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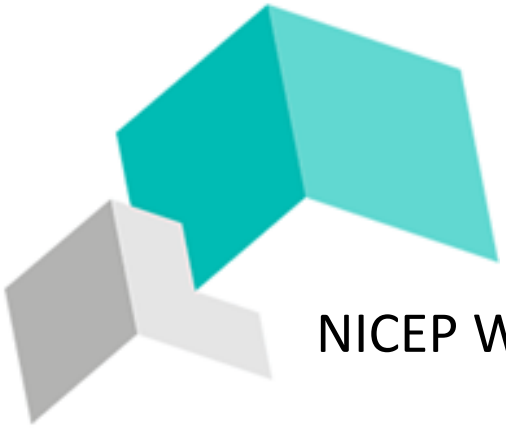

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How Much Is That Star in the Window? Professorial Salaries and Research Performance in UK Universities

Gianni De Fraja
Giovanni Facchini
John Gathergood

Nottingham Interdisciplinary Centre for Economic and Political Research
School of Politics, The University of Nottingham, Law & Social Sciences Building, University Park, Nottingham, NG7 2RD
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Gianni De Fraja
The University of Nottingham
gianni.defraja@nottingham.ac.uk

Giovanni Facchini
The University of Nottingham
giovanni.facchini@nottingham.ac.uk

John Gathergood
The University of Nottingham
john.gathergood@nottingham.ac.uk

How Much Is That Star in the Window? Professorial Salaries and Research Performance in UK Universities

Gianni De Fraja* Giovanni Facchini† John Gathergood‡

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Abstract

Using individual level data on the salary of all UK university professors, matched to results on the performance of academic departments from the 2014 Research Excellence Framework, we study the relationship between academic salaries and research performance. The UK higher education sector is particularly interesting because professorial salaries are unregulated and the outcome of the official research evaluation is a key financial concern of universities. To frame our analysis, we present a simple model of university pay determination, which shows that pay level and pay inequality in a department are positively related to performance. Our empirical results confirm these theoretical predictions; we also find that the pay-performance relationship is weaker for the more established and better paying universities. Our findings are also consistent with the idea that higher salaries have been used by departments to recruit academics more likely to improve their performance.

Keywords: Higher education competition, Research funding, University sector, Salary inequality

JEL Codes: D47, H42, I28, L30.

*University of Nottingham, School of Economics, Università di Roma "Tor Vergata", and C.E.P.R. Email: gianni.defraja@nottingham.ac.uk.

†University of Nottingham, School of Economics, C.E.P.R. and GEP. Email: giovanni.facchini@nottingham.ac.uk.

‡University of Nottingham, School of Economics and Network for Integrated Behavioural Science. Email: john.gathergood@nottingham.ac.uk.

1 Introduction

The pay structure is a key driver of the performance of firms. The positive correlation between firm performance and average pay is firmly established in the literature (e.g. Nickell and Wadhwani 1990, Nickell et al. 1994, Hildreth and Oswald 1997, and Abowd et al. 1999). Some evidence suggests that firms which exhibit also higher within-firm pay *inequality* achieve better performance (Grund and Westergaard-Nielsen 2008, Edmans and Gabaix 2015, Mueller et al. 2016).

The pay-performance relationship holds true not just in commercial firms (Lazear 2000), but also in some organisations which lack a monetary measure of success, such as schools (Lavy 2009). Is the same true for universities? Do universities which pay more, and vary salaries more across their academics, perform better? The subject of often heated discussion among academics, there is surprisingly little systematic evidence on this important question. The limited existing literature (Altbach et al. 2012) has focused on broad national differences in university pay rather than variation among institutions within a country.

To help fill this gap, we study the relationship between pay and performance among academic departments in UK universities. The British setting offers two key features of interest for policy makers around the globe interested in improving the working of the higher education sector. First, unlike many other European countries, salaries of UK full professors are not subject to national regulation, other than a nationally agreed minimum. Universities are free to compete over professorial pay, and do so fiercely. This is reflected in large salary differences, with the highest paid professors in some of the elite institutions earning as much as seven times the national agreed minimum. Second, the measure of performance provided by the official evaluation of UK Universities, the Research Excellence Framework (REF), determines government research funding. This is the main source of research income for UK institutions. In addition, there is a "rank multiplier" effect, as REF performance also enters as a component in many university league tables and therefore affects student recruitment and other sources of direct research income. Hence UK universities have strong incentives to recruit and retain professors whose presence may improve their REF performance, and in this paper we strive to uncover whether they set pay structures to pursue this goal.

To frame our investigation, we propose a simple theoretical set-up, where universities aim to maximise research success, which in turn determines their government research funding. In the model, as in practice in the REF, each academic department is assessed individually, and a university optimisation problem is how to allocate limited resources across departments so as to maximise an aggregate measure of research success. We assume a production function whose inputs are elastically supplied capital and different kinds of labour, to capture different attributes of the academics employed. Our model shows that the average and the standard deviation of pay are collinear, and it predicts a positive correlation between

the research performance of an academic department and the average salary of its staff and between performance and the standard deviation of salaries.

The theoretical model is taken to a dataset comprising the pay of all full professors in a UK post in October 2013, and the performance of their department in REF 2014. The theoretical predictions of our model are given strong empirical support. In particular, we show that there is a positive relationship between professorial pay and REF performance. This finding is quite robust: it holds in regressions where we control for a range of departmental characteristics and for university and subject fixed effects, in a specification with very high explanatory power. This result also holds across the whole range of academic disciplines. Interestingly, we find that the pay-performance relationship is weaker among the most well known research intensive universities, and stronger among the more recently established ones. We also find a positive relationship between professorial pay inequality (as measured by the standard deviation of salaries within a department) and REF performance at the department level. This finding is statistically significant for disciplines in the the arts and humanities and even more so for the sciences and engineering; but not in medicine and biology and the social sciences. This relationship, however, is not robust to institution-specific fixed effects: our theoretical model predicts collinearity between departmental average pay and pay dispersion, which is confirmed by the data. Therefore it is not surprising that the link between REF performance and within-department pay inequality should vanish once we control for subject and institution fixed effects.

An insight on the nature of the causal link between average professorial pay and research performance can be gleaned by separately analyzing the determinants of the different aspects of performance that are measured and combined into the overall REF result. As explained in detail in Section 3.1, three dimensions are considered to assess research performance: output, environment, and impact. The output score is determined by the quality of the publications of the members of the department *at the census date*, irrespectively of where the research was carried out. Environment and impact are instead evaluated through written submissions, and focus on activities carried out in the department over the entire time period assessed, irrrespective of which institution is currently employing the researcher who contributed to them. That is, output is "transferable", impact is not.[1] Interestingly, we find that the positive association between salary and overall performance is in large part due to the relationship between salary and the evaluation of the "transferable" research output. We find instead no link between average salary and the impact score. This result is consistent with universities giving more weight, when hiring or promoting academics, to a high performance in output, the "transferable" dimension, in turn suggesting that they do deliberately try to attract

[1]To use a fictitious example, suppose Professor Lapping publishes important papers while he is employed by Poppleton University. He then moves to Porterhouse College *before* the REF census date. Then his publications will be included in the "output" submission of Porterhouse College and in the "impact" submission of Poppleton University.

professors whose track record affects the REF performance.

Finally, we provide some evidence for ''insider'' behaviour among the REF panel members: *ceteris paribus*, departments in which at least one member of staff sits on the REF peer-review evaluation panel perform better in the exercise. Interestingly, this effect is driven only by the environment and impact components of the aggregate quality measure, arguably those which involve more subjective judgment by the panel members.

Several papers have studied the previous incarnations of the REF. Early comprehensive analyses (e.g. Johnes et al. 1993, Taylor 1995, Sharp and Coleman 2005) have emphasised the role played by systematic "biases" in the panels' quality assessment, based on characteristics of the institutions (new universities vs. more established ones, institutions based in England vs. those based in other parts of the country, units of assessment that had a panel member vs. those which did not, and so on). Controlling for the "quality" of the submission in the 1996 and 2001 assessments of the economics and econometrics departments, Clerides et al. (2011) do not find systematic evidence of "biases" in favor of specific institutions, with the exception of membership in the panel, which has a positive and significant impact on the ranking of the department in the 1996 exercise. This is in line, as well as with this paper, with Butler and McAllister's (2009) study of the evaluation of the political science panel in the 2001 exercise.[2]

A different viewpoint taken by a long established literature is the link between research productivity and compensation at the individual level. Measuring academic productivity is challenging, and one key advantage of the analysis carried out in this paper is that we can rely on the systematic and comprehensive assessment of research carried out by the REF. In an early review of the literature Diamond (1986) focuses on citations as an indicator of a researcher's impact on her field of expertise, and finds that the marginal effect of an additional citation on individual income is positive. Several other contributions have instead differentiated between the number of citations, which are typically used as a proxy for "quality" and the number of papers published, which are typically used as a measure of "quantity". Most papers study a small sample of departments (e.g. Hamermesh et al. 1982, Moore et al. 1998 and Bratsberg et al. 2010). In a recent paper, Hamermesh and Pfann (2012) consider instead a large group of 43 economics department at public institutions in the United States, and find a positive effect of output on wages, whether measured by citations ("quality") or by number of papers ("quantity"). A small recent strand of this literature studies the determinants of indivuduals' research output in continental Europe: among these, Bosquet and Combes (2013), Zinovyeva and Bagues (2010, 2015) and Checchi et al. (2014) in France, Spain, and Italy, respectively. The first of these shows that the characteristics of colleagues matter for research, while the last two focus on the link between research performance and the likelihood of promotion.

[2]The important role played by the panel composition on the evaluation process of academics has been emphasised also by Zinovyeva and Bagues (2015) for the case of Spain.

The rest of the paper proceeds as follows. We present a simple theoretical model of resource allocation within universities in Section 2. The main features of the REF and the data used in the analysis are described in Section 3. Our results are presented in Section 4, and Section 5 concludes. Additional results and more information on the UK university sector are available in the Appendices.

2 University Pay and Competition

We model the UK higher education sector as an industry comprising K universities, indexed by $k = 1, \ldots, K$. They aim to maximise their research in the n academic disciplines, indexed by $i = 1, \ldots, n$. To do so, they allocate their endogenously determined budget to acquire the necessary inputs: capital and academic labour.

We can think of the budget allocation within a university as a two stage process. In the first stage, the centre allocates resources to the various disciplines; subsequently, the departments where each discipline is studied spend their devolved budget in order to maximise their objective function.

While a large body of literature on the organisation of large institutions (Milgrom and Roberts, 1992) emphasises the role played by conflict of interest among players within them, it is plausible to assume that the university as a whole, the heads of departments, and individual academics all share the same goal with regards to research, namely the maximisation of its quality. For this reason we posit a complete information setting.

2.1 The department optimisation problem

Academic departments can be thought of as producing two goods: teaching and research. Given that the focus of our analysis is on understanding the effects of the competition induced by the REF, in this section we abstract from explicitly describing the teaching production process, and focus instead on research. Any teaching constraints, such as the requirement to recruit a given number of students, are not modeled here, and are implicitly captured in the production function or in the budget constraint. We model research as produced using three inputs: capital and two types of labour, which can be thought of as academics of different quality (good professors and superstars): if we had homogeneous labour earnings, inequality could not emerge in equilibrium. The restriction to two types only is convenient and immaterial, as will become evident.

The two types of labour differ in their supply and in their productivity. Specifically, we

assume that the supply of labour type ℓ is given by [3]

$$L_\ell = \mu_\ell w_\ell, \qquad \ell = 1, 2. \tag{1}$$

The research output of university k in discipline i, $k = 1, \ldots, K$, $i = 1, \ldots, n$, is denoted by $\rho_{k,i}$, and obeys a Cobb-Douglas technology:

$$\rho_{k,i} = \theta_k L_1^{\alpha_1} L_2^{\alpha_2} K^{\beta_i}, \tag{2}$$

where K is the amount of capital, given by labs, equipment, technical personnel, etc. and L_ℓ is the amount of labour of type ℓ, $\ell = 1, 2$. The different elasticities in the supply function of the two types of labour capture different job market opportunities, which depend on an academic's research potential. The parameter θ_k characterises the overall research productivity of an institution, and varies by institution: different universities may have different productivities, and this could be due for example to different research environments and international connections.[4] β_i is a parameter determining the importance of capital in a given discipline: naturally, research in some disciplines is more "capital–intensive" than in others, for example on account of factors affecting all institutions such as laboratory costs and the like. Note that β_i is the only difference among disciplines: allowing labour productivity α_ℓ, or supply elasticity μ_ℓ, to vary would not change the analysis in substantial ways. In addition, both θ_k and β_i could vary both by discipline and institution, but keeping them fixed across one dimension matches our empirical specification.

Consider therefore a given department. Suppose it receives from the central university administration a fixed budget B_i. Its budget constraint is:

$$rK + w_1 L_1 + w_2 L_2 = B_i. \tag{3}$$

[3] We assume this to be the supply of labour in discipline i faced by university k, $k = 1, \ldots, K$, $i = 1, \ldots, n$. We therefore ignore any oligopsonistic interaction among institutions: taking them into account would change the absolute levels of academic employment and salaries, but would not alter their *relative* values across institutions and disciplines, which is the focus of our paper.

[4] If academics are willing to trade-off a university's prestige and overall research environment for a lower salary, then prestigious university would find it easy to hire and retain high quality academics and hence enjoy a higher productivity. We take θ_k to be exogenously fixed: it may depend on reputation or history, and in particular, it is not affected by changes in the "quality" of other departments. Thus our analysis is based on the idea that correlation between the quality of the various departments in a given university is not a necessary consequence of technological spillovers, but may be caused by an unobserved factor, common to all departments. See De Fraja and Valbonesi (2012), or De Fraja (2016) for similar set-ups.

