2008 and Scoppa 2009).

[21]As for example reported in the press (la Repubblica, 10 May 2000) by Antonio Iavarone, currently professor at Columbia University, "The professor of paediatrics, Renato Mastrangelo, required us to include the name of his son among the authors of our scientific publications; [...] around 25 publications are attributed to his son even though he did not contribute to them". While an econometric analysis based on output could identify undeserving relations promoted beyond what their record suggests, in the presence of an output level justifying promotion, without intimate knowledge of the genesis of

5 Empirical strategy

5.1 Dealing with sorting by scientific sector, I: orderliness.

The large number of scientific sectors is crucial to our empirical strategy, as it lends plausibility to the assumption that candidates can reliably predict the importance which their appointment and promotion panels will attribute to publications in refereed journals. It however raises a potential endogeneity issue in the allocation of academics to scientific sectors. With many narrowly defined scientific sectors, it is possible that academics may self-select into different scientific sectors within the same research area: thus candidates and panellists would share the same attitude towards the relative importance of publications and other activities. For example, if biologists with a comparative advantage in publishing in refereed journals all opt for a given scientific sector within biology, and the others opt instead for a different one, then the correlation between individual productivity and selection criteria would be a spurious one, generated by the correlation of both variables with the unobservable comparative advantage for publishing in refereed journals in both sets of agents, the panel members and the applicants. The large number of scientific sectors, and the variability of the index x within broad research area shown by Figure 3 makes this a potential problem, as it is clearly relatively easy for an academic to choose the scientific sector within their broad area.

To deal with this problem, we instrument the index of orderliness with two variables which capture the degree of homogeneity of the leadership of a scientific sector, the set of full professors from where the membership of the panel will be chosen. These variables are the standard deviation of the research output of the full professors, and the number of associate and assistant professors per full professor in the sector.[22] The idea is inspired by the more objective nature of a publication count, which may serve as a default option should the leadership of the scientific sector fail to determine a less objective criterion. Thus a large group of full professors with different publication records may find it more difficult to agree on a subjective criterion, be it the quality of teaching or the extent of the engagement with the wider society, than a smaller group of academics with similar balance between publications and other academic activities.

each article, we cannot distinguish whether the influence of a father on his son's output is through undue pressure on third parties to improve his son's publications record or through high quality genetic inheritance.

[22]Taking each of these measures in turn, or averaging them out, or changing the way they are calculated does not affect the results.

5.2 Dealing with sorting, II: posts and competitors.

By the same token, having small scientific sector within which competition is channelled certainly improves academics' precision in assessing both N and K, the likely number of academics who will be competing and the likely number of posts competed over. These magnitudes can be reasonably linked to the number of young and old academics, the former affecting the number of applicants for future jobs, and the latter the future pattern of retirements and hence the number of jobs. And as with the importance of publications in refereed journals, smaller scientific sectors exacerbate the peril of academics within a broad research area sorting according to their comparative advantage into sectors with different values of N and K. To deal with this potential spurious correlation between N or K and the academics' individual characteristics which might emerge if academics sorted themselves into different scientific sectors within their broad research area, we exploit a change in an important detail in the nature of the appointment process.

The centralised mechanism regulating promotions and appointments in Italian universities described above, in Section 3, was radically changed at the end of the 1990s with Law 3 July 1998, n 210. This was approved in October 1998, came into effect after the summer of 1999, so that the first promotions under the new rules took place towards the end of 1999. The main thrust of the reform was to decentralise the appointment process, making it closer to the US and UK model: instead of having to choose from the closed list of the winners of the national competition, which often it had had no input in, when an institution received funding to fill a post in a given scientific sector, a national panel was appointed, whose task it was to appoint to that specific post.[23]

A second aspect of the reform can potentially affect the equilibrium effort level derived theoretically in Section 2. Aside from the switch from national to local competition, the law introduced the restriction that the number of applications that a candidate could submit in each year could not exceed five. The rationale behind this rule was to reduce the workload for appointment committees, by limiting the number of applications to a given post. While the decentralisation affected all academics equally, this second aspect of the reform affected different academics differently. This is so

[23] The composition of the panel changed only marginally with the reform, with the inclusion of one representative of the institution where the selected candidate would be appointed. Some other details were changed: while each competition was for one post at a given university, the panel could, and typically did, qualify up to two additional candidates (later reduced to one), who could subsequently be appointed to a different university, without an additional selection process.

because all academics faced the same cap of five applications per year, but the number of new post varied widely by scientific sector, because it depended not only on the size of the scientific sector, which was itself varied widely, as we showed in footnote 7, but also to esoteric unknowables such as the pattern of relative clouts of each scientific sector within the faculties in the universities where funds for appointments within the period were allocated.[24] If at the start of their career academics could reasonably anticipate the future trend in the number of posts and competitors in the various scientific sectors, and perhaps even the possibility of a decentralisation in the appointment process in line with international practice, few could have predicted a rule imposing a cap on applications, let alone one of unpredictable tightness. This makes the tightness of the post-reform constraint as good as random, and creates a convenient quasi-experimental environment, one which can address the potential problem of academics self-sorting into sectors according to their different competitive conditions. Appendix E.3 suggests that, indeed, whether or not the constraint was tight was not correlated with the pre-reform output.

We capture empirically the role of this constraint on different individuals, by creating a variable R, "Constraints on applications", which is obtained by counting the number of posts filled in each post-reform year in each scientific sector, attributing a score of 0, 1, 2 according to whether the number of posts filled in that year is less than 5, between 5 and 12, and more than 12, respectively.[25] This variable is set to zero before 1999. As with homonymy, making the variable categorical indicates low, medium, and high likelihood of the constraint binding, reflecting our inability exactly to determine whether the constraint is in fact binding at the time of a person's promotion, due to erratic time lags between the opening of a vacancy and its filling.

The distribution of this variable is illustrated in Figure 4. The vertical bars on the LHS measure the number of professors who had low, medium or high probability of facing the constraint in a given year after the reform. The RHS panel reports, in each year, the mean value in the year, both for assistants and for associate professors.

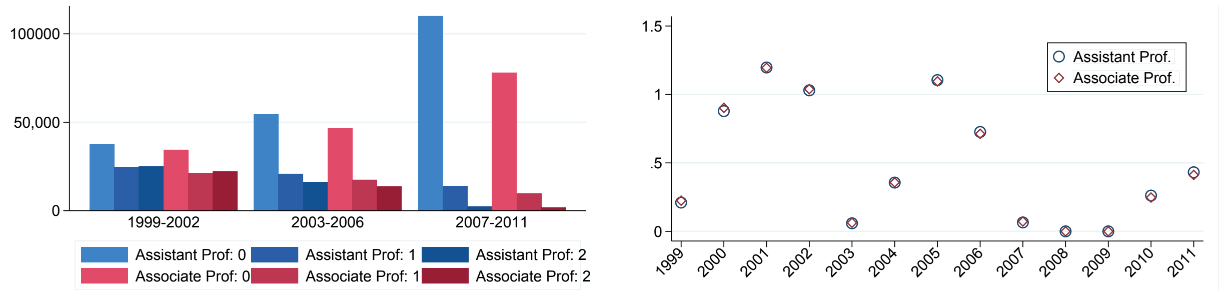
The potential role of this detail of the reform can be gleaned from the Table 4. The

[24]For example if the central administration of a university allocates a post to the faculty of economics, then it is up to the faculty of economics to choose whether the appointee should belong to one scientific sector rather than another. This might depend on short term teaching needs and the current relative number of professors in the various economics scientific sectors, and is almost impossible to predict in advance.

[25]There is a degree of arbitrariness in these numbers, to take into account, mentioned above in footnote 23 the additional promotions that the panels could award without increasing the number of applications formally made by the candidates. Modifying these boundaries within reasonable values hardly changes the estimated coefficients.

Figure 4:
Distribution of the R variable

Frequency of R by year   Yearly average of R.



Note: On the LHS panel, the vertical axis measures the number of professors who faced a weak, when the value of R is 0, medium, $R = 1$, and tight, $R = 2$, constraint on applications in their scientific sector in each year. The RHS panel measures the yearly average of R, which is identically 0 prior to the 1999 reform, as explained in the text.

four top left cells in each half of the table show the average output (in log) of assistant and associate professors, relative to the output of full professors in their discipline. Academics in each group are divided into two sets according to a threshold value of a variable that measures how tight the constraint on the number of application is in their scientific sector. Both groups are shown to increase their output after the reform, but the professors who were constrained by the limit of the number of applications, both assistant and associate, appear to increase their output by less than those who were less constrained.

5.3 The 1999 reform in theory.

The figures in Table 4 are raw population averages and so they ignore both the non-linearities highlighted in Section 2 which suggest that different academics respond differently to changes in conditions, and the other factors influencing effort. A formal theoretical analysis is needed to unravel the overall effect, and we therefore begin by adapting Proposition 1 to the rules set by the new law. We consider the decentralisation first. The rules allowed different panels in the same scientific sector to make their selection according to different criteria, and anecdotal evidence suggests that they did so. We capture this by assuming that when there are K posts available, there are also K different panels, each assigning one post, and by interpreting x as the probability that each of these panels appoints on the basis of the ranking determined by the publications in refereed journals. Thus, with probability x^K all posts are assigned on the basis of publications alone, with probability $Kx^{K-1}(1-x)$ all but one are, with probability

Table 4:
Academics' output Pre- and Post-reform.

	Pre-reform	Post-reform	Difference
Assistant Professors			
Unconstrained scientific sector	1.484	1.926	0.442
Constrained scientific sector	1.781	2.036	0.254
Difference-in-difference			0.188
Associate Professors			
Unconstrained scientific sector	1.595	2.012	0.417
Constrained scientific sector	1.87	2.214	0.343
Difference-in-difference			0.074

Note: Each cell reports the average output of assistant (top part of the table) and associate (bottom part) professors, relative to the the output of full professors working in the same scientific sector. The label "Constrained scientific sector" identifies the subset of professors who were registered in scientific sectors where the rule on the constraint on application in force after the 1999 reform was above a given threshold, and vice versa.

$\frac{K!}{2!(K-2)!}x^{K-2}(1-x)^2$ all but two are, and so on, until, with probability $(1-x)^K$, none is.[26] This changes the link between a candidate's effort and her probability of winning, and so, for given K, N, and x, her payoff and thus her incentive to exert effort is different in the post-reform environment.

The cap on the number of applications that a candidate can make in each year can be modelled formally as follows. Consider one of N candidate competing for K posts, and let M be the limit to the number of positions that each candidate could apply for in a year. The K posts are assigned through K competitions, each appointing to one post. When $K > M$, the game is richer than that studied in Section 2, because the candidates who face a constrain choose, in addition to effort, which of the posts to apply for. As before, there are no entry costs, so it is payoff maximising for every candidate to enter as many competitions as allowed, and each candidate therefore applies for $\widehat{K} = \min\{K, M\}$ positions. When $K > M$, the game has many pure strategy equilibria, and one mixed strategy equilibrium. Denoting by $\lfloor \frac{MN}{K} \rfloor$ the integer part of $\frac{NM}{K}$, in each pure strategy equilibrium, there two groups of posts: $\Big(K - (MN \bmod K)\Big)$ posts have $\lfloor \frac{MN}{K} \rfloor$ applications and $(MN \bmod K)$ posts have $\left(\lfloor \frac{MN}{K} \rfloor + 1\right)$ applications. In the mixed strategy symmetric equilibrium each player applies to any given post with probability $\frac{M}{K}$, so that all competitions have, in expectation, the same number of candidates, $\frac{NM}{K}$. Thus we define the expected number of candidates in each competition as $\widehat{N} = N \min\left\{\frac{M}{K}, 1\right\}$. Since no one can hold more than one post, if a candidate

[26] This is the extreme case where a panel either relies exclusively on the publications, or ignores them completely. In the polar case where each panel uses the same criterion and gives weight x to publications and $(1-x)$ to other criteria, the situation is the same as in the national competition: it is still the case that to be promoted it is necessary to be one of the K top ranked among the N applicants.

receives multiple offers, she must reject all but one of them, and so each post not taken is filled with the next preferred available candidate.

We can now extend Proposition 1 to the post-reform environment.

Proposition 2. *When K separate "local" panels appoint to the K posts, and candidates can apply to at most M posts, the optimal strategy for each of the N candidates is to exert effort towards publishing in refereed journals given by*

$$B(v_i) = \frac{\sum_{k=0}^{\widehat{K}-1} \binom{\widehat{K}}{k} x^{\widehat{K}-k} (1-x)^k \int_{\underline{v}}^{v_i} y Z'_{\widehat{K}-k,\widehat{N}-k}(y)\, dy}{\sum_{k=0}^{\widehat{K}-1} \binom{\widehat{K}}{k} (1-x)^{\widehat{K}-k} x^k}, \tag{6}$$

where $Z_{KN}(v)$ is defined above in (2), and $\widehat{K} = \min\{K, M\}$, and $\widehat{N} = N \min\left\{\frac{M}{K}, 1\right\}$.[27]

Figure 5 illustrates the effect of the reform on effort. It reproduces the black solid line in Figure 1 and adds to it the two red lines which depict the effort levels when the restriction on the number of applications is not binding (the dash-dotted line) and when this restriction is binding (the dotted line). The curves show that more productive academics exert less effort: the negative effect on effort of the switch to local competition is reinforced by the cap on applications. The less productive academics, on the other hand, exert more effort after the reform when they are registered in a sector where the cap on the number of applications is binding. Recall that whether this cap was binding in a year depends not only on the size of the scientific sector, but also the pattern of appointments in the different institutions and scientific sectors.

As in Section 2, we can collect the testable implications described above in a formally stated conjecture. Recall that we have postulated a one-to-one relationship between effort and output.

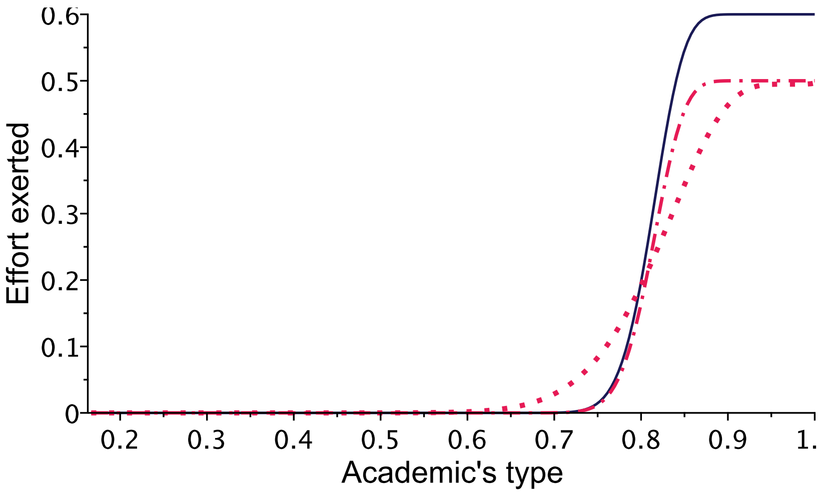
Conjecture 2. *(i) Ceteris paribus, more productive academics reduce effort after the reform. (ii) Academics with a lower value of the productivity parameter exert more effort following the reform if they are in a scientific sector where the cap on the number of applications is binding.*

6 Econometric specification

As we anticipated at the end of Section 3, we estimate our model on two unbalanced panels, one comprising assistant professors aiming to become associate, the other associate professors aiming to become full professor. The panel structure allows us to control for the influence on effort of individual characteristics with the individual fixed

[27] Since $\widehat{N}$ may be non-integer, factorial is replaced by the gamma function when appropriate.

