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Publish or Perish: An Analysis of the Academic Job Market in Italy

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Publish or Perish? Incentives and Careers in Italian Academia*

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Abstract

We derive a theoretical model of effort in the presence of career concern based on the multi-unit all-pay auction, and closely inspired by the Italian academic market. In this model, the number of applicants, the number of new posts, and the relative importance of the determinants of promotion determine academics' effort. Because of the specific characteristics of Italian universities, where incentives operate only through promotion, and where all appointment panels are drawn from strictly separated and relatively narrow scientific sectors, the model fits well Italian academia, and we test it in a newly constructed dataset which collects the journal publications of all Italian academics working in universities. We find that individual researchers respond to incentives in the manner predicted by the theoretical model: more capable researchers respond to increases in the importance of the measurable determinants of promotion and in the competitiveness of the scientific sector by exerting more effort; less able researchers do the opposite.

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1 Introduction

This paper studies the career concerns of the academics working in Italian universities. Like other economic agents, academics are subject to incentives, and beside its independent interest, understanding how academics respond to them is an indispensable component of any attempt to improve the behaviour and performance of the university sector. Improvement, is felt by many in Italy, is long overdue: while there are pockets of excellence, as is natural in a huge sector,[1] university teaching and research languish in mediocrity,[2] and successive government have strived to reform the system to improve its performance.

The Italian university sector follows a complex system of nationally mandated rules, typically designed to narrow the scope for cronyism by blunting discretion and subjective judgements (Perotti 2008), which on the whole design a weak incentive system. Because the rules are explicit and are applied uniformly across universities and subject areas, they lend themselves precisely to formal modelling. In this paper, we build upon the established model of the all-pay auction for multiple units (Barut et al 2002); in this model, bidders compete to be awarded one of K identical prizes, with each bidder paying her bid, and the highest K bidders receiving one of the prizes. This model captures closely the situation in Italy prior to 1999, and is easily modified to account for the changes introduced by the 1999 reform. The analogy stems from viewing the output of academics as bids, which involve a utility cost, and stochastically award a prize, as in other natural applications of the all-pay auction, such as R&D investment of the award of a patent (Grossman and Shapiro 1986), or the exertion of effort for progression in an organisation hierarchy (Lazear and Rosen 1981), or lobbying (Baye et al 1993), rent-seeking (Anderson et al 1998),

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

[2]In the most recent QS world ranking of universities, 29 countries boast a higher ranked university than Bologna, the highest ranked Italian one, which fluctuates between 173rd and 194th place. The “college premium”, the ratio of earnings of those with tertiary and secondary education puts Italy in an intermediate position among OECD countries, and has decreased from 1.65 in 2004 to 1.48 in 2009 (OECD 2013, Table A6.2a).

and the others reviewed in Siegel (2009).

A difference of academic effort is that the activities which are evaluated when assessing candidates' relative claims to promotion are multi-dimensional in nature: they include at the very least teaching and research, but also management and external impact, all of which contribute to an institution's prestige and success. This requires us to adapt the standard all-pay multiple units auction model, where bids are monetary and naturally ranked, and the highest bidders receive the prize, by allowing the award of the prizes to be determined by a range of criteria, in a stochastic manner, where, moreover, only one of these criteria is observed and measured by the analyst.

Formally, we model in Section 2.1 a number of bidders, the professors of a given rank in a discipline, competing for the award of one of a fixed number of promotion "slots" in the higher rank, their bid being the effort exerted in each of the dimensions of performance which might impress the appointment panel. We posit that bids translate into performance (in a deterministic manner, though including a random component would add nothing but notation), and that academics differ not in their valuation of the prize, but in their cost of exerting effort: more "able" individuals derive less disutility from the exertion of effort.

The model predicts a highly non-linear response of individual effort to competitive conditions: roughly speaking, low ability individuals do not respond, and the rate of increase in effort first increase, then, at high ability levels, decreases with ability, see Section 2.4. Intuitively, this is because for both low and high ability individuals the likelihood of promotion (winning the auction) is not strongly influenced by additional effort: for the former is useless, for the latter unnecessary. The theoretical model is sufficiently flexible to allow us to study the more nuanced and occasionally counterintuitive theoretical effects of the changes in competitive conditions, introduced in 1999, in the rules governing appointments and promotions. The gist of the change in the rules was to decentralise to some extent the appointment process; incorporating the rule changes into the model shows a small change in the direction of a tendency to decrease (to increase) the effort exerted by high ability (low ability) individuals.

We test the theoretical model with a large dataset including all the individuals who have held a post in an Italian university at any time between 1990 and 2011. We take the measurable dimension of their output to be the articles they published in that period in journals listed in the Web of Knowledge proprietary dataset, suitably adjusting to account for the different publication patterns in different disciplinary areas. All other activities potentially undertaken by academics are included in the set of non-observable activities, from teaching, to publication of books or articles in journals not included in the Web of Knowledge, to administration, and perhaps also to seeking out influential friends and networks, as it might cross readers' mind who are familiar with Italian academia. The panel structure of the dataset allows us to control with individual fixed effects for time invariant individual characteristics, summarised in the theoretical model by the idiosyncratic value of the cost of effort.

We find the theoretical prediction of the model confirmed, not just broadly, but in many important details as well. Individuals respond to changes in the variables which will determine their likelihood of being promoted, namely the number of posts available, the number of competitors and the likely importance of that dimension for the panel's decisions, roughly in line with the non-linear fashion predicted theoretically. High ability individuals exert more effort if the measured dimension of output increases in importance or if the sector becomes more competitive, either through an increase in the number of potential applicants or through a reduction in the number of posts available, whereas lower ability individuals exert less effort in response to these changes. These results are robust to changes in the definitions of some variables, and to different specifications of the dynamic structure of the model. Also as predicted theoretically, the effects of the various reform is hard to detect in the behaviour of Italian academics in this period.

To the extent that the analysis delivers a policy oriented message is that Italian academics respond to incentives in the manner predicted by the multiple unit all-pay auctions, even where these incentives are generally considered to be weak (Perotti 2008). Reforming gradually the system in the directions which would be suggested by the theoretical model proposed might presumably generate the expected responses in the direction of increase effort and output by Italian researchers.

The paper is organised as follows. Section 2.1 describes the model. Our data is described in detail in Section 3, the econometric specification is set out in Section 4, and the details of how we construct the variables is in Section 5. Section 6 provides our empirical results, following the theoretical suggestion of the comparative statics analysis of Section 2.4 and Section 7 concludes the paper. An Appendix contains more detail on the preparation of the dataset and additional empirical results.

2 Theory

2.1 The model

This section presents a highly stylised model of career progression and competition among academics in Italian universities. A population of N academics compete for promotion to the next rung of their career ladder: they exert costly effort to produce their output. Subsequently, K professorships in a given discipline 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 in a single process all the new post holders.[3]

In practice, academics incur the cost of effort well in advance of the opening of the vacancy they will apply for, and so the variables which will determine their likelihood of being appointed are not yet known. When we consider the empirical specification we posit rational expectations, that is, that 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. In this section, we avoid repeating "expected", "future", and so on, and we describe a static time frame, where effort translates instantly into output, which in turn determines the outcome of the bidding, with the implicit assumption that all future benefits are actualised at the present.

We capture the multi-dimensionality of academics' effort with the assumption that candidates expect the selection panel to make its decision based on one of two criteria. Formally, candidates believe that with probability x the selection criterion is a known measure of performance, and with probability $(1 - x)$

[3]Thus for example, funding for 44 new associate professorships in Italian universities 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. Which of the appointees went to which university was left to individual negotiation, which did not, however, affect pay in any way, as institutions had no freedom whatsoever to alter the pay scale determined by a scale based on years of service, and not even the ability to refund moving costs.

the selection depends on a different dimension, which we do not observe, but which is understood by all agents involved, the panel and the candidates themselves. The nature of these other determinants of success, in particular whether or not they can be influenced by the candidates, is immaterial. The variable x varies from research area to research area, thus capturing differences in the nature of output among disciplines, which stylised facts, confirmed by empirical evidence (Abramo et al 2014 for the case of Italy), suggest to be substantial.

Candidates exert their effort levels before the appointment of the selection panel, thus knowing only the probabilities x and $(1 - x)$, which for example are related to the nature and the relative power of the members of the cohort of senior professors in their research area, among whom the panel will be chosen: they do not know the actual realisation of the draw which decides what will form the basis of the selection.[4] Once the panel is selected, it chooses the candidates to be appointed to the K available posts the candidates ranked highest according to its preferred criterion.

We assume a deterministic relationship between effort and measurable output: given the static nature of the game we study, adding a random disturbance would add little. Thus, when the appointment is made along the measurable dimension, the candidates with the highest effort are appointed. We leave unspecified the link between effort and the other possible determinant of promotion: indeed our analysis is robust to the extreme assumption that this determinant of promotion cannot be influenced by the candidates.

Candidates differ in their idiosyncratic cost of effort: specifically, we assume that prior to the game each academic is assigned by nature a parameter $v_i \in [\underline{v}, 1]$ (a normalisation) randomly drawn from the distribution $F : [\underline{v}, 1] \to [0, 1]$. This is their individual type, and if candidate i exerts effort b_i and a_i along the two dimensions, then she incurs a utility cost given by

$$c(a_i, b_i, v_i) = \frac{C(a_i + b_i)}{h(v_i)}, \tag{1}$$

where $C'(\cdot) > 0$, $C''(\cdot) \geqslant 0$, and similarly $h'(v_i) > 0, h''(v_i) \geqslant 0$. A natural

[4] To fix ideas, one can think of the observable dimension as publications in refereed journals, and of the other dimensions as teaching. Then x and $(1 - x)$ are the probabilities that the panel will rank candidates according to publications and teaching ability; and x is (a function of) the share of senior professors who consider publications to be more important than teaching as a criterion for promotion.

interpretation of v_i is "ability": a higher value of v_i implies that exerting effort is easier, and so a given output requires less effort. We assume that effort along the two dimensions is additive.[5] For definiteness and in order to obtain explicit solutions, the distribution F is assumed to be uniform:

$$F(z) = \frac{z}{\bar{v}}, \qquad z \in [\underline{v}, 1]. \tag{2}$$

Its density is therefore $\bar{v} = 1 - \frac{1}{\underline{v}}$. The expected payoff to a candidate is simply the difference between the expected benefit of being promoted by the panel, which is the same for everyone and normalised to 1, and the cost of effort (1).

Effort must be expended in advance, and of course its cost must be incurred whether or not the candidate wins the competition. For this reason, the natural modelling set-up is that of the all-pay auction. In the next four Sections we solve the model, we introduce the changes brought in by the 1999 reform in Italian academia, and we investigate how comparative statics changes in the parameters cause the equilibrium to vary.

2.2 A multi-unit all pay auction.

In the static game described in the above section, each player knows her own type, and chooses $a_i, b_i \geqslant 0$. Player i's payoff is $1 - \frac{c(a_i, b_i)}{v_i}$ if she is ranked 1 to K, and is $-\frac{c(a_i, b_i)}{v_i}$ otherwise. A strategy for player i is a pair of functions, $A_i(v_i)$ and $B_i(v_i)$, which associate the type v_i to the effort levels exerted, $a_i = A_i(v_i)$ and $b_i = B_i(v_i)$.

The appropriate equilibrium concept for this game is Bayesian equilibrium, and we derive it in the rest of this section.

Following the standard auction argument, since all candidates are ex-ante identical (their types are all drawn from the same distribution), they all cor-

[5] This reflects the view held by many academics that effort allocated to, say, teaching is effort subtracted to research. It is sometimes asserted that there are complementarities, perhaps in the individual "production function", as suggested by Becker (1975) and (1979), or Mankiw (1998)) or as spurious correlation with an unobserved underlying variable "academic talent", which helps both teaching and research (De Fraja and Valbonesi 2012): the balance between these tendencies lends plausibility to our assumption that the marginal productivity of effort along one dimension is unaffected by the effort exerted along the other dimensions an acceptable compromise.

rectly believe that each uses the same strategy. To determine the optimal level of effort it is necessary to determine the expected payoff obtained by type v_i for exerting the effort levels a_i and b_i, with the assumption that all other types exert effort levels $A_i(v)$ and $b_i = B_i(v)$.

Empirically, we observe for each candidate only the measurable dimension, and therefore we concentrate the theoretical analysis on the determination of the effort level along this dimension. We look for conditions where the effort along the measurable dimension is not affected by competitive environment along the other dimension. A simple example where this is true is when the likelihood of being appointed if the appointment panel chooses dimension A is purely random, independent of any action taken by any of the candidates: this however is by no means necessary for our analysis to hold.