Thus department i in institution k maximises (2) subject to (1) and (3). To lighten notation, let

$$A_i = \alpha_1^{\frac{\alpha_1}{2}} \mu_1^{\frac{\alpha_1}{2}} \alpha_2^{\frac{\alpha_2}{2}} \mu_2^{\frac{\alpha_2}{2}} \left(\frac{2\beta_i}{r}\right)^{\beta_i}, \tag{4}$$

$$c_i = \alpha_1 + \alpha_2 + 2\beta_i. \tag{5}$$

Note that $\frac{c_i}{2}$ is a measure of the returns to scale of the production function for research, adjusted to take into account the effect of the inelastic supply of the two types of labour.

Proposition 1. *The solution of the maximisation problem of department i in institution k satisfies:*

$$L_\ell = \sqrt{\frac{\alpha_\ell \mu_\ell}{c_i}} B_i, \qquad \ell = 1, 2, \tag{6}$$

$$K = \frac{2\beta_i}{c_i} \frac{B_i}{r}, \tag{7}$$

and the output is given by

$$\rho^*_{k,i}(B_i) = \theta_k A_i \left(\frac{B_i}{c_i}\right)^{\frac{c_i}{2}}. \tag{8}$$

Proof. The problem of department i is:

$$\begin{aligned} \max_{L_1, L_2} \quad & \ln \theta_k + \alpha_1 \ln L_1 + \alpha_2 \ln L_2 + \beta_i \ln K \\ & \text{s.t.: } rK = B_i - w_1 L_1 - w_2 L_2 \\ & L_\ell = \mu_\ell w_\ell \qquad \ell = 1, 2. \end{aligned}$$

Substituting the constraint into the maximand, we can write this problem as:

$$\max_{L_1, L_2} \ln \theta_k + \alpha_1 \ln L_1 + \alpha_2 \ln L_2 + \beta_i \ln \left(B_i - \frac{L_1^2}{\mu_1} - \frac{L_2^2}{\mu_2}\right) - \beta \ln r.$$

Solving the first order conditions of the above gives (6). This, substituted into (3) and using definitions (4) and (5) gives the expression for the level of capital (7). The total research output (8) is also obtained by direct substitution. □

Proposition 1 indicates that the amounts of both capital and labour employed by a department increase with the budget (B_i) allocated to it, whereas the amount of labour (capital) employed declines (increases) with the importance of capital in the production process, measured by β_i. As for total output, it increases with the budget allocated to the unit, though it does not do so in proportion to the returns to scale, because labour costs increase with demand. The sign of the derivative of output with respect to the parameter β_i is the same as the sign of $\ln \frac{2\beta_i B_i}{c_i r}$: therefore it is negative when the budget is low, but it becomes positive

for a large enough budget. In other words, small departments become smaller still as capital intensity increases, whereas large ones instead increase further in size. This tallies with the observation that capital intensive departments tends to be large. An immediate consequence of Proposition 1 is the following.

Corollary 1. *Academic salaries in department i in institution k are given by:*

$$w_\ell = \sqrt{\frac{\alpha_\ell B_i}{c_i \mu_\ell}}, \qquad \ell = 1, 2. \tag{9}$$

The mean salary is given by

$$\bar{w} = \frac{\alpha_1 + \alpha_2}{\sqrt{\alpha_1 \mu_1} + \sqrt{\alpha_2 \mu_2}} \sqrt{\frac{B_i}{c_i}}, \tag{10}$$

and the standard deviation by

$$\sigma_w = \sqrt[4]{\frac{\alpha_1 \alpha_2}{\mu_1 \mu_2}} \frac{\sqrt{\alpha_1 \mu_2} - \sqrt{\alpha_2 \mu_1}}{\sqrt{\alpha_1 \mu_1} + \sqrt{\alpha_2 \mu_2}} \sqrt{\frac{B_i}{c_i}}. \tag{11}$$

Proof. Simply substitute (6) into (1) to obtain (9). (10) and (11) are simple calculations. □

The derivative of both the mean salary (10) and of the standard deviation (11) is proportional to the derivative of the last term in each expression, which is $-ci^{-\frac{3}{2}} B_i^{\frac{1}{2}} < 0$, when differentiating with respect to β_i, and $\frac{1}{2} - ci^{-\frac{1}{2}} B_i^{-\frac{1}{2}} > 0$ with respect to B_i. This gives the testable implications that the mean salary and the dispersion of salaries within a department are collinear, and that both increase with the budget allocated to the department.

2.2 The university maximisation problem

We now consider the university's allocation problem. We make the following assumptions regarding the objective function and the resources a university has at its disposal.

Assumption 1. *The objective function of university k is*

$$U_k = \sum_{i=1}^{n} u_i \rho^*_{k,i}(B_i), \qquad k = 1, \ldots, K. \tag{12}$$

That is, university k aims at maximising the total weighted output of its departments, given in (8), with exogenously given weights, u_i. The main ideas of this stage are conveyed by this simple formulation, which could be extended, with no conceptually important changes, by making the payoff depending on an institution's rank in each discipline, rather than the level of its output, or including an exponent for the output (indicating preference for equality or inequality, if smaller or greater than 1).

The next assumption establishes a link between research success and overall resources made available by the government to university k, $\bar{B}$. While, in practice, resource are allocated each year on the basis of past success, we can think of the simultaneous set-up presented here as the steady state of the interaction among the government, universities, and academics.

Assumption 2. *The overall budget (exogenously) allocated to university k is*

$$\bar{B} = \sum_{i=1}^{n} \gamma_i \rho^*_{k,i}\left(B_i\right). \tag{13}$$

The weights γ_i are exogenously given, fixed by the government agency in charge of university funding. A linear formulation is a very natural starting point for the analysis. While the funding agency could adopt a different funding formula, for example by giving higher weight to very good performance, or vice versa by offering extra help to struggling departments, as we explain in Section 3.1, the formula used in practice in the 2014 REF is linear in the performance of an institution's departments, and the government rewards excellence in performance. Incorporating external sources of revenues, such as sponsorships, grant funding, income from patents or donations from alumni, would not alter the analytical set-up, as all these are positively related to prestige. The weights may or may not be proportional to the utility weights in (12), u_i.

Recall definitions (4) and (5) to write university k's problem as:

$$\max_{\{B_i\}_{i=1}^n} \quad \sum_{i=1}^{n} u_i \theta_k A_i c_i^{-\frac{c_i}{2}} B_i^{\frac{c_i}{2}} \tag{14}$$

$$\text{s.t.:} \sum_{i=1}^{n} B_i = \sum_{i=1}^{n} \gamma_i \theta_k A_i c_i^{-\frac{c_i}{2}} B_i^{\frac{c_i}{2}}. \tag{15}$$

Corollary 2. *Let $\beta_i < 1 - \frac{\alpha_1+\alpha_2}{2}$. Then there exists a $\lambda_k > 0$, such that the solution of university k's problem is given by:*

$$B_i = c_i \left(\frac{\left(u_i + \lambda_k \gamma_i\right) A_i \theta_k}{2\lambda_k} \right)^{1-\frac{c_i}{2}}, \qquad i = 1, \ldots, n. \tag{16}$$

Proof. The first order conditions for the Lagrangen of problem (14)-(15) are

$$\frac{1}{2} u_i \theta_k A_i c_i^{1-\frac{1}{2}c_i} B_i^{\frac{1}{2}c_i - 1} - \lambda_k \left(1 - \frac{1}{2} \gamma_i \theta_k A_i c_i^{1-\frac{1}{2}c_i} B_i^{\frac{1}{2}c_i - 1} \right) = 0$$

Rearranging, we derive (16). For this condition to identify a maximum, $\frac{1}{4} B_i^{\frac{1}{2}c_i - 2} \left(c_i - 2\right) c_i^{1-\frac{1}{2}c_i} < 0$, which is the case if $c_i < 2$, that is if $\beta_i < 1 - \frac{\alpha_1+\alpha_2}{2}$, as assumed. □

Corollary 2 implies that, in the steady state, universities with a higher θ_k devote more

resources to their departments, which will also produce higher output. This holds in every discipline i, implying that there is a ranking of institutions, with some performing better in all disciplines and paying their professors more. Note also that in the special case where the ratio between u_i and γ_i is constant in i, that is when the relative "prestige" of any two disciplines equals their relative funding, the Lagrange multiplier disappears from the budget allocation (16), that is all departments grow and shrink proportionally according to the funding granted to the university, measured by γ_i.

Finally, note that to close the model (16) is substituted into (15) to obtain λ_k as a function of the β_i's and θ_k, and the other parameters. Writing this as $\lambda\left(\theta_k; \boldsymbol{\beta}\right)$, where $\boldsymbol{\beta} = (\beta_1, \ldots, \beta_n)$, we can determine the research output of each discipline as a function of the exogenous parameters:[5]

$$\rho^*_{k,i} = \theta_k A_i c_i^{\frac{c_i}{2}} \left(\frac{\left(\frac{u_i}{\lambda(\theta_k;\boldsymbol{\beta})} + \gamma_i \right) A_i \theta_k}{2} \right)^{c_i\left(1-\frac{c_i}{2}\right)}. \tag{17}$$

3 Data

To assess the predictions of our model, we combine public information on the submissions and results from the REF, available on the REF 2014 website, with information on the characteristics of UK Professors as at October 2013 (the month of the census date for the inclusion of academic staff in the REF). In this section we start by presenting the institutional environment of the REF, we discuss next the sample construction, and we then present some summary statistics.

3.1 Research Excellence Framework (REF) Outcome Data

The REF 2014 is a government run evaluation to assess the quality of research in UK higher education institutions, and similar exercises have been carried out a regular intervals since 1992. As explained on the REF website, its goal is threefold: first, public funding bodies will use the assessment outcomes to inform the selective allocation of their grant for research to the institutions which they fund, with effect from 2015-16; second, "the assessment provides accountability for public investment in research and produces evidence of the benefits of this investment" and third "the assessment outcomes provide benchmarking information and establish reputational yardsticks, for use within the higher education sector and for public information." Importantly, the funding allocated on the basis of REF results is substantial. It corresponds to approximately 40% of the total allocated to UK universities through a system of an annual grants, and to about one quarter of all taxpayer money awarded to higher

[5]Note that it is not practical to obtain explicit expressions for $\rho^* k, i$, as it is highly non-linear in the parameters. For example the an increase in the capital-intensiveness of a discipline, measured by β_i, first increases the research performance then decreases it, due to the increase in cost and the beneficial effect of diverting resources to other "less expensive" disciplines.

education institutions.[6] For this reason the REF plays a key role in the UK higher education system.

The REF process involves peer-review assessment by 36 subject-specific expert panels of the "reach and significance" of the research carried out by the academics submitted for assessment. The 36 panels are grouped into four "Main Panels", corresponding to very broad disciplinary areas: roughly medicine and biology, the other sciences and engineering, the social sciences, and the arts and humanities. Universities are not obliged to submit all their departments for evaluation, nor are they compelled to submit all the academic members of each department taking part in the assessment exercise. By not doing so though they forgo part of their funding, which is based on a formula increasing in the number of academics submitted. Panels assess academic departments in three areas: research output, environment and impact.

Output is assessed through the evaluation of scholarly work (such as books or journal articles), with each academic required to submit four different items.[7] Outputs are attributed to the academic at the institution in which they are employed on 31 October 2013, the REF census date, even when they were produced while the faculty member was employed by a different institution. The environment component is a written submission describing the achievements of the academic department, together with data on research grant income and PhD completions. Similarly, impact is assessed by considering written submissions of 'case studies', one for every eight academics submitted, accompanied by supporting evidence which shows how the research of the department has brought benefits *outside of academia* through, for example, influence on government policy or industry practice.

As a result of the evaluation, each academic department is assigned a numerical 'quality' profile which describes the percentage of the department's output, environment and impact rated on a 5-point "star" scale from 4* to 0*, where 4* is defined as "Quality that is world-leading in terms of originality, significance and rigour" and 0* is "Quality that falls below the standard of nationally recognised work." Each component (output, environment and impact) is assessed, and the disciplinary panel aggregates this information in a single quality profile, given by a weighted average of the three components. More precisely, let π_i^s be the proportion of department (i,k)'s submission judged to be of quality $s^\star$, with $s = 0, 1, \ldots, 4$. π_i^s is then given by

$$\pi_i^s = 0.65O_i^s + 0.2I_i^s + 0.15E_i^s \quad s = 0, 1, \ldots, 4, \tag{18}$$

[6] Detailed information of how public funds are allocated to UK universities can be found at www.hesa.ac.uk/stats-finance. The full set of REF rules, the identity of the reviewers, and the outcomes are available at www.ref.ac.uk.

[7] Hamermesh and Pfann (2012) find a negative correlation between the number of citations and the number of papers published by the members of a sample of top US economics departments. Thus the small number of items individuals are required to submit for the REF, might indicate that the UK policy maker preferences are skewed towards the "quality" of research, measured by citations, rather than the sheer publication count.

where O_i^s, I_i^s, and E_i^s are the shares of department i's research output, impact and environment which has been attributed a grade $s^\star$ by the panel. Clearly $\sum_{s=0}^{4} O_i^s = 1$, and similarly for I_i^s and E_i^s and hence for π_i^s.

The quality profiles (18) of individual departments are typically used to construct two indicators. The first is the grade point average, GPA, which is used by the media in the public discourse to rank departments in national league tables. GPA is calculated as a weighted average of the scores, with the proportion in each category as weight: department i's GPA is calculated simply as:

$$GPA_i = \sum_{s=0}^{4} \pi_i^s s. \tag{19}$$

The second indicator is a funding score formula, FS, which is used by the government as the basis to determine research funding allocations. This formula is intended to provide incentives towards high quality research, and so it gives high weight to $4^\star$ output, and no weight to output judged less than $3^\star$.[8] With the above notation, and N_i denoting the number of full–time equivalent researchers submitted by institution i, its yearly funding until the following evaluation exercise is given by

$$FS_i = \Gamma_i \left(4\pi_i^4 + \pi_i^3\right) N_i, \tag{20}$$

where Γ_i is a coefficient of proportionality which is subject specific and determined every year depending on the overall public funding for universities.