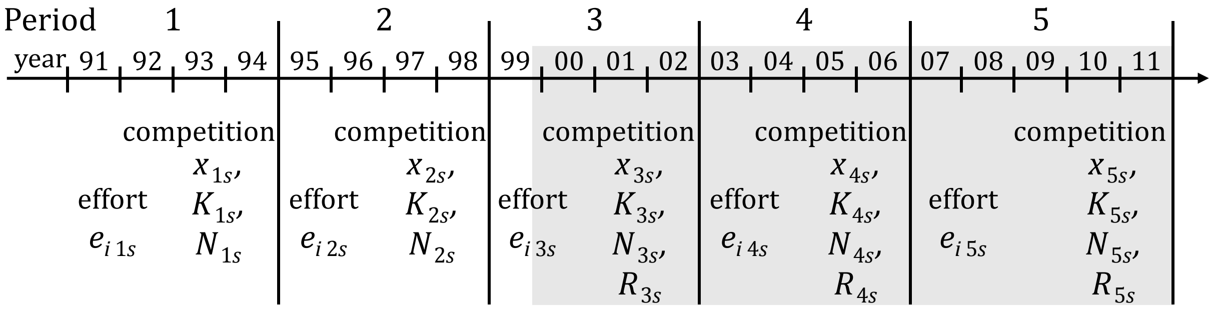
Figure 5:
Equilibrium effort by ability type pre- and post-reform



Note: The curves denote the effort exerted by academics of different types, measured along the horizontal axis, for fixed $N = 150$, $K = 25$, $x = 0.6$. The solid black line is the same as in Figure 1, measuring the pre-reform effort, the function in (1). The post-reform equilibrium level of effort is shown by the red lines, determined in Proposition 2: the dotted line depicts the full effect of the reform, obtained in (6), the dash-dotted red line is the effect the reform would have if the cap on the number of applications, set in the example at $M = 5$, were absent.

effects. Although we have yearly observation both for promotions and for output, it is preferable to choose, for the time dimension of the panel, a longer interval. As we explained, prior to the 1999 reform, all the appointments in each scientific sector in a funding cycle happened at the same time. Moreover, ministerial funding for new professorial posts was not staggered across scientific sectors, so that the pattern of appointments shows distinct peaks prior to the turn of the century: the overwhelming majority of the appointees began working in the same year, a different year of each cycle for associate and full professors. Some appointments began in different years: this was usually due to delays in the completion of the committee's decision process or by appeals by rejected candidates. While individual appointments within a scientific sector were no longer necessarily simultaneous after the 1999 reform, in practice, the funding cycle did not change under the new rules: all posts, for all scientific sectors, were advertised simultaneously, and the thousands of appointment panels worked in parallel. Thus the highly uneven pattern of appointments continued after 2000. Given this dramatic bunching, it seems preferable to smooth it out by aggregating several years into one period, which therefore constitutes the time unit of our panel. The four year length of a period is a very close approximation to the temporal pattern of

Figure 6:
Timeline for competitions for appointments and promotions.



appointments, and leads to the aggregation into five periods presented in Table 2.[28] A longer time unit than one year also reflects the gap between the exertion of effort and the publication of the output resulting from that effort. A separate concern could be the existence of a link, for example one created by policy, between productivity and the number of new posts. As Section E.4 in the Appendix argues, there is no discernible pattern suggesting that K and N are determined by the natural pattern of promotions, retirements, and change in the overall student numbers.

Figure 6 illustrates schematically the sequence of events. At the beginning of each period, candidates form beliefs about the conditions which will be in force at the time the decision on their application for promotion is made, described by the parameters, x_{ts}, K_{ts}, N_{ts}, and R_{ts}, the importance of publications for promotion, the number of posts, the number of competitors, and, from period 3, the tightness of the constraint in period t and in scientific sector s. These variables have of course the same values for all individuals in the same rank within a scientific sector in each period, and vary by scientific sector and by period. Given these beliefs, the candidates choose how much effort to exert towards publications relative to effort towards other activities. Effort determines publications, which are the individual's output in that period. At the end of the period, the appointment panel assess the candidates. The shaded area is the post-reform period, when competitions were local and there was a constraint on the number of applications per year.

Thus our panel dataset has "professor-period" as the unit of observation; it is unbalanced, as some professors are only present in some periods. In practice, of course, some individual characteristics may change from period to period as they are influenced by events unfolding in time, rather than solely by features fixed at entry into the

[28]We have also experimented with different subdivisions for the two panels, one for associate and a different one for full professors, and the results do not vary.

panel.

To incorporate the discussion at the end of in Section 5, which suggests that, following the reform, the relevant values of the parameter K and N are in fact $\widehat{K}$ and $\widehat{N}$, to take into account the possible presence of the constraint on applications. As explained above, we do not know the precise number of applications allowed to each individual in each period, and we therefore proxy $\widehat{N}_{ts}$ with $N_{ts} + \lambda R_{ts}$, where R_{ts} is the variable that measures the intensity of the reform in sector s in period t. The first three coefficients of (3) and the interaction of the number of competitors with the variable R, which measures the strength of the constraint are obtained as panel estimations for the two groups of professors we consider, assistant and associate. The estimates are reported below, with the standard errors below the coefficients, and the stars denoting the usual significance thresholds.

$$o_{its} = \alpha_0 + \underset{0.011}{.045^{***}} x_{ts} - \underset{0.004}{0.013^{***}} K_{ts} + \left(\underset{0.027}{0.171^{***}} - \underset{0.002}{0.01^{***}} R_{ts} \right) N_{ts} + \gamma_C C_{ts} + \varepsilon_{itsu}, \quad (7)$$

$$o_{its} = \alpha_0 + \underset{0.01}{.01} x_{ts} + \underset{0.004}{0.014^{***}} K_{ts} + \left(\underset{0.019}{0.035^{*}} - \underset{0.001}{0.006^{***}} R_{ts} \right) N_{ts} + \gamma_C C_{ts} + \varepsilon_{itsu}, \quad (8)$$

where the fixed effects are all included in the error term. The estimated equations (7), for assistant professors, and (8), for associate professors, show the anticipated signs for x_{ts} and $R_{ts}N_{ts}$, though the former is not statistically significant for associate professors. The theoretical analysis does not lead us to expect a specific sign for K_{ts} and N_{ts}.

The estimates reported above have all the expected sign. However, they calculate the *average* effect on effort, and thus inevitably neglect the strongly non-linear relationship between an academic's position in the distribution of types in her scientific sector, and her responses to changes in the parameters which we established in the the theoretical analysis. To account for these non-linearities, we begin by dividing the sample into groups of professors of similar type. Formally, we let $\mathcal{Q}$ be a partition of the set of associate (respectively, assistant) professors in sector s in period t, and for $q \in \mathcal{Q}$, we let $\delta^q_{its} = 1$ if individual i is in the subset $q \in \mathcal{Q}$ in period t, and $\delta^q_{its} = 0$ otherwise. That is, we attach to each individual the percentile of her position, in each period, in the ordering of the academics in her rank. Since $\mathcal{Q}$ is a partition, $\sum_{q \in \mathcal{Q}} \delta^q_{its} = 1$. We then run four separate regressions for both sets of individuals: each using as sample only the professors for whom $\delta^q_{its} = 1$, $q = 1, \ldots, 4$, that is those in the same interval of the type distribution in their respective scientific sector. The results of this exercise are presented in the first two columns of Table 5. These OLS regressions are pooled, because a panel estimation would lead to the academics who change interval from one period to the next to be dropped from the regression samples of both intervals: not only almost one third of the observations would be lost, but the omitted academic are likely to be those most responsive to the conditions in their environment. While the results are consistent with the theoretical analysis and with the results in (7) and (8), in the rest of the analysis, in order to make the most of the panel structure of the dataset, we prefer to resort to a different technique to capture the potential non-linearities: this is to interact the three variables of interest, x_{ts}, K_{ts}, and N_{ts}, with the ranking dummies δ^{q}_{its}. We use this technique, in alternative to quantile regression, because the theoretical analysis links a person's effort to her position in the distribution within her scientific sector (the function F appears in the equilibrium level of effort (1)). That is, what matters is not her absolute "type", but the position of her type in the distribution of her competitors' types. Thus for example two individuals in different scientific sectors s and s' may exert the same effort, and hence obtain the same output, and they would be placed in the same quantile with a standard quantile regression. However, if one is in the top decile of the types in her scientific sector (her $\delta^{q_{10}}_{its} = 1$), and the other in the sixth decile of hers (she has $\delta^{q_6}_{its'} = 1$), the theoretical analysis of Section 2 says that these individuals would respond differently to, for example, the same increase in the number of competitors: empirically, this would be reflected in $\alpha_{10K} K_{ts}$ being different from $\alpha_{6K} K_{ts}$ in (9) below. To reflect these non-linearities, we therefore replace (3) with

$$o_{its} = \alpha_0 + \sum_{q \in \mathcal{Q}} \delta^{q}_{its} \Big(\alpha_{qx} x_{ts} + \alpha_{qK} K_{ts} + \alpha_{qN} \left(N_{ts} + \lambda_q R_{ts} \right) \Big) + \gamma_C C_{ts} + f_i + \xi_t + \sigma_s + \zeta_u + \varepsilon_{its}. \tag{9}$$

The estimates of the coefficients $\alpha_{qR} = \alpha_{qN} \lambda_q$, therefore, represent the effect of the reform on individuals' response to changes in the competitive conditions.[29] Equation (9) is our main specification.

7 Results

Our main results are in Table 5. Our base specification is in the third and fourth columns, which report the coefficients for the two regressions: assistant professors intending to become associate, and associate professors intending to become full professors. These are obtained from the estimation of (9) with the natural log for the variables K and N. Individual output is weighted with the number of co-authors. The clustering of the standard errors is by scientific sector, the level of the main independent variables

[29] In the theoretical model we showed that R affects K as well as N. We have run all the regressions with the interaction between K and R and the results are qualitatively unchanged. Including both interactions determines collinearity between the four variables N, K, $R \times N$, and $R \times K$.

and of the IV we use.[30] We run two versions of the main regression, which differ in $\mathcal{Q}$, the partition of the academics in their scientific sector. Specifically, ordering the N_{st} academics in scientific sector s in period t from the least to the most productive, Table 5 is built using the partition

$$\mathcal{Q} = \left\{ \left(0, \frac{N_{st}}{2}\right], \left(\frac{N_{st}}{2}, \frac{7N_{st}}{10}\right], \left(\frac{7N_{st}}{10}, \frac{9N_{st}}{10}\right], \left(\frac{9N_{st}}{10}, N_{st}\right] \right\}, \tag{10}$$

whereas we drew Figures 7-9 using the results of the regressions based on the partition

$$\mathcal{Q} = \left\{ \left(\frac{(j-1)\, N_{st}}{10}, \frac{jN_{st}}{10} \right] \right\}_{j=1,\ldots,10}. \tag{11}$$

Thus, for Table 5 we consider four unequally sized groups, those separated by the median, the seventh, and ninth decile. Instead, for Figures 7-9 are obtained dividing the academics in each scientific sector into ten identical intervals.[31] The reason we present the table with four groups is help the presentation by having fewer coefficients; we chose unequal sizes for the groups, rather than quartiles, because, as predicted in the theory section and indeed confirmed by Figures 7-9, the estimated coefficient are very similar for the types below the median. Comparison of Table 5 and Figures 7-9 suggests that the loss of information in the table is limited.

In detail, Table 5 is organised as blocks of estimated coefficients, one block for each of our variables of interest, (i) the importance of publications in WoK journals, the index of orderliness x, (ii) the log of the number of posts available in the sector, (iii) the log of the number of competitors, and (iv) the additional effect on the 1999 reform measured via the reduction of the number of competitors. Within each block, the four coefficients are the effect of a change in the variable on individuals in different position in the ranking of their scientific sector. Thus the first coefficient is the effect on an academic's output of a change in the orderliness of scientific sector of an academic whose output places her below the median in a given period. And so on for the other coefficients: the second row is the value for individuals whose output is between the median and the seventh decile, the third row for those between deciles seven and nine, and the last row for the top academics, those with output above the ninth decile of the distribution in their scientific sector, in the given period.

In Figures 7 and 9, the horizontal axis is the (inverse) rank of the academic's type

[30] Table A7 in the appendix shows that the estimations gain little in significance when clustering is at the individual professor rather than at the scientific sector level.

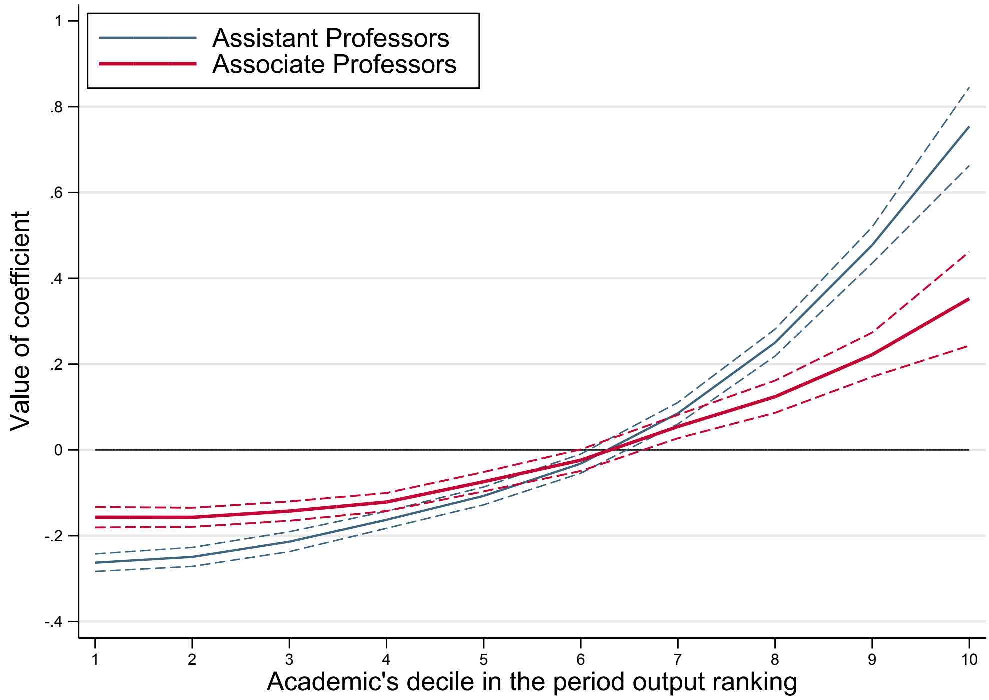
[31] Notice therefore that the results reported in Table 5 can be obtained from the regressions used to draw Figures 7-9 with the additional restrictions $\alpha_{1z} = \alpha_{2z} = \alpha_{3z} = \alpha_{4z} = \alpha_{5z}$, $\alpha_{6z} = \alpha_{7z}$, and $\alpha_{8z} = \alpha_{9z}$.

Table 5:
Determinants of Academics' Effort, and Robustness Checks.

Dependant variable: Individual output in period t	Four Separate Regressions: Sample Split		Base Regression: coauthors weighting		Instrumental variables: homogeneity		Output weighted with impact factor		Deciles computed using cumulative output	
	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.
Orderliness: below median	0.057***	0.034***	-0.196***	-0.123***	-0.354**	-0.498***	-0.175***	-0.123***	-0.128***	-0.055***
	0.009	0.006	0.020	0.016	0.141	0.159	0.019	0.014	0.021	0.012
Deciles 6 and 7	0.206***	0.162***	0.024*	0.005	0.526***	0.371**	0.038***	0.008	0.110***	0.045***
	0.030	0.025	0.013	0.012	0.113	0.189	0.014	0.014	0.021	0.014
Deciles 8 and 9	0.473***	0.290***	0.345***	0.151***	1.405***	1.226***	0.322***	0.165***	0.235***	0.072***
	0.062	0.052	0.040	0.030	0.133	0.271	0.039	0.029	0.041	0.025
Top decile	0.901***	0.521***	0.709***	0.287***	1.795***	1.478***	0.614***	0.257***	0.084	-0.040
	0.126	0.102	0.081	0.062	0.283	0.410	0.070	0.059	0.057	0.055
Number of posts: below median	-0.006**	-0.005**	0.013*	0.035***	0.036	-0.028	0.011*	0.034***	0.006	0.021***
	0.003	0.002	0.007	0.005	0.036	0.034	0.006	0.005	0.006	0.004
Deciles 6 and 7	-0.022**	-0.024***	-0.006	0.012***	0.057	0.012	-0.005	0.015***	0.002	0.015***
	0.011	0.009	0.005	0.004	0.049	0.033	0.005	0.004	0.009	0.005
Deciles 8 and 9	-0.033	-0.044**	-0.025*	-0.019**	0.095	0.078**	-0.033**	-0.026***	0.000	0.000
	0.026	0.020	0.014	0.008	0.064	0.037	0.014	0.008	0.014	0.007
Top decile	-0.032	-0.019	-0.071***	-0.017	0.238***	0.235***	-0.065***	-0.019	-0.004	0.012
	0.051	0.047	0.024	0.022	0.069	0.043	0.021	0.021	0.017	0.018
Competitors: below median	0.013***	0.011**	0.036*	-0.044***	0.010	0.069***	0.050**	-0.034**	0.005	-0.022
	0.005	0.005	0.020	0.015	0.014	0.016	0.020	0.017	0.023	0.018
Deciles 6 and 7	0.040***	0.063***	0.065***	-0.007	-0.038	-0.013	0.077***	0.001	0.027	0.003
	0.015	0.018	0.021	0.015	0.027	0.014	0.021	0.017	0.026	0.017
Deciles 8 and 9	0.04	0.106***	0.105***	0.053***	-0.088	-0.105***	0.122***	0.061***	0.055*	0.051***
	0.032	0.035	0.025	0.017	0.055	0.030	0.025	0.018	0.029	0.019
Top decile	0.054	0.150*	0.245***	0.204***	-0.138**	-0.118**	0.241***	0.189***	0.142***	0.144***
	0.055	0.079	0.028	0.023	0.056	0.049	0.026	0.023	0.028	0.021
Effect of reform: below median	-0.001***	0	0.002	0.002	0.003	-0.004	0.001	0.002	-0.004**	0.001
	0.001	0.001	0.001	0.002	0.003	0.003	0.001	0.002	0.001	0.002
Deciles 6 and 7	-0.006***	-0.008***	-0.002	0	-0.004*	0.002	-0.003**	-0.002	-0.003*	-0.005***
	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002
Deciles 8 and 9	-0.012***	-0.017***	-0.010***	-0.004	-0.014***	0.005	-0.009***	-0.003	-0.011***	-0.013***
	0.004	0.004	0.002	0.003	0.005	0.004	0.003	0.003	0.003	0.003
Top decile	-0.032***	-0.033***	-0.033***	-0.040***	-0.038***	-0.028***	-0.031***	-0.033***	-0.035***	-0.034***
	0.009	0.008	0.006	0.005	0.007	0.007	0.005	0.005	0.005	0.006
R-squared			0.434	0.361	0.279	0.157	0.363	0.283	0.201	0.111
First stage F-test (p-value)					0.000	0.000				