To derive the effort level along the measurable dimension $B(v_i)$ exerted by candidate i whose effort cost parameter is v_i, let $V(b)$ be the inverse of $B(v_i)$ (existence of the inverse follows from monotonicity, the argument for which is standard). If candidate i exerts effort b_i her probability of winning one of the K prizes is (see Barut et al, 2002, Eq. (2), p 679):

$$Z_{KN}(V(b_i)) = \sum_{j=N-K}^{N-1} \frac{(N-1)!}{(N-j-1)!j!} F(V(b_i))^j (1 - F(V(b_i)))^{N-j-1}. \quad (3)$$

In order to obtain explicit solutions, we take a convenient functional form for the relation between payoff and effort along the non-measurable dimension. Specifically, if $\pi_A(\boldsymbol{a})$ is a candidate's belief regarding her probability of success along the non-measurable dimension, we assume:

$$\pi_A(\boldsymbol{a}) = g(v)\, a_i. \quad (4)$$

That is, promotion if the non-measurable dimension is chosen depends linearly only on her own effort along that dimension; $g(v)$ is a positive function, increasing or decreasing, chosen to ensure that $\pi_A(\boldsymbol{a}) \in [0,1]$ on the domain of a_i and v .

Proposition 1 *Let the cost of effort and the payoffs for winning along the non measurable dimension be given by (1) and (4). The optimal strategy for each candidate is to exert effort level along the measurable dimension given by*

$$B(v_i) = \frac{x}{1-x} \int_{\underline{v}}^{v_i} \frac{1}{g(y)} Z'_{KN}(y)\, dy. \quad (5)$$

Proof. Given the probability of winning, (3), the expected payoff of candidate with ability v_i who chooses effort levels a_i and b_i is:

$$E\Pi_i = xZ_{KN}\left(V\left(b_i\right)\right) + \left(1-x\right)\pi_A\left(a_i\right) - \frac{C\left(a+b\right)}{h\left(v\right)}. \tag{6}$$

Differentiate the above with respect to a_i and b_i to get:

$$\frac{\partial \Pi_i}{\partial a_i} = \left(1-x\right)\pi_A'\left(a_i\right) - \frac{C'\left(a_i+b_i\right)}{h\left(v\right)} = 0 \qquad i=1,\ldots,N, \tag{7}$$

$$\frac{\partial \Pi_i}{\partial b_i} = xZ_{KN}'\left(V\left(b_i\right)\right)V'\left(b_i\right) - \frac{C'\left(a_i+b_i\right)}{h\left(v\right)} = 0 \qquad i=1,\ldots,N. \tag{8}$$

Because the strategy profile is symmetric, all players use the same strategies, and $V(b_i) = v_i$ (Barut et al p 680); (7) can be written as

$$\frac{\left(1-x\right)\pi_A'\left(a_i\right)}{C'\left(a_i+b_i\right)} = \frac{1}{h\left(V\left(b_i\right)\right)},$$

which, substituted into (8), gives, using (4):

$$xZ_{KN}'\left(V\left(b_i\right)\right)V'\left(b_i\right) = \left(1-x\right)g\left(V\left(b_i\right)\right)$$

$$\frac{x}{1-x}\frac{Z_{KN}'\left(V\left(b_i\right)\right)}{g\left(V\left(b_i\right)\right)} = \frac{1}{V'\left(b_i\right)}. \tag{9}$$

The first order conditions are sufficient, given that $\frac{d^2E\pi_i}{db_i^2} < 0$, which follows immediately from Barut et al (Appendix, p 706-707), $\pi_A''\left(a_i\right) = 0$, and $C''\left(\cdot\right) \geqslant 0$.

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

$$B'\left(v_i\right) = \frac{x}{1-x}\frac{Z_{KN}'\left(v_i\right)}{g\left(v_i\right)}, \qquad B\left(\underline{v}\right) = 0, \tag{10}$$

which has solution

$$B\left(v_i\right) = \frac{x}{1-x}\int_{\underline{v}}^{v_i}\frac{Z_{KN}'\left(v_i\right)}{g\left(v_i\right)}dz. \tag{11}$$

■

Clearly the assumptions made with regard to the functions $\pi_A\left(\boldsymbol{a}\right)$ and $c\left(a_i, b_i, v\right)$ impose some restrictions. However, results analogous to Proposition 1 can be derived with alternative assumptions on these functional forms. For example, suppose that effort cost is separable in its two dimensions.

Proposition 2 *Let the cost of effort (1) satisfy $C''\left(\cdot\right) = 0$. The optimal strategy for each candidate is to exert effort level along the measurable dimension given by*

$$B\left(v_i\right) = \frac{x}{C'\left(\cdot\right)}\int_{\underline{v}}^{v_i} h\left(y\right)Z_{KN}'\left(y\right)dy. \tag{12}$$

Proof. Given $C''(\cdot) = 0$, (8) can be written as

$$\frac{\partial \Pi_i}{\partial b_i} = x Z'_{KN}\left(V\left(b_i\right)\right) V'\left(b_i\right) - \frac{C'\left(\cdot\right)}{h\left(V\left(b_i\right)\right)} = 0, \qquad i = 1, \ldots, N.$$

The rest of the proof follows the same steps of the proof of Proposition 1. ■

Note that $C'(\cdot)$ is a positive constant.

2.3 Local vs national competition

Proposition 1 above applies to academic appointments in Italy up to the adoption of the new rules dictated by the reform ushered in by Law 3 July 1998, n 210.[6] While a considerable degree of centralisation remained, the appointment process become "local", and, with some important exceptions, more recognisable to academics working in the US or in the UK. When an institution received permission to fill a post in a given scientific sector, a panel was nominated (made of professors in that scientific sector, mostly from other universities), whose job it was to appoint to that specific post.[7]

A second relevant aspect which should be incorporated in the model presented in Section 2.2 is the restriction of the number of applications that a candidate can make in each year. This latter change is relatively straightforward to model formally: let M be the limit to the number of positions that each candidate could apply for in a year, and let N and K be the number of competitors and competitions each with one post. Assume that candidates choose randomly which M competitions to enter, so that all competitions have, in expectation, the same number of candidates. Then the number of competitions a candidate enters is $\hat{K} = \min\{K, M\}$.[8] Given this, the expected number of candidates in each competition is $\hat{N} = N \min\left\{\frac{M}{K}, 1\right\}$: note that $\hat{N}$ may be non-integer, while $\hat{K}$ is an integer. Since no one can hold more than one

[6] The law (DPR n.390), approved in October 1998, began to take effect after the summer of 1999, so that the first promotions under the new rules took place towards the end of 1999.

[7] As is often the case, the legal details are slightly more complex: while each competition was for one post at a given university, the panel could, and typically did, select up to two additional candidates (later reduced to one), who could subsequently be appointed to a different university, without an additional competition. This could be modelled formally, as we suggest in footnote 9, but the additional algebraic notation is not worth the increase in the adherence to the actual situation.

[8] Note that in the absence of entry costs, it is payoff maximising for every candidate to enter as many competitions as allowed.

post, if a candidate 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.

There are two alternative ways to model the switch from national to local competition. One is to view each competition decided either along the measurable dimension or along the non-measurable one. This changes the link between a candidate's effort and her probability of winning, and so her payoff and thus her incentive to exert effort is different in the new environment, for given K, the number of posts, N, the number of competitors, and x, the importance of the measurable dimension. To see why, take the simplest case where there are just two posts available. With a national competition, either both posts are assigned according to the measurable dimension or neither is: the former occurs with probability x, the latter with probability $(1-x)$. With two separate competitions, on the other hand, all posts are assigned according to the measurable performance with probability x^2 and none with probability $(1-x)^2$; with the residual probability, $2(1-x)x$, exactly one of the posts is assessed on the measurable dimension. The analogy to more posts is immediate: with K posts, with probability x^K all are assigned according to the measurable performance, with probability $Kx^{K-1}(1-x)$ only one is, with probability $\frac{K!}{2!(K-2)!}x^{K-2}(1-x)^2$ exactly 2 are, and so on, until, with probability $(1-x)^K$ none is.[9]

A different way to model local competitions is to assume that candidates believe that the winners of a competition will be those who score highest on a measure given by a weighted average of the measurable and non-measurable criteria, with weights x and $(1-x)$. Analytically, this would make a national competition with given K, N, and x identical to a local one with the same values: post-reform all appointment panels would be making their decision on the basis of the same criterion (the weighted average with weights x and $(1-x)$). We believe that this modelling option is less satisfactory, in view of the pervasive perception that different appointment panels in the same scientific sector differed widely in their appointment criteria. Its implication that academics incentives are not altered by the switch to local competitions would also run counter to one of the motivations of the reform, which was indeed to modify academics behaviour: as we show, both theoretically and empirically, the switch to

[9]The detail noted in footnote 7 can be incorporated by assuming that if K posts (where K is even) are to be assigned then there are $\frac{K}{2}$ competitions, and the probability of all them being assigned according to the measurable performance is $x^{\frac{K}{2}}$, the probability of exactly one of them being assigned according to the measurable performance is 0, the probability of exactly two of them being assigned according to the measurable performance is $\frac{K}{2}x^{\frac{K}{2}-2}(1-x)$, exactly 3 is 0, exactly 4 is $\frac{\frac{K}{2}!}{2!\left(\frac{K}{2}-2\right)!}x^{\frac{K}{2}-4}(1-x)^2$, and so on.

local competitions, has however an effect which is at best limited. Therefore, in the rest of this Section, we study academics' equilibrium strategy when they expect each local competition to be run exclusively along one dimension.

Proposition 3 *Let the cost of effort and the payoffs for winning along the non measurable dimension be given by (1) and (4). When K separate competitions assign the K posts, the optimal strategy for each candidate is to exert effort level along the measurable dimension given by*

$$B(v_i) = \frac{\sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} x^{\hat{K}-k} (1-x)^k \int_{\underline{v}}^{v_i} \frac{Z'_{\hat{K}-k,\hat{N}-k}(y)}{g(y)} dy}{\sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} (1-x)^{\hat{K}-k} x^k}. \tag{13}$$

Proof. If in all the competitions the selection is via the observable dimension, then, from the point of view of an individual candidate, the situation is as it would be if there were a single competition with $\hat{K}$ posts and $\hat{N}$ competitors: she disregards the competition she has not entered. Thus if in all the competitions the selection is via the observable dimension her payoff is

$$Z_{\hat{K}\hat{N}}(V(b_i)).$$

This happens with probability $x^{\hat{K}}$. If instead only $\hat{K}-1$ of the competitions are run along the measurable dimension, the payoff is

$$Z_{\hat{K}-1,\hat{N}-1}(V(b_i)),$$

as one of the competitors wins the competition run on the non-measurable dimension and is "withdrawn" from the pool, together with that competition. This happens with probability $\binom{\hat{K}}{1} x^{\hat{K}-1}(1-x)$. And so on for all possible combinations of relevant dimensions along which the competition is run, down to $\hat{K}-1$, when only one competition. Adding up gives a payoff of

$$\sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} x^{\hat{K}-k} (1-x)^k Z_{\hat{K}-k,\hat{N}-k}(V(b_i)) + \sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} (1-x)^{\hat{K}-k} x^k \pi_A(a_i) - \frac{C(a+b)}{h(V(b_i))}; \tag{14}$$

the second addendum is the probability weighted payoff when the individual wins a competition not decided by the measurable dimension. Differentiation of (14) gives the two first order conditions corresponding to (7) and (8):

$$\sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} (1-x)^{\hat{K}-k} x^k \pi'_A(a_i) - \frac{C'(a+b)}{h(V(b_i))} = 0, \tag{15}$$

$$\sum_{k=0}^{\hat{K}-1} \binom{\hat{K}}{k} x^{\hat{K}-k} (1-x)^k Z'_{\hat{K}-k,\hat{N}-k}(V(b_i)) V'(b_i) - \frac{C'(a+b)}{h(V(b_i))} = 0, \tag{16}$$

which, as in Proposition 1, implies:

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

and the result follows. ■

The analogous of Proposition 2 is given next.

Proposition 4 *Let the cost of effort (1) satisfy $C''(\cdot)=0$. When K separate competitions assign the K posts, the optimal strategy for each candidate is to exert effort level along the measurable dimension given by*

$$B\left(v_i\right)=\frac{\sum_{k=0}^{\hat{K}-1}\binom{\hat{K}}{k}x^{\hat{K}-k}\left(1-x\right)^{k}\int_{\underline{v}}^{v_i}h\left(y\right)Z'_{\hat{K}-k,\hat{N}-k}\left(y\right)dy}{C'\left(\cdot\right)\sum_{k=0}^{\hat{K}-1}\binom{\hat{K}}{k}\left(1-x\right)^{\hat{K}-k}x^{k}}.$$

Proof. As before, given $C''(\cdot)=0$, (16) becomes

$$V'\left(b_i\right)\sum_{k=0}^{\hat{K}-1}\binom{\hat{K}}{k}x^{\hat{K}-k}\left(1-x\right)^{k}Z'_{\hat{K}-k,\hat{N}-k}\left(V\left(b_i\right)\right)-\frac{C'\left(a+b\right)}{h\left(V\left(b_i\right)\right)}=0.$$

This is independent of a_i and the proof follows. ■

2.4 Comparative statics

We aim to fit the model developed above model to the behaviour of Italian academics. An algebraic comparison of comparative statics changes is too cumbersome, and in this brief section we lay the ground for our empirical analysis with a more intuitive graphical investigation of the comparative statics effects of parameter changes. In all the diagrams in this Sections, we have assumed that $C'(\cdot)=1$ and $h(z)=z$, so the cost function is $\frac{a_i+b_i}{v_i}$. The pictures do not change qualitatively for different plausible functional forms.