Do UK universities place greater emphasis on their GPA or funding scores? Institutions are not required to submit all their academics and may choose whom to submit for assessment, and the presence of N_i in (20), but not in (19) creates for them an important trade-off. GPA, for its immediacy and simplicity is a good measure of prestige, and is used in many league tables. If institutions only cared about the GPA, then they should submit very few researchers, in the limit only their best ones. This however would harm their funding, which is proportional to the number of staff submitted for assessment. To account for these potentially different objectives, in our analysis we consider both measures of performance.

We close this subsection by stressing the important difference between the various components of the quality indicator in generating incentives in recruitment and retention of academics. An individual department which hires a professor just before the REF census date is able to reap the rewards for that academic's research output over the previous years, even though the research was conducted at a different institution. This is not true, however, for impact, the research leading to which must have been carried out in the department (indeed,

[8] While institutions did not know the exact details of the formula, which were determined after the publication of the results, (Else 2015), they knew the principles which would underpin it.

as in the example in footnote 1, the academic's previous employer can include her work as one of its case studies). Similarly, it would be hard for a department to argue that someone with a very short tenure could have had the opportunity to affect its research "environment". Put another way, the value to the institution of an academic's outputs travels with her, but the value of her contribution to the environment and impact of a department does not. This suggests that, when hiring (or responding to outside offers) prior to the REF census date, institutions should value more a researcher with a stellar publication record, even though it has no demostrable impact outside academia, than a researcher whose less prestigious recent publications can however be shown to have influenced a certain Act of Parliament or an EU directive.

3.2 Sample Construction

To construct our dataset, we match individual characteristics of UK professors with information on the REF performance of the department of which they are members. The characteristics of the pay and age structure of UK departments are derived from data provided by the UK Higher Education Statistical Agency (HESA). This agency maintains information about all individuals employed with the academic rank of full professor by a higher education institution in the UK as of October 2013.[9] HESA matches each individual to one of the 36 REF panels, and therefore we use the composition of departments determined by this match, even if there may be instances in which an individual in a given department is submitted to a different panel for assessment (for example, an economics member of staff might have been submitted to the management panel). Information about the average pay and its standard deviation within a department is obtained from this data, which also reports details of the age structure of departments' professoriate: in particular, for each department, we know the fraction of professors whose age falls in each ten-year band.

The departmental characteristics are calculated excluding all professors paid a full-time equivalent of less than a threshold value of £50,500 in 2013.[10] To reduce the possibility of identifying individuals, the sample is limited to units with more than three full-time equivalent professors, and we exclude units which were not submitted to the REF. We also omit the only department of the London Business School, which is an extreme outlier, paying an average professorial salary more than three times higher than the national average, and which has very low reliance on government funding. Together these restrictions reduce our sample from approximately 17,000 full-time equivalent professors to 16,400. The final piece of infor-

[9] There are approximately 17,000 full-time equivalent professorial positions in the UK which are filled by approximately 19,000 individuals, some of whom work part-time.

[10] This is to account for the fact that in a subset of the institutions, there are academics who are paid a very low full-time equivalent annual pay, and are employed for a very small fraction of the time (a typical figure is 10%). Our understanding is that some institutions classify as professorial staff collaborators (such as external examiners) who would be considered external payees in other institutions, and whose research cannot be submitted to the REF evaluation. All our results are robust if we include also professors paid less than the threshold.

mation we add is the total remuneration of the universities' heads, typically known as Vice Chancellors, which is published every year in the Times Higher Education newspaper.

In our analysis we divide institutions into the four "Main Panels" defined by the REF exercise and also into five groups, according to their institutional characteristics. These are the most established universities, which include the original Russell group, and are therefore labeled "Russell" – Oxbridge, LSE, and the authors' institution among them; the defunct "1994 group", younger and smaller research-intensive universities, – York, Essex, Queen Mary among them; "New Universities" mostly created from locally controlled vocational institutions; "specialist" institutions, such as the Royal College of Arts, whose focus is exclusively on a single discipline; and the rest, mostly universities with historically less emphasis on research (such as Hull, Bradford), labeled "Others". A full listing of the groups is provided in Appendix A.

3.3 Summary Statistics

Summary data on the characteristics of the 1171 academic departments that comprise our final dataset are reported in Table 1. The average department has approximately 14 professors (full-time equivalent), with an average pay at around £74,000. The number of professorial FTE range from 3 to over 300 professors in a department, the biggest is a very large medical school. Average salary ranges from just above £50,000 to just below £130,000. The standard deviation suggests a considerable range of pay inequality across the sector.[11] Over two thirds of professors fall in the 41-60 age range. The Table also includes summary data for the total number of full-time equivalent staff, including non-professors, submitted to the REF, the pay of the university Vice Chancellor, and a dummy indicating whether a member of academic staff from the department sat on the REF peer-review panel. We use these variables as controls in our analysis.

The lower part of the table summarises the performance of departments in the REF exercise. The mean overall grade point average is 2.96 out of a theoretical maximum of 4, ranging from 1.51 to 3.78. These GPA scores translate to funding score values between close to 0 and over 900. Summary data is also provided for each component of the GPA quality score, showing that some units managed to obtain top score for their research environment and research impact. A breakdown of average scores across the full quality profile is reported in Table A1 in the Appendix.

The distribution of average departmental salary and of REF funding scores is shown in Figure 1. Departments are grouped according to the REF main panel which evaluated them (on the LHS panels), and by the type of the university they are part of (on the RHS panels). The top panels in Figure 1 illustrate a right-tail of high paying departments across panels

[11] Academic pay dispersion has grasped little attention; exception are studies of inequalities due to sex and race, (for example, Porter et al. 2008), the usefulness of citation data in evaluation exercises (Wooding et al. 2015) and alternative measures of research performance (Hearn 1999).

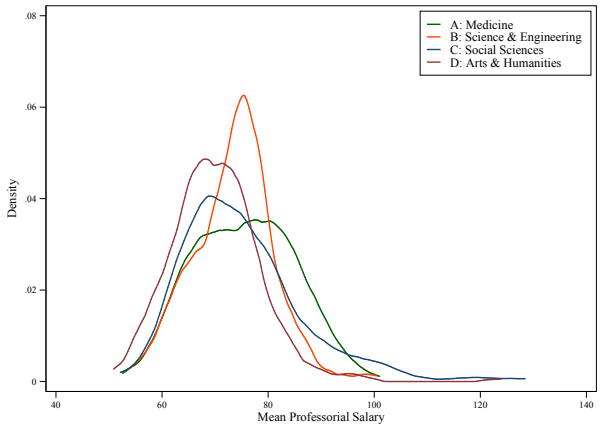
Table 1: Summary Statistics Departmental Level Pay

	mean	sd	min	max
Professorial FTE	14.17	20.31	3.00	311.00
Average Salary	73.65	9.81	50.87	128.46
Standard Deviation Salary	12.35	7.44	0.00	63.02
% Age under 40	5.05	8.68	0.00	66.67
% Age 41-50	30.98	18.34	0.00	100.00
% Age 51-60	38.38	19.32	0.00	100.00
% Age over 60	25.59	18.48	0.00	100.00
FTE Submitted to REF 2014	33.73	32.57	2.00	449.74
Vice Chancellor Pay (£000s)	299.30	62.81	143.00	623.00
Department has a REF Panel Member	0.39	0.49	0.00	1.00
Funding Score	58.82	74.16	0.36	939.96
Overall Grade Point Average	2.96	0.33	1.51	3.78
Outputs Grade Point Average	2.86	0.29	1.39	3.68
Environment Grade Point Average	3.13	0.60	0.75	4.00
Impact Grade Point Average	3.15	0.55	0.70	4.00

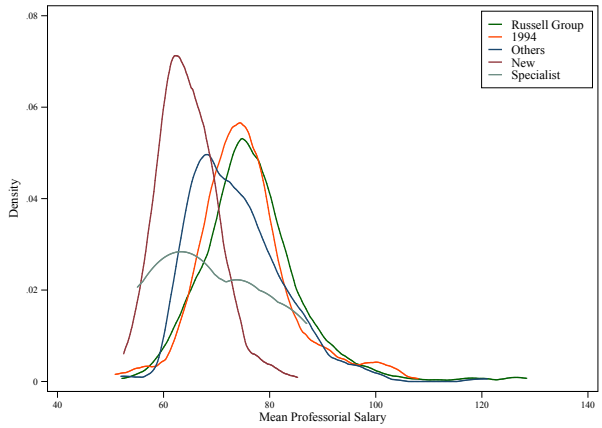
Notes: Sample size = 1171 academic departments submitted to REF 2014. Professorial FTE counts the total FTE of professors in the department. FTE submitted to REF 2014 measures the total number of FTE (including non-professorial researchers) submitted to the REF evaluation. Vice Chancellor pay is total remuneration (including salary and discretionary payments). Department has a REF Panel Member is a dummy variable indicating whether the REF 2014 main panel or sub-panel included a member of the department. Total salary bill is sum of departmental professorial pay. Definitions of funding score and other REF Grade Point Average variables are provided in the main text.

Figure 1: Distribution of Average Salary and REF Performance (Funding Score) Among Academic Departments by REF Main Panel and University Type, 2013

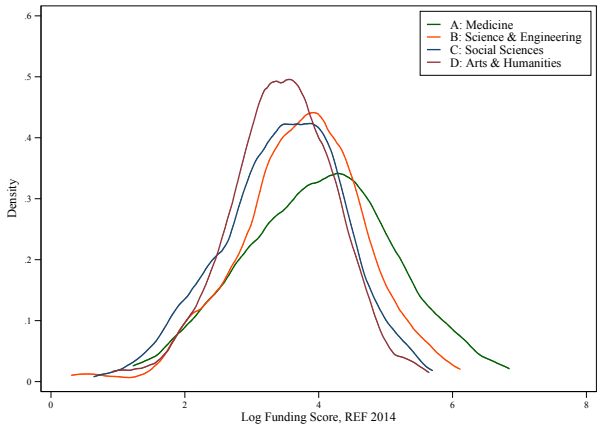
(A) Average Salary By REF Main Panel



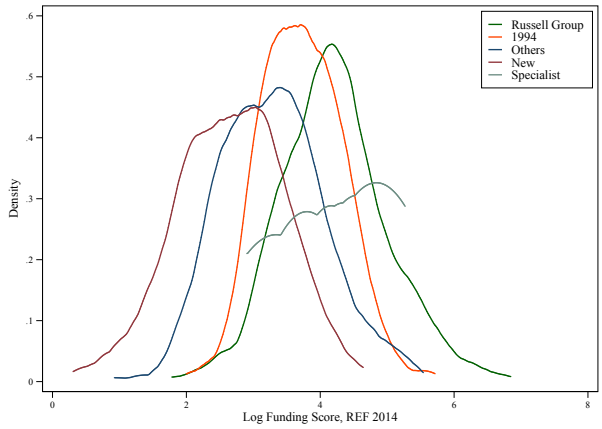
(B) Average Salary By University Type



(C) REF Funding Score By REF Main Panel



(D) REF Funding Score By University Type



Note: Sample size in all figure panels = 1171. Panels A and B illustrate distribution of average departmental salary among academic departments classified by REF Main Panel (panel A) and university type (panel B). Panels C and D illustrate distribution of REF Funding Score among academic departments classified by REF Main Panel (panel C) and university type (panel D). Kernel densiy functions, epanechnikov kernel.

Table 2: Correlation Between REF Performance Measures

	Funding Score	GPA Score	GPA Outputs	GPA Environ.	GPA Impact
Funding Score	1				
GPA Score	0.473***	1			
GPA Outputs	0.369***	0.901***	1		
GPA Environment	0.506***	0.845***	0.635***	1	
GPA Impact	0.379***	0.777***	0.477***	0.644***	1

Note: Sample size = 1171 departments submitted to REF 2014. For explanation of performance measures see main text.

and university types, with more pronounced skewness in the social sciences and specialist universities. The distributions of funding scores, shown in the bottom panels, are similar across panels, with a higher average among the medicine panel due to the typically large size of units of assessment in medical schools. Panel D shows variation in performance across university types, suggesting a hierarchical ranking with the Russell group of universities on average the strongest performers, followed by the "1994" group, the "Others" and the "New Universities".

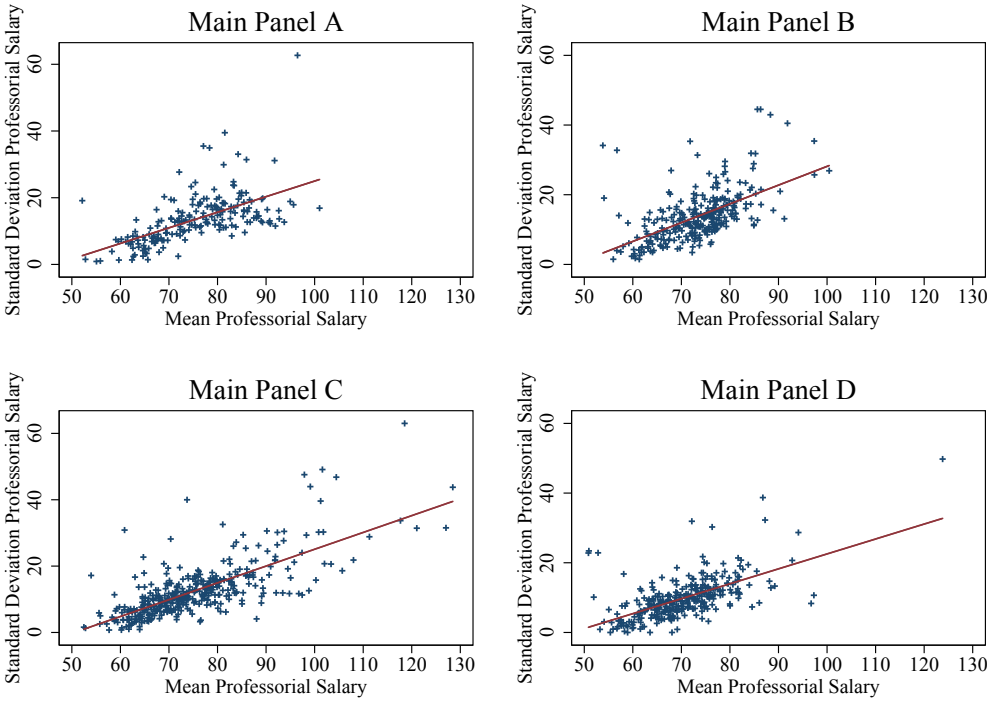
Table 2 shows the correlation matrix across the different measures of research performance we consider in our study. By construction, the GPA for output, environment and impact are highly correlated with the overall GPA score. Correlations between the funding score, the GPA Score and its components are instead much lower, indicating that these alternative measures are likely to contain different types of information.