Note: *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$. In all pairs of columns, the number of observations is 120,095 and 90,894 for the 47,572 assistant and the 37,066 associate professors respectively. Standard errors are clustered by scientific sector and are reported in small font below each coefficient. All the regressions include a constant, the share of women, the share of appointments from outside the Italian academia, the average age of the potential applicants, the homonymy coefficients as explained in the text, and also scientific sector, university, period and individual fixed effects. Columns 1 and 2 are obtained from four separate OLS regressions, with different samples. In these columns, the first coefficient in each block is obtained from the sample constituted by the observations where the professor's output is below the median for the period/scientific sector. The second coefficient is similarly obtained with the samples made of the observations from the median to the seventh decile, the third from the seventh to the ninth decile, and the fourth the observations in the top ten percent in each period/scientific sector. There are scientific sector, university, and period, but not individual, fixed effects. The base regressions are in Columns 3 and 4, where individual output is weighted with the number of co-authors. Columns 5 and 6 are IV estimates with the homogeneity of the set of the full professors in the scientific sector in the period as an instrument for the orderliness index. Columns 7 and 8 are a robustness test with the weighting for the different publications determined by the impact factor; columns 9 and 10 are another robustness test, where an individual's type is computed according to the cumulative output.

Figure 7:
Effect of a change in the index of orderliness.



Note: Regression coefficients α_{qx} in estimation (9), for a ten-interval partition of the type distribution. The dashed lines include the 95% confidence intervals.

in her scientific sector, and the corresponding ordinate measures the effect of a change in the exogenous variable on the output of the academics with that rank. The dashed lines are the 95% confidence interval around the coefficient; we do not shown them in Figure 8, to avoid clogging it. This figure shows, as dashed lines, the effect of N alone, that is the effect for those academics for whom $R_{ts} = 0$ for every t, the constraint is not binding at any time, post-reform as well as pre-reform. The solid line is the sum of the coefficients in the third and in the fourth blocks, for N and $N \times R$, that is α_{qN} and α_{qR} respectively, calculated when R is 2, its maximum possible value. The vertical intercept of the solid line is therefore the effect of a change in the number of competitors on the effort of an academic in a scientific sector where the post-reform constraint on the number of applications is binding whenever she may apply for promotion.

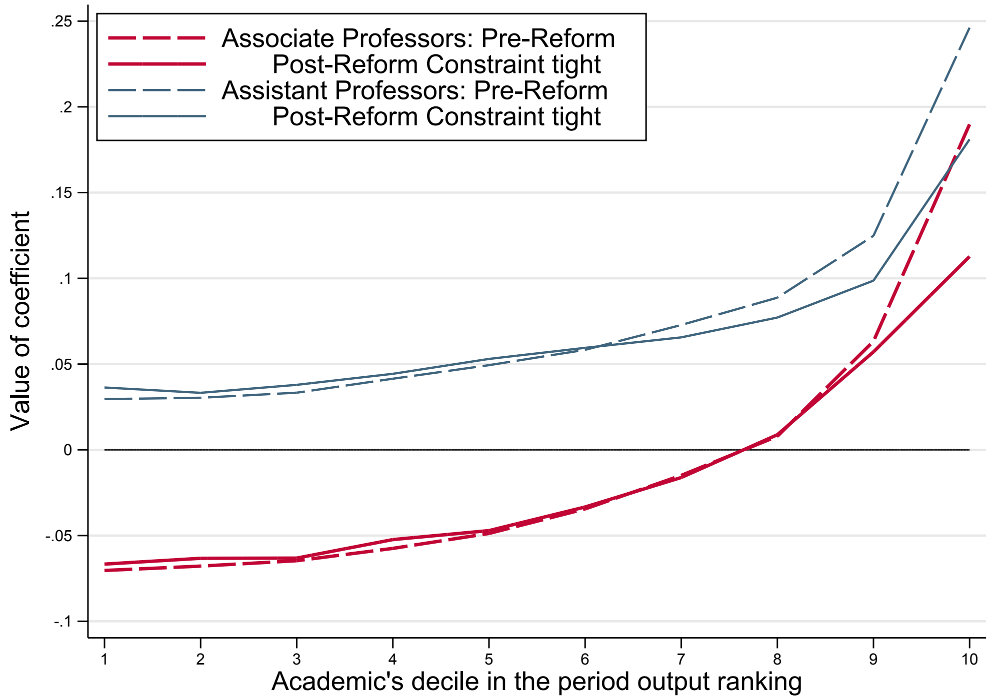
For both sets of academics, an increase in orderliness increases effort for productive individuals, as predicted by Conjecture 1.(i), derived from the LHS panel of Figure 2, and reduces effort for less productive ones. An increase in competition, whether achieved via a reduction in the number of posts, K, the second block of coefficients, or via an increase in the number of potential applicants, N, the third block, increases effort of high types and reduces effort for high cost types, in line with Conjecture 1.(ii)-1.(iv). One exception to this concordance with the theory given by the assistant professors below the median, who appear to increase marginally their output. Notice also that the differences in response between assistant and associate professors, such as the former being more responsive to an increase in the importance of international publications as selection criterion, may be explained by the fact that the extent of competition differs in the two sectors, and as Figure 2 shows, relatively small changes in competition may cause substantial changes in response. The position of the two curves and the coefficients in the first row of Table 5 (the first two columns excepted) suggest an effect not predicted by the theoretical model, a discouragement for the least productive academics: they seem to respond to an increase in orderliness with a *reduction* in their effort.[32] Figure 8 also illustrates a result neatly in line with the prediction of the theoretical model: productive (less productive) academics who are constrained in the number of applications they can make respond to increases in the competitiveness of their environment more weakly (more strongly) than their unconstrained colleagues, as predicted by Conjecture 2.(i) (by Conjecture 2.(i)).

The main regression is in the third column, for assistant professors aiming to become associate, and in the fourth, for associate professors aiming to become full professor. In the first two columns we report the results obtained by running the four separate regressions for each set of academics, selecting the sample for each regression using the value of the partition dummies δ^{q}_{its}, for partition (10). While there are differences, the main qualitative features are the same as in the third and fourth column.

To get a handle on the quantitative significance of our results, consider the main regression in Table 5, third and fourth column. Suppose the index of orderliness for promotion to associate of increased by one standard deviation in the average scientific sector, from 0.6 to 0.73. This would determine an increase in output of 3%, 4.4%, and 9% for an assistant professor whose output is between the median and the seventh decile, between the seventh and the ninth decile, and one whose output is in the top 10% among her peers, respectively. It would however *reduce* by 2.5% the output of an assistant professor whose output is below the median. All these are percentages of the average output of the full professors in the sector. Overall, there are 165 assistant professors in the average sector, and so their aggregate output would increase by

[32]A natural modification of the theoretical model which could determine such discouragement is a non-linear cost of effort: if increased effort along one dimension were to increase the marginal cost of effort along other dimensions, then academics for whom effort is very costly, would reduce it in response to a an increase in importance, in order to reduce the cost of effort along other dimensions.

Figure 8:
Effect of a change in the number of competitors.



Note: Regression coefficients α_{qN} in estimation (9), for a ten-interval partition of the type distribution. The confidence intervals are not drawn, to avoid cluttering the figure. As Table 5 indicates, the coefficients are significant for the highest deciles.

$(0.09 \times 0.1 + (0.044 + 0.03) \times 0.2 - 0.025 \times 0.5) \times 165 = 0.98$. This increase in the importance of international publications would thus increase the number of papers written by the assistant in the sector professors almost equal to the output of a full professor. Similarly, and more specifically, suppose the number of posts for full professor in economics were reduced by 1 (0.92%) in the third period: then similar calculations would predict that this increase in competition would increase the number of papers produced by the economics associate professors by $(0.17 \times 0.1 + (0.019 - 0.012) \times 0.2 - 0.035 \times 0.5) \times 331 \times 1.48 = 7.05$ papers per year, as the average number of paper written by full professors in the sector is 1.48.

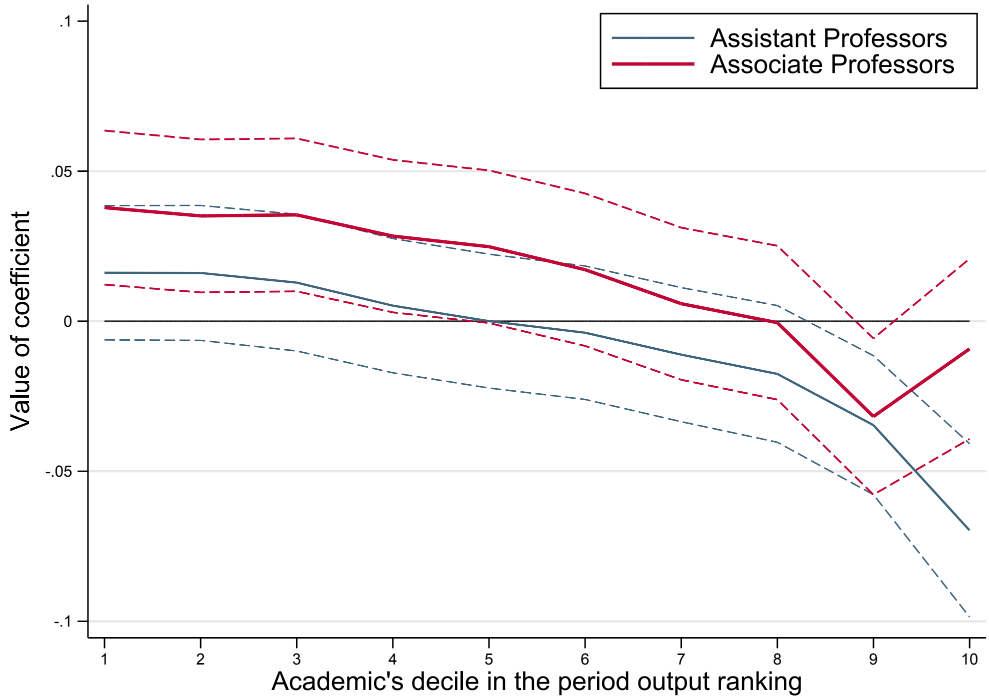
In the next two columns of Table 5, the fourth and the sixth, we report the results of the instrumental variable estimation, using the "homogeneity" of the full professors as instruments for the orderliness index x. This homogeneity is proxied by the standard deviation of the output of the full professors, and by their number relative to the number of assistant and associate professors. Using only the former changes the result only by a small amount, the signs and the order of magnitudes of the coefficients are very close. Comparison of the corresponding columns suggests that the qualitative nature of the results is mostly unchanged relative to the OLS. Some coefficients do change sign, in particular those determining the “competition” variables, K, and N. Recall however we showed in the theoretical analysis (Section 2 and in particular Figure 2) that these variables have been shown to have potentially different effects according to the values of the other parameters. On the other hand, the effect of the orderliness and the effect of the reform on effort, which are unambiguously signed in the theoretical analysis, are qualitatively similar in columns 3 and 5 and in columns 4 and 6 of Table 5, as the first and the last blocks of coefficients show. The results of the first stage regression are reported in Table A8 of the online appendix.

In the rest of Table 5 we report some robustness checks; these confirm that the main results change little with the details of the econometric specification chosen, and suggest some interesting considerations. The seventh and eighth columns in the table show the coefficient when the output is measured as the number of papers published in WoK weighted by the position of the journal in the impact factor ordering of journals for that research area according to the impact factor.[33] The coefficients are qualitatively very similar to those reported in the first two columns. Together with the high correlation between these measures of output and other plausible ones with different weights for authors and importance of the outlet, these two columns suggest that our results are robust to changes to the way output is measured.

Appointment committees are free to choose the criteria to apply in choosing whom to appoint. We have so far postulated that candidates, when assessing the orderliness of past decision making of these committees, assume that they have ranked the candidates according to the output of those candidates in the period where the appointments take place: that is, they base their decisions on the candidates recent record. On the other hand, the candidates might instead believe that the committees choose to rank individuals according to their entire careers. In this case the position of a candidate might be different, and given that the position of a candidate in the ranking of their scientific sector determines their effort, so would potentially be the effort. In the ninth and tenth column of Table 5, we therefore report the coefficients estimated when an academic’s ranking in their scientific sector is determined by their lifetime achievement, that is taking into account both all the past publications and also the influence of these publications, determined by the real h-index we have used above. These regressions are similar to our base regression, reported in the third and fourth

[33]Correspondingly, the cumulative output used to compute the orderliness index is also computed weighting with the impact factor.

Figure 9:
Effect of a change in the number of posts.

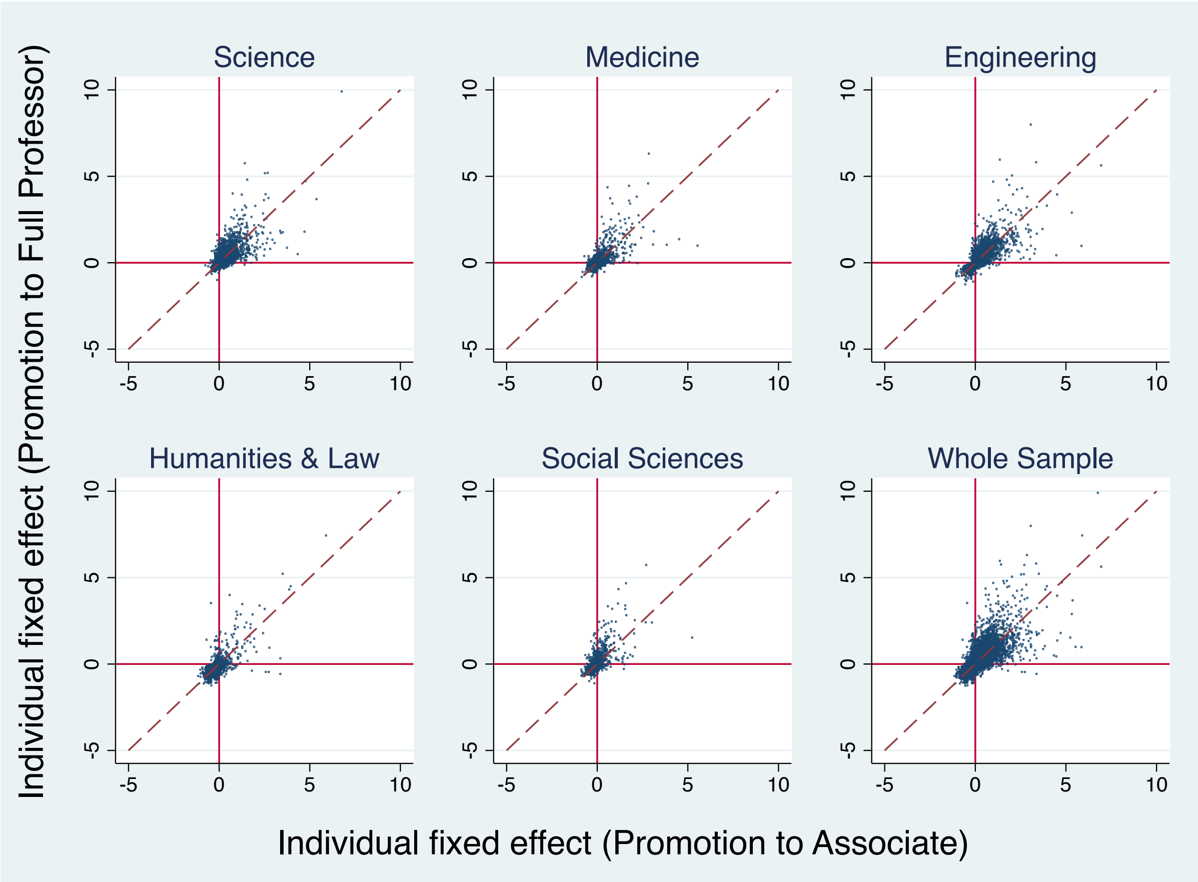


Note: Regression coefficients α_{qx} in estimation (9), multplied by -1, for a ten-interval partition of the type distribution. The dashed lines include the 95% confidence intervals.

column. There are some differences in the coefficients for the parameters measuring competition, K and N, but those for the effect of the reform and the importance of publication do not vary qualitatively, with one important exception. Individuals in the top decile do not appear to increase their effort. This tallies somehow with Figure 1 and the LHS panel of 2, which shows that the response to a change in orderliness tends to become constant for the most productive academics, and therefore lower as a proportion of output. Intuitively, we can think of an academic who, having hit a good number of prestigious outlets in the past, needs little additional effort to gain promotion. This effect is more pronounced when competition is relaxed (the thinner lines in the figure), and arguably, in a world were past career is taken into account, competition is more relaxed as the impact of a new paper on the total is more limited than when past successes lose their shine after a few short years.