The plots in Figures 1-4 show the comparative statics effects of changes in K, N and x. Note first of all, the striking non-linearity of the changes; as we explain below, this has important consequences for our estimation strategy.

The horizontal axis in Figure 1 measures an academic's type $v\in[\underline{v},1]$. The vertical axis shows the *change* in the effort exerted by a type v academic as a consequence of one less post in her research area. The thicker the curve the higher the number of posts to begin with and therefore the less stiff the competition: thus the thin line shows the change in effort when the number of posts changes from 7 to 6,

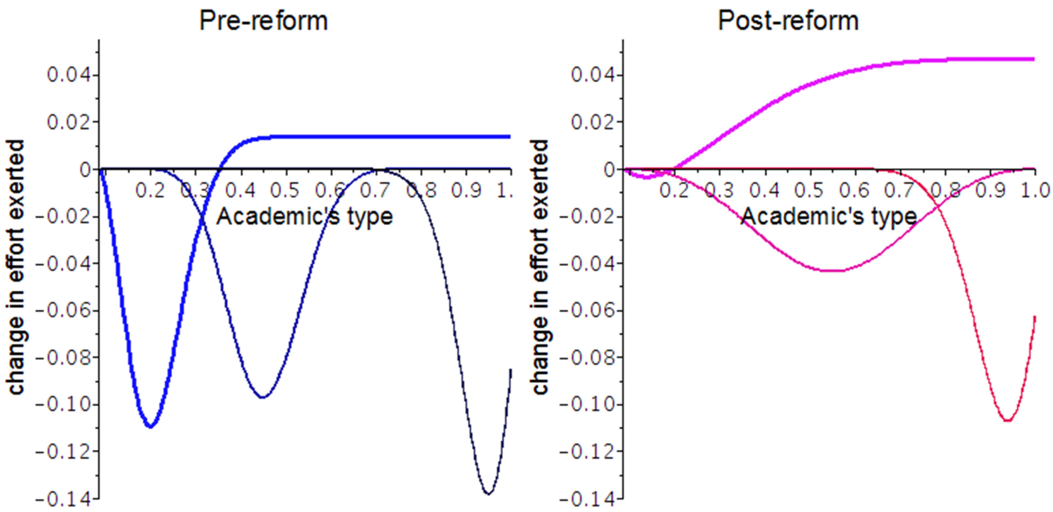

Figure 1: Decrease by 1 in the number of posts available, for fixed $N = 45$, $M = 5$ and $x = 0.8$, and K increasing from 7 to 22 to 37 as the line gets thicker.

the medium line a change from 22 to 21, the thickest line from 37 to 36. We can see that an increase in competition, lower K, decreases the effort exerted by academics, except for high ability individuals when competition is relatively low to begin with, the thick line in the two panels of Figure 1. The effect, however, is not evenly distributed: there is a middle range of abilities who respond more strongly, by reducing their effort in the face of stiffer competition. This middle range itself shifts towards lower ability types when competition decreases, to the point where, when it is low enough, high ability types *increase* their effort in response to the reduction in the number of posts, as the thickest curve shows.

Upon reflection, these comparative statics effects are natural. There are N competitors for K posts. For all types, an increase in effort increases the likelihood of gaining a rank. But the only gain that matters is being K-th instead of $(K+1)$-th: the higher likelihood of gaining a position in other ranks – 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 high types are very likely to end up high up in the ranking, their chance of being around the threshold position is low, and so they do not change effort much. By the same token, low ability types exert little effort to begin with and the discouragement effect of the lower chance of winning is necessarily small. Middle types are instead quite likely to be around the "borderline" position, where gaining one place in the ranking is the difference

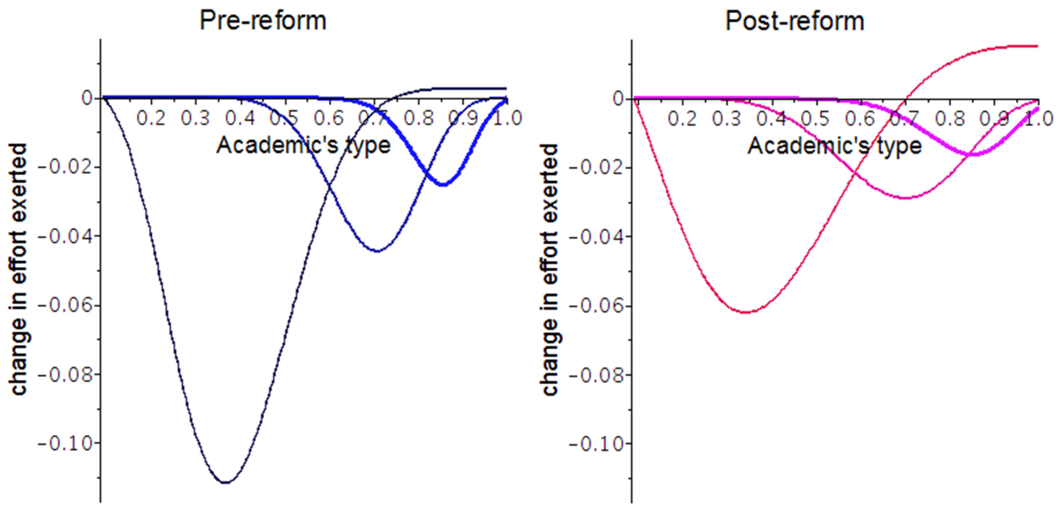

Figure 2: Increase by 1 in the number of competitors, for fixed $K = 10$, $M = 5$ and $x = 0.8$, and N increasing from 15 to 28 to 45 as the line gets thicker.

between being appointed and not being appointed, making their effort less likely to be useful and so decreasing it in equilibrium.[10] In other words, the change in the cost-benefit balance of an decrease in competition is different for different types, which generates different response to change in the competitive conditions.

The message conveyed by Figure 2, where the increase in competition is obtained through an increase in the number of competitors rather than a reduction in the number of posts, is essentially the same.

We state the idea contained in Figures 1 and 2 formally in a fashion that translates naturally into an econometric hypothesis in Conjecture 1.

Conjecture 1 *(i) A reduction in competition increases output for candidates of intermediate ability. (ii) If the initial level of competition is lower, the range of abilities where the effort increases becomes lower, and (iii) for very low competition, high ability academics exert less effort as a consequence of an increase in the number of posts.*

There is also a direct size effect, illustrated by Figure 3. This shows the effect of keeping the ratio $\frac{K}{N}$ constant (at $\frac{1}{5}$), and increasing both the number of posts and

[10]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.

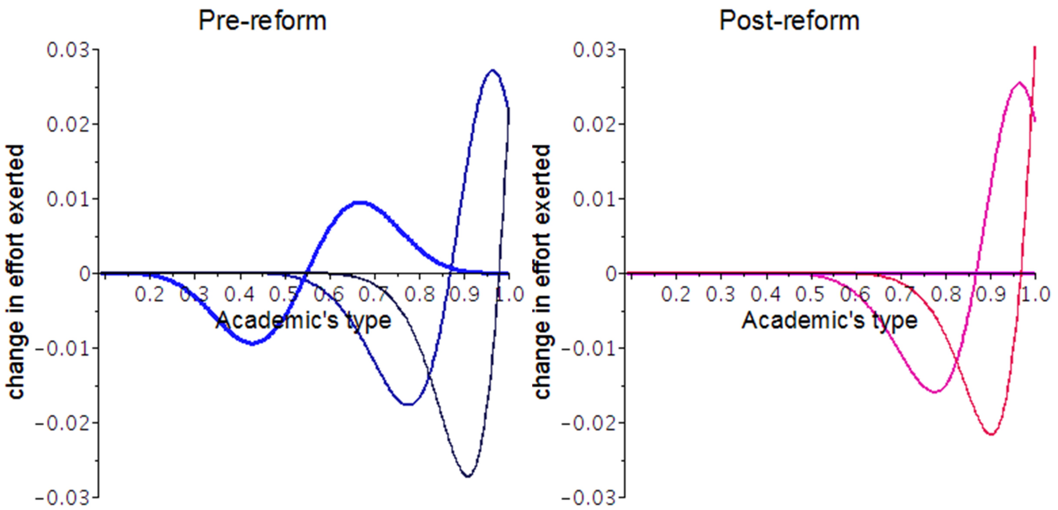

Figure 3: Increase in the size of the market, for fixed $x = 0.8$, $M = 5$ and K and N taking values $(2, 20)$ and $(3, 30)$ (thin line), $(4, 20)$ and $(5, 25)$ (medium line), and $(10, 20)$ and $(11, 22)$ (thick line).

the number of candidates in the same proportion. The thicker the line the larger the size. Pre-reform, and post-reform for small market, we see that effort is lower for low ability types, and higher for high ability types. Post-reform, when K exceeds M, that is when only M competitions can be entered, then size has no effect, as the thick line on the axis shows on the panel on the right of Figure 3. This discussion can be formulated as a formal empirical prediction.

Conjecture 2 *(i) Both with national and with local competition, an increase in the size of the sector, maintaining the competitiveness constant, increases output for high ability candidates and reduces output for low ability candidates. Thus, an increase in size increases the standard deviation of output. (ii) Following the 1999 reform, for high K, a proportional change in K and N leaves output unchanged.*

Consider next changes in the probability of the measurable dimension determining the winner. This is illustrated in Figure 4.

The pattern is relatively simple, an increase in x increases the effort of all types. Both pre and post reform, the effect is stronger for higher types when competition is tougher (thick line), and so we can propose the following conjecture.

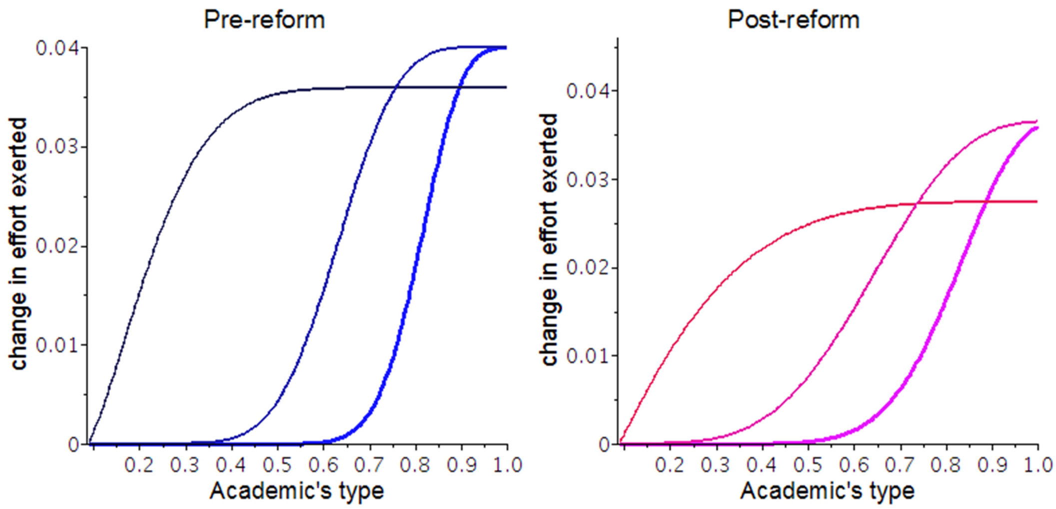

Figure 4: Increase by 0.05 in the importance of the measurable dimension, for fixed $x = 0.8$, $M = 5$ and $K = 12$, and N increasing from 15 to 28 to 45 as the line gets thicker.

Conjecture 3 *Both with national and local competition, an increase in the importance of the measurable dimension increases output along this dimension; the effect is stronger for high ability types and when competition is tougher.*

We end this section with Figure 5, which compares the effort level before the reform, illustrated by the black curve, with that after the reform, shown by the red curves. The dashed red curve shows the effect of the switch to local competition, ignoring the constraint on the number of competition that candidates can enter, whereas the solid red curve includes this constraint as well, and so it shows the combined effect of the two changes on candidates effort. We note that the change due to the switch to local competition is a small reduction in the effort exerted by all candidates. The intuition for is this result is that the expected number of posts allocated according to the measurable dimension is lower with local competitions than with a national competition: to see why, consider a candidate's expectations of number of competitors per post: with national competition she compete for every post with all the other candidates, and so the expectation is $\frac{xK}{N}$. With local competition, a candidate compete with all the others for only one of the posts, as one of the winners drops out of all the other competitions; the competitions might be run in sequence or if they are run simultaneously, the "order" is determined by the

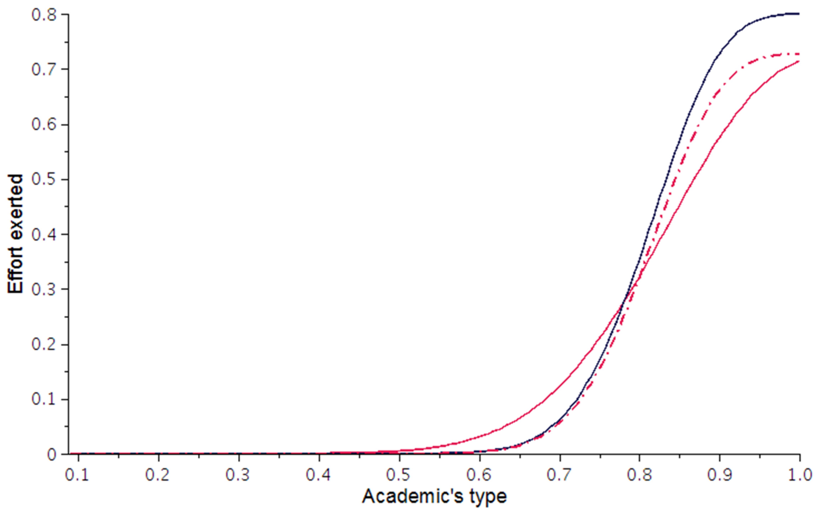

Figure 5: National (black curve) vs Local (red curves) competition, for fixed $N = 45$, $K = 12$, $M = 5$ and $x = 0.8$. The dashed red curve ignores the effect of the constraint on the number of applications per year.

preferences of the individuals who are offered more than one post. Given this, with local competitions, a candidate's expectations of number of competitors per post is $\sum_{j=0}^{K-1} \binom{\hat{K}}{j} \frac{x^{K-j}(1-x)^j}{\bar{v}(N-j)} (K-j)$ which is less than $\frac{x}{\bar{v}} \frac{K}{N}$.