Figure 2 illustrates a strong positive relationship between average salary and its standard deviation across all main panels and university types. This is a stylised confirmation of Corollary 1, which predicted a linear relation between the mean and the standard deviation of the salary in each academic department. This strong collinearity suggests that mean and standard deviation supply broadly similar information.

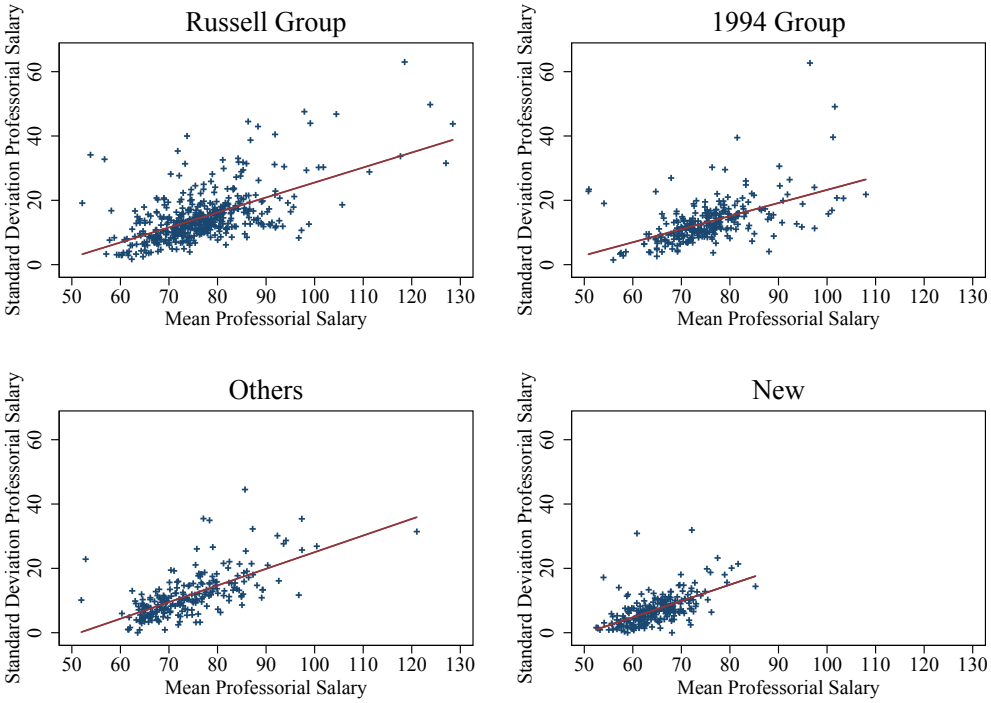
Figure 3 illustrates the unconditional correlation between our main variables of interest: average departmental pay and funding score. It shows a positive average pay - performance gradient across subject areas and university types. The slopes of the fitted regression lines are similar across main panels, but less so across university types: the fitted line has a lower gradient in the Russell group universities and is steeper in the "New Universities". These figures indicate important differences in the pay - research performance relationship, which we model in our econometric analysis.

Figure 2: Correlation Between Mean Pay and SD Pay

(A) By REF Main Panel



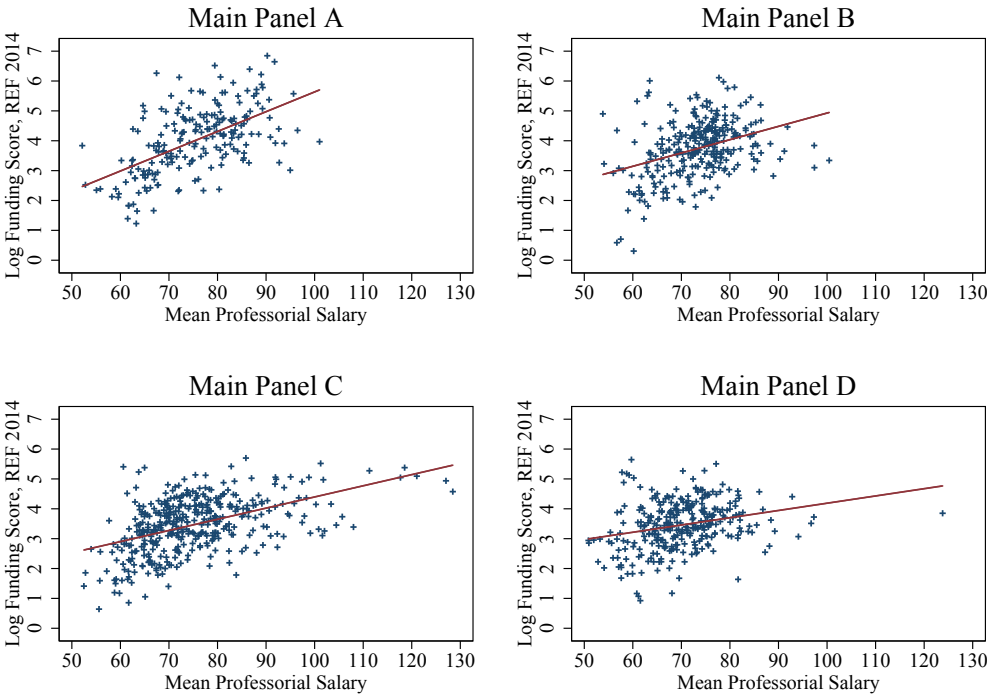
(B) By University Type



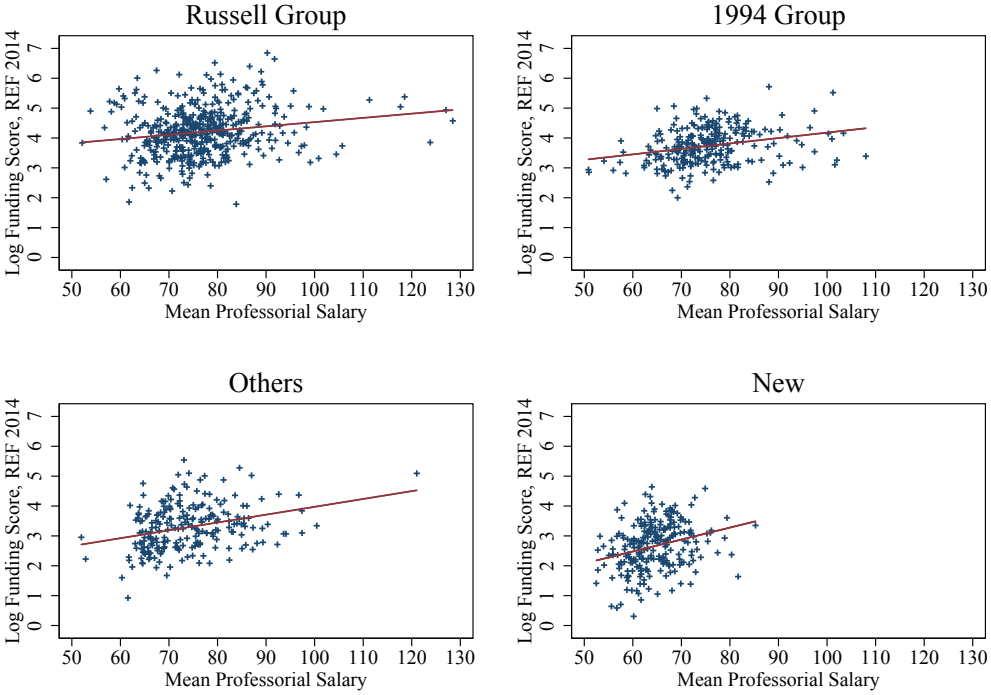
Note: Each observation is an individual academic department. Figure show scatter plots and fitted regression lines. Observations grouped by REF Main Panel (Figure panel A) and University Type (Figure panel B).

Figure 3: Correlation Between Mean Departmental Pay and REF Funding Score

(A) By REF Main Panel



(B) By University Type



Note: Each observation is an individual academic department. Figure show scatter plots and fitted regression lines. Observations grouped by REF Main Panel (Figure panel A) and University Type (Figure panel B)

4 Results

In this section we present our main results. We estimate a series of econometric models taking the following general form:

$$REFOutcome_{ik} = \beta_0 + \beta_1 AvSalary_{ik} + \beta_2 StDevSalary_{ik} + \beta_3 \mathbf{X}_{ik} + I_i + I_k + \epsilon_{ik}, \quad (21)$$

where $REFOutcome_{ik}$ is a measure of REF success for the submission made by university k to the panel assessing disciplinary field i, that is the success of department (i,k). In the main text this is the natural log of the funding score, reflecting the set-up of the theoretical model; in Table 6 and in the tables in the appendix it is the overall GPA. When we estimate specifications using GPA score as the dependent variable the results deliver qualitatively very similar patterns (see Figures A4 and A5, and Tables 3 and A3 in the Appendix).

$AvSalary_{ik}$ and $StDevSalary_{ik}$ are the average salary of the professoriate in department (i,k) and its standard deviation (both in logs), and the matrix $\mathbf{X}_{ik}$ contains additional controls including the total number of professorial full time equivalents (FTE) (in logs), the total number of FTE members of staff submitted to the REF (in logs), an indicator for whether the department had a member of staff serving on the corresponding REF panel, the total remuneration of the university's head (in logs), and the share of individuals in the professoriate who are respectively below 40 years of age, between 41 and 50 years of age, and between 51-60 years of age, with the professors older than 61 as the reference group. In some specifications we also include discipline (I_i) and institution (I_k) specific fixed effects to account respectively for subject and institution specific, unobserved common characteristics.

Table 3 presents our main results. Column 1 shows estimates from a parsimonious specification in which the only regressors are average salary and its standard deviation. The coefficients on both variables are positive and strongly statistically significant at the 1% level. In Column 2 we add a series of covariates to the model, which improve four-fold the fit of our specification. Results in Column 2 indicate that the size of the submission, measured by the *total* number of academic staff, thus including non-professors, improves the REF performance. At the same time, the additional effect of submitting professors rather than less senior staff is not significantly different from zero. Moreover, we find that having a member of staff on the corresponding REF panel has a positive and significant effect on the REF funding score. There is also a positive association between REF performance and the university head's total compensation (see Figure A6 in the Appendix for more details). With the inclusion of controls in Column 2 the magnitude of the impact of the average salary and of its standard deviation decrease, while remaining statistically significant at the 1% level.

In Columns 3 and 4 we additionally include unit of assessment and institution fixed ef-

Table 3: OLS Regression Estimates: Department Pay Characteristics and REF 2014 Performance. Dependent Variable: REF Funding Score

	(1) No controls	(2) + Controls	(3) + Unit FE	(4) + Inst. FE
Log Average Salary	1.857**	0.461**	0.857**	0.505**
	(0.256)	(0.107)	(0.103)	(0.110)
Log SD Salary	0.382**	0.065**	0.059**	0.026
	(0.050)	(0.021)	(0.020)	(0.018)
Log Professorial FTE		0.036	0.149**	0.079**
		(0.020)	(0.020)	(0.018)
Log REF FTE		1.127**	1.107**	1.055**
		(0.022)	(0.021)	(0.019)
Panel Member = 1		0.151**	0.094**	0.040*
		(0.022)	(0.020)	(0.017)
Log Vice Chancellor Pay		0.251**	0.155**	
		(0.053)	(0.048)	
% Age under 40		0.130	0.410**	0.285**
		(0.120)	(0.112)	(0.094)
% Age 41-50		-0.067	0.134*	0.139**
		(0.065)	(0.061)	(0.053)
% Age 51-60		-0.086	0.017	0.005
		(0.062)	(0.058)	(0.050)
R-squared	0.222	0.872	0.903	0.946
Observations	1171	1171	1171	1171

Notes: Sample size = 1171 academic departments submitted to REF 2014. Dependent variable is natural log of research funding score. Column 1 includes log average salary and log sd salary only. Additional columns add control variables as described in table header. Vice Chancellor pay variable omitted from Column 5 as it is collinear with institution fixed effects. Standard errors in parenthesis. * Denotes significance at 5% level, ** at 1% level.

fects.[12] This improves the fit of the models, to 90% (column 3) and 94.6% (column 4) respectively. in both specifications the average wage keeps a robust robust link with the REF performance. Column 4, instead shows that the link between research performance and wage inequality is not statistically significant when we control for unobserved institution specific heterogeneity, suggesting that this relationship is due to institutional variation.

The magnitude of the effects we have uncovered is substantial. For instance, a 10% increase in average salary is associated with a 5% increase in the REF funding; a 10% increase in the size of the total REF submission is associated to an equivalent increase in REF performance, whereas the additional effect of a 10% increase in the number of professorial FTE employed is only a modest 0.7% increase in the REF funding. Having a member of the department on the evaluation panel increases instead the funding score by almost 4%: arguably a non-negligible effect. Finally, we also find that a larger share of younger professors is positively correlated with success in the REF. In particular, the results in column 4 suggest a cut-off age of about 50: replacing an older professor with an under-50 is associated with an increase in funding of one-two percentage points in the average department.[13] We find very similar results when GPA score is used as the dependent variable (see Table A2 in the Appendix, which shows qualitatively very similar relationships between pay and performance).

Analysis of the fixed effect coefficients offers us an insight in systematic differences across fields and institutions that are not captured by our observables. Figure 4 displays plots of the university fixed effects with 95% confidence intervals, taking as baseline Oxford University. Similarly, Figure 5 plot the corresponding estimates for the subject coefficients, where we the omitted unit is represented by the Economics and Econometrics panel.