The individual fixed effects we estimate offer an interesting confirmation of the soundness of our approach. These fixed effects, which are functions of individuals' types v_i, measure differences in the effort exerted by different individuals who find themselves in identical conditions. Conceptually they capture the "underlying pro-

Figure 10:
Individual Fixed Effects for two Promotions.



Note: The plots show the individual fixed effect for promotion to associate professor (the third column of Table 5) and the individual fixed effect for promotion to full professor (the fourth column) for academics who have been promoted twice in the 21 year period. A handful of outliers have fixed effects estimated higher than 10, which are off the scale of the two axes.

ductivity" in normal conditions, and are determined by talents, skills, personality and attitude towards research, which are both unobservable and in principle roughly constant throughout a person's professional life, and should therefore exhibit a degree of serial correlation, though perhaps not perfect, as life events, personal and professional alike, may modify these traits to some extent. 19,046 individuals, 23% of the total (among them one of the authors) appear in both our dataset, first as assistant professors competing to become associate, then as associate professors. For them, we can therefore estimate two separate fixed effects, which are obtained from completely separate datasets: the parameters are different, and the output of a period appears in both regressions only when a person is promoted twice in the same period. Figure 10 plots the fixed effect derived from the regression that estimates effort exerted when competing to become full professor against that exerted, earlier in one's career, to become associate professor. The visual impression of a good association among these two sets of fixed effects is confirmed by the high value, 0.63, of the correlation between them. Note that there appear to be no qualitative differences between broad research areas. The concentration of the fixed effects pairs on the positive quadrant is a natural consequence of the sample selection, given that those who appear in both regression have been twice successful in their applications for promotion, and have all reached the highest academic rank. We find their stability across time as a further confirmation of the correspondence between our theoretical set-up and our empirical specification.

8 Concluding remarks

This paper studies the response of Italian academics to changes in competitive conditions. We study the period from 1990 to 2011. Like in many other countries, appointments and promotions were determined by peer assessed academic quality, but the legislation which governed them, striving to reduce the scope of unethical behaviour by the decision makers, introduced many explicit and detailed rules. These can be mapped into a theoretical set-up which allows a precise quantification of the changes in an individual academic's incentives determined by changes in the competitive conditions of her research area. The model predicts differential responses to competitive conditions for individuals with different characteristics; specifically, the change in effort level in response to exogenous changes differ according to individuals' position in the publication's ranking of her discipline. If the competitive conditions change, for example because more jobs become available, then productive individuals, for whom exerting effort is "cheap", who were therefore exerting a good deal of effort, were already highly likely to be promoted, and so have relatively little incentive to exert "extra" effort. But for someone in the middle of the ranking, the laxer competitive conditions, for example the availability of an additional post, might mean that effort becomes more productive, in the sense that "extra" effort might be rewarded with a relatively large increase in the probability of winning the additional job made available.

Following our theoretical analysis, we include these non-linearities in our econometric strategy, applied to the dataset we have built, which collects the publications in international scientific journals written by academics working in Italian universities. This strategy is made possible by the insular nature of Italian academia, where entry tends to happen at the lowest level, and early exit is very rare. We find that the model predicts well both the general lines and also the details of the theoretical model, regarding the different response to changes in the exogenous conditions by different types of individuals. Thus our analysis suggests that the contest model described by the multiple-unit all-pay auction does capture the utility function of academics, even where, like in the period we study in Italy, the incentives they operate under are rather weak.

We exploit, in testing the model, an important detail of the reform of the university system which took place in 1999, the introduction of an upper limit to the number of applications for promotions an individual professor could make in each calendar year. Intended to reduce the burden on members of the promotions panels, this had the additional and unintended consequence of relaxing the competitive condition for some, but not all the academics. The correspondence between the theoretical model and the behaviour of the Italian academics we study is confirmed by the empirical analysis, which shows that the most productive academics increased their effort less than those unaffected by the rule, whereas all the less productive ones increased it, just as predicted by the theory. To the extent that the multi-unit all-pay auction model is a good fit of the behaviour of academics, a broad policy indication suggested by our analysis would therefore be that strengthening incentives, for example by rewarding success more explicitly, might generate the expected responses in the direction of increased effort and output by Italian researchers. This paper does not try to determine the overall effect of the reform. This effect is in principle hard to disentangle from any time trend in the work patterns of academics, and is shown to be limited in Battistin et al (2014). It instead uses the way in which details of the reform result in a possibly counterintuitive theoretical effect, which is matched in the empirical analysis. The complexity of the response, proved at a theoretical level and confirmed in the empirical application, hints at an important policy contribution from our paper is to highlight the importance fully to understand the incentives put in play by complex rules in order to anticipate possible unintended consequence on individual behaviour created by new legislation, lest they cause unexpected and undesired outcomes.

References

Abramo, Giovanni, Ciriaco Andrea D'Angelo, and Francesco Rosati, "Career Advancement and Scientific Performance in Universities," *Scientometrics*, 2014, *98*, 891–907.

Allesina, Stefano, "Measuring Nepotism through Shared Last Names: The Case of Italian Academia," *PLoS ONE*, 2011, *6*, e21160.

Althouse, Benjamin M, Jevin D West, and Carl T Bergstrom, "Differences in Impact Factor Across Fields and Over Time," *Journal of the American Society for Information Science and Technology*, 2009, *60*, 27–34.

Anderson, Simon P, Jacob K Goeree and Charles A Holt, "Rent Seeking with Bounded Rationality: An Analysis of the All-Pay Auction," *Journal of Political Economy*, 1998, *106*, 828–853.

Archambault, Éric, David Campbell, Yves Gingras, and Vincent Larivièr, "Comparing Bibliometric Statistics Obtained from the Web of Science and Scopus," *Journal of the American Society for Information Science and Technology*, 2009, *60*, 1320–1326.

Barut, Yasar, Dan Kovenock, and Charles N Noussair, "A Comparison of Multiple-Unit All-Pay and Winner-Pay Auctions under Incomplete Information," *International Economic Review*, 2002, *43*, 675–708.

Battistin, Erich, Daniele Checchi, and Stefano Verzillo, "La riforma di decentramento dei concorsi universitari in Italia," *Rassegna Italiana di Valutazione*, 2014, *58*, 50–79.

Baye, Michael R, Dan Kovenock, and Casper G de Vries, "Rigging the Lobbying Process: An Application of the All-Pay Auction," *American Economic Review*, 1993, *83*, 289–294.

Becker, William, "The University Professor as a Utility Maximiser and Producer of Learning, Research and Income," *Journal of Human Resources*, 1975, *10*, 109–115.

__ , "Professorial Behavior Given a Stochastic Reward Structure," *American Economic Review*, 1979, *69(5)*, 1010–1017.

Bosquet, Clément and Pierre-Philippe Combes, "Do Large Departments Make Academics More Productive? Agglomeration and Peer Effects in Research," CEPR Working Paper 9041 London, UK March 2013.

Carmichael, H. Lorne, "Incentives in Academics: Why is There Tenure?," *Journal of Political Economy* , 1988, *96(3)*, 453–472.

Checchi, Daniele, "Tenure. An Appraisal of a National Selection Process for Associate Professorship," *Giornale degli Economisti e Annali di Economia*, 1999, *58*, 137–181.

__ , Gianni De Fraja, and Stefano Verzillo, "Publish or Perish? Incentives and Careers in Italian Academia" CEPR Working Paper 10084 London, UK July 2014.

__ , __ , and __ , "Selections from Ordered Sets" *Social Choice and Welfare*, 2018, *50(4)*, 677-703.

D'Angelo, Ciriaco Andrea, Cristiano Giuffrida, and Giovanni Abramo, "A Heuristic Approach to Author Name Disambiguation in Bibliometrics Databases for Large-Scale Research Assessments," *Journal of the American Society for Information Science and Technology*, 2011, *62*, 257–269.

De Fraja, Gianni and Paola Valbonesi, "The Design of the University System," *Journal of Public Economics*, 2012, *96*, 317–330.

De Philippis, Marta, "Multitask Agents And Incentives: The Case of Teaching and Research for University Professors," CEP Discussion Paper 1386, London School of Economics, London, 2015.

Dietza, James S and Barry Bozemanb, "Academic Careers, Patents, and Productivity: Industry Experience as Scientific and Technical Human Capital," *Research Policy*, 2005, *34*, 349–367.

Durante, Ruben, Giovanna Labartino, and Roberto Perotti, "Academic Dynasties: Decentralization and Familism in the Italian Academia," NBER Working Paper No. 17572 NBER November 2011.

Fudenberg, Drew, Richard Gilbert, Joseph Stiglitz, and Jean Tirole, "Preemption, Leapfrogging, and Competition in Patent Races," *European Economic Review*, 1983, *22*, 11383.

Grossman, Gene M and Carl Shapiro, "Research Joint Ventures: An Antitrust Analysis," *Journal of Law, Economics and Organization*, 1986, *2*, 315–37.

Guns, Raf and Ronald Rousseau, "Real and Rational Variants of the h-index and the g-index," *Journal of Informetrics*, 2009, *3*, 64–71.

Hirsch, J E, "An Index to Quantify an Individual's Scientific Research Output," *Proceedings of the National academy of Sciences of USA*, 2005, *102*, 16569–16572.

Kelchtermans, Stijn and Reinhilde Veugelers, "The Great Divide in Scientific Productivity: Why the Average Scientist Does not Exist," *Industrial and Corporate Change*, 2011, *20*, 295–336.

Klavans, Richard and Kevin W Boyack, "Is there a Convergent Structure of Science? A Comparison of Maps using the ISI and Scopus Databases," *11th International Conference of the International Society for Scientometrics and Informetrics*, 2007, Madrid, Spain.

Koenker, Roger W and Gilbert Bassett, "Regression Quantiles," *Econometrica*, 1978, *46*, 33–50.

Lazear, Edward and Shewrin Rosen, "Rank-Order Tournaments as Optimum Labor Contracts," *Journal of Political Economy*, 1981, *89*, 841–864.

López-Cózar, Emilio Delgado, Nicolás Robinson-García, and Daniel Torres-Salinas, "The Google Scholar Experiment: How to Index False Papers and Manipulate Bibliometric Indicators," *Journal of the Association for Information Science and Technology*, 2014, *65*, 446–454.

Mankiw, N Gregory, "My Rules of Thumb," in Michael Szenberg, ed., *Passion and Craft: Economists at Work*, University of Michigan Press, 1998.

Moss, David, "When Patronage Meets Meritocracy: Or, The Italian Academic *Concorso* as Cockfight," *European Journal of Sociology*, 2012, *53*, 205–231.

OECD, *Education at a Glance*, Paris: OECD, 2013.

Perotti, Roberto, *L'università truccata*, Torino, Italy: Einaudi, 2008.

Scoppa, Vincenzo, "Intergenerational Transfers of Public Sector Jobs: A Shred of Evidence on Nepotism," *Public Choice*, 2009, *141*, 167–188.

Siegel, Ron, "All-Pay Contests," *Econometrica*, 2009, *77*, 71–92.

Siow, Aloysius, "Tenure and Other Unusual Personnel Practices in Academia," *Journal of Law, Economics, & Organization* , 1998, *14(1)*, 152–173.

Verzillo, Stefano, "Efficiency and Scientific Productivity in the Italian Universities." PhD dissertation, University of Milan, Italy 2013.

Zinovyeva, Natalia and Manuel Bagues, "The Role of Connections in Academic Promotions," *American Economic Journal: Applied Economics*, 2015, *72(2)*, 264–292.

__ , Mauro Sylos-Labini, and __ ,"Does the Gender Composition of Scientific Committees Matter?," *American Economic Review*, 2017, *107(4)*, 1207–1238.

Online Appendix (not for publication)

A Proof of the Propositions

Proof of Proposition 1. Given the probability of winning, (2), the expected payoff of candidate of type v_i who chooses effort levels b_i is:

$$E\Pi_i = xZ_{KN}\left(V\left(b_i\right)\right) - \frac{b_i}{v_i}.$$

Differentiate the above with respect to b_i to get:

$$\frac{\partial E\Pi_i}{\partial b_i} = xZ'_{KN}\left(V\left(b_i\right)\right)V'\left(b_i\right) - \frac{1}{v_i} = 0. \tag{A1}$$

Because the strategy profile is symmetric, all players use the same strategies, and $V(b_i) = v_i$ (Barut et al 2002, p 680). Therefore (A1), can be written as:

$$xV\left(b_i\right)Z'_{KN}\left(V\left(b_i\right)\right) = \frac{1}{V'\left(b_i\right)}. \tag{A2}$$

The first order conditions are sufficient, given that $\frac{d^2E\pi_i}{db_i^2} < 0$, which follows immediately from Barut et al (2002, Appendix, pp 706-707).

Recall that $B\left(v_i\right)$ is the inverse of $V\left(b_i\right)$, and the above can be written as

$$B'\left(v_i\right) = xv_iZ'_{KN}\left(v_i\right), \qquad B\left(\underline{v}\right) = 0, \tag{A3}$$

which has solution given by (1), and this establishes the result.

□

Proof of Proposition 2. Suppose a candidate has applied for $\widehat{K}$ positions, each with $\widehat{N}$ applicants. If all the appointments are made according to research output then, from the point of view of an individual candidate, the situation is as it would be if there were a single competition with $\widehat{K}$ posts and $\widehat{N}$ competitors: she disregards the competition she has not entered. Thus if all the appointments are made according to research output, her payoff is

$$Z_{\widehat{K}\widehat{N}}\left(V\left(b_i\right)\right).$$

This happens with probability $x^{\widehat{K}}$. If instead only $\widehat{K}-1$ of the appointments are made according to research output the payoff is

$$Z_{\widehat{K}-1,\widehat{N}-1}\left(V\left(b_i\right)\right),$$

as one of the competitors wins the competition which disregards publications and is "withdrawn" from the pool, together with that competition. This happens with probability $\binom{\widehat{K}}{1}x^{\widehat{K}-1}\left(1-x\right)$. Of course, she can win that competition as well, but the probability of this happening is independent of b_i. And so on for all possible combinations of publications mattering/not mattering for the K appointments. Adding up over all the possible criteria gives the first term in (A4) below. From this, we subtract the cost of effort.

$$\sum_{k=0}^{\widehat{K}-1}\binom{\widehat{K}}{k}x^{\widehat{K}-k}\left(1-x\right)^k Z_{\widehat{K}-k,\widehat{N}-k}\left(V\left(b_i\right)\right)-\frac{b_i}{v_i}. \tag{A4}$$

Differentiation of (A4) gives the first order conditions which correspond to (A1):

$$\sum_{k=0}^{\widehat{K}-1}\binom{\widehat{K}}{k}x^{\widehat{K}-k}\left(1-x\right)^k Z'_{\widehat{K}-k,\widehat{N}-k}\left(V\left(b_i\right)\right)V'\left(b_i\right)-\frac{1}{V\left(b_i\right)}=0. \tag{A5}$$

The expression corresponding to (A2) in Proposition 1 is now derived for for this case:

$$V\left(b_i\right)\frac{\sum_{k=0}^{\widehat{K}-1}\binom{\widehat{K}}{k}x^{\widehat{K}-k}\left(1-x\right)^k Z'_{\widehat{K}-k,\widehat{N}-k}\left(V\left(b_i\right)\right)}{\sum_{k=0}^{\widehat{K}-1}\binom{\widehat{K}}{k}\left(1-x\right)^{\widehat{K}-k}x^k}=\frac{1}{V'\left(b_i\right)},$$

and the result follows. □

B Institutional details

The Italian university sector in the period we consider experienced fairly significant changes, as it went from a fully centralised system under direct control by the government, to a degree of autonomy for individual universities. This process was gradual and begun with Law n. 168, approved formally in 1989, which however was implemented slowly and in a piecemeal fashion and became fully operative more than a decade later. Before this law, universities were part of the state bureaucracy, degrees programmes were identical across the country and university professors were civil servants. With the new law, a block grant was awarded to each university and they were allowed some discretion in setting tuition fees (starting in 1993), a degree of teaching autonomy (1997), and permitted to introduce post-graduate degrees (in 1999, in accordance with Europe's "Bologna" process).