The constraint on the number of applications per year has the same effect as a reduction in the number of competitors, and so it encourages the lower ability academics, and discourages effort by high ability ones. The relative pattern is similar for different values of the parameters, giving a suggestion we translate into an econometric hypothesis in Conjecture 4.

Conjecture 4 *Ceteris paribus, high ability academics exert marginally less effort and have lower output along the measurable dimension following the reform, and low ability candidates exert marginally more effort and have higher output along the measurable dimension.*

As the comparison of of the LHS and RHS panels of Figures 1-4 suggests, the 1999 reforms is not expected to determine substantial differences in effort. Figure 5 confirms that the effect of the reform is small, and it suggests it to be due mostly to the constraint on the number of applications, and therefore more likely to be effective in larger scientific sectors.

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
% female	0.41	0.25	0.1	0.45	0.34	0.19
% WoK	0.59	0.62	0.59	0.68	0.61	0.69

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

3 Data

The theoretical analysis gives a number of predictions on the effort exerted by candidates as a function of a number of observable environmental variables: the competitiveness of the sector, determined by the variables K and N, the size of the "market", captured by the number of candidates relative to the number of posts, and the importance of the observed dimension of output, which is measured by the variable x. Effort translates into output via a monotonic, possibly stochastic, relation. In this section we describe in detail the construction of these variables.

3.1 The datasets

Our data comes from three sources, one collecting individuals, one their publications, and the third the journals where these appear.

Information on individuals is the administrative data from the Italian Ministry of Education, University and Research (MIUR) which assembles information on everyone who has an academic job in Italian universities, public or private. The data contains annual information on 81399 individuals, and reports their age and sex, their scientific sector, their university affiliation, and their academic rank.

With negligible exceptions, every person has one of three ranks: assistant professor (*ricercatore*), associate professor, and full professor (*professore di seconda* and *di prima fascia*, respectively). Table 1 presents two snapshots of the aggregate faculty in Italian universities, at the beginning and at the end of the period we study; the years in between display the expected evolution. Table A5 in the appendix breaks down this aggregate picture by broad disciplinary area.

Some individual became associate or full professors without having previously held a lower rank post: these were individuals working outside the Italian university system, in Italy or abroad. In the whole period, 4578 individuals became associate professor without being assistant professor prior to their promotion, this is 19.3%

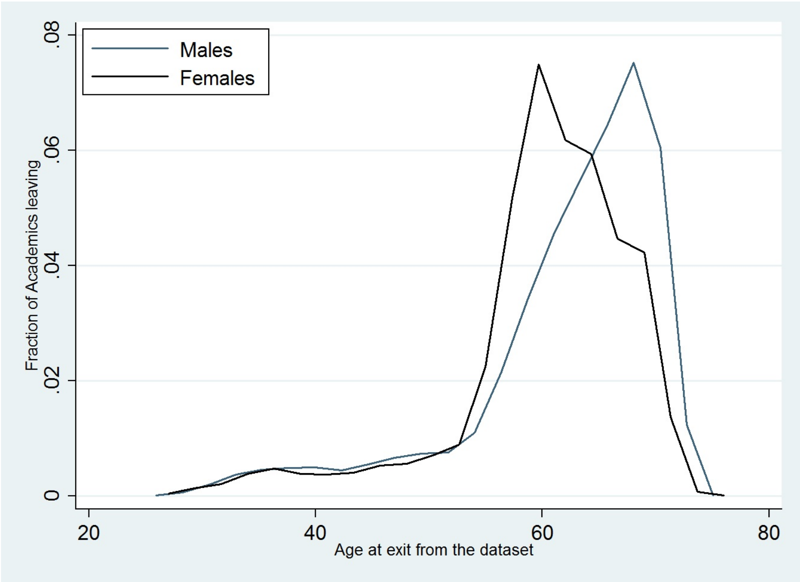

Figure 6: Age distribution of associate and assistant professors who leave the dataset within the sample period.

of all promotions in the period, and 584, 4% of promotions, became full professor from outside the Italian university system. We exclude these individuals from the estimations, because it is not clear that the incentives they operate under prior to their appointment are those operating in the Italian university system which form the object of our study. Other individuals exit the system prior to retirement age: this is a relatively rare event for assistants and associate professors, the individuals whose effort we aim to explain: Figure 6, which depicts the age distribution of exits from the system for associate and assistant professors, strongly suggests that exit from the dataset is determined by attrition, death and other exogenous events, and reaching normal retirement age, which at the time was 60 for women and 65 for men, is the norm. A pattern of exit 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: 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. We have also repeated the analysis excluding all individuals who exit the system prior to reaching the age of 59, and the results do not change.

The theoretical analysis models effort as determined by the exogenous conditions academics expect to face, which are summarised by the parameters K, N, and x.

While in general it is difficult to determine them precisely, the special features of the Italian university system make this task relatively simple. Each academic is allocated to one – and only one – of 370 "scientific sectors" (*settore scientifico disciplinare*). These sectors are very important for career progression, as posts and evaluations are carried out within each scientific sector; moreover, they are strongly separated from each other: thus, for example, if it is decided that a professor in Economic Policy (the sector with code SECS/P02) should be appointed at the University of Bologna, then the appointment panel for this post will be composed exclusively[11] of professors from the same sector, some of whom may be full some associate, some in post at the University of Bologna some in post elsewhere, depending on the rules in force at the time the vacancy opens. These scientific sectors are the units of our analysis. They are fairly small, the average number of full professors in each is 43, the standard deviation is 46, and distribution is fairly skewed, see Figure 7. This indicates that our assumption is not far-fetched that candidates be able to form an accurate assessment of the preferences of the likely membership of the promotion and appointment panels.[12]

There are two important idiosyncrasies of the Italian academic system in place in the period we consider. Firstly, salary and all other perquisites are fully determined by rank and seniority: in particular there is no change in salary following a horizontal move. This implies that incentives operate only through promotions, which in turn we can identify precisely by observing changes in the in academic rank: once full professorship has been reached, there are no further incentive mechanisms in place. "Negative" incentives do not operate either, as dismissals for low productivity are non-existent in practice. Secondly, unlike many other countries, there was no separate channel for internal promotions, so anyone who has changed academic rank without changing university has in fact competed with all those who held the same rank in the same scientific sector in different universities or outside the system. Together with the relatively limited salary increase associated with promotion to the next rank, these imply that incentives are on whole weak.

[11] With the exception of very small scientific sectors, where there might not be enough qualified professors: professors from similar scientific sector would be seconded in this case.

[12] To fix ideas, most Italian economists are in SECS/P01 "Economics", a sector which had 341 full professors in 2007, and the largest size in the dataset, SECS/P02 "Economic policy" (149 full professor in 2007), SECS/P03 "Public finance" (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).

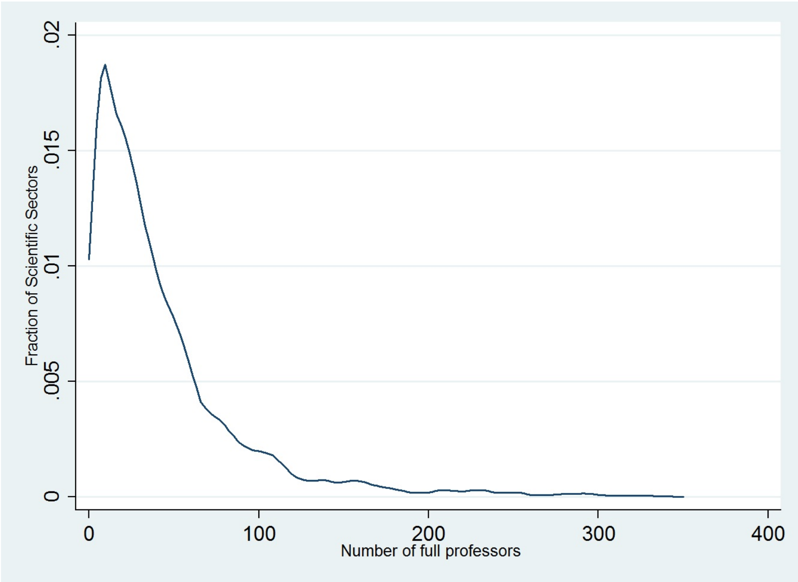

Figure 7: Distribution of the number of full professors in scientific sectors.

The second data source is the record of international research publications by Italian academics which we have obtained from the web-version of the Thomson Reuters Web of Knowledge (formerly ISI, WoK hereafter).[13] This proprietary dataset indexes more than 12,000 journals in the fields of arts, humanities, sciences and social sciences.[14] For each article the dataset reports the title, the authors' surname and first initial, their affiliation, 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 period 1990-2011, where at least one author listed an Italian university or research centre among his/her affiliations. This harvest yielded almost two million publications, which required a considerable amount of "cleaning" work, described in greater detail in Verzillo (2013).

[13]The main alternative bibliometric sources are Scopus and Google Scholar. Scopus excludes completely humanities (Klavan and Boyak, 2007) thus reducing the scope for comparison across disciplines. At the time of writing, Google Scholar has some reliability problems (Delgado López-Cózar et al 2014). At any rate, the literature comparing the Scopus and ISI databases (Archambault et al. 2009) documents high correlations among the bibliometric measures derived from them.

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

We have linked this dataset to the Journal Citation Report, our third source of data. This allowed us to attach to each paper the impact factor[15] over the period 2008-2012, as well the scientific areas where each journal belongs.

3.2 Dealing with homonymy

Homonymy creates two kinds of problems. Firstly, there are professors who hold a post at an Italian university and who share surname and initial with an individual who lists in a paper an affiliation with the same university without holding in that year a post of professor: often PhD students, or post-doc, or doctors working in a university hospital. Secondly, there are individuals who share their name and the first initial with another academic employed at the same time by the same university. Unlike the first group, we can quantify this second: it contains 4969 academics; of these, 846 work in the same research area as their homonym (these numbers are, respectively, 6.1% and 1.04% of the total).[16]

This mis-attribution of publications due to homonymy is a measurement error, which reduces the efficiency of the estimations, but does not introduce bias unless it is correlated with characteristics of interest, such as the competitiveness of the scientific sector, or the importance of WoK publications for promotion. While in general one would have no reason to think that art historian E Ferrari should be more likely to have a WoK publishing homonym than engineer E Ferrari, a recent strand of literature[17] has used homonymy to identify "nepotism" in Italian academia. Nepotism is defined as the process by which undeserving individuals are appointed to professorships thanks to the influence of their relations. 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

[15] And other quality measures proposed by the bibliometric literature such as the immediacy index, the eigenfactor score and the article influence score: these metrics are compared by Chang et al (2010).

[16] A hypothetical example illustrates the source of the problem: suppose that the university of Modena employs in a given year Enzo Ferrari (in the faculty of medicine) and Emilia Ferrari (in economics). Because they have the same affiliation, their publications are indistinguishable. Similarly, if 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 same university, this article would be attributed by our download procedure to Ernesto.

[17] Durante et al 2011, Allesina 2011, Moss 2012, interpreted as evidence of nepotism in Perotti 2008 and Scoppa 2009.

population is interpreted as evidence of nepotism (Durante et al. 2013). To the extent that nepotism, which may be unevenly distributed across disciplines and geographical areas, may affect scientific productivity, either positively or negatively, it is important to control for it, to reduce any omitted variable biases. The theoretical model we developed in Section 2.1 encompasses this possibility: nepotism could simply be the non-measurable dimension along which candidates are selected.

We address the 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.

In addition to the disambiguation strategy, we also 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 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, not necessarily the same initial in the databases, in the same year working outside their university and 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 discipline. 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 distinguish between a situation where a person's output is unaffected by the presence of a relative, or artificially inflated by unethical practices.[18]

[18] 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 output level justifying promotion, without intimate knowledge of the genesis of each article, we cannot distinguish whether the influence of a father on his son's output is through undue pressure on third parties to help his son's publications or through high quality genetic inheritance, which also enhances his son's output.