To get a handle on the magnitude of these effects a department in the discipline with the highest discipline fixed effect (sports science or communications and media studies) would receive approximately *twice*[14] the annual funding than an otherwise identical department in the discipline with the lowest estimated fixed effect (economics and econometrics).[15] Conversely, a given department in the institution with the lowest estimated institution fixed effect, would receive a funding 78% lower than an otherwise identical department (same discipline, same average pay, same age structure, same size, and so on) at Oxford University.

The lower REF success on average of the Economics and Econometrics UK departments

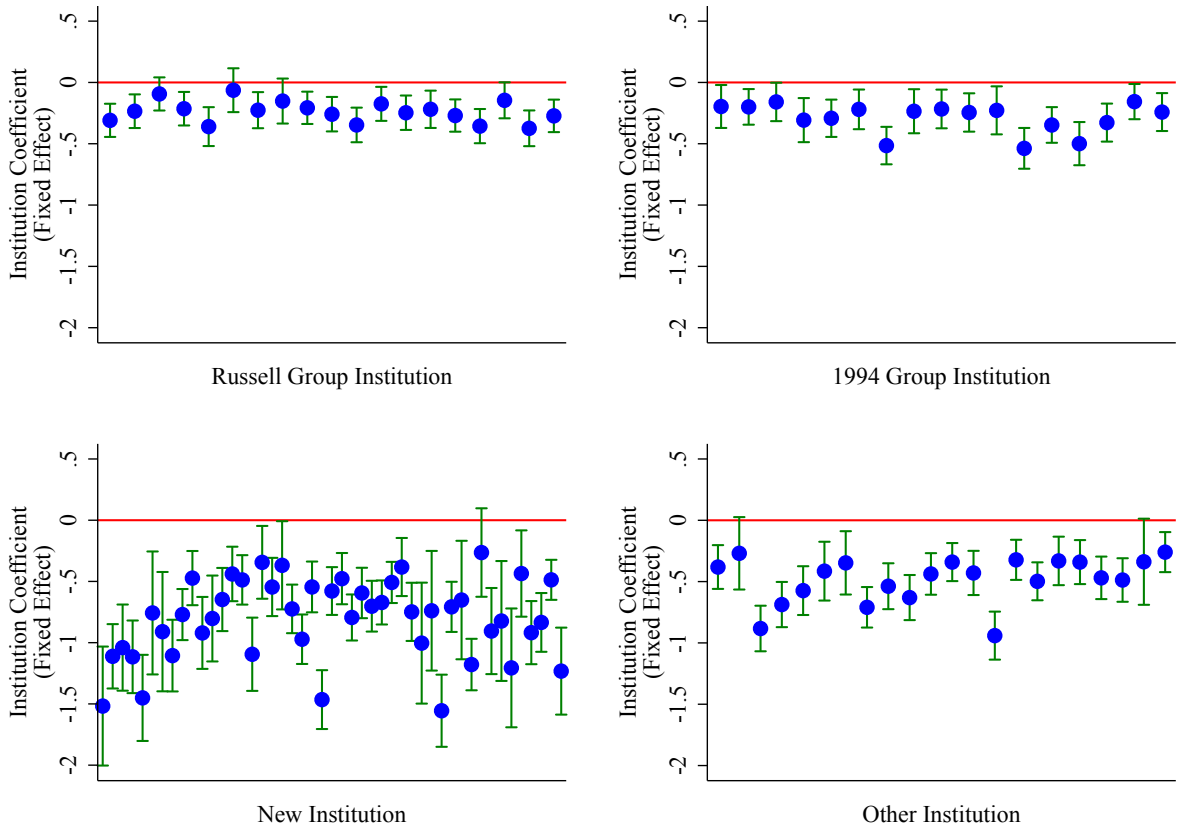
[12] When including institution fixed effects, the Vice Chancellor pay variable, cannot be separately identified, and so we remove it.

[13] The average department has 14.4 members, so replacing an over 60 one with a younger one increases the number of under 50 professors by 6.94%. Given the coefficients of 0.309 and 0.14, *ceteris paribus* this swap increases the funding score by 2.14% for a under-40 and by 0.97% for someone with age between 40 and 50

[14] In a regression of $\ln Y$ on covariates, if a dummy variable switches from 0 to 1, the percentage impact on Y is $100\,(e^c - 1)$, where c is the estimated coefficient of the dummy variable. See Halvorsen and Palmquist (1980) and Giles (1982) for details.

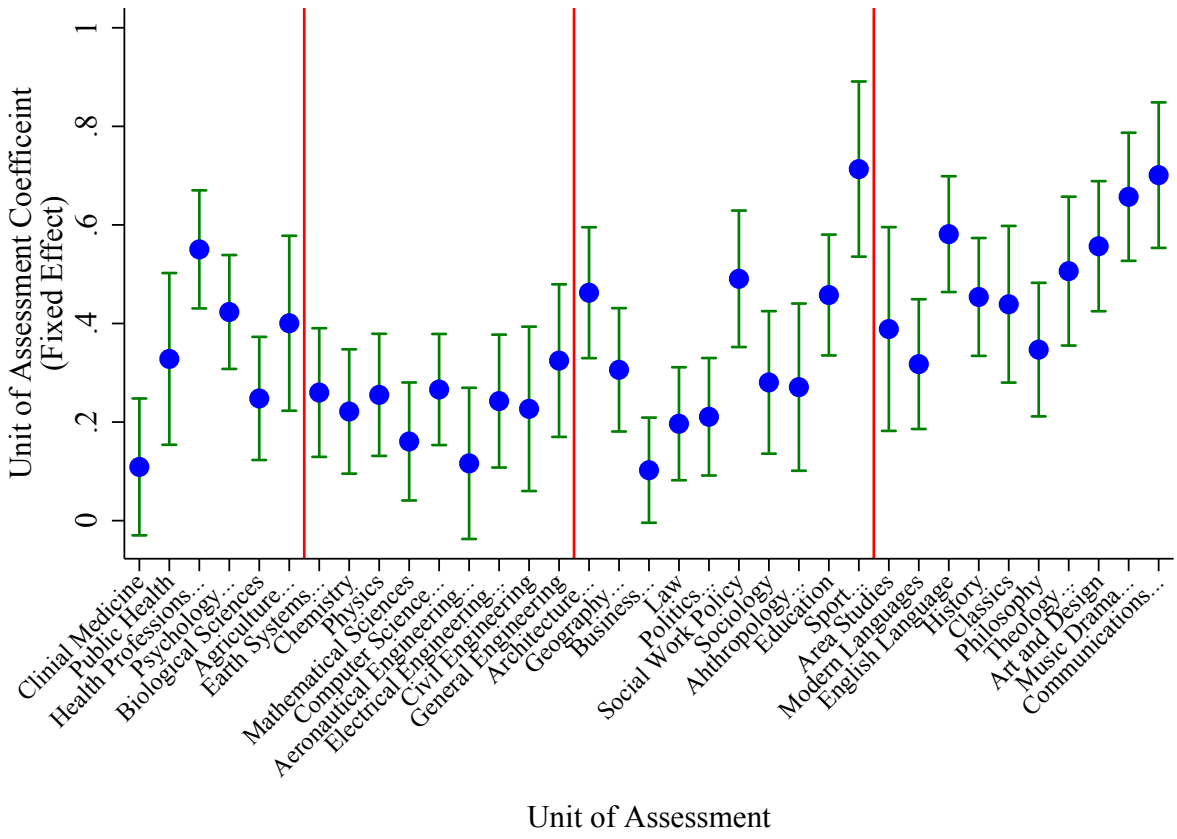
[15] Recall that the total funding accruing to an institutions following its departments' research quality is calculated according to (20). Since the value of Γ_i in these two disciplines is the same, their relative actual annual funding is equal to their relative funding score.

Figure 4: Institution Fixed Effects Coefficients from Baseline Funding Regression Table 3, Column 4. Omitted Institution: Oxford University



Note: Figure shows estimated coefficients on university fixed effects, from Table 3, Column 4. Omitted institution is Oxford University. 95% confidence intervals in whiskers.

Figure 5: Plot of Estimated Unit of Assessment Fixed Effects from Regression Model (Omitted Unit = Economics and Econometrics)



Note: Figure shows a plot of the estimated unit of assessment fixed effects from Table 3, Column 4. Omitted group is Unit of Assessment 18, Economics and Econometrics. 95% confidence intervals shown in whiskers.

could be due either to a lower "quality" of the average submission in the field, or to a more "demanding" assessment of research by this panel's members, and our data are unable to shed any light on which of these alternative explanation is more likely. Similarly for the institutions: it might be that the quality of the research submitted by staff at Oxford university is higher that in other institutions, or that panel members across the range of disciplines awarded higher scores to submissions from Oxford.

So far our analysis has highlighted the existence of a strong, positive relationship between average professorial wage and REF performance. One important question is whether the shape of this relationship varies across fields. We tackle this question two ways. First, we estimate the main model specification in Column (2) in Table 3 separately for sub-samples corresponding to the four main REF panels.[16] Then, we repeat the exercise by running a series of subject specific models for each of the 36 units of assessment.

The results by main panel are reported in Table 4. The effect of average salary is positive

[16]Given the smaller sample size, we choose not to include fixed effects in these specifications.

Table 4: OLS Regression Estimates for REF Main Panel samples

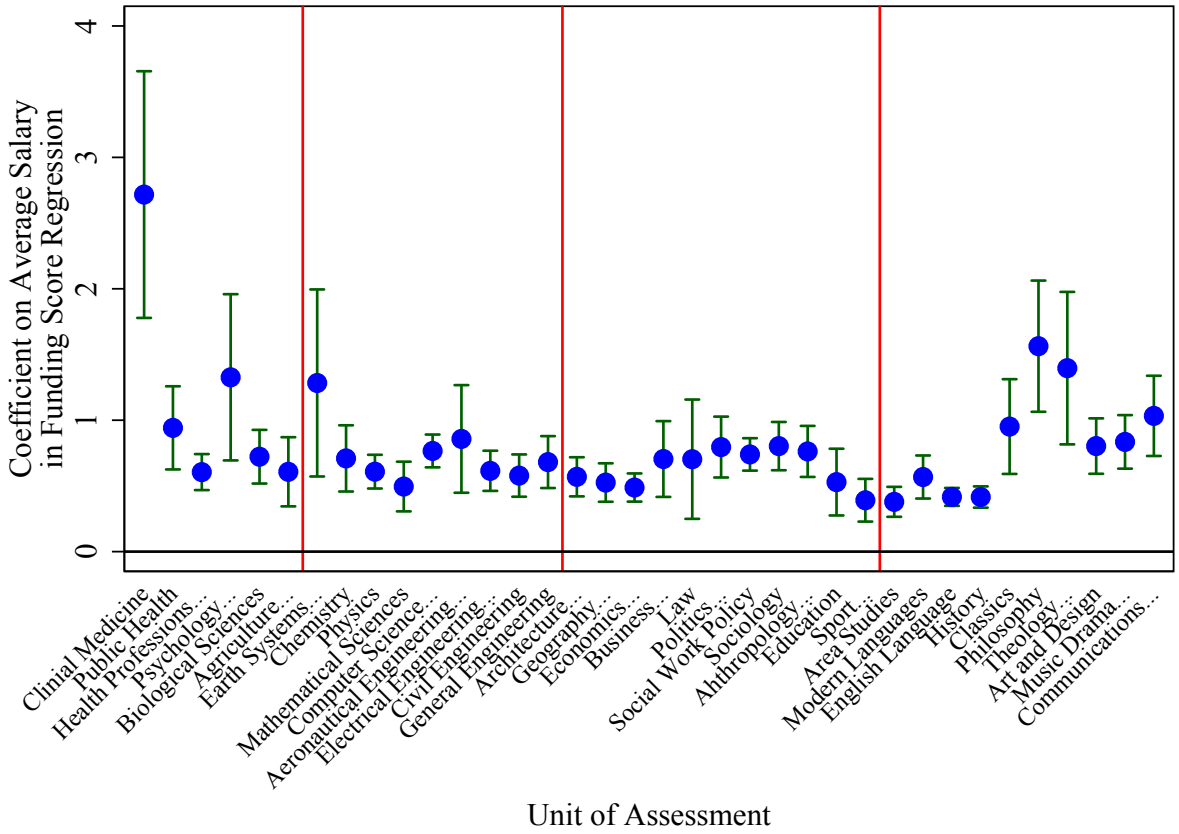
	(1) Panel A	(2) Panel B	(3) Panel C	(4) Panel D
Log Average Salary	1.263**	0.515*	0.361	0.622**
	(0.276)	(0.232)	(0.185)	(0.178)
Log SD Salary	0.029	0.142**	0.054	0.075*
	(0.049)	(0.047)	(0.041)	(0.031)
Log Professorial FTE	-0.026	0.156**	0.023	0.135**
	(0.035)	(0.044)	(0.039)	(0.039)
Log REF FTE	1.142**	1.090**	1.221**	1.037**
	(0.045)	(0.048)	(0.041)	(0.037)
Panel Member = 1	0.082	0.097*	0.174**	0.119**
	(0.050)	(0.043)	(0.040)	(0.036)
Log Vice Chancellor Pay	0.225	0.152	0.196*	0.199*
	(0.127)	(0.105)	(0.095)	(0.084)
% Age under 40	0.448	0.577*	0.181	0.146
	(0.359)	(0.274)	(0.196)	(0.182)
% Age 41-50	-0.054	0.029	0.036	0.123
	(0.171)	(0.142)	(0.114)	(0.097)
% Age 51-60	-0.065	-0.101	-0.015	0.016
	(0.149)	(0.145)	(0.113)	(0.093)
R-squared	0.926	0.897	0.850	0.878
Observations	199	284	390	298

Note: Dependent variable is natural log of research funding score. OLS regression estimated on four mutually exclusive samples of academic departments categorised by REF Main Panel. * Denotes significance at 5% level, ** at 1% level.

and statistically significant except in Main Panel C, the social science disciplines. It is considerably larger in the main panel A (medicine and biology), than in other subject areas: all the coefficient are pairwise statistically significantly different, except the difference between Main Panels B and C, whose equality is rejected with p-value 0.0753. Moreover, the independent role of the standard deviation in wages in the overall sample appears to be driven by the disciplines in main panels B and D, science and engineering and arts and humanities. Furthermore, the effect of having a panel member uncovered in column (2) of Table 3 is not statistically significant for medicine and biology, and it is quantitatively more important for the Social Sciences than for science and engineering and arts and humanities. Using the GPA score as the measure of research performance, yields qualitatively very similar results – see Table A3 in the Appendix.