Like in many countries, US and UK among others, each university was organised in faculties, and faculties in turn in institutes, laboratories, and departments. Roughly speaking, teaching was done by faculties and research by the institutes, labs, and departments. The appurtenance of an academic to a faculty was formalised in the paperwork, while other links were less formal. There were three ranks for academics: assistant, associate, and full professor. Each academic had to be registered as member of one and only one of the 371 scientific sectors created at central level; there was no requirement that all members of a faculty or of a department had to belong to the same scientific sector, and it was not uncommon for a professor in a scientific sector to be in a faculty not closely related to his/her research interests.[1]

Even though in the 1990s universities were given some managerial and financial autonomy, university professors maintained their status of public employees: pay scales[2] and career progress were uniform across the country, mechanically determined on the basis of seniority and age, and no merit pay was possible. Academics had to be hired through public "competitions", with rigid and uniform rules.

Positions for assistant professor, while authorised centrally before financial autonomy, were filled with a local interview process which would have been recognisable to US and UK academics. This however, had to be preceded by two unseen written examinations. The procedure for new posts for full and associate professors were instead radically different. All posts which the government decided to fund in a pluriennial planning cycle were advertised simultaneously in *all* subject areas for *all* universities. These calls were meant to happen every two years, though in practice they were delayed, as a cost-cutting measure, and happened at four yearly intervals, as illustrated by Table 2 in the text. Formally, anybody could apply, not even a degree was necessary, though in practice potential applicants were academics in the lower rank in the same scientific sector, plus some from similar scientific sectors, and people from outside the Italian university system. Schematically, the procedure was for each university to submit requests for a number of posts in each of the 371 scientific sectors, with their proposed internal allocation to faculties, and for the ministry to accede to some of these requests. Selection committees were formed using a combination of

[1]This was somewhat inevitable due to the fairly broad nature of the teaching, so that, for example, economics graduates, had, by law, to pass several exams in law, accounting, management, foreign languages, medical students had to study physics and law, engineering students mathematics and management, and so on.

[2]The salary scales were (and are) overlapping: the lower rungs of the full professor scale being well below the upper rungs of the associate professor's scale, although promotions maintained length of service so that did not imply a pay-cut.

elections by peers and random draws.[3] Selection committees had much discretion in establishing criteria for promotion, in the spirit of the self-regulating academia, including the relative importance of outputs and activities such as teaching and contribution to the wider society. Committees, however, had to agree on these criteria and make them public after their first meeting. Though not explicitly required in the rules, in practice the number of "winners" was equal to the number of posts advertised.

Once appointed, academics were allocated to the faculties that had opened the positions. Following a probation period lasting three years, tenure was granted by a national committee, who very occasionally required a further review, two years hence. It could terminate employment, though this was a rare event indeed. Once tenured, a professor gained full freedom of movement across departments within the same university, while movement across universities was limited by availability of financial resources in the destination university. On the other hand, changes of the scientific sector of appurtenance required the approval of a national committee (CUN-Consiglio Universitario Nazionale, a consulting body for the Ministry, elected nationally by all professors).

In the year 1999, following the increase in the financial autonomy of universities, they took over the responsibility of hiring and competitions became "local". Each department competed with the other departments in the university to obtain funding to fill positions. The vacancy opened, a committee was formed, again with a high degree of centralisation: members of the appointing department were always a minority. Even though there was only one post available, the committee could grant eligibility ("idoneità") to up to three applicants (subsequently reduced to two), among whom the department chose the preferred candidate. The other eligible candidates could be hired by other universities without embarking into the formal appointment procedure (for a more detailed description see Moss 2012). In order to avoid the risk of inflating the number of applications to each opening, the law introduced a cap of five to the number of potential applications that each academic could submit each year.

At the end of 2010, another major reform (Law n. 240) granted university more bud-

[3] Committees were composed of an odd number of members (five, seven, or nine, depending on the expected number of applications). In the case of competitions for associate professorships, the committee for each scientific sector comprised two, three, or four associate professors and three, four, or five full professors, all belonging to that scientific sector. In the competition for full professorships, all members had to be full professors. The selection of members differed slightly in the two ranks: all full professors in a scientific sector elected triple the number of required members, and then the Ministry randomly drew the committee. The opposite order was followed to form the appointment committees for associate professorships: first the Ministry drew triple the number of required members, and then full and associated professors elected their respective representatives in the selecting committee.

getary autonomy, and relaxed marginally the Ministry's control over degree courses and other teaching matters. From the personnel viewpoint, the main change was the explicitly introduction of internal promotions, conditional on obtaining a qualification in national competitions. Prior to it, during the period we study, the Italian system did not have "internal" promotions. Someone who had been in post as associate professor in a university had to wait for a full professor post to be advertised, and then apply like everyone else to the national competition. Universities simply did not have the legal authority to sanction a change of rank. This law also changed the position of assistant professor. This was tenured until 2010, and it was replaced by temporary three year contracts (so called type A post) and tenure-track contracts (type B) of the "up-or-out" variety.

The contractual obligation for associate and full professors requires 350 hours per year being devoted to teaching and administrative duties (250 hours for part-time professors), but nothing was formally expected regarding research activity. New reforms which begun in the 2010s introduced some evaluation of departmental research (the VQR), but in the period we study, the only incentive to conduct good research and to obtain highly visible publications derives from career aspirations.

C Construction of the dataset

We present here some additional details of the preparation of the dataset.

C.1 Regression sample

We run two regressions, one for assistant professors (ricercatori) one for associate professors. In each regression, we include an academic/period observation if in that period the academic can be promoted to the next rank in the hierarchy, or if the academic is in the rank for the first time, and were in a lower rank in the previous period. Clearly, the individual fixed effect can be calculated only for those academics who appear in a given regression in at least two periods.

Table A1 illustrates eight plausible cases, with fictitious names. The first five columns show in which periods the academic appear in the dataset, then when he or she is included in the two regression, and whether their fixed effect is calculated.

With these criteria for inclusion in the regression sample, the number of observations the base and most other regressions is 120,095 and 90,894 for the assistant and associate regressions, with 47,572 and 37,066 different academics, respectively.

Table A1:
Inclusion in the Regression according to rank in each period.

	Period					Regression		Regression	
Name	P1	P2	P3	P4	P5	Assoc	FE?	Full	FE?
Frodo Baggins	Ric	AP	Full	Full	Full	P1-P2	Yes	P2-P3	Yes
Saruman	Ric	Ric	Ric	Ric	AP	P1-P5	Yes	-	-
Arwen	AP	AP	Full	Full	-	-	-	P1-P3	Yes
Gollum	-	-	-	-	AP	-	-	P5	No
Gríma Wormtongue	Ric	Ric	AP	AP	Full	P1-P3	Yes	P3-P5	Yes
Galadriel	Ric	Full	Full	Full	Full	P1-P2	Yes	-	-
Bilbo Baggins	-	-	Ric	Ric	Ric	P3-P5	Yes	-	-
Sauron	Full	Full	Full	Full	-	-	-	-	-

Note: Eight fictitious academics, and their inclusion in our two regressions, according to their rank: Assistant Professor (Ric), Associate Professor (AP) or Full Professor (Full) in the last year of each of the five periods.

C.2 Size of Scientific Sectors

Figure A1 depicts the distribution of the scientific sectors by size, pooling the years together. Size is measured as the average number of full professors in a year in a given scientific sector. The largest size is reached by "Economics" (the sector labelled SECS/P01) in 2007, with 341 full professors. See footnote 7 for information on the size of other subdisciplines related to economics.

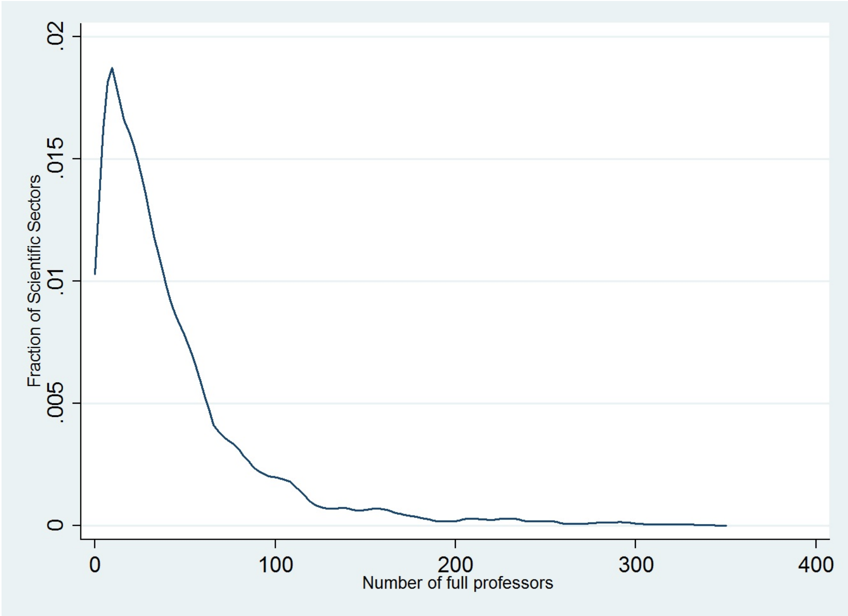
C.3 Pre-1994 Scientific Sectors

The scientific sector to which each professor was allocated was not recorded prior to 1994: we therefore "back-fill" by assigning the earliest recorded scientific sector to a person's missing values of the preceding years. In addition, a reclassification of the codes took place in 2000: we have mapped the old codes into the new ones following the relevant pieces of legislation: Decreto Ministeriale 23 December 1999, available, in Italian, at `www.miur.it/UserFiles/116.htm` and `http://attiministeriali.miur.it/media/174798/allegato%20a_def.pdf`.

C.4 Early exit from the database

Figure A2, which depicts the age distribution of exits from the system for associate and assistant professors as the solid lines, strongly suggests that exit from the dataset is determined by attrition, deaths and other exogenous events: reaching normal retire-

Figure A1:
Distribution of the number of full professors in scientific sectors.



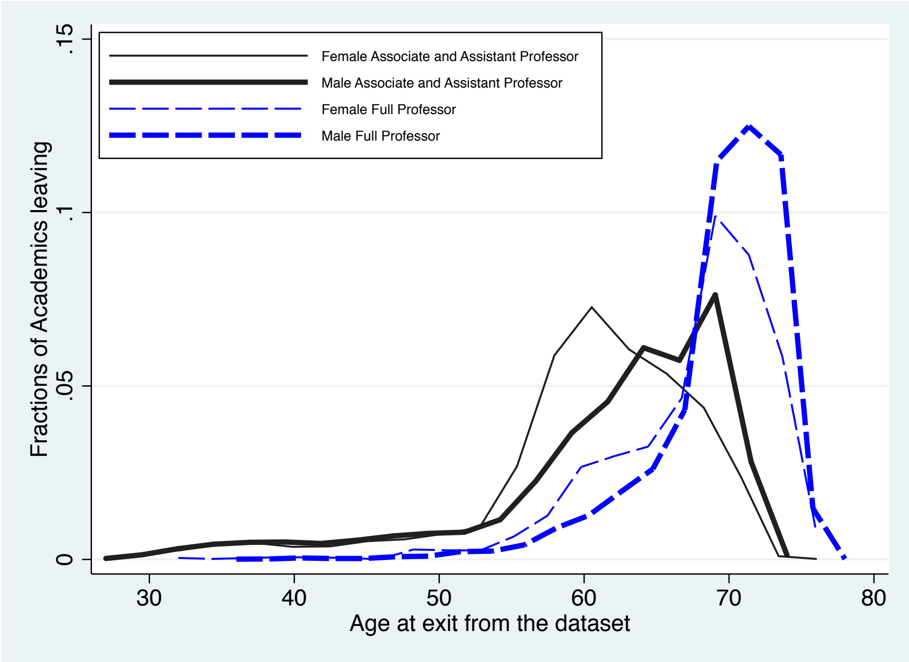
Note: Kernel density of the number of full professors in period times scientific sectors.

ment age is the norm. Regular exits from the system due to outside work opportunities would probably exhibit a different age pattern, as younger academics would be more likely to take such opportunities, and perhaps also differ for men and women. That only 0.1% of assistant and associate professors born between 1950 and 1960 leave the system before the age of 50, an age beyond which people are unlikely to emigrate or leave the university career, suggests that the incentives created by work opportunities outside the system are at best marginal. It therefore seems likely that career prospect outside Italian academia, for example in more rewarding academic positions abroad, were not a source of motivation for the individuals in our dataset.

C.5 Disambiguation of homonymy

In this section we explain how we have attempted to reduce the misattribution of papers to academics who share the surname and the initial with someone who works at an institution associated with the same university where they work. We begin by aggregating the scientific sectors into 29 groups (using the alphabetic part of the codes for the scientific sectors themselves). We then use the allocation of journals to 260 "subdisciplines" by the Journal Citation Report to calculate the frequency with which professors from each of the 29 research areas publish in journals assigned to these subdisciplines, and the frequency with which papers published in a subdisciplines

Figure A2:
Age distribution of leavers



Note: Kernel density of the age at which Italian academics leave the university sector in the sample period. The normal legal retirement age for university professors (and a few other public sector posts) was 60 for female and 70 for male associate and assistant professors and 70 for female and 75 for male full professors; this could be extended in some special cases.

are by professors in each research area. We then allocate an article that *prima facie* appears to have been written by a given Italian professor to that professor if either of these frequencies exceeds a certain value. The value itself is different for different research areas and different subdisciplines. In other words, if professors from a certain research areas appear to publish only occasionally in journals in a certain discipline, and if publications in journals from that subdiscipline are written only occasionally by professors in that research areas, then we attribute all such publications to homonymy, and do not allocate them to professors in the given research areas.

Formally, consider a paper published by author Y who is classified in the Ministry database as pertaining to research area B and who has published in a journal assigned by the Journal Citation Report to subdiscipline X. We attribute this paper to professor Y if the share of papers written by professors in research area B published in subdiscipline X (the share of the total of papers published by professors in research area B), exceeds a proportion of the Herfindal index (taken as a measure of the concentration of subdisciplines where professors in research area B publish) *or* if the share of papers written by professors in research area B published in subdiscipline X (the share of the total of papers published by in subdiscipline X), exceeds a proportion of the Herfindal index (taken as a measure of the concentration of professors' publications in research areas who publish in journals in subdiscipline X). We adjust for concentration – using the Herfindal index – because certain research area tend to publish almost exclusively in certain journals, and vice versa, certain journal subdisciplines tend to attract almost exclusively professor from certain research areas. When homonyms are also in the same disciplinary area, we share arbitrarily the papers among them. For example, if Enzo and Emilia Ferrari both held posts in Law in 1997 at the University of Modena, each of the downloaded papers authored by E Ferrari would be attributed to Enzo with probability $\frac{1}{2}$.