4 Econometric specification

After cleaning the dataset and adjusting for homonymy, we are left with 1,142,971 papers, concentrated in the later years; of these 44.8% are by academics in science scientific sectors, and 40% by academics in medical schools.

Table 2: Promotions and Appointments.

Period	Assist - Assoc	Assoc - Full	Assist - Full
1990-1994	2,539	1,618	83
1995-1998	2,441	301	46
1999-2002	7,064	6,462	198
2003-2006	4,879	3,639	50
2007-2011	2,252	1,448	22
Total	19,175	13,468	399

Source: Italian Ministry of Education, Universities and Research

The time pattern of promotions is rather uneven in time, as documented by Checchi and Verzillo (2014). This reflected the intention of the legislator in the pattern of the university funding. Therefore, we aggregate years into longer periods, as shown in Table 2, which also summarises the number of promotions recorded in our dataset, so that our panel dataset has a "professor-period" as the unit of observation.[19] The panel is unbalanced, as naturally some professors are only present in some periods.

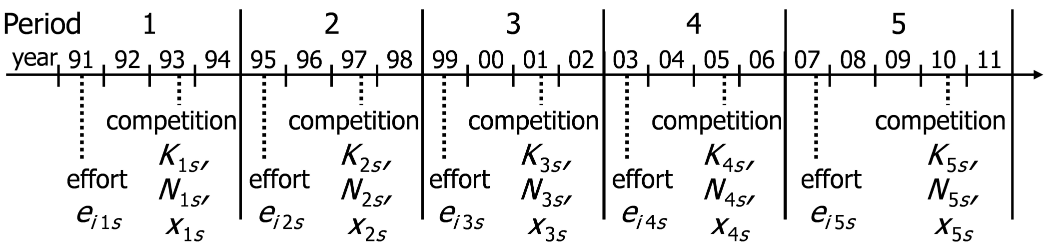

Figure 8: The timeline for competitions for appointments and promotions.

[19]The low number of promotions in the second period is a consequence of the staggering of the funding cycles for associate and full professors prior to the 1999 reform. Following the replacement of the national competition with delegated decisions, the pattern of promotions is similar for the two ranks, but the uneven pattern of university funding still allows us to identify three distinct waves of promotions (see Checchi and Verzillo 2014).

The time lags between the exertion of effort and its determination of a person's academic output, and between the publication of output and its valuation by the appointment panel, require the explicit description of the dynamic structure of actions and consequences. 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 will be made, described in the theoretical model developed in Section 2.1 by the parameters, K, N, and x, the number of posts, the number of competitors, and the importance of the measurable dimension for promotion. These variables have of course the same values for all individuals within a scientific sector within a period, and vary by scientific sector and by period. Based on these beliefs, which we assume to be correct on average, the candidates choose how much effort to exert along the measurable dimension. Effort translates into publications, perhaps in expectation, measured by their individual output in that period. Subsequently, competitions take place, and candidates are assessed.

This time structure implies that the exogenous conditions in a period determine effort, and hence output, in the same period. This could be either because academics apply for posts during the period, 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. This is summarised in Figure 8, and translates econometrically into the following equation:

$$o_{its} = \alpha_0 + \alpha_k K_{ts} + \alpha_n N_{ts} + \alpha_x x_{ts} + \alpha_c C_{ts} + f_i + \xi_t + \varepsilon_i, \tag{17}$$

where K_{ts}, N_{ts}, and x_{ts} are (functions) of the number of posts, the number of competitors, and the importance of the measurable dimension of output in scientific sector s in period t. C_{ts} are time varying controls described at the very end of Section 5.3. The individual and period fixed effects included in (17), f_i and ξ_t account for unobserved differences among individuals and different conditions in different periods.

The comparative statics effects illustrated with the diagrams in Section 2.4 suggest strong non linearities in the responses of academics of different types to changes in the parameters. To capture these non-linearities, we allow the coefficients α_k, α_n, and α_x in (17) to differ for different types by partitioning the set of individuals in each scientific sector according to their output, which is a monotonic function of type. Formally, we make use of interactions between variables related to competitions – indexed by period t and subject area s – and an individual's position in the distribution of ability of her sector. Given the monotonic relationship between ability and output, the latter is given by her position in the ranking of output within period t

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

	Assistant		Associate		Full	
	Mean	sd	Mean	sd	Mean	sd
Mean Output	0.269	0.521	0.355	0.673		
Output (weighted with IF)	0.391	1.122	0.514	2.047		
Index x	0.605	0.127	0.607	0.128		
x (weighted with IF)	0.602	0.127	0.603	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
Promotions from outside			0.184	0.170	0.066	0.179
Broad Homonymy Dummy	0.277	0.442	0.276	0.441	0.288	0.446
Narrow Homonymy Dummy	0.007	0.080	0.006	0.076	0.007	0.081
Rule	0.582	0.638	0.504	0.601		
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.

and subject area s. Thus we estimate:

$$o_{its} = \alpha_0 + \alpha_{qk}K_{ts} + \alpha_{qn}N_{ts} + \alpha_{qx}x_{ts} + \alpha_c C_{ts} + f_i + \xi_t + \varepsilon_i. \tag{18}$$

o_{ist} is the output of academic i, who, in period t, is in scientific sector s. We estimate (18) by interacting the three variables K_{ts}, N_{ts}, and x_{ts} with dummies representing appurtenance to the various regions of the output distribution. To assist presentation, we present estimates for a coarser partition of the individuals in the scientific sector, given both the theoretical analysis and the large number of individuals with zero output in several scientific sectors, to prepare Table 4 we split the distribution at the median and at the seventh and ninth decile. In contrast, Figures 9-11 estimate each decile separately.

Rather than the academics' expectations implied by (17) and (18), one could hypothesize longer lags between effort and competitions, 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 values of K, N, and M in the next period. In this case

(18) is replaced by:

$$o_{i,t,s} = \alpha_0 + \alpha_{qk} K_{t+1,s} + \alpha_{qn} N_{t+1,s} + \alpha_{qx} x_{t+1,s} + \alpha_c C_{ts} + f_i + \xi_t + \varepsilon_i. \qquad (19)$$

We reports the estimations of (19) in columns 5 and 6 in Table 4.

5 Constructing the variables.

5.1 Individual output in a period.

We construct two measures of output as the weighted number of publications in WoK journals published by a given professor in a given period.

In the first measure the weight is $\frac{2}{1+N}$, where N is the number of authors.[20] For our second measure we weight the number of papers with the impact factor ranking of the journal: 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 subdiscipline, 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.[21] The correlation between these measures is 0.856, and hence it is not surprising that regressions run with either give very similar results, as shown in Table 4. Different disciplines have widely different standards regarding the quantity of publications, as anyone is aware who has sat in a university-wide promotion committee. 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, define o_{ist} 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

[20]This is the weighting used by Checchi (1999), and implies that having two papers with one co-authors is a higher output than having one single-authored paper, and reflects the practice of forming a first impression of someone's CV by looking at its "length". Using the more straightforward $\frac{1}{N}$ makes no qualitative difference to any of the results. Abramo et al (2014) suggest weighting differently the first and the last authors in science publications: we have calculate 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.

[21]Even though the individual output is normalised by disciplinary area, taking quartiles 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.

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 of publication p. Then, we measure o_{ist} as

$$o_{ist} = \frac{\sum_{p \in \mathcal{P}_{it}} w_{pt}}{\frac{\sum_{f \in \mathcal{F}_{st}} \sum_{p \in \mathcal{P}_{ft}} w_{pt}}{\# \mathcal{F}_{st}}}. \tag{20}$$

In (20), the numerator is person i's weighted number of publications. At the denominator, $\sum_{p \in \mathcal{P}_f} w_{pt}$ 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 $\#\mathcal{F}_s$ denotes the number of elements in the set $\mathcal{F}_s$.

5.2 The variables K_{ts} and N_{ts}

K_{ts} is the number of 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. It is therefore obtained as the count of all promotions to the rank, and the number of "new entries" into that rank from outside the Ministry database.

For the associate professorship competitions, the number of (potential) applicants, N_{ts}, is the number of assistant professors who are in scientific sector s during any year in the period, or in the last year of the previous period and were appointed associate professor in the initial year of the period, and the number of assistant professors who become associate professors in scientific sector s from being assistant professor in a different scientific sector. We do not include in the count those who were appointed from outside the system: given our aim to determine the response of applicants to competitive conditions, excluding them from the number of potential applicants implies that the academics inside the system were not expecting these "outsiders" to be competitors at the time they choose their effort level.

For full professor competitions, N_{ts} is given by 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 associate professors who become full professors in scientific sector s from being associate professors in a different scientific sector, and the number of assistant professors who become directly full professors, whether from scientific sector s or from a different sector.[22]

[22]Unlike Bosquet et al (2013), our dataset cannot distinguish between those who apply for a post and are not appointed from those who do not enter it at all, and can thus be considered a reduced form of a two-stage model where individuals first choose whether to

As the analysis of Section 2.4 illustrates, the changes introduced with the 1999 reform affect academics' effort. As the comparative statics captured in Figure 5 suggest, the main effect is due to the constraint on the number of applications to be made in each year. It would be inappropriate simply to include a dummy taking value 1 if the constraint is binding at the time of a person's promotion. In the first place, the correspondence between the year in which a post is advertised and the year in which the appointee is recorded in the Ministry database is not one-to-one: some appointment are quick, others are delayed by bureaucracy and appeals, so it is not accurate to count the number of potential applications with the number of appointments. In addition, the constraint, like the other variables affecting effort, operates in expectations: individuals will consider the role of the constraint to the extent they believe it will be binding. If there are many posts in their sector, they will believe it highly likely that the constraint will bind; vice versa, if few jobs are to be filled in their scientific sector, they will simply ignore it. We capture this by creating a variable "Constraints on applications", which takes value 0, 1, 2 according to whether the number of posts filled in a year is less than 5, between 5 and 10, and more than 10, respectively. This variable is obviously set equal to zero before 1999. Figure 5 suggests again a non-linear effect, and we interact it with the decile dummies, as with the other explanatory variables.

5.3 The importance of the measurable dimension

If K and N are relatively straightforward, there does not exist a natural measure for the importance of the measurable dimension in the selection.

The choice of K winners from a pool of N applicants is the selection of K elements from a set of N ranked elements. We develop elsewhere (Checchi et al 2014) an index for the comparison of such selections, and we take this index as the measure of the importance of the measurable dimension. This index assigns to any selection from any set whose elements are ranked, a number between 0 and 1, in such a way that given any two selections from any two sets, if one selection is *obviously closer* than the other to the selections that would be made if only the highest ranked elements were selected, then the value of the index assigned to the first selection is higher than the value assigned to the second selection. In the above, "obviously closer" means that it satisfies a number of natural axioms. This index, which takes value 1 (respectively, value 0) if only the best ranked (respectively, worst ranked) candidates

apply and if they do are considered for appointment. Unlike Zinovyeva and Bagues (2010 and 2012), we cannot control for the identities of the members of the appointment panel.

are appointed allows, comparisons between selections of different sizes from sets of different sizes.[23] The expression for this index is:

$$x_{ts} = \frac{\frac{K_{ts}(2N_{ts}-K_{ts}+1)}{2} - \sum_{j=1}^{N_{ts}} \delta(j)\, j}{K_{ts}(N_{ts} - K_{ts})},$$

where K_{ts} and N_{ts} are the number of posts and competitors in scientific sector s in period t and $\delta(j)$ is an indicator function taking value 1 if the j-th ranked competitor is selected, and 0 otherwise. The above can be rewritten more intuitively as:

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

where 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 when all the worst and all the 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 ($r_{ts} = r_{ts,\min}$).

It would be incorrect to use the measure of output developed in Section 5.1 to determine the ranking of candidates for the construction of the index x_{ts}. This is because the appointment panels are required to, and typically do, evaluate the overall contribution of candidates, not restricting attention to the recent output, and also has discretion to judge the influence and importance of an applicants' work. It therefore seems preferable to combine information of past output with information regarding the importance of this output, and so to determine a person's ranking for the construction of the index x_{ts} in scientific sector s in period t, we take the first factor of a principal component analysis of a candidate's *cumulative* output up to period t, and her *real* h-index[24] in the last year of period t, weighted in the two

[23]The downside of this very broad applicability is that there are pairs of selections which cannot be ordered in an obvious manner in terms of closeness to the ranking: the axioms proposed by Checchi et al (2014) are minimal, so there are pair of selections whose comparison does not satisfy all the axioms.

[24]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^o 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.

different ways used to calculate the output measures in Section 5.1. Both these measures are reported in the summary statistics Table 3. The correlation between these measures is anyway extremely high, 0.986 for promotion to associate professor and 0.973 for promotion to full professor. On the other hand the correlation between the measure between ranks is only 0.263.

The inclusion of individual and period fixed effects controls for the time invariant unobservable characteristics; as additional controls, we include the share of women and the average age of the competitors. Finally, we include the homonymy dummies described above at the end of Section 3.2.

6 Results

Table 4 reports our main results; greater detail is in the appendix. Our preferred specification is in Columns 1 and 2: individual output is weighted with the number of co-authors, and correspondingly the index x is the principal component of the real h-index and the number of papers weighted with the number of authors. The first columns report the coefficients for assistant professors intending to become associate, the second for associate professors intending to become full professors.