The difference among main panels conceals some heterogeneity among the disciplines that make up the four groups. Figure 6 plots the coefficient estimates for the average professorial wage, with 95% confidence intervals shown in error bards, from the same model

Figure 6: Coefficient Plots From Unit of Assessment Sample OLS Regressions



Note: Figure shows regression coefficient values and 95% confidence intervals (shown by vertical whisker bars) for coeffiecient estimates on average pay variable in OLS regression of funding score against average pay and controls (control variables as in Table 3, Column 3). Separate regressions estimated for each unit of assessment sample.

specification as in column (2) of Table 4, run separately by subject. Interestingly, our findings indicate that the positive and significant relationship between average professorial wage and REF performance holds for *all* disciplines. At the same time, some important differences in the magnitude of the effects emerge, even *within* each main panel. In particular, the professorial pay-performance link appear to be particularly strong in Clinical Medicine, Philosophy, Theology, Psychology and Earth Systems. It is instead much weaker in Sports Related Studies, Area Studies, English Language and Literature, and History. We see no clear differences among these subjects which would cause the pay-performance relationship to differ according to this pattern.

As suggested by Panel (D) of Figure 1, the average REF performance differs across University types, with Russell Group universities ahead of the other groups. To what extent is this result affected by the shape of the pay–performance relationship? To answer this question, in Table 5 we run the same specification as in Column (2) of Table 3 on four different subgroups of institutions: the "Russell group", the "1994 group", the "New Universities"

Table 5: OLS Regression Estimates for University Type samples

	(1) Russell	(2) 1994	(3) Others	(4) New
Log Average Salary	0.064	1.0135**	1.749**	2.107**
	(0.111)	(0.192)	(0.516)	(0.516)
Log SD Salary	0.002	0.041	-0.004	-0.088
	(0.030)	(0.048)	(0.049)	(0.062)
Log Professorial FTE	0.007	0.037	0.039	0.037
	(0.022)	(0.041)	(0.055)	(0.078)
Log REF FTE	1.107**	1.047**	1.162**	1.245**
	(0.024)	(0.049)	(0.056)	(0.070)
Panel Member = 1	0.050*	0.097*	0.115*	0.141
	(0.024)	(0.039)	(0.058)	(0.106)
Log Vice Chancellor Pay	0.250**	-0.026	0.105	-0.052
	(0.061)	(0.110)	(0.161)	(0.173)
% Age under 40	-0.123	0.207	0.342	0.160
	(0.148)	(0.215)	(0.331)	(0.354)
% Age 41-50	-0.169	0.053	-0.083	-0.035
	(0.085)	(0.136)	(0.148)	(0.185)
% Age 51-60	0.016	0.144	-0.165	-0.267
	(0.089)	(0.131)	(0.139)	(0.173)
R-squared	0.942	0.793	0.811	0.707
Observations	458	260	225	220

Note: Dependent variable is natural log of research funding score. OLS regression estimated on four mutually exclusive samples of academic departments categorised by University Type. Sample of 'specialist' universities not included as it contains only 8 observations. See Appendix A for details of classifications of universities. * Denotes significance at 5% level, ** at 1% level.

and the "Others" (we omit specialist universities as they represent only a total of eight departments).

We find that there is no statistically significant relationship between average professorial wage and REF performance in the "Russell group" of institutions. We find instead the latter to be positive and strongly significant for all other groups. Furthermore, the slope of the relationship appears to be steeper when we move in turn from the "1994 group" to "Others" and to the "New Universities", indicating that this link is stronger among those institutions with a less well-established research reputation.[17] The same patterns continue to hold also when we replace funding score with the GPA score as the dependent variable. These results are available in Appendix Table A3.

As we have pointed out in Section 3.1, the overall research profile of a unit is obtained as a weighted average of the profiles in each of the three components of outputs, environment and

[17] t-test strongly reject equality between any two pairs of the Average Salary coefficients of Table 5.

impact. Importantly, while output can easily be transferred across departments by hiring the faculty member who has produced it, this is not true for the case of environment and impact. Thus we expect that if universities use higher salaries to improve their REF performance, the effect of wages should be stronger on output than on the other components of overall GPA. To assess this implication, in Table 6 we present the results of four empirical models, where the dependent variables are overall REF GPA and its components, using the specification from Column 4 of Table 3 which, as we pool all the data in these models, includes unit and institution fixed effects.

In Column (1) we show that the basic patterns uncovered while using the funding score continue to hold when we use overall GPA as the dependent variable. From the specifications in Columns (2) – (4) we can see that the overall positive association between average salary and REF performance is driven primarily by the relationship between salary and output GPA and, to a lesser extent, by the relationship between salary and environment GPA. There is instead no evidence for a positive relationship between average salary and impact GPA, which is consistent with the idea that institutions are not able to "buy-in" impact success.

The results also indicate some interesting differences in the role played by some of our controls. In particular, we find that having a member of staff sitting on the panel has a positive and statistically significant effect on the GPA obtained for research environment and impact. There is no significant effect instead on the GPA obtained for output. These results are consistent with the idea that panel membership might be more important for the elements of the REF evaluation that are arguably more subjective, rather than for those which are based on more objective criteria such as the reputation of the outlet where a scholarly work has been published, its impact factor or the number of citations received.

Finally, results in these regressions also indicate a strong relationship between the age profile of the academic department and performance in outputs GPA, but not for environment and impact GPA (though the coefficient on the proportion of under 40 professors is positive and weakly significant in the model for outputs GPA). Departments with younger researchers typically produce stronger outputs, in many subjects young professors are the most productive in the quality of their research.

Table 6: OLS Regression Estimates: Department Pay Characteristics and REF Component GPA Scores

	(1) Overall GPA	(2) Outputs GPA	(3) Environment GPA	(4) Impact GPA
Log Average Salary	0.407**	0.494**	0.376*	0.133
	(0.086)	(0.083)	(0.158)	(0.198)
Log SD Salary	0.011	-0.011	0.076**	0.038
	(0.014)	(0.014)	(0.026)	(0.033)
Log Professorial FTE	0.051**	0.024	0.090**	0.103**
	(0.014)	(0.014)	(0.026)	(0.033)
Log REF FTE	0.065**	-0.001	0.306**	0.101**
	(0.015)	(0.014)	(0.027)	(0.034)
Panel Member = 1	0.031*	0.012	0.064**	0.065*
	(0.013)	(0.013)	(0.024)	(0.031)
% Age under 40	0.262**	0.329**	0.182	0.115
	(0.074)	(0.071)	(0.135)	(0.170)
% Age 41-50	0.118**	0.179**	0.024	-0.013
	(0.042)	(0.040)	(0.076)	(0.096)
% Age 51-60	0.013	0.044	-0.018	-0.062
	(0.039)	(0.038)	(0.072)	(0.090)
R-squared	0.731	0.677	0.721	0.475
Observations	1171	1171	1171	1171

Note: Sample size = 1171 departments submitted to REF 2014. Dependent variable is Column 2 the grade-point-average score for the department output component, Column 3 environment component and Column 4 impact component. Models include institution and unit of assesment fixed effects. * Denotes significance at 5% level, ** at 1% level.

5 Conclusion

This paper studies the relationship between pay and research performance in UK universities. The UK setting is interesting because universities can freely compete on the salaries they offer to senior academics, and have an objective measure of research performance, which universities have strong incentives to target. To frame our analysis, we have proposed a simple theoretical model in which academics are inputs into the production of research, and universities seek to maximise the weighted average of the research quality evaluations. The model predicts that research performance is increasing in the average level of salary in a department and in its standard deviation.

Our empirical results support the model's prediction that spending more on recruitment is associated with better research outcomes. In other words, the incentives put in place by policy makers do work in the expected direction. Across all disciplines we see a positive relationship between the average salary paid by academic departments and REF performance, measured either by funding score or GPA. This is true both in subjects areas which anedoctal evidence suggests to be more competitive, such as business and management, economics, engineering, and also in subjects where there appears to be far less cross-institution movement of staff and possibly less competition, (among them, arts and humanities).

That universities respond to the REF rules by pursuing academics who will contribute to the measured research performance is suggested also by our analysis of the three components that make up the aggregate research score of the university. The positive salary-performance gradient is due mainly to the relationship between salary and scholarly publications: when an academic is head-hunted, this is the component of her recent record that can be transferred from one institution to another, whereas any "impact" that her research may have had contributes to the score of her previous institution.

Those whose task is to design the details of the evaluation process should also consider our consistent finding that, after controlling for other potential covariates, panel membership is associated with stronger performance, and this result in turn is driven by the effect of panel membership on the arguably more subjective "environment" and "impact" components of the evaluation.

As a final caveat, we should stress that our results should be interpreted with care. The data is a rich source of information on the characteristics of academic departments and their performance in the REF exercise, but our econometric analysis allows us to model only associations between characteristics and performance. We do not have natural experiments in our data, or other sources of identification which could be used to establish a clear causal link.

While individual UK academics will no doubt find these results of much interest, they warrant wider attention, as they contain important lessons on the effects of liberalising pay

and introducing competition for resources in a largely publicly funded system. These lessons may be useful for other European countries, which are in the process of creating a lively quasi-market system in the university sector.

References

Abowd, J. M., F. Kramarz, and D. N. Margolis (1999). High wage workers and high wage firms. *Econometrica 67*, 251–333.

Altbach, P. G., L. Reisberg, M. Yudkevich, G. Androushchak, and I. F. Pacheco (2012). *Paying the Professoriate: A Global Comparison of Compensation and Contracts*. New York: Routledge.

Bosquet, C. and P.-P. Combes (2013, March). Do large departments make academics more productive? Agglomeration and peer effects in research. CEPR Working Paper 9041, London, UK.

Bratsberg, B., J. Ragan, and J. Warren (2010). Does raiding explain the negative returns to faculty seniority? *Economic Inquiry 48*, 704–721.

Butler, L. and I. McAllister (2009). Metrics or peer review? evaluating the 2001 uk research assessment exercise in political science. *Political Studies Review 7*, 3–17.

Checchi, D., G. De Fraja, and S. Verzillo (2014). Publish or perish? An analysis of the academic job market in Italy, 1991-2012. CEPR Discussion Paper 10084, London, UK.

Clerides, S., P. Pashardes, and A. Polycarpou (2011). Peer review vs metric-based assessment: Testing for bias in the RAE ratings of UK economics departments. *Economica 78*, 565–583.

De Fraja, G. (2016). A theoretical analysis of public funding for research. *Rand Journal of Economics*. forthcoming.

De Fraja, G. and P. Valbonesi (2012). The design of the university system. *Journal of Public Economics 96*, 317–330.

Diamond, A. M. (1986). What is a citation worth? *Journal of Human Resources 21*, 200–215.

Edmans, A. and X. Gabaix (2015). Executive compensation: A modern primer. Technical Report 21131, NBER Working Paper Series.

Else, H. (2015). Research funding formula tweaked after REF 2014 results. *Times Higher Education 20 February*.

Giles, D. E. (1982). The interpretation of dummy variables in semilogarithmic equations: Unbiased estimation. *Economics Letters 10*, 77–79.

Grund, C. and N. Westergaard-Nielsen (2008). The Dispersion of Employees' Wage Increases and Firm Performance. *ILR Review 61*, 485–501.

Halvorsen, R. and R. Palmquist (1980). The interpretation of dummy variables in semilogarithmic equations. *The American Economic Review 70*, 474–475.

Hamermesh, D. and G. A. Pfann (2012). Reputation and earnings: The roles of quality and quantity in academe. *Economic Inquiry 50*, 1–16.

Hamermesh, D. S., G. E. Johnson, and B. A. Weisbrod (1982). Scholarship, citations and salaries: Economic rewards in economics. *Southern Economic Journal 49*, 472–481.

Hearn, J. C. (1999). Pay and Performance in the University: An Examination of Faculty Salaries. *The Review of Higher Education 22*, 391–410.

Hildreth, A. K. G. and A. J. Oswald (1997). Rent-sharing and wages: Evidence from company and establishment panels. *Journal of Labor Economics 15*, 318–337.

Johnes, J., J. Taylor, and B. Francis (1993). The research performance of UK universities: a statistical analysis of the results of the 1989 research selectivity exercise. *Journal of the Royal Statistical Society, Series A 156*, 271–286.

Lavy, V. (2009). Performance Pay and Teachers' Effort, Productivity, and Grading Ethics. *American Economic Review 99*, 1979–2011.

Lazear, E. (2000). Performance pay and productivity. *American Economic Review 90*, 1346–1361.

Milgrom, P. R. and J. Roberts (1992). *Economics, Organization and Management*. New York: Prentice Hall.

Moore, W. J., R. J. Newman, and G. K. Turnbull (1998). Do academic salaries decline with seniority? *Journal of Labor Economics 16*, 352–366.

Mueller, H. M., P. P. Ouimet, and E. Simintzi (2015). Wage inequality and firm growth. Technical Report 20876, NBER Working Paper Series.

Nickell, S., J. Vainiomaki, and S. Wadhwani (1994). Wages and product market power. *Economica 61*, 457–473.

Nickell, S. and S. Wadhwani (1990). Insider forces and wage determination. *The Economic Journal 100*, 496–509.

Porter, S. R., R. K. Toutkoushian, and J. V. Moore III (2008). Pay Inequities for Recently Hired Faculty, 1988-2004. *The Review of Higher Education 31*, 465–487.

Sharp, S. and S. Coleman (2005). Ratings in the research assessment exercise 2001 – the patterns of university status and panel membership. *Higher Education Quarterly 59*, 153–171.

Taylor, J. (1995). A statistical analysis of the 1992 research assessment exercise. *Journal of the Royal Statistical Society, Series A 158*, 241–261.