C.6 Recovering the h-index

For all its limitations, the h-index is gaining acceptance as a measure of a person's influence with their academic colleagues. To construct the h-index we need the number of papers and the citations each paper has received. The information we downloaded from WoK contains only the total number of citations at the time of download, and, in order to avoid downloading all the papers that cite a given paper and allocate each citation to the year in which the paper was cited, we assume that all papers in a given sub-discipline have the same time pattern of citations, and attributed the accumulated number of citations to each of the years since the paper's publication according to that pattern.[4]

Rather than the h-index, we calculate the *real* h-index (Guns and Rousseau (2009, p 67, expression (6)), which has the twofold advantage of taking continuously distributed values, and of refining the ordering of different individuals. For example, if individuals A's publications have 10, 1, and 0 citations, individuals B's publications have 1, 1, and 0 citations, both would have an h-index of 1, but individuals A has a real h-index of 1.9, whereas individuals B's real h-index is 1. This reduces considerably the number of ties in a way consistent with the importance of a person's output.

C.7 Orderliness x in different scientific sectors

Are there differences between research areas? This question is inspired by two recent assessment exercises carried out in the Italian university system, one assessing the research activities of every Italian university department, and the other determining

[4]Thus, for example, if all the papers in physics have received $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{4}$, $\frac{1}{6}$ of citations in the first four years after publications, and none in the successive years, then we have assumed that a paper published in 2002 which had 12 citations at the time of download had received 4 citations in 2002, 3 in 2003, 3 in 2004, and 2 in 2005, and none subsequently.

Table A2:
Descriptive statistics of the index of orderliness.

Period	Non-Bibliometric			Bibliometric			T-test
	mean	st.dev	n	mean	st.dev	n	p-value
1990-1994	0.017	(0.179)	144	0.047	(0.258)	190	0.88
1995-1998	0.093	(0.232)	128	0.314	(0.338)	172	1.00
1999-2002	0.045	(0.165)	159	0.363	(0.222)	192	1.00
2003-2006	0.041	(0.147)	154	0.339	(0.254)	195	1.00
2007-2011	0.086	(0.226)	136	0.302	(0.360)	190	1.00
1990-2011	0.055	(0.192)	721	0.273	(0.311)	939	1.00

Note: Orderliness of appointments and promotions to associate professor of bibliometric and non-bibliometric scientific sectors in Italian universities. Mean, standard deviation and number of scientific subsectors where at least one promotion occurred in a period. The the last column reports the p-values of mean difference tests between non-bibliometric and bibliometric scientific sectors.

which Italian assistant and associate professors were qualified for promotion. In these exercises, each of the scientific sectors was classified as either "bibliometric" or "non bibliometric",[5] with different assessment rules for the two types: assessment in the bibliometric scientific sectors had to utilise explicitly quantitative measures of publications in journals indexed in the Web of Knowledge and Scopus databases, while the non bibliometric relied exclusively on peer review. As far as we are aware, however, whether a given scientific sector was bibliometric or non bibliometric was decided by the government agency subjectively rather than following some objective algorithm. It might therefore be of interest to know whether the ministerial classification reflects differences in the criteria used in the past by promotion and appointment panels in the different scientific sectors. We do so here using the index of orderliness (5).

Table A2 reports the mean by scientific sector, split between bibliometric and non-bibliometric scientific sectors. As Table A2 shows, there are substantially differences in the role of ranking as determined by publication in international journals, which play on average a greater role in scientific sectors classified as bibliometric by the government. The same message is conveyed by Figure 3, which gives the kernel density of the orderliness computed for each scientific sector within each broad research area, and shows that on average the bibliometric/non-bibliometric divide is valid. Note that there is substantial variation *within* research areas to cast doubts on the

[5]The Ministry groups these 371 scientific sectors into broad research areas, and classifies Mathematics, Physics, Chemistry, Biology, Medicine, Engineering, Psychology, Agriculture and Veterinary Sciences as "bibliometric", and Humanities, Law, Sociology, Political Sciences, Architecture, History, Philosophy, Economics and Statistics as "non-bibliometric".

overall validity of the classification for a substantial minority of the scientific sectors: within each broad research area some sectors are more bibliometric than others, and their differences, as suggested by the P-values in Table A2 do not justify the sharp difference in assessment methodology. Finally, note that while the area of "Economics, Management and Statistics" is classified by the government as "non-bibliometric", the orderliness of its scientific sectors generates a kernel density, drawn in Figure 3 as the thicker dashed line, which is similar to the corresponding curves for the bibliometric broad research areas.

D Disaggregated analysis by broad research area.

We report more disagregated descriptive statistics and further empirical results which might be of interest to some readers.

The 371 scientific sectors can be grouped into five "broad research areas", Science, Medicine, Engineering, Art Humanities and Law, and Social Science. Tables A3 and A4 break down the information in Tables 1 and 2 by period and by broad subject area. Similarly, Table A5 gives the breakdown of the summary statistics, presented in aggregate in Table 3, by broad research area. This information is further broken down by period for the index of orderliness in the second part of Table A5.

In Table A6 we split the sample by broad research area. The main results reported in Table 5 hold in each subsample, indicating limited differences across broad research areas. Statistical significance declines, especially in the Arts, Humanities and Law, and in the social sciences. This is not surprising due to the lower importance of publishing in WoK outlets for academics in those disciplines.

E Further results

Table A7 reports the results of further robustness tests in respect of the clustering of the standard errors, of the temporal structure of academics' decision making, and of the computation of the expected number of potential competitors, N.

E.1 Clustering of the standard errors.

Recall that in the main table in the text, Table 5, we clustered the standard errors at the level of the variation in the main RHS variables, and of the instrument in the IV estimation, namely the scientific sector. As some individual changed scientific sector, we dropped them from the regression, given that there might be something different about them.

In the first three pairs of columns in Table A7, we report the comparison between the main regression (the first two columns in Table 5), which we report in columns 3 and 4 in Table A7, and two regressions where the clustering is at individual professor level, rather than at scientific sector level. In columns 5 and 6, we use the same sample as in the main regression: coefficients and the number of observations are obviously identical, and there is a small reduction in the standard errors. In columns 1 and 2 in Table A7, we report the regression with the entire sample, that is including the individuals who have changed scientific sector before or at promotions. When we cluster at individual level, the coefficients are essentially unchanged, suggesting that the small number of individuals dropped has no effect on the estimates.

E.2 Different time scale

The time structure implied by (9) assumes that effort in period t is determined by the period t variables. This could be either because academics apply for posts during the period, when they know the conditions which prevail in their sector, or, if they plan to apply in the next period, because they have static expectations and believe that the current conditions will prevail in the future as well. One could instead hypothesize longer lags between effort and applications, and forward looking individuals, who assume that they will apply for posts in the next period, and hold rational expectations regarding the future values of the variables, so that their period t output is affected by the expected values of x, K, and N in the next period. In this case (9) is replaced by:

$$o_{its} = \alpha_0 + \sum_{q \in \mathcal{Q}} \delta^q_{its} \Big(\alpha_{qx} x_{t+1,s} + \alpha_{qK} K_{t+1,s} + \alpha_{qN} \left(N_{t+1,s} + \lambda_q R_{t+1,s} \right) \Big) + \gamma_C C_{ts} + f_i + \xi_t + \sigma_s + \zeta_u + \varepsilon_{its}. \quad \text{(A6)}$$

We reports the estimations of (A6) in the seventh and eighth columns in Table A7, with this assumption that individuals base their choice of effort on the conditions expected for the next period. The coefficients for x are similar, those for K, N, and for the interaction of N and R less so, suggesting that academics were relatively more able to anticipate the future values of the importance of refereed publications than the number of competitors or posts in future periods. It also suggest that the introduction of the cap on the number of applications was not anticipated. Alternatively, it might be that academics respond to current conditions and that the similarity of the value of x in the first two columns, and in the fifth and sixth is simply due to the fact that x changes little from one period to the next.

E.3 Randomness of the post-reform constraint.

To confirm further the quasi-experimental nature of the tightness of the constraint, in this subsection we show that there *before the reform* was no systematic difference in the trend of output in sectors in which *after the reform* the constraint turns out to be binding. We run two very simple regressions of Δ_s, the proportional difference in average productivity in sector s, $s = 1, \ldots, 371$, between the two pre-reform periods on $\overline{R}_s$ the average tightness of the reform in the third and fourth period (we exclude period 5, because the constraint was slack for most sectors). That is, we run the regression:

$$\Delta_s = \alpha + \beta \overline{R}_s + \xi_s, \tag{A7}$$

where

$$\Delta_s = \frac{\overline{o}_{s2} - \overline{o}_{s1}}{\overline{o}_{s1}}, \tag{A8}$$

$$\overline{R}_s = \frac{R_{s3} + R_{s4}}{2}, \tag{A9}$$

where in turn $\overline{o}_{st}$ is the average output in sector s in period t, and R_{st} is the tightness of the constraint in sector s in period t. From this we obtain:

$$\Delta_s = \underset{0.105}{0.386^{***}} - \underset{0.439}{0.295} \overline{R}_s + \xi_s,$$

$$\Delta_s = \underset{0.084}{0.207^{***}} - \underset{0.369}{0.179} \overline{R}_s + \xi_s,.$$

The first regression is for the assistant professors sample the second for the associate professors. The lack of statistical significance, and a value of $R^2 = 0.001$ in both cases indicate the absence of correlation between the tightness of the post-reform constraint on application and the pre-reform productivity trends.

We have also replaced $\overline{R}_s$ with $\overline{\overline{R}}_s$, a dummy taking value 1 if and only if $\overline{R}_s$ is above the median (other plausible threshold give similar result), and obtained the following

$$\Delta_s = \underset{0.123}{0.439^{***}} - \underset{0.163}{0.171} \overline{R}_s + \xi_s,$$

$$\Delta_s = \underset{0.098}{0.122^{***}} + \underset{0.130}{0.103} \overline{R}_s + \xi_s,.$$

Here again the lack of statistical significance indicates the average similarity of the pre-reform trends of treated and untreated scientific sectors, the treated ones being those where the constraint on application was tight after the reform. The R^2 is 0.004

and 0.002, respectively.

E.4 The evolution of the variables.

Th aim of this subsection is to confirm that the temporal pattern of the three main variables x, K, and N is indeed the one that would be expected in a stable environment, where the government, while conscious of the overall funding total is not striving to micromanage the allocation to scientific sectors. To this aim, we construct the trend, by period, of the three variables in the two sample (the log for K and N). As it would be cumbersome to present all 371 of them, we choose those for the scientific sectors which fall at the nine interior deciles (that is, the 10-th, 20th, 30-th and so on percentiles) according to the ranking determined by that variable in the first period. This is in Figure A3. We also plot the scatter of the mean and standard deviation (both calculated over the five periods observed) of these same variables for all the 371 scientific sectors (Figure A4). The lack of any discernible pattern in either set of diagrams can be taken as an indication that funding was determined by the natural turnover and changes in overall patterns of student numbers rather than anything more related to the characteristics of the sector, such as size or the importance of the measurable dimension.

F Fixed effects

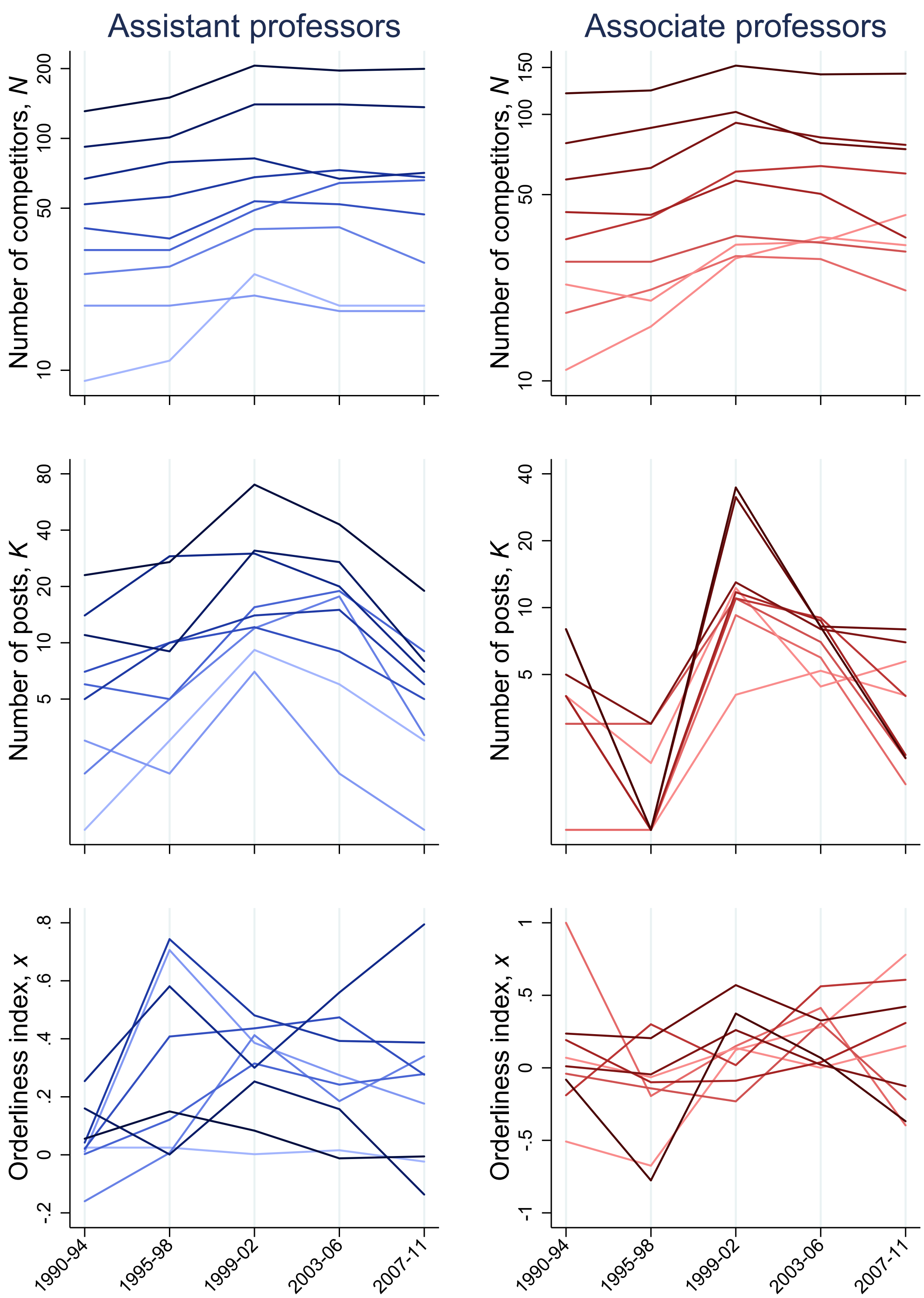
The value of the fixed effect for each Italian university, excluding the smaller specialist ones is shown in Table A9 for the two regressions. This could be taken as a measure of an independent effect on a person's output due to the fact of being employed by a given institution. Most effects are not significantly different from 0, which, as mentioned in the text, is what one would expect given that incentives operate at national level.