The Table presents four blocks of estimated coefficients; the fifth block, given at the bottom, is calculated as the difference between the corresponding coefficients in the second and third block. Within each block, we give four coefficients: as we divide academics into different "groups" of deciles to reflect the different response that individuals of different ability give to exogenous changes in their competitive conditions, illustrated by the theoretical model. The first coefficient is the effect on the output of the academic whose output is below the median of their scientific sector of the corresponding variable in their sector. The second row is the value for individuals whose output is in the sixth and seventh decile of the distribution of output in their sector, the third row for deciles eight and nine, and the last row for the academics whose output is in the top decile. The first block measures the effects of changes in the importance of the measurable dimension, the index x, the middle block reports the effect, in each quantile group, of an increase in the log of the number of posts available in the sector, and the third the effect of a change in the log of the number of competitors. The fourth block the importance of the rule on the number of applications per year, and the calculated block at the bottom the role of the size of the scientific sector.

The appendix reports the corresponding results for quartiles, while the Figures below plots the coefficients when the regressions are run with the interactions with

Table 4: Main results in the first two columns, and robustness checks.

Determinants of Individual productivity	Base Regression Coauthors weighting		Output weighted with impact factor		Future values: K, M, N		Instrumental variables: openness and average age	
	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.
Metric-basedness: below median	-0.311***	-0.187***	-0.435***	-0.288***	-0.403***	-0.187***	-0.483***	-0.622***
	0.010	0.010	0.020	0.019	0.015	0.017	0.061	0.192
Deciles 6 and 7	0.016	-0.032**	-0.007	-0.091***	-0.271***	-0.134***	0.145	0.915***
	0.013	0.015	0.026	0.027	0.015	0.015	0.095	0.244
Deciles 8 and 9	0.536***	0.179***	0.780***	0.207***	0.063***	-0.001	0.491**	-1.568***
	0.020	0.024	0.039	0.045	0.017	0.018	0.196	0.329
Top decile	1.271***	0.552***	1.773***	0.422**	0.912***	0.429***	1.737***	3.714***
	0.061	0.074	0.140	0.175	0.035	0.043	0.257	0.702
Number of posts: below median	0.008***	0.026***	0.020***	0.044***	-0.006**	0.018***	0.016***	0.101***
	0.002	0.002	0.004	0.005	0.003	0.004	0.004	0.015
Deciles 6 and 7	-0.005*	0.012***	0.005	0.027***	-0.009***	0.008**	0.007*	0.053***
	0.002	0.003	0.004	0.006	0.003	0.004	0.004	0.016
Deciles 8 and 9	-0.015***	-0.009**	-0.015**	-0.012	-0.015***	-0.019***	0.003	0.032**
	0.004	0.004	0.006	0.008	0.003	0.004	0.004	0.016
Top decile	-0.049***	-0.014	-0.089***	-0.044	-0.051***	-0.065***	-0.030***	-0.052***
	0.013	0.014	0.034	0.042	0.006	0.008	0.005	0.019
Competitors: below median	0.050***	-0.032***	0.017	-0.103***	0.041***	0.011	0.002	-0.237***
	0.009	0.010	0.020	0.026	0.010	0.012	0.010	0.031
Deciles 6 and 7	0.042***	-0.014	0.004	-0.084***	0.034***	0.015	0.021*	-0.037
	0.009	0.010	0.020	0.027	0.010	0.012	0.011	0.031
Deciles 8 and 9	0.025***	0.020**	-0.022	-0.030	0.017*	0.039***	0.002	0.048
	0.009	0.010	0.020	0.027	0.010	0.012	0.012	0.033
Top decile	0.080***	0.131***	0.120***	0.215***	0.006	0.104***	0.037***	0.304***
	0.014	0.014	0.027	0.036	0.011	0.013	0.010	0.034
Reform constraint: below median	-0.012***	0.029***	0.001	0.047***	-0.040***	-0.001	0.010*	0.150***
	0.003	0.004	0.006	0.011	0.004	0.006	0.005	0.027
Deciles 6 and 7	-0.019***	0.003	-0.001	0.028**	-0.039***	-0.001	0.023***	0.043
	0.005	0.006	0.009	0.011	0.005	0.007	0.006	0.028
Deciles 8 and 9	-0.034***	-0.025***	-0.046***	0.002	-0.032***	-0.009	-0.017***	-0.034
	0.006	0.008	0.012	0.015	0.005	0.007	0.006	0.028
Top decile	-0.120***	-0.181***	-0.242***	-0.245***	-0.014	-0.060***	-0.068***	-0.186***
	0.020	0.026	0.062	0.067	0.010	0.014	0.008	0.029
Observations	124,832	93,482	124,832	93,482	93,278	70,033	124,832	93,482
R-squared	0.428	0.360	0.200	0.149	0.305	0.227		
F-statistics in the first stage							2.83	3.87
Number of different professors	49,076	37,996	49,076	37,996	41,646	33,120	49,076	37,996
$\ln(K)$ - $\ln(N)$: below median	-0.425***	0.583***	0.035	0.147***	-0.048***	0.008	0.014	0.082***
	0.009	0.010	0.021	0.029	0.011	0.013	0.012	0.013
Deciles 6 and 7	-0.046***	0.025**	0.001	0.111***	-0.043***	-0.007	-0.013	0.056***
	0.009	0.011	0.021	0.030	0.011	0.014	0.013	0.013
Deciles 8 and 9	-0.039***	-0.029**	0.006	0.018	-0.032***	-0.059***	0.001	0.028**
	0.011	0.012	0.022	0.302	0.011	0.014	0.014	0.014
Top decile	-0.129	-0.144***	-0.209***	-0.259***	-0.057***	-0.168***	-0.067***	-0.074***
	0.022	0.022	0.051	0.064	0.014	0.018	0.012	0.014

Note: *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$. Standard errors clustered by individual in small font below coefficient. Constant, female share, average age, homonymy, period and individual fixed effects included. The coefficients in the last block are calculated from the estimated coefficients.

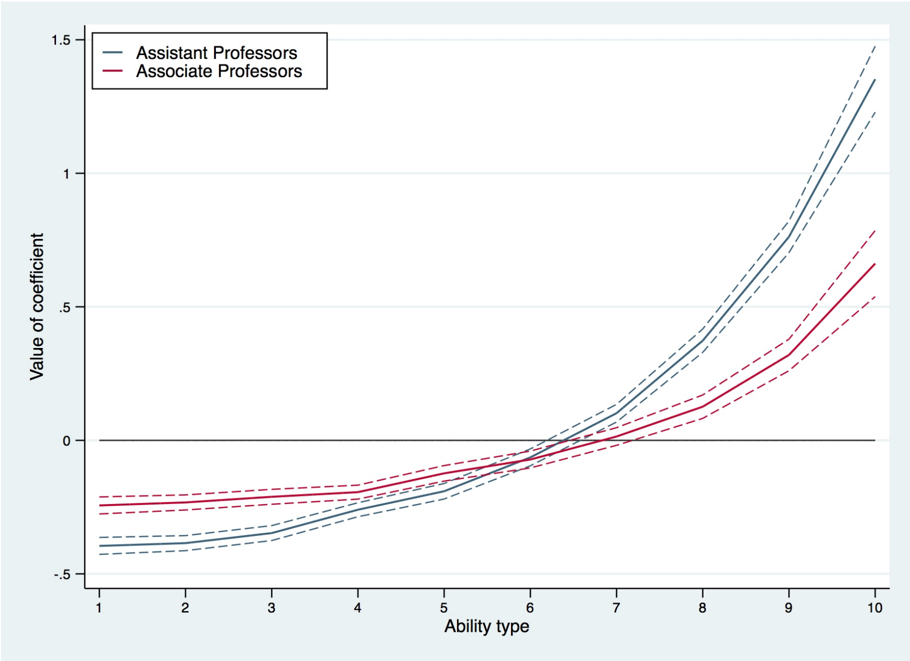

Figure 9: Effect of a change in metric-basedness.

Regression coefficients for x at the mid-point of each decile in the ability distribution

all ten deciles as separate regressors.

In each of Figures 9-11, the horizontal axis is the decile of ability and the corresponding ordinate the coefficient measuring the effect of a change in the exogenous variable on the output of the academics allocated to that decile according to their output. The dashed lines are the 90% confidence interval around the coefficient.

All three figures depict responses which, to a considerable degree, match the theoretical predictions derived in section 2.2. Thus Figure 9 shows how higher ability academics, who produce more to begin with are also more responsive to an increase in the importance of the measurable dimension, as suggested in Conjecture 3. Moreover, the effect is stronger for assistant professors, who face a more competitive environment, than for associate professors. The position of the two curves suggests a discouragement effect for low ability academics, who respond to an increase in metric-basedness with a *reduction* in their effort: this is not predicted by the theory, but could be due to substitutability in effort along different dimensions: as the non-measurable dimension becomes more important, more effort is devoted to it, which might increase the marginal cost of effort along the measurable dimension.

Figures 10 and 11 convey the same message. Competitiveness, a reduction in the

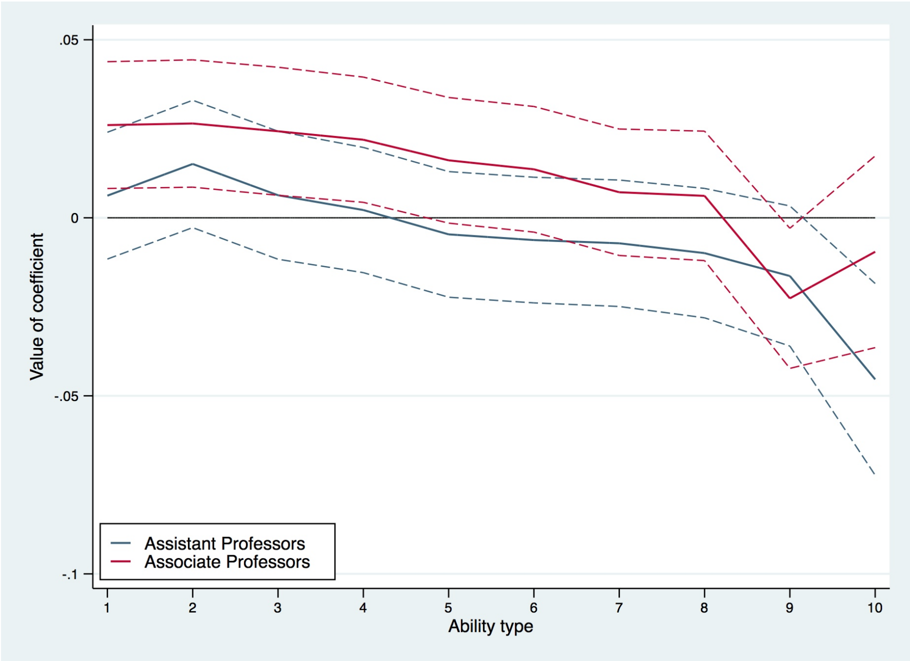

Figure 10: Effect of a change in the number of posts.
Regression coefficients for K at the mid-point of each decile in the ability distribution

ratio between posts and potential applicants, increases effort of high ability types and reduces effort for low ability types, in line with Conjecture 1. The message is more precise for associate professors, as can be seen comparing the red and the blue lines.

In the rest of the section we carry out some robustness checks; these confirm that the main results do not change according to the details of the econometric specification chosen. More such tests are collected in the appendix. The third and fourth 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 ranking of journals for that research area according to the impact factor, and where the index x is also measured using this weighting for the output component. The coefficients do not differ qualitatively from the first two columns.

In the next two columns we explore in more detail the dynamic structure, and report the estimation of (19), we it is postulated that individual base their effort on the output expected for the next period. The differences are not substantial, indicating a degree of stability of expectations, and that the timing of the competition relative to the time when effort is exerted is not a fragile variable in the determination of our results.

Given the anecdotal evidence regarding the relative importance of publication in journals for different subjects, it might be of interest to analyse separately the behaviour of academics working in different areas. As shown in the appendix there is no statistically significant difference in the estimated coefficient across the five broad areas of Science, Medicine, Engineering, Art Humanities and Law, and Social Science. This might seem puzzling, though close investigations of the different scientific sectors within each of these areas suggests (see Checchi et al 2014, Section 4) that there is sufficient variation in the competitive conditions across scientific sectors *within* each research area to explain this homogeneity. This, however, may raise the question of endogeneity in the choice of the selection criterion by the appointing committees. If academics do self-select into different scientific sectors within the same research area, both candidates and panellists would share the same attitude towards the measurable dimension of output, which might create endogeneity of the variable. For example, if biologists with a high cost of effort along the measurable dimension all opt for a given scientific sector within biology, and those with a low cost of effort for a different one, then the correlation between individual productivity and selection criteria would be driven by the unobservable type. The very variability of the index x within broad research area makes this a problem, as it is arguably easier for an academic to switch from a scientific sector within a broad area, than changing area altogether. This self-selection problem is somehow lessened by the measurement of individual output *relative* to the average output of the full professors in the scientific sector. Nevertheless, to reduce the potential problems which might be caused by short term changes in behaviour, we instrument the index x using two variables which might be correlated with the importance of the measurable dimension, but are uncorrelated with individual output in an OLS regressions, namely the share of appointments from outside the university system and the average age of full professors in the scientific sector. The former, the share of academics who are not promoted from a lower rank, typically working in foreign universities, in the private sector, or in public sector research institutions, suggests a sector less inward-looking, more open to the international standard provided by the measurable dimension. Similarly for the average age of the full professor: a younger leadership should be correlated with greater importance of the measurable dimension. The qualitative nature of the results is unchanged relative to the OLS, as the last two columns in Table 4 show.