Wooding, S., T. N. Van Leeuwen, S. Parks, S. Kapur, and J. Grant (2015). Uk doubles its "world-leading" research in life sciences and medicine in six years: Testing the claim? *PLoS ONE 10*, 1–10.

Zinovyeva, N. and M. Bagues (2010). Does gender matter for academic promotion? Evidence from a randomized natural experiment. FEDEA Documento de Trabajo 2010-15, Madrid.

Zinovyeva, N. and M. Bagues (2015). The role of connections in academic promotions. *American Economic Journal: Applied Economics 7*, 264–292.

Appendix

Table A1: Summary Statistics Departmental Level REF Performance by Component

	mean	sd	min	max
Overall % 4*	26.59	14.70	0.00	79.00
Overall % 3*	47.28	11.81	3.00	83.00
Overall % 2*	22.21	12.12	0.00	75.00
Overall % 1*	3.41	5.50	0.00	55.00
Overall % 0*	0.51	1.35	0.00	11.00
Outputs % 4*	21.53	11.23	0.00	69.70
Outputs % 3*	48.34	12.21	0.00	100.00
Outputs % 2*	25.67	11.96	0.00	72.90
Outputs % 1*	3.93	5.77	0.00	60.60
Outputs % 0*	0.52	1.18	0.00	10.30
Environment % 4*	33.58	33.46	0.00	100.00
Environment % 3*	47.51	27.61	0.00	100.00
Environment % 2*	16.80	23.67	0.00	100.00
Environment % 1*	2.07	9.32	0.00	90.00
Environment % 0*	0.04	0.84	0.00	25.00
Impact % 4*	37.74	28.08	0.00	100.00
Impact % 3*	43.67	22.96	0.00	100.00
Impact % 2*	15.14	19.55	0.00	100.00
Impact % 1*	2.57	8.84	0.00	90.00
Impact % 0*	0.87	5.22	0.00	40.00

Note: Sample size = 1171 departments submitted to REF 2014. For explanation of REF performance measures see main text.

Table A2: OLS Regression Estimates: Department Pay Characteristics and REF 2014 Performance. Dependent Variable: Grade Point Average Score

	(1) No controls	(2) + Controls	(3) + Unit FE	(4) + Inst. FE
Log Average Salary	0.681**	0.385**	0.725**	0.407**
	(0.091)	(0.083)	(0.082)	(0.086)
Log SD Salary	0.113**	0.057**	0.038*	0.011
	(0.018)	(0.016)	(0.016)	(0.014)
Log Professorial FTE		0.027	0.109**	0.051**
		(0.015)	(0.016)	(0.014)
Log REF FTE		0.130**	0.108**	0.065**
		(0.017)	(0.017)	(0.015)
Panel Member = 1		0.114**	0.076**	0.031*
		(0.017)	(0.016)	(0.013)
Log Vice Chancellor Pay		0.198**	0.133**	
		(0.041)	(0.038)	
% Age under 40		0.179	0.349**	0.262**
		(0.093)	(0.089)	(0.074)
% Age 41-50		0.014	0.114*	0.118**
		(0.050)	(0.049)	(0.042)
% Age 51-60		-0.027	0.024	0.013
		(0.049)	(0.046)	(0.039)
R-squared	0.197	0.369	0.499	0.731
Observations	1171	1171	1171	1171

Notes: Sample size = 1171 departments submitted to REF 2014. Dependent variable is GPA score. Column 1 includes log average salary and log sd salary only. Additional columns add control variables as described in table header. Vice Chancellor pay variable omitted from Column 5 as it is collinear with fixed effects. Standard errors in parenthesis. * Denotes significance at 5% level, ** at 1% level.

Table A3: OLS Regression Estimates by Main Panel (Grade Point Average Score)

	(1) Panel A	(2) Panel B	(3) Panel C	(4) Panel D
Log Average Salary	0.853**	0.461**	0.402**	0.582**
	(0.217)	(0.176)	(0.142)	(0.159)
Log SD Salary	0.035	0.096**	0.024	0.057*
	(0.038)	(0.035)	(0.031)	(0.027)
Log Professorial FTE	-0.022	0.123**	0.013	0.115**
	(0.027)	(0.033)	(0.030)	(0.035)
Log REF FTE	0.120**	0.092*	0.206**	0.052
	(0.035)	(0.036)	(0.032)	(0.033)
Panel Member = 1	0.071	0.083*	0.129**	0.099**
	(0.039)	(0.032)	(0.030)	(0.032)
Log Vice Chancellor Pay	0.199*	0.091	0.175*	0.180*
	(0.100)	(0.080)	(0.073)	(0.075)
% Age under 40	0.296	0.570**	0.204	0.142
	(0.282)	(0.208)	(0.151)	(0.163)
% Age 41-50	0.010	0.014	0.091	0.092
	(0.135)	(0.108)	(0.087)	(0.086)
% Age 51-60	-0.023	-0.085	0.038	0.008
	(0.117)	(0.110)	(0.087)	(0.083)
R-squared	0.438	0.515	0.402	0.345
Observations	199	284	390	298

Note: Sample size = 1171 departments submitted to REF 2014. Dependent variable is GPA score. OLS regression estimated on four mutually exclusive samples of academic departments categorised by REF Main Panel.
* Denotes significance at 5% level, ** at 1% level.

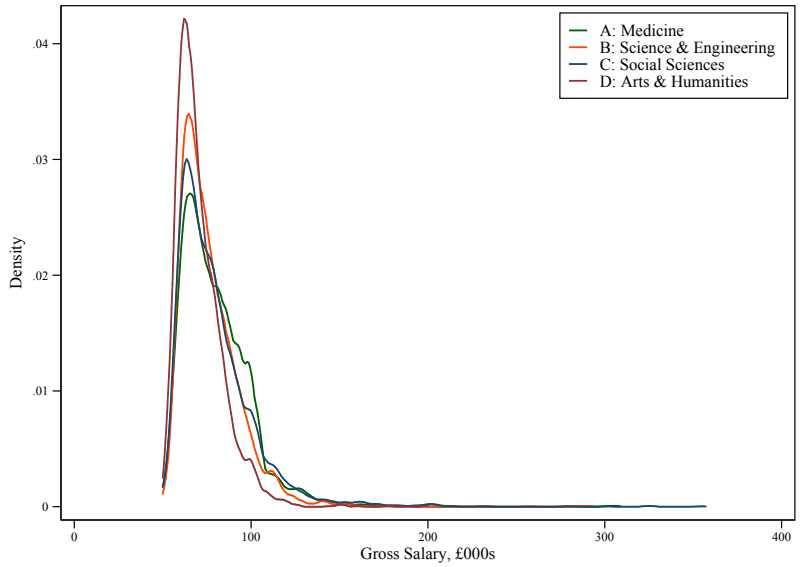
Table A4: OLS Regression Estimates by University Type (Grade Point Average Score)

	(1) Russell	(2) 1994	(3) Others	(4) New
Log Average Salary	0.024	1.204**	1.456**	1.572**
	(0.099)	(0.246)	(0.206)	(0.318)
Log SD Salary	0.017	0.040	0.017	-0.073
	(0.025)	(0.036)	(0.034)	(0.038)
Log Professorial FTE	0.023	0.029	0.033	0.031
	(0.015)	(0.030)	(0.038)	(0.046)
Log REF FTE	0.070**	0.040	0.133**	0.158**
	(0.022)	(0.036)	(0.039)	(0.043)
Panel Member = 1	0.024	0.076**	0.100*	0.120
	(0.022)	(0.029)	(0.040)	(0.065)
Log Vice Chancellor Pay	0.215**	-0.019	0.079	-0.038
	(0.052)	(0.082)	(0.112)	(0.106)
% Age under 40	0.055	0.195	0.109	0.253
	(0.126)	(0.159)	(0.230)	(0.216)
% Age 41-50	0.009	0.122	-0.090	0.044
	(0.073)	(0.101)	(0.103)	(0.113)
% Age 51-60	0.042	0.171	-0.129	-0.092
	(0.077)	(0.097)	(0.097)	(0.106)
R-squared	0.180	0.097	0.215	0.256
Observations	458	260	225	220

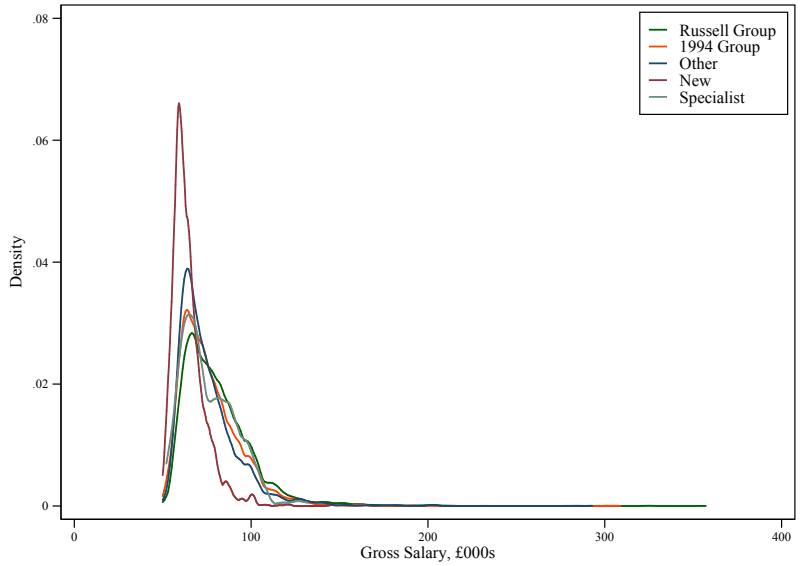
Note: Sample size = 1171 departments submitted to REF 2014. OLS regression estimated on four mutually exclusive samples of academic departments categorised by University Type. Sample of 'specialist' universities not shown as it contains only 8 observations. * Denotes significance at 5% level, ** at 1% level.

Figure A1: Distribution of Pay of UK Professors by REF Main Panel and University Type, 2013

(A) By REF Main Panel



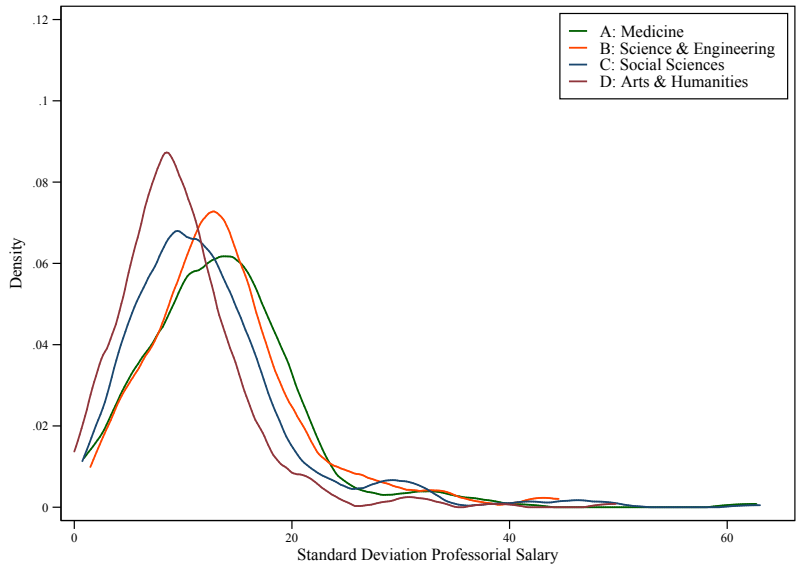
(B) By University Type



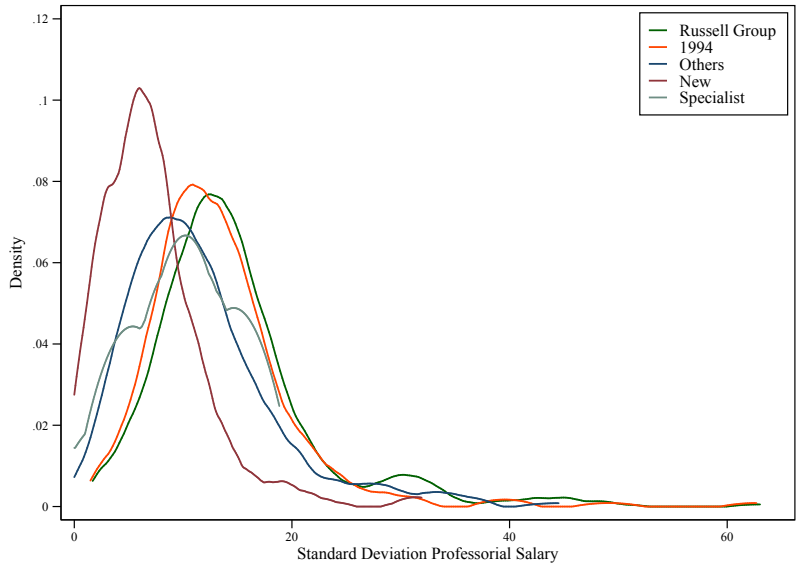
Note: Kernel density plots illustrates pay distribution for all UK Professors. Professors assigned to REF Main Panel by their affiliation to submitting unit within their University. Kernel density functions, epanechnikov kernel.