Table A3:
Promotions and Appointments by Period and Broad Research Area

Disciplinary Area	from Assist. to Assoc.	from Assoc. to Full	from Assist to Full	from Outside to Assoc.	from Outside to Full
Science					
1990-1994	869	610	29	304	51
1995-1998	752	30	1	145	12
1999-2002	2,094	1,829	33	242	64
2003-2006	1,354	900	6	164	24
2007-2011	607	349	7	78	15
Medicine					
1990-1994	404	204	13	246	17
1995-1998	108	124	21	82	20
1999-2002	889	828	48	460	47
2003-2006	687	525	4	321	30
2007-2011	301	256	2	93	13
Engineering					
1990-1994	444	265	4	149	9
1995-1998	693	21	5	82	3
1999-2002	1,033	1,100	12	88	9
2003-2006	811	554	3	118	13
2007-2011	406	201	4	38	9
Arts, Hum. & Law					
1990-1994	546	392	34	226	28
1995-1998	537	82	16	137	18
1999-2002	2,099	1,918	93	549	62
2003-2006	1,383	1,140	33	449	36
2007-2011	615	449	7	127	25
Social Sciences					
1990-1994	276	147	3	106	10
1995-1998	351	44	3	46	8
1999-2002	949	787	12	136	21
2003-2006	644	520	4	128	19
2007-2011	323	193	2	61	20
Total	19,175	13,468	399	4,575	583

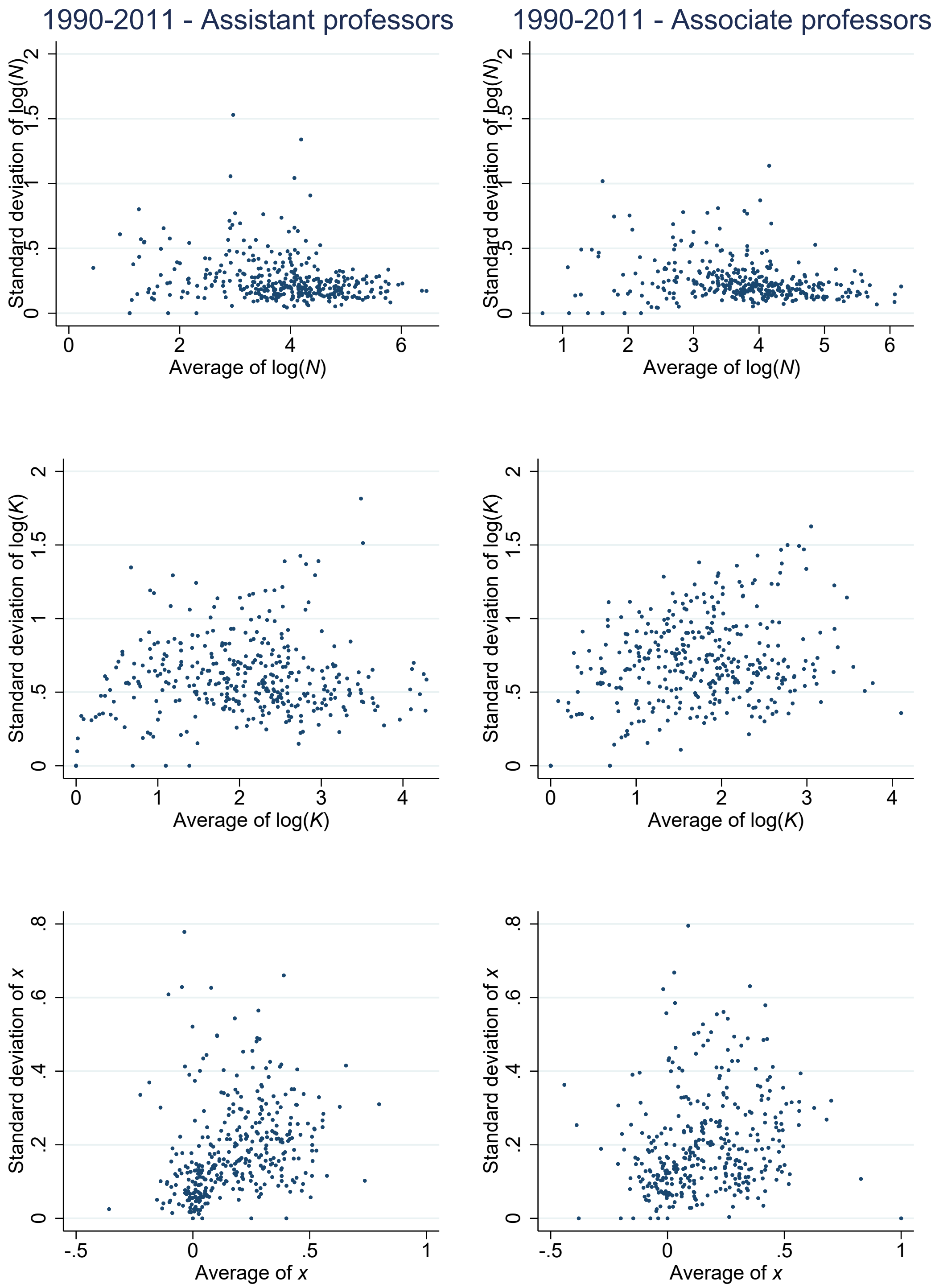
Note: Breaking down of Table 2 by broad research area. See the note of Table 2 for details.

Figure A3:
Time trend of the main independent variables.



Note: The figures illustrate the time trend of the three variables in a sample of nine scientific sectors, in each regression sample. The sectors are chosen as the nine interior deciles of the distribution of N. The colour of the line is depicted progressively darker as N increases in the sample.

Figure A4:
Mean and standard deviation of the main independent variables.



Note: The figures illustrate the average and the standard deviation across the five time periods, of the three variables, N, K, and x in all the scientific sectors, in each regression sample. Outliers, numbering no more than two, removed from the sample.

Table A4:
Number of professors by rank, broad discipline and period

Discipline	Stat	1991-1994			1995-1998			1999-2002			2003-2006			2007-2011		
		Assist.	Assoc.	Full	Assist.	Assoc.	Full	Assist.	Assoc.	Full	Assist.	Assoc.	Full	Assist.	Assoc.	Full
Science	Number	21,812	28,418	21,623	22,466	23,121	18,619	24,072	24,832	20,755	25,993	24,682	23,564	37,285	28,293	25,795
	Switchers	0	0	0	4	4	3	16	107	80	53	173	131	47	71	59
	Avg age	37.6	47.89	53.86	39.53	51.10	56.75	41.20	51.31	57.62	42.49	51.67	58.28	43.52	52.56	59.27
		5.76	7.13	7.76	6.39	7.45	7.78	7.17	8.50	7.85	7.82	8.75	7.95	7.89	8.12	7.39
	% female	0.44	0.29	0.11	0.44	0.29	0.12	0.47	0.31	0.13	0.50	0.35	0.16	0.50	0.37	0.18
	%WoK	0.89	0.80	0.83	0.91	0.82	0.85	0.91	0.86	0.90	0.91	0.89	0.92	0.91	0.92	0.94
Medicine	Number	18,022	16,959	10,295	15,503	13,573	8,779	17,758	13,233	9,401	20,440	13,416	10,227	25,862	15,665	11,921
	Switchers	0	0	0	1	1	0	26	41	16	83	111	82	72	75	62
	Avg age	41.64	49.70	57.22	44.76	52.84	59.95	46.45	53.52	59.91	47.87	53.86	59.52	49.03	55.46	60.28
		4.71	7.05	7.69	5.60	7.00	7.77	6.61	6.94	7.75	7.38	7.11	7.04	8.26	7.16	6.24
	% female	0.28	0.16	0.05	0.29	0.17	0.06	0.32	0.19	0.07	0.36	0.22	0.10	0.38	0.24	0.12
	%WoK	0.85	0.83	0.86	0.86	0.85	0.89	0.87	0.89	0.93	0.87	0.92	0.95	0.88	0.94	0.96
Engineering	Number	9,765	11,296	9,104	10,221	9,632	7,926	10,436	10,766	9,602	11,234	10,961	11,777	17,197	13,282	13,857
	Switchers	0	0	0	2	0	2	15	44	36	26	67	49	28	50	41
	Avg age	39.75	48.92	53.92	40.69	51.25	56.79	41.63	50.21	56.82	41.91	49.65	57.09	41.98	50.53	58.16
		7.64	8.03	7.95	8.32	8.70	7.90	9.06	9.81	8.33	9.40	9.76	8.53	8.25	8.75	8.05
	% female	0.19	0.11	0.04	0.19	0.12	0.05	0.23	0.13	0.06	0.26	0.16	0.08	0.28	0.18	0.09
	%WoK	0.58	0.52	0.61	0.65	0.55	0.64	0.65	0.62	0.70	0.66	0.67	0.73	0.67	0.71	0.77
Arts, Hum. & Law	Number	23,773	17,729	15,875	21,481	14,537	13,719	2,114	16,244	16,668	21,467	17,918	20,977	31,523	21,740	25,058
	Switchers	0	0	0	4	4	2	34	125	102	61	225	209	92	131	107
	Avg age	42.69	49.56	54.40	45.09	52.60	57.12	46.27	52.15	57.44	46.04	51.55	57.98	45.10	52.20	58.94
		5.92	7.09	8.20	7.13	7.44	7.95	8.50	8.67	7.97	9.66	9.16	8.25	9.38	8.98	7.94
	% female	0.56	0.39	0.17	0.54	0.40	0.19	0.55	0.43	0.23	0.56	0.46	0.27	0.55	0.47	0.30
	%WoK	0.20	0.22	0.24	0.21	0.23	0.26	0.19	0.24	0.28	0.19	0.23	0.30	0.18	0.23	0.31
Social Sciences	Number	6,908	6,149	5,682	7,285	5,248	5,059	7,060	6,608	6,529	7,496	7,276	8,629	12,236	9,150	10,905
	Switchers	0	0	0	1	1	0	3	49	36	29	91	80	38	53	43
	Avg age	40.04	48.11	52.15	41.20	50.73	55.10	41.99	49.18	55.85	41.92	48.69	56.17	41.51	49.34	56.99
		6.89	7.46	7.39	7.81	8.20	7.32	8.84	9.60	7.94	9.25	9.84	8.78	8.45	9.10	8.71
	% female	0.40	0.23	0.09	0.39	0.25	0.10	0.42	0.28	0.14	0.45	0.32	0.17	0.46	0.35	0.20
.	%WoK	0.36	0.31	0.35	0.40	0.34	0.38	0.37	0.40	0.43	0.35	0.42	0.47	0.32	0.44	0.51

Note: Standard deviation of age under the corresponding average. %WoK: Proportion of professors with at least one publication in the WoK dataset.

Table A5:
Summary Statistics for the variable used in the regressions by broad disciplinary area

	Science				Medicine				Engineering				Arts, Hum. and Law				Social Sciences			
	Assist.		Assoc.		Assist.		Assoc.		Assist.		Assoc.		Assist.		Assoc.		Assist.		Assoc.	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Output	0.014	0.076	0.016	0.085	0.011	0.291	0.018	0.415	0.031	0.248	0.034	0.224	0.033	0.456	0.085	3.652	0.020	0.215	0.029	0.295
Orderliness Index	0.660	0.126	0.605	0.174	0.614	0.148	0.630	0.132	0.634	0.132	0.608	0.141	0.527	0.072	0.535	0.107	0.573	0.093	0.559	0.123
Orderliness (weighted with IF)	0.657	0.125	0.603	0.173	0.620	0.150	0.632	0.134	0.628	0.130	0.605	0.140	0.522	0.070	0.527	0.095	0.568	0.092	0.556	0.119
Orderliness Index																				
1990-94	0.556	0.149	0.631	0.202	0.544	0.132	0.607	0.165	0.530	0.172	0.588	0.159	0.518	0.105	0.507	0.097	0.521	0.115	0.558	0.170
1995-98	0.732	0.147	0.510	0.212	0.674	0.248	0.620	0.219	0.693	0.144	0.448	0.075	0.543	0.123	0.509	0.183	0.593	0.142	0.624	0.185
1999-02	0.720	0.116	0.615	0.115	0.762	0.105	0.677	0.121	0.655	0.130	0.613	0.148	0.521	0.091	0.536	0.097	0.556	0.102	0.555	0.084
2003-06	0.715	0.116	0.630	0.141	0.731	0.135	0.661	0.124	0.658	0.174	0.625	0.142	0.521	0.091	0.560	0.125	0.543	0.098	0.571	0.116
2007-11	0.724	0.148	0.656	0.215	0.705	0.172	0.666	0.183	0.667	0.159	0.670	0.193	0.546	0.118	0.533	0.125	0.591	0.166	0.524	0.158
Number of Posts K	28.8	29.8	19.5	22.3	31.8	35.3	19.1	19.2	21.3	17.7	13.5	14.7	20.7	21.5	13.4	14.5	35.3	31.8	22.7	23.5
Number of competitors N	169.4	125.1	183.8	135.2	258.5	208.7	194.9	152.4	105.7	73.6	97.0	65.4	117.1	74.1	83.1	49.2	155.1	100.4	132.8	87.9
Average age in the sector	40.8	2.3	50.8	1.8	45.9	2.8	53.1	2.1	41.1	1.1	50.1	1.1	44.9	1.4	51.5	1.3	41.3	0.8	49.2	1.1
Share of women in the sector	0.467		0.323		0.327		0.196		0.231		0.140		0.550		0.428		0.425		0.287	
Promotions from outside	0.142		0.091		0.312		0.062		0.112		0.029		0.210		0.057		0.155		0.082	
Broad Homonymy dummy	0.274		0.274		0.290		0.279		0.277		0.294		0.269		0.262		0.271		0.265	
Narrow Homonymy dummy	0.004		0.006		0.020		0.017		0.005		0.004		0.002		0.001		0.004		0.002	
Region: North East	0.226		0.215		0.233		0.255		0.272		0.284		0.189		0.181		0.255		0.241	
North West	0.213		0.232		0.163		0.184		0.169		0.187		0.193		0.231		0.193		0.239	
Centre	0.262		0.260		0.288		0.278		0.259		0.240		0.301		0.285		0.275		0.274	
South and Islands	0.299		0.294		0.316		0.283		0.300		0.289		0.317		0.302		0.277		0.246	
Observations	14,292		11,760		8,936		6,721		7,470		5,837		13,137		9,899		5,437		4,063	

Note: disciplinary area is missing in 265 cases.

Table A6:
Results of base regressions, coauthors weighting, by broad disciplinary area

Determinants of Individual productivity	**Disciplinary Area**											
	Base Regression		Science		Medicine		Engineering		Hum. & Law		Social Sciences	
	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.
Orderliness: below median	-0.196***	-0.123***	-0.062**	-0.063***	-0.005	-0.039	-0.302***	-0.250***	-0.094***	-0.025	-0.233***	-0.080
	0.020	0.016	0.025	0.018	0.017	0.033	0.044	0.060	0.029	0.020	0.041	0.056
Deciles 6 and 7	0.024*	0.005	-0.019	0.015	-0.010	0.019	0.142***	-0.009	-0.033	-0.003	-0.146***	-0.042
	0.013	0.012	0.021	0.020	0.018	0.024	0.053	0.034	0.031	0.021	0.046	0.036
Deciles 8 and 9	0.345***	0.151***	0.045	0.028	0.005	0.013	0.783***	0.412***	0.076*	0.006	0.296***	0.112
	0.040	0.030	0.046	0.038	0.027	0.057	0.101	0.087	0.044	0.047	0.066	0.084
Top decile	0.709***	0.287***	0.050	0.126	0.089	0.079	1.767***	0.970***	0.239	0.073	1.190***	0.427
	0.081	0.062	0.104	0.087	0.105	0.128	0.266	0.252	0.182	0.159	0.244	0.287
Number of posts: below median	0.013*	0.035***	0.035***	0.018*	0.004	0.022	-0.009	-0.025	0.002	0.016**	0.008	0.025
	0.007	0.005	0.010	0.009	0.005	0.013	0.021	0.016	0.007	0.007	0.010	0.020
Deciles 6 and 7	-0.006	0.012***	-0.001	0.005	-0.002	0.007	-0.008	-0.025	-0.000	0.015*	0.002	0.015
	0.005	0.004	0.015	0.008	0.006	0.009	0.027	0.017	0.006	0.008	0.013	0.020
Deciles 8 and 9	-0.025*	-0.019**	-0.022	-0.004	-0.007	0.016	0.006	-0.018	-0.002	-0.005	-0.019	0.021
	0.014	0.008	0.018	0.014	0.009	0.017	0.036	0.024	0.007	0.012	0.019	0.019
Top decile	-0.071***	-0.017	-0.096**	-0.053*	-0.040*	0.098**	-0.041	0.090	-0.055*	-0.010	-0.081	0.051
	0.024	0.022	0.040	0.028	0.021	0.042	0.104	0.074	0.031	0.029	0.050	0.066
Competitors: below median	0.036*	-0.044***	-0.176***	-0.026	0.019	-0.156***	0.151**	0.043	0.025	-0.029	0.091	-0.041
	0.020	0.015	0.046	0.029	0.044	0.040	0.072	0.038	0.018	0.019	0.064	0.027
Deciles 6 and 7	0.065***	-0.007	-0.104**	0.032	0.050	-0.111***	0.173**	0.066*	0.027	-0.027	0.096	-0.025
	0.021	0.015	0.046	0.029	0.044	0.039	0.073	0.037	0.018	0.019	0.063	0.026
Deciles 8 and 9	0.105***	0.053***	-0.021	0.116***	0.103**	-0.047	0.190**	0.093**	0.032*	-0.006	0.122**	0.006
	0.025	0.017	0.046	0.030	0.043	0.039	0.072	0.040	0.017	0.019	0.059	0.025
Top decile	0.245***	0.204***	0.172***	0.303***	0.241***	0.073	0.327***	0.181***	0.151***	0.127***	0.290***	0.180***
	0.028	0.023	0.059	0.032	0.045	0.046	0.096	0.067	0.025	0.025	0.064	0.041
Effect of Reform: below median	0.002	0.002	0.005***	0.006***	0.004***	0.005**	0.011**	-0.001	0.004**	0.005**	-0.004	0.003
	0.001	0.002	0.002	0.002	0.001	0.002	0.005	0.007	0.001	0.002	0.003	0.005
Deciles 6 and 7	-0.002	-0.000	0.003	0.000	0.002	0.002	0.003	0.003	0.003*	0.005*	-0.005	0.001
	0.002	0.002	0.003	0.003	0.003	0.003	0.007	0.004	0.002	0.003	0.003	0.003
Deciles 8 and 9	-0.010***	-0.004	-0.012***	-0.016***	-0.008***	-0.009**	-0.011*	0.010	0.001	-0.000	-0.005	-0.006
	0.002	0.003	0.004	0.004	0.003	0.004	0.006	0.008	0.002	0.003	0.003	0.006
Top decile	-0.033***	-0.040***	-0.033***	-0.044***	-0.018***	-0.047***	-0.054***	-0.035*	-0.022***	-0.042***	-0.034***	-0.055***
	0.006	0.005	0.010	0.007	0.007	0.010	0.018	0.019	0.008	0.013	0.010	0.015
Observations	120,095	90,894	35,164	30,329	24,970	16,963	16,818	13,056	31,380	21,532	11,763	9,014
R-squared	0.434	0.361	0.642	0.567	0.514	0.413	0.563	0.338	0.182	0.190	0.472	0.424
Number of different professors	47,572	37,066	13,866	11,464	8,660	6,514	7,284	5,667	12,529	9,500	5,233	3,921

Note: *** p≤0.01, ** p≤0.05, * p≤0.1. The first two columns are identical to the third and the fourth column in Table 5. The next five pair of coulmns repeat the regression for the five "broad research areas" subsamples. See the note in Table 5 for details of the regressions.