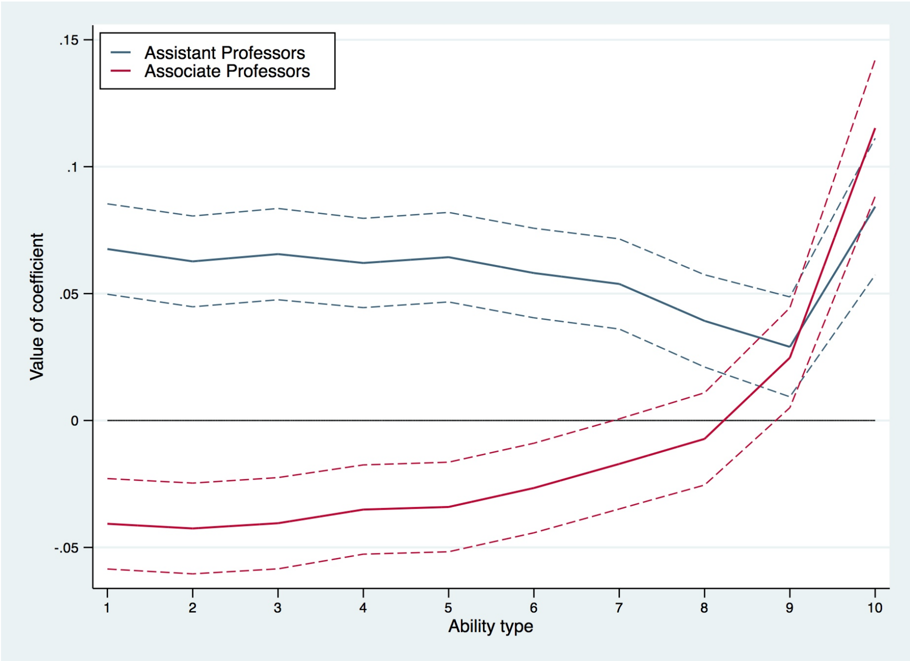

Figure 11: Effect of a change in the number of competitors.
Regression coefficients for N at the mid-point of each decile in the ability distribution.

7 Concluding remarks

This paper studies the response of Italian academics to the competitive conditions they face. We construct a theoretical set-up moulded by the details of the legislation governing promotions and appointments in Italy in the period from 1990 to 2011. The model predicts differential responses to competitive conditions for individuals with different abilities, and so end up with different levels of output: the theory predicts that the change in effort level in response to exogenous changes differ according to individuals' position in the ability ranking. Intuitively, this happens because individuals whose cost of effort differ, choose effort levels such that the benefit of "extra" effort differ. If the competitive conditions change, for example because more jobs become available, then a high ability individual, for whom effort is "cheap" who was exerting a lot of effort is already highly likely to be promoted, and so has relatively little incentive to exert "extra" effort. But for someone in the middle of the ability ranking, the laxer competitive conditions might translate into high productivity of effort, in the sense that "extra" effort might be rewarded with a relatively large increase in the probability of winning the additional job made available.

We exploit these non-linearities in our econometric strategy. We build a dataset collecting the publications in academic journals written by academics working in Italian universities. We exploit the highly uneven time trend of new appointments, which reflect the highly centralised appointment and promotion process and funding patterns, and the very low turnover in the profession: entries tend to happen at the lowest level, and exit is relatively 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 of different types of individuals.

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A1 Appendix

In this appendix, we first clarify how we have dealt with some important but technical issues in the preparation of the dataset, and subsequently we present further results which might be of interest to some readers.

A1.1 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 attiministeriali.miur.it/media/174798 /allegato%20a_def.pdf.

A1.2 Disambiguation of homonymy

In this section we explain how we have attempted to reduce the mis-attribution 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 broader 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 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.[25]

[25]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

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 from 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.

When homonyms are also in the same broader 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 $\frac{1}{2}$.

A1.3 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 the rather daunting task of 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.[26] Rather than the h-index, we calculate the *real* h-index, which has the twofold advantage of taking continuously distributed values, and of refining the ranking 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. We split the remaining

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' 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.

[26]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 publications at the time of download had received 4 citations in 2002, 3 in 2003, 3 in 2004, and 2 in 2005, and none subsequently.

ties randomly, and calculate the index for each scientific sector for 50 random ways of breaking the ties and we average the resulting values of the index derived in each case.

A1.4 Further summary statistics and additional results

Tables A1 and A2 break down the information in Tables 1 and 2 by period and by broad subject area. Similarly, A3 gives the breakdown of the summary statistics, presented in aggregate in Table 3, by broad disciplinary area. This information is further broken down by period for the index of metric-basedness in Table A4.

In table A5 we split the sample by broad research area. The main results reported in Table 4 hold in each subsample, indicating limited differences across broad disciplines. Statistical significance declines, especially in the Arts, Humanities and Law, and in the social sciences.

Recall that in the main body of the paper we have bracketed professors together according to asymmetric groups of deciles, to account for very similar output in the lower part of the distribution of types. Lest be thought that the partition given in the body of the paper affects our result, in Table A6 we partition individuals into four quartiles. As the first two columns show, the pattern is preserved of heterogeneous response to external conditions by ability: more talented academics are more productive when metric-basedness is more relevant and when competition is fiercer. This pattern survives even when we split the sample by research area, despite loss of statistical significance in many cases.

Table A7 reports the breakdown of the regression by time periods: it is hard to detect a pattern, confirming the relative limited importance of the 1999 reform, except insofar as the constraint on the number of applications did affect output, as shown in the last block of reported coefficients.

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Table A1: Number of professors by rank, broad discipline and period

Discipline	Stat	1991-1994 Assist.	1991-1994 Assoc.	1991-1994 Full	1995-1998 Assist.	1995-1998 Assoc.	1995-1998 Full	1999-2002 Assist.	1999-2002 Assoc.	1999-2002 Full	2003-2006 Assist.	2003-2006 Assoc.	2003-2006 Full	2007-2011 Assist.	2007-2011 Assoc.	2007-2011 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
	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
	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
	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
	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
	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 A2: Promotions and Appointments by Period and Broad Disciplinary Area

Disciplinary Area	Assist.-Assoc.	Assoc.-Full	Assist.-Full
Science			
1990-1994	869	610	29
1995-1998	752	30	1
1999-2002	2,094	1,829	33
2003-2006	1,354	900	6
2007-2011	607	349	7
Medicine			
1990-1994	404	204	13
1995-1998	108	124	21
1999-2002	889	828	48
2003-2006	687	525	4
2007-2011	301	256	2
Engineering			
1990-1994	444	265	4
1995-1998	693	21	5
1999-2002	1,033	1,100	12
2003-2006	811	554	3
2007-2011	406	201	4
Arts, Hum. & Law			
1990-1994	546	392	34
1995-1998	537	82	16
1999-2002	2,099	1,918	93
2003-2006	1,383	1,140	33
2007-2011	615	449	7
Social Sciences			
1990-1994	276	147	3
1995-1998	351	44	3
1999-2002	949	787	12
2003-2006	644	520	4
2007-2011	323	193	2
Total	19,175	13,468	399

Source: Italian Ministry of Education, Universities and Research

Table A3: 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
Mean 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
Output (weighted with IF)	0.013	0.048	0.015	0.049	0.009	0.062	0.016	0.139	0.024	0.103	0.025	0.107	0.016	0.140	0.025	0.233	0.012	0.079	0.019	0.118
Index x	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
x (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
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	0.028	0.323	0.035	0.327	0.043	0.196	0.031	0.231	0.038	0.140	0.030	0.550	0.006	0.428	0.036	0.425	0.028	0.287	0.051
Promotions from outside	0.142	0.141	0.091	0.23	0.312	0.195	0.062	0.114	0.112	0.127	0.029	0.118	0.210	0.181	0.057	0.165	0.155	0.118	0.082	0.191
Broad Homonymy dummy	0.274	0.440	0.274	0.439	0.290	0.448	0.279	0.443	0.277	0.442	0.294	0.449	0.269	0.438	0.262	0.434	0.271	0.440	0.265	0.435
Narrow Homonymy dummy	0.004	0.061	0.006	0.076	0.020	0.135	0.017	0.126	0.005	0.065	0.004	0.060	0.002	0.049	0.001	0.036	0.004	0.061	0.002	0.047
Region: North East	0.226	0.012	0.215	0.003	0.233	0.016	0.255	0.003	0.272	0.021	0.284	0.009	0.189	0.014	0.181	0.016	0.255	0.016	0.241	0.020
North West	0.213	0.009	0.232	0.007	0.163	0.015	0.184	0.005	0.169	0.006	0.187	0.004	0.193	0.007	0.231	0.016	0.193	0.006	0.239	0.014
Centre	0.262	0.016	0.260	0.004	0.288	0.035	0.278	0.007	0.259	0.028	0.240	0.007	0.301	0.026	0.285	0.004	0.275	0.024	0.274	0.012
South and Islands	0.299	0.013	0.294	0.003	0.316	0.018	0.283	0.012	0.300	0.020	0.289	0.010	0.317	0.006	0.302	0.006	0.277	0.035	0.246	0.010
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 A4: Summary statistic for the importance of publication in WoK journals for promotion by academic rank

Period	Science		Medicine		Engineering		Hum. & Law		Social Sciences	
	Assoc.	Full	Assoc.	Full	Assoc.	Full	Assoc.	Full	Assoc.	Full
1990-94	0.556	0,631	0.544	0,607	0.530	0,588	0.518	0,507	0.521	0,558
	0.149	0,202	0.132	0,165	0.172	0,159	0.105	0,097	0.115	0,170
1995-98	0.732	0,510	0.674	0,620	0.693	0,448	0.543	0,509	0.593	0,624
	0.147	0,212	0.248	0,219	0.144	0,075	0.123	0,183	0.142	0,185
1999-02	0.720	0,615	0.762	0,677	0.655	0,613	0.521	0,536	0.556	0,555
	0.116	0,115	0.105	0,121	0.130	0,148	0.091	0,097	0.102	0,084
2003-06	0.715	0,630	0.731	0,661	0.658	0,625	0.521	0,560	0.543	0,571
	0.116	0,141	0.135	0,124	0.174	0,142	0.091	0,125	0.098	0,116
2007-11	0.724	0,656	0.705	0,666	0.667	0,670	0.546	0,533	0.591	0,524
	0.148	0,215	0.172	0,183	0.159	0,193	0.118	0,125	0.166	0,158

Note: Index of metric-basedness when candidates are ranked by the number of papers adjusted for the number of authors. The number in small font under the mean by broad area is the standard deviation.

Table A5: Results of base regressions, coauthors weighting, by broad disciplinary area