Table A7:
Results of base regressions, different clustering of the standard errors, and different time structure.

Determinants of Individual productivity	Full Sample		Final Sample		Final Sample		Future values		N includes outsiders	
Std. errors clustering	Individual Level		Scientific Sector		Individual Level		Scientific Sector		Scientific Sector	
	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.
Orderliness: < median	-0.196***	-0.123***	-0.196***	-0.123***	-0.196***	-0.123***	-0.190***	-0.091***	-0.196***	-0.123***
	0.005	0.005	0.020	0.016	0.005	0.005	0.026	0.020	0.020	0.016
Deciles 6 and 7	0.025***	0.006	0.024*	0.005	0.024***	0.005	0.041**	0.003	0.024*	0.005
	0.007	0.008	0.013	0.012	0.007	0.008	0.017	0.015	0.013	0.012
Deciles 8 and 9	0.341***	0.148***	0.345***	0.151***	0.345***	0.151***	0.352***	0.145***	0.345***	0.151***
	0.011	0.013	0.040	0.030	0.012	0.013	0.049	0.042	0.040	0.030
Top decile	0.712***	0.301***	0.709***	0.287***	0.709***	0.287***	0.821***	0.313***	0.710***	0.287***
	0.035	0.041	0.081	0.062	0.036	0.041	0.105	0.100	0.081	0.062
Number of posts: < median	0.013***	0.035***	0.013*	0.035***	0.013***	0.035***	0.008	0.020***	0.012***	0.035***
	0.002	0.002	0.007	0.005	0.002	0.002	0.008	0.008	0.007	0.005
Deciles 6 and 7	-0.005**	0.013***	-0.006	0.012***	-0.006**	0.012***	-0.009	-0.019**	-0.007	-0.012***
	0.002	0.003	0.005	0.004	0.002	0.003	0.006	0.008	0.005	0.004
Deciles 8 and 9	-0.026***	-0.018***	-0.025*	-0.019**	-0.025***	-0.019***	-0.050***	-0.073***	-0.026***	-0.019***
	0.004	0.004	0.014	0.008	0.004	0.004	0.015	0.014	0.014	0.008
Top decile	-0.073***	-0.020	-0.071***	-0.017	-0.071***	-0.017	-0.109***	-0.131***	-0.072***	-0.017
	0.013	0.013	0.024	0.022	0.013	0.013	0.032	0.037	0.024	0.022
Competitors: < median	0.023***	-0.051***	0.036*	-0.044***	0.036***	-0.044***	-0.020	0.049	0.034***	-0.044***
	0.009	0.010	0.020	0.015	0.010	0.011	0.020	0.036	0.020	0.015
Deciles 6 and 7	0.051***	-0.015	0.065***	-0.007	0.065***	-0.007	0.001	0.089**	0.062***	-0.007
	0.009	0.010	0.021	0.015	0.010	0.011	0.021	0.036	0.021	0.015
Deciles 8 and 9	0.092***	0.045***	0.105***	0.053***	0.105***	0.053***	0.047*	0.152***	0.103***	0.052***
	0.009	0.010	0.025	0.017	0.010	0.011	0.024	0.038	0.025	0.017
Top decile	0.232***	0.198***	0.245***	0.204***	0.245***	0.204***	0.169***	0.310***	0.242***	0.202***
	0.011	0.012	0.028	0.023	0.013	0.013	0.030	0.043	0.028	0.024
Effect of reform: < median	0.002***	0.002***	0.002	0.002	0.002***	0.002***	0.002	-0.000	0.002	0.002
	0.000	0.001	0.001	0.002	0.000	0.001	0.002	0.002	0.001	0.002
Deciles 6 and 7	-0.002**	-0.001	-0.002	-0.000	-0.002**	-0.000	0.005**	0.004**	-0.002	-0.000
	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.002	0.002
Deciles 8 and 9	-0.010***	-0.004***	-0.010***	-0.004	-0.010***	-0.004***	0.005	0.011***	-0.010***	-0.004
	0.001	0.001	0.002	0.003	0.001	0.001	0.004	0.003	0.002	0.003
Top decile	-0.031***	-0.039***	-0.033***	-0.040***	-0.033***	-0.040***	-0.010	0.003	-0.033***	-0.040***
	0.004	0.004	0.006	0.005	0.004	0.004	0.008	0.012	0.006	0.005
Observations	124,832	93,469	120,095	90,894	120,095	90,894	70,614	45,396	120,095	90,894
R-squared	0.438	0.365	0.434	0.361	0.434	0.361	0.434	0.419	0.434	0.361
Number of different professors	49,076	37,993	47,572	37,066	47,572	37,066	35,832	25,902	47,572	37,066

Note: *** p≤0.01, ** p≤0.05, * p≤0.1. the first six columns are the estimation of (9) with different assumptions about the clustering of the standard errors, see Section E.1 for details. Columns 7 and 8 are the estimation of (A6), where a different temporal structure is postulated, as explained in Section E.2. The last two columns repeat the base regression including in the count of the number of potential competitors also those appointed from outside Italian academia. See the note in Table 5 for details of the regressions.

Table A8:
First stage regressions: Interaction of index x with partition.

	Assistant professors				Associate professors			
	Below median	Deciles 6 and 7	Deciles 8 and 9	Top decile	Below median	Deciles 6 and 7	Deciles 8 and 9	Top decile
Interaction of sd								
Below median	0.00831***	-0.00855***	-0.00991***	-0.00506***	0.0313***	-0.00473***	-0.00509***	-0.00218***
	(0.000695)	(0.000466)	(0.000452)	(0.000304)	(0.00805)	(0.00160)	(0.00146)	(0.000634)
Deciles 6 and 7	-0.0250***	0.0234***	-0.00916***	-0.00479***	-0.0109**	0.0363***	-0.00485***	-0.00190**
	(0.000827)	(0.000554)	(0.000538)	(0.000361)	(0.00505)	(0.00614)	(0.00178)	(0.000798)
Deciles 8 and 9	-0.0272***	-0.00853***	0.0250***	-0.00423***	-0.0131***	-0.00501***	0.0380***	-0.00134
	(0.000846)	(0.000567)	(0.000550)	(0.000370)	(0.00494)	(0.00172)	(0.00623)	(0.00106)
Top Decile	-0.0276***	-0.00907***	-0.00842***	0.0312***	-0.0144***	-0.00576***	-0.00177	0.0423***
	(0.00109)	(0.000731)	(0.000710)	(0.000477)	(0.00471)	(0.00168)	(0.00217)	(0.00629)
Interaction of ratio								
Below median	0.0371***	0.0134***	0.0104***	0.00378***	0.0329	-0.000536	-0.00348	-0.00299
	(0.00211)	(0.00141)	(0.00137)	(0.000922)	(0.0237)	(0.00697)	(0.00669)	(0.00338)
Deciles 6 and 7	0.0309***	0.0158***	0.0128***	0.00453***	0.00782	0.0288	-0.00322	-0.00203
	(0.00257)	(0.00172)	(0.00167)	(0.00112)	(0.0197)	(0.0190)	(0.00771)	(0.00345)
Deciles 8 and 9	0.0282***	0.0136***	0.0115***	0.00612***	0.00887	0.00147	0.0202	-0.00226
	(0.00262)	(0.00176)	(0.00171)	(0.00115)	(0.0177)	(0.00718)	(0.0177)	(0.00457)
Top decile	0.0265***	0.0107***	0.0176***	0.00281*	0.00326	-0.00208	0.000415	0.0229
	(0.00356)	(0.00238)	(0.00231)	(0.00155)	(0.0161)	(0.00729)	(0.00742)	(0.0176)
Observations	109,142	109,142	109,142	109,142	83,766	83,766	83,766	83,766
F-test	401.10***	303.2***	338.3***	203.6***	398.6***	250.8***	267.77***	128.53***
Number of professors	36,619	36,619	36,619	36,619	29,938	29,938	29,938	29,938

Note: First stage regression results (intrumental variables only), for the regression in column 3 and 4 in Table 5. See the note in that table for details of the independent variables. The instruments are the standard deviation of the output of the full professors, and the ratio of the numbers of full and associate/assistant professors in the scientific sector in the period. See Section 5 in the main text for details. The F-test row reports, for each first stage regression, the F-test of excluded instruments.

Table A9:
Estimated fixed effects for the Italian universities.

Region	University	Assist Estimate	Assist PValue	Assoc Estimate	Assoc PValue
Puglia	Bari	0.043	0.714	0.187	0.566
Basilicata	Basilicata	0.066	0.716	0.231	0.447
Lombardia	Bergamo	0.127	0.143	0.237	0.424
Emilia Romagna	Bologna	0.063	0.636	0.270	0.415
Lombardia	Brescia	0.108	0.207	0.321	0.277
Lombardia	Bocconi Milano	0.227	0.035	0.177	0.556
Sardegna	Cagliari	0.265	0.000		
Marche	Camerino	0.098	0.353	0.210	0.482
Lazio	Cassino e Lazio Meridionale	0.128	0.145	0.225	0.446
Sicilia	Catania	0.220	0.118	0.159	0.608
Calabria	Catanzaro			0.095	0.763
Abruzzo	ChietiPescara	0.069	0.506	0.261	0.402
Veneto	Ca’ Foscari Venezia	0.110	0.335	0.319	0.282
Lombardia	Cattolica Del Sacro Cuore	0.066	0.491	0.336	0.280
Lazio	Europea Di Roma	0.146	0.091	0.269	0.363
Emilia Romagna	Ferrara	0.132	0.209	0.312	0.457
Toscana	Firenze	0.253	0.193	0.291	0.333
Puglia	Foggia	0.114	0.546	0.243	0.401
Liguria	Genova	0.083	0.519	0.325	0.265
Lombardia	I.U.S.S. Pavia	0.090	0.335	0.264	0.382
Lombardia	Insubria	0.129	0.137	0.304	0.301
Lombardia	Iulm Milano	0.022	0.834	0.384	0.283
Abruzzo	L’Aquila	0.108	0.224	0.344	0.251
Lombardia	Liuc Castellanza	0.109	0.220	0.185	0.541
Lazio	Luiss Guido Carli Roma	0.139	0.138	0.236	0.428
Puglia	Lum Jean Monnet	0.141	0.169	0.308	0.305
Lazio	Luspio	0.067	0.510	0.342	0.254
Lazio	Libera Univ. Maria Ss.AssuntaLumsa Roma	0.111	0.203	0.233	0.437
Trentino Alto Adige	Libera Univ. Di Bolzano	0.589	0.041	0.293	0.835
Marche	Macerata	0.148	0.154	0.288	0.329
Sicilia	Messina	0.116	0.242	0.222	0.458
Lombardia	Milano	0.090	0.353	0.455	0.177
Lombardia	MilanoBicocca	0.137	0.221	0.209	0.479
Emilia Romagna	Modena e Reggio Emilia	0.117	0.170	0.325	0.267
Calabria	Mediterranea di Reggio Calabria	0.102	0.190	0.230	0.439
Campania	Napoli Federico II	0.151	0.081	0.214	0.468
Veneto	Padova	0.163	0.081	0.377	0.216
Sicilia	Palermo	0.144	0.190	0.172	0.591
Emilia Romagna	Parma	0.117	0.186	0.229	0.437
Lombardia	Pavia			0.551	0.147
Umbria	Perugia	0.121	0.156	0.335	0.255
Piemonte	Piemonte Orientale	0.229	0.025	0.280	0.352
Toscana	Pisa	0.176	0.069	0.345	0.287
Campania	Parthenope Di Napoli	0.111	0.197	0.241	0.415
Marche	Politecnica delle Marche	0.094	0.330	0.258	0.382
Puglia	Politecnico di Bari	0.101	0.307	0.250	0.389
Lombardia	Politecnico di Milano	0.139	0.117	0.439	0.217
Piemonte	Politecnico di Torino	0.120	0.175	0.196	0.505
Lazio	Roma Foro Italico	0.078	0.440	0.232	0.440
Lazio	Roma La Sapienza	0.095	0.590	0.120	0.683
Lazio	Roma Tre	0.013	0.919	0.047	0.936
Lazio	Roma Tor Vergata	0.145	0.415	0.297	0.359
Lombardia	S. Raffaele Milano	0.031	0.834	0.343	0.257
Puglia	Salento	0.105	0.275	0.278	0.366
Campania	Salerno	0.074	0.454	0.346	0.242
Campania	Sannio di Benevento	0.110	0.223	0.273	0.351
Sardegna	Sassari	0.094	0.416	1.323	0.196
Piemonte	Scienze Gastronomiche Bra	0.036	0.783	0.252	0.398
Toscana	Siena	0.070	0.531	0.312	0.293
Friuli Venezia Giulia	Sissa Trieste	0.157	0.157	0.212	0.481
Toscana	Sum Ist. Italiano di Scienze Umane Firenze	0.050	0.755	0.198	0.533
Toscana	Scuola IMT Lucca	0.143	0.262	0.368	0.248
Toscana	Scuola Normale Superiore di Pisa	0.044	0.750	0.555	0.105
Toscana	Scuola Superiore Sant’Anna	0.126	0.157	0.188	0.519
Campania	Seconda Univ. Napoli	0.076	0.401	0.284	0.347
Calabria	Stranieri di Reggio Calabria	0.011	0.926	0.235	0.451
Umbria	Stranieri di Perugia			0.662	0.038
Toscana	Stranieri di Siena	0.028	0.760	0.256	0.384
Abruzzo	Teramo	0.101	0.408	0.301	0.310
Piemonte	Torino	0.063	0.466	0.362	0.219
Trentino Alto Adige	Trento	0.068	0.581	0.239	0.429
Friuli Venezia Giulia	Trieste	0.236	0.042	0.349	0.262
Lazio	Tuscia	0.090	0.318	0.278	0.350
Friuli Venezia Giulia	Udine	0.099	0.363	0.153	0.620
Sicilia	UKE Univ. Kore di Enna	0.143	0.082	0.157	0.589
Lazio	Unicusano Telematica Roma	0.175	0.066	0.305	0.292
Marche	Urbino Carlo Bo	0.090	0.535	0.104	0.832
Lazio	Univ. Campus BioMedico di Roma	0.086	0.328	0.286	0.331
Lombardia	Univ. Telematica ECampus	0.172	0.131	0.222	0.451
Campania	Univ. Telematica Giustino Fortunato	0.114	0.191	0.272	0.356
Lazio	Univ. Telematica Guglielmo Marconi	0.124	0.154	0.285	0.331
Lazio	Univ. Telematica Internazionale Uninettuno	0.111	0.243	0.183	0.548
Campania	Univ. Telematica Pegaso	0.153	0.101	0.279	0.344
Lazio	Univ. Telematica Unitelma Sapienza	0.123	0.157	0.221	0.448
Lazio	Univ. Telematica Universitas Mercatorum	0.099	0.312	0.216	0.462
Veneto	Univ. Iuav Di Venezia	0.123	0.182	0.337	0.291

Note: Estimated university fixed effects from the regression specified in (9), for the samples of assistant and associate professors. Details of the regression are in the note of Table 5.