Determinants of Individual productivity	Base Regression		Science		Medicine		Engineering		Hum. & Law		Social Sciences	
	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.	Assist	Assoc.
Metric-basedness: below median	-0.435***	-0.288***	-0.304***	-0.278***	-0.103***	-0.219***	-0.733***	-0.719***	-0.059	0.003	-0.459***	-0.177*
	0.020	0.019	0.035	0.028	0.020	0.031	0.080	0.067	0.097	0.082	0.153	0.102
Deciles 6 and 7	-0.007	-0.091***	-0.248***	-0.055	-0.036	-0.088*	0.289***	-0.156*	0.050	-0.023	-0.275**	-0.055
	0.026	0.027	0.050	0.042	0.032	0.052	0.090	0.084	0.091	0.106	0.132	0.113
Deciles 8 and 9	0.780***	0.207***	0.271***	0.086	0.142**	-0.021	2.063***	0.889***	0.357***	0.322**	0.396**	0.443***
	0.039	0.045	0.062	0.070	0.061	0.078	0.157	0.178	0.117	0.140	0.190	0.163
Top decile	1.773***	0.422**	0.794***	0.305	0.948***	0.175	3.808***	1.890***	1.401*	-0.191	0.011	-0.044
	0.140	0.175	0.198	0.220	0.217	0.310	0.399	0.427	0.780	1.336	1.277	0.540
Number of posts: below median	0.020***	0.044***	0.046***	0.039***	0.014***	0.030***	-0.003	-0.027**	0.018	0.035	-0.000	0.068***
	0.004	0.005	0.007	0.007	0.005	0.006	0.021	0.013	0.016	0.023	0.018	0.014
Deciles 6 and 7	0.005	0.027***	0.006	0.021**	0.003	0.027***	0.056**	-0.023	0.015	0.043*	-0.026*	0.026
	0.004	0.006	0.010	0.010	0.006	0.010	0.027	0.020	0.015	0.024	0.015	0.023
Deciles 8 and 9	-0.015**	-0.012	0.003	-0.022	-0.020*	0.054***	0.157***	0.019	0.014	0.031	-0.037**	-0.004
	0.006	0.008	0.014	0.015	0.011	0.012	0.038	0.026	0.018	0.028	0.019	0.027
Top decile	-0.089***	-0.044	-0.089*	-0.104***	-0.068*	0.186***	0.009	0.234**	-0.206*	-0.244	-0.178	-0.002
	0.034	0.042	0.046	0.040	0.040	0.063	0.146	0.097	0.124	0.260	0.128	0.106
Competitors: below median	0.017	-0.103***	-0.183***	-0.088**	-0.089***	-0.223***	0.189**	-0.046	-0.026	-0.127	0.269***	-0.143***
	0.020	0.026	0.031	0.035	0.029	0.055	0.079	0.051	0.056	0.105	0.084	0.048
Deciles 6 and 7	0.004	-0.084***	-0.101***	-0.045	-0.058**	-0.190***	0.070	-0.078	-0.038	-0.121	0.275***	-0.132***
	0.020	0.027	0.031	0.035	0.029	0.057	0.082	0.052	0.056	0.105	0.086	0.050
Deciles 8 and 9	-0.022	-0.030	-0.065**	0.062*	0.003	-0.122**	-0.144*	-0.156***	-0.058	-0.142	0.232***	-0.109**
	0.020	0.027	0.033	0.036	0.029	0.056	0.084	0.050	0.059	0.107	0.087	0.055
Top decile	0.120***	0.215***	0.151***	0.322***	0.114***	0.019	-0.022	-0.114	0.168	0.349	0.689***	0.352***
	0.027	0.036	0.047	0.040	0.035	0.069	0.148	0.088	0.117	0.292	0.233	0.102
Reform: below median	0.001	0.047***	0.031***	0.062***	0.023***	0.065***	0.066***	0.031	0.017	0.076	-0.029	0.033
	0.006	0.011	0.008	0.010	0.007	0.012	0.017	0.024	0.019	0.051	0.023	0.025
Deciles 6 and 7	-0.001	0.028**	0.038***	0.048***	0.020*	0.035*	0.020	0.043	0.016	0.048	-0.065**	0.111***
	0.009	0.011	0.013	0.017	0.011	0.021	0.027	0.033	0.024	0.035	0.030	0.033
Deciles 8 and 9	-0.046***	0.002	-0.092***	-0.005	-0.043**	-0.051**	-0.078**	0.022	-0.000	0.046	-0.040	0.092*
	0.012	0.015	0.022	0.028	0.018	0.023	0.038	0.041	0.026	0.036	0.035	0.048
Top decile	-0.242***	-0.245***	-0.303***	-0.212***	-0.160**	-0.439***	-0.372***	-0.383***	-0.139	-0.308	-0.418	-0.344**
	0.062	0.067	0.056	0.068	0.067	0.091	0.107	0.145	0.178	0.316	0.262	0.163
Observations	124,832	93,482	35,614	28,962	24,556	16,067	16,831	12,634	31,662	20,869	11,984	8,897
R-squared	0.200	0.149	0.550	0.453	0.372	0.307	0.432	0.311	0.062	0.041	0.211	0.350
Number of different professors	49,076	37,996	14,281	11,705	8,907	6,625	7,444	5,770	13,074	9,731	5,448	4,039

Disciplinary Area (spanning columns Science through Social Sciences)

Note: *** p≤0.01, ** p≤0.05, * p≤0.1. Standard errors clustered by individual in small font below coefficient. Constant, female share, average age, homonymy, period and individual fixed effects included.

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

Determinants of Individual productivity	Base Regression		Science		Medicine		Engineering		Hum. & Law		Social Sciences	
	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.
Metric-basedness: 1^{st} Quartile	-0.357***	-0.214***	-0.135***	-0.197***	-0.093***	-0.271***	-0.667***	-0.594***	-0.141***	-0.034	-0.188***	-0.143**
	0.012	0.012	0.020	0.022	0.015	0.030	0.052	0.046	0.038	0.035	0.072	0.069
2^{nd} Quartile	-0.217***	-0.138***	-0.134***	-0.115***	-0.076***	-0.106***	-0.370***	-0.370***	-0.124***	-0.015	-0.092	-0.168***
	0.012	0.012	0.022	0.021	0.016	0.027	0.047	0.046	0.032	0.036	0.062	0.058
3^{rd} Quartile	0.092***	-0.002	-0.023	-0.010	-0.027	-0.013	0.413***	0.132***	-0.074**	-0.001	-0.023	-0.127*
	0.014	0.016	0.028	0.028	0.022	0.042	0.057	0.051	0.036	0.033	0.072	0.074
4^{th} Quartile	0.821***	0.331***	0.233***	0.172***	0.194***	0.339***	1.996***	1.290***	0.194**	0.108	0.764***	0.337***
	0.031	0.038	0.054	0.053	0.063	0.116	0.102	0.129	0.086	0.096	0.170	0.129
Number of posts: 1^{st} Quartile	0.008***	0.028***	0.038***	0.023***	0.015***	0.028***	-0.043***	-0.040***	0.003	0.018***	-0.004	0.028**
	0.002	0.002	0.005	0.005	0.003	0.006	0.013	0.010	0.005	0.006	0.009	0.013
2^{nd} Quartile	0.001	0.019***	0.014*	0.016***	0.009***	0.010*	-0.050***	-0.048***	0.001	0.013**	-0.007	0.008
	0.002	0.002	0.008	0.006	0.003	0.006	0.014	0.011	0.005	0.006	0.008	0.009
3^{rd} Quartile	-0.007***	0.007**	0.005	0.010	0.002	0.008	0.001	-0.024**	0.002	0.007	-0.012	0.010
	0.003	0.003	0.008	0.006	0.004	0.007	0.017	0.011	0.005	0.006	0.009	0.011
4^{th} Quartile	-0.024***	-0.011	-0.041***	-0.023*	-0.014	0.036**	0.053	0.066***	-0.025**	-0.003	-0.007	0.016
	0.006	0.007	0.015	0.013	0.011	0.016	0.033	0.025	0.013	0.014	0.018	0.024
Competitors: 1^{st} Quartile	0.068***	-0.023**	-0.109***	-0.023	-0.050**	-0.123***	0.263***	0.114***	0.022	-0.025	0.107	-0.047*
	0.010	0.010	0.021	0.022	0.021	0.032	0.040	0.035	0.016	0.019	0.068	0.026
2^{nd} Quartile	0.065***	-0.017*	-0.068***	-0.008	-0.039*	-0.115***	0.241***	0.102***	0.022	-0.026	0.099	-0.031
	0.010	0.010	0.023	0.022	0.021	0.033	0.041	0.036	0.015	0.019	0.068	0.025
3^{rd} Quartile	0.055***	0.000	-0.029	0.036	-0.014	-0.087***	0.144***	0.057	0.016	-0.024	0.098	-0.030
	0.010	0.010	0.022	0.022	0.021	0.032	0.042	0.035	0.015	0.019	0.069	0.025
4^{th} Quartile	0.058***	0.065***	0.087***	0.153***	0.058**	-0.032	0.011	-0.035	0.040**	0.028	0.083	0.017
	0.011	0.011	0.025	0.023	0.023	0.034	0.049	0.039	0.019	0.023	0.075	0.031
Reform: 1^{st} Quartile	-0.011***	0.023***	0.013**	0.032***	0.013**	0.025***	0.005	0.023	0.009	0.014	-0.023	-0.015
	0.004	0.005	0.005	0.008	0.005	0.009	0.013	0.018	0.008	0.010	0.014	0.020
2^{nd} Quartile	-0.013***	0.020***	0.015**	0.044***	0.014**	0.025**	0.021	0.037*	0.013*	0.021*	-0.023	0.020
	0.004	0.005	0.007	0.009	0.006	0.012	0.014	0.019	0.007	0.011	0.016	0.017
3^{rd} Quartile	-0.021***	0.002	-0.011	0.003	-0.008	0.015	-0.003	0.046**	0.014*	0.032***	-0.033**	0.014
	0.005	0.006	0.010	0.011	0.009	0.015	0.020	0.021	0.008	0.012	0.016	0.020
4^{th} Quartile	-0.080***	-0.082***	-0.122***	-0.113***	-0.095***	-0.144***	-0.099***	-0.026	-0.032	-0.079**	-0.085***	-0.061
	0.010	0.014	0.018	0.023	0.021	0.032	0.030	0.044	0.019	0.031	0.027	0.043
Observations	124,832	93,482	35,614	28,962	24,556	16,067	16,831	12,634	31,662	20,869	11,984	8,897
R-squared	0.312	0.237	0.536	0.416	0.343	0.272	0.469	0.261	0.077	0.086	0.263	0.244
Number of different professors	49,076	37,996	14,281	11,705	8,907	6,625	7,444	5,77	13,074	9,731	5,448	4,039

Note: *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$. Standard errors clustered by individual in small font below coefficient. Constant, female share, average age, homonymy, period and individual fixed effects included.

Table A7: Results of base regressions, coauthors weighting, by period

Determinants of Individual productivity	**Period** 1990-1994		1995-1998		1999-2002		2003-2006		2007-2011	
	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.	Assist.	Assoc.
Metric-basedness: below median	-0.481***	0.045**	-0.014	-0.093***	0.145***	0.163***	0.049***	0.221***	-0.035***	0.026*
	0.027	0.021	0.019	0.023	0.021	0.021	0.019	0.021	0.014	0.014
Deciles 6 and 7	-0.526***	0.114***	0.102***	-0.159***	0.530***	0.406***	0.418***	0.393***	0.316***	0.230***
	0.029	0.023	0.019	0.023	0.022	0.023	0.020	0.024	0.017	0.018
Deciles 8 and 9	-0.399***	0.262***	0.399***	-0.322***	1.210***	0.916***	1.067***	0.754***	0.829***	0.626***
	0.045	0.031	0.025	0.030	0.027	0.032	0.026	0.036	0.030	0.030
Top decile	0.655***	0.929***	1.456***	-0.354***	2.638***	2.197***	2.339***	1.746***	1.798***	1.037***
	0.108	0.096	0.069	0.082	0.077	0.114	0.078	0.111	0.077	0.087
Number of posts: below median	0.000	-0.012***	-0.035***	0.002	-0.029***	-0.074***	-0.060***	-0.047***	-0.067***	-0.028***
	0.004	0.002	0.002	0.003	0.004	0.005	0.004	0.004	0.004	0.004
Deciles 6 and 7	0.022***	0.006**	-0.022***	-0.004	0.020***	-0.048***	-0.049***	-0.059***	-0.061***	-0.054***
	0.004	0.003	0.002	0.003	0.005	0.006	0.005	0.006	0.005	0.005
Deciles 8 and 9	0.091***	0.043***	-0.018***	-0.016***	0.073***	-0.051***	-0.047***	-0.130***	-0.047***	-0.101***
	0.006	0.004	0.004	0.005	0.007	0.011	0.008	0.011	0.008	0.009
Top decile	0.248***	0.108***	-0.066***	-0.018	0.252***	-0.006	0.054*	-0.178***	-0.036	-0.231***
	0.020	0.016	0.013	0.025	0.026	0.037	0.028	0.029	0.027	0.031
Competitors: below median	-0.031***	0.025***	0.048***	-0.034***	0.089***	0.122***	0.122***	0.098***	0.081***	0.042***
	0.006	0.004	0.004	0.009	0.005	0.007	0.005	0.006	0.005	0.007
Deciles 6 and 7	-0.027***	0.020***	0.042***	-0.015*	0.013**	0.090***	0.079***	0.105***	0.054***	0.054***
	0.006	0.004	0.004	0.009	0.006	0.007	0.005	0.006	0.006	0.007
Deciles 8 and 9	-0.055***	0.023***	0.034***	0.037***	-0.085***	0.060***	0.022***	0.137***	0.017**	0.070***
	0.008	0.005	0.004	0.009	0.007	0.010	0.008	0.009	0.008	0.009
Top decile	-0.153***	0.069***	0.041***	0.190***	-0.272***	0.025	-0.097***	0.179***	0.016	0.242***
	0.020	0.014	0.009	0.014	0.023	0.031	0.022	0.025	0.018	0.019
Reform: below median					-0.045***	-0.047***	-0.059***	-0.065***	-0.064***	-0.075***
					0.003	0.005	0.003	0.005	0.004	0.007
Deciles 6 and 7					-0.024***	-0.045***	-0.032***	-0.078***	-0.038***	-0.086***
					0.004	0.007	0.004	0.006	0.007	0.011
Deciles 8 and 9					-0.008	-0.017*	-0.005	-0.041***	-0.010	-0.058***
					0.006	0.010	0.006	0.009	0.013	0.019
Top decile					-0.127***	-0.117***	-0.059***	-0.024	-0.088**	0.032
					0.020	0.032	0.020	0.026	0.043	0.056
Observations	19,708	16,133	19,064	7,364	28,522	26,079	28,586	23,803	28,952	20,103
R-squared	0.339	0.390	0.416	0.338	0.457	0.420	0.455	0.426	0.447	0.447

Note: *** p≤0.01, ** p≤0.05, * p≤0.1. Standard errors clustered by individual in small font below coefficient. Constant, female share, average age, homonymy, period and individual fixed effects included.