Figure A2: Distribution of Standard Deviation in Salary Among Academic Departments by REF Main Panel and University Type

(A) SD Salary By REF Main Panel



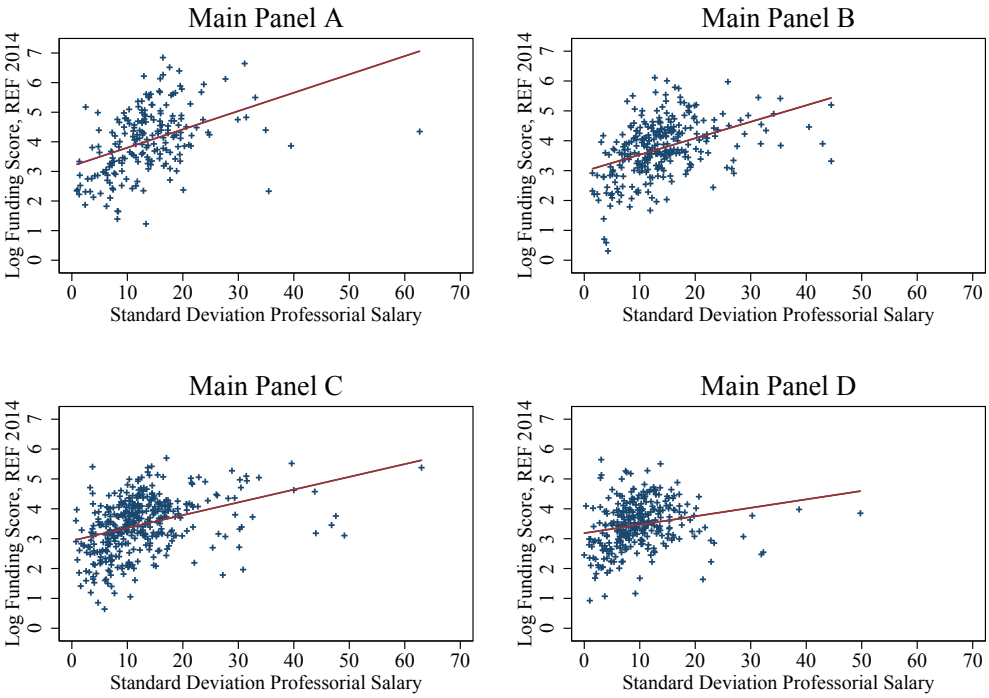
(B) SD Salary By University Type



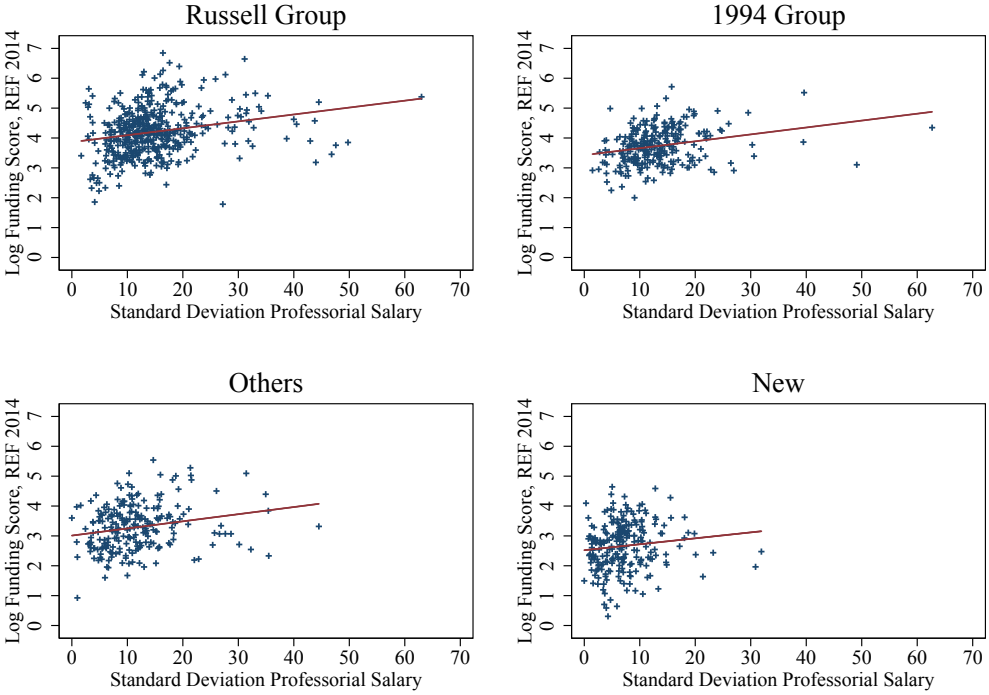
Note: Kernel density plots illustrate the distribution of the standard deviation of salary at the academic department level, sample size 1171 academic departments. Panel A groups departments by REF Main Panel, Panel B groups departments by University Type. Kernel density functions, epanechnikov kernel.

Figure A3: Correlation Between Standard Deviation of Departmental Pay and Funding Score

(A) By REF Main Panel



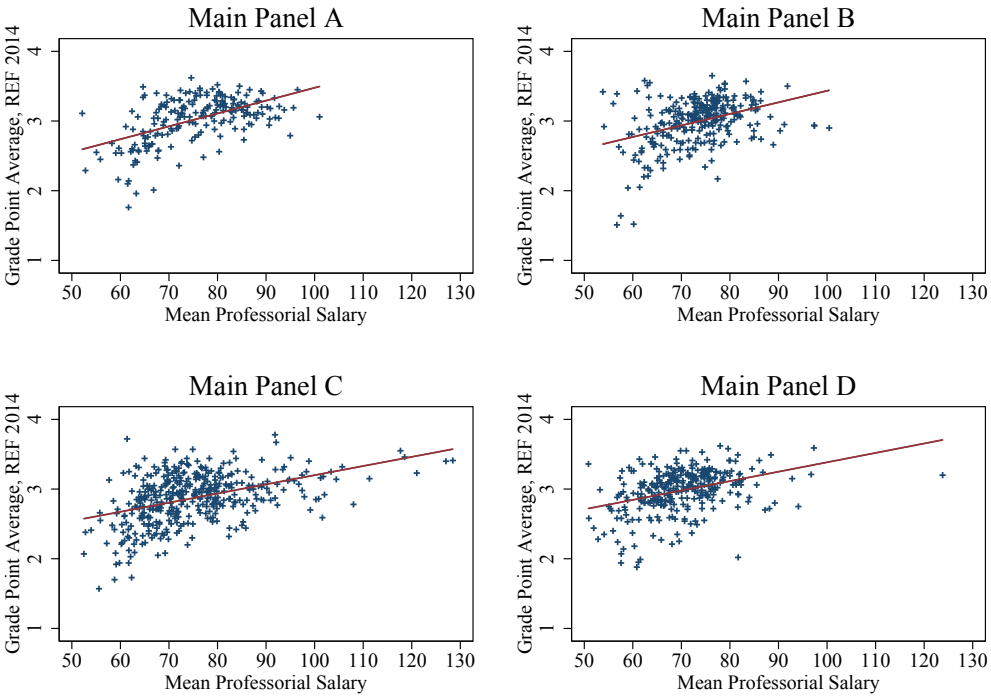
(B) By University Type



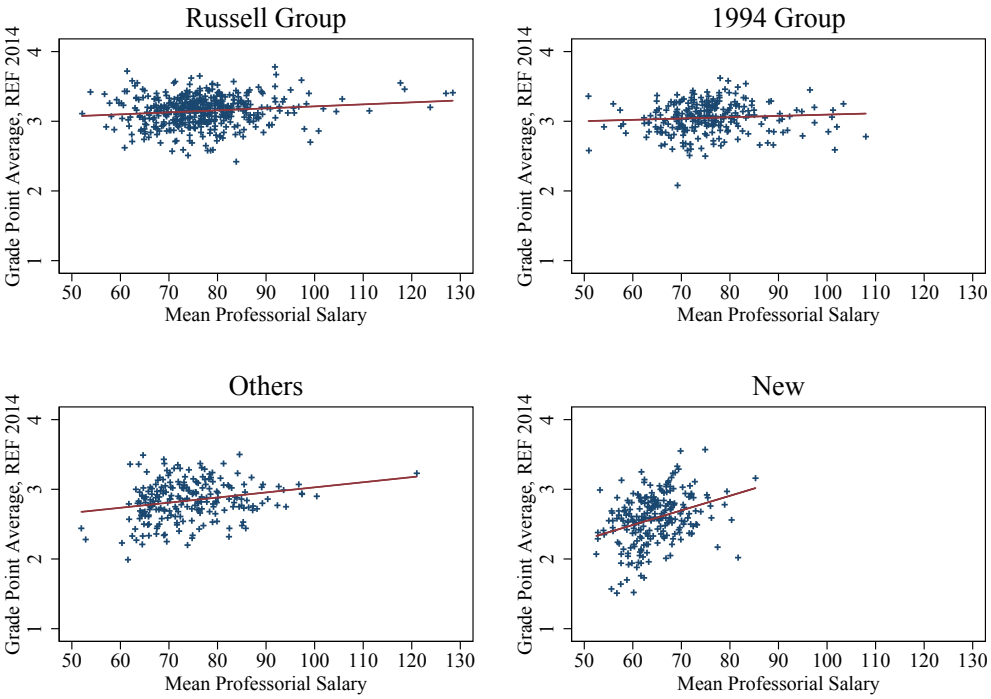
Note: Each observation represents an individual academic department. Figure show scatter plots and fitted regression lines. Observations grouped by REF Main Panel (figure panel A) and University Type (figure panel B)

Figure A4: Correlation Between Mean Pay and GPA Score

(A) By REF Main Panel



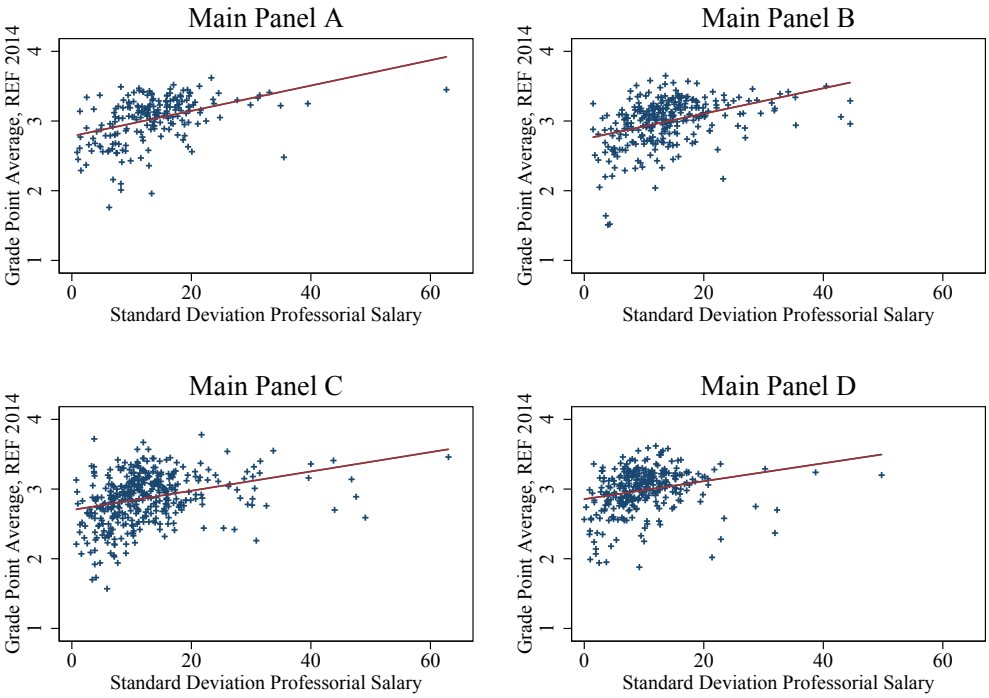
(B) By University Type



Note: Each observation represents an individual academic department. Figure show scatter plots and fitted regression lines. Observations grouped by REF Main Panel (figure panel A) and University Type (figure panel B).

Figure A5: Correlation Between SD Pay and GPA Score

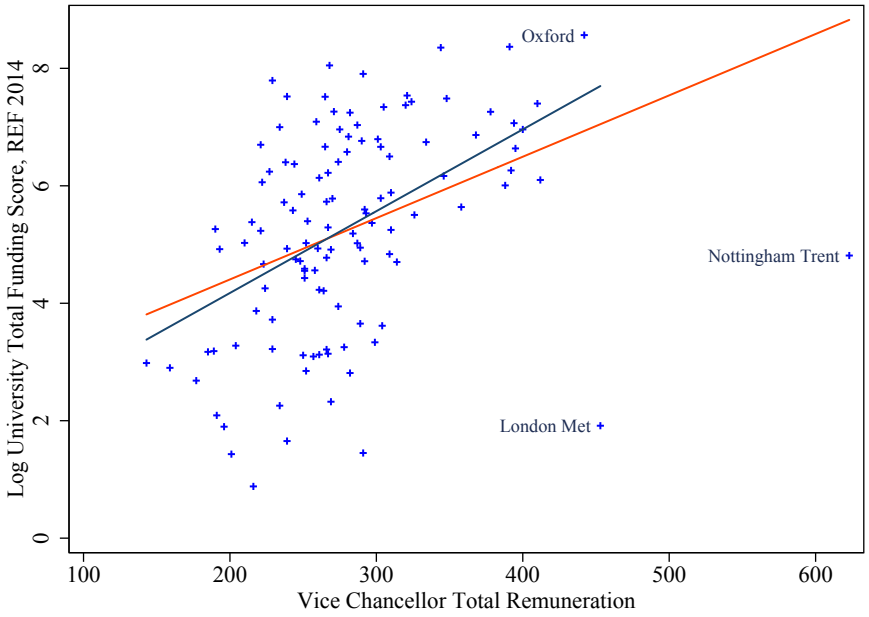
(A) By REF Main Panel



(B) By University Type

Note: Each observation represents an individual academic department. Figure show scatter plots and fitted regression lines. Observations grouped by REF Main Panel (figure panel A) and University Type (figure panel B).

Figure A6: Vice Chancellor Pay and Funding Score Performance



Note: Each observation corresponds to an individual university. Figure shows a scatter plot of total remuneration of university vice chancellors (x-axis, including pension contributions and discretionary payments) and log funding score (y-axis). The red fitted regression line is estimated on all observations; the blue fitted regression line is fitted on observations exlcuding the far-right outlier value.

A Classification of UK Universities by Types

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This appendix lists the members of the University 'Type' Groups used in the analysis. These groupings are based the membership of University associations.

Russell Group: In 1994 a group of 17 'research intensive' UK universities formed an association known as the 'Russell Group', which grew to 20 Universities by 2006. In 2012 four additional universities joined from the newly-defunct '1994' group. Our classification of 'Russell Group' uses the 20 members from 2006 onwards on the basis that this group represents long-running core members.

University of Birmingham
University of Bristol
University of Cambridge
Cardiff University
University of Edinburgh
University of Glasgow
Imperial College London
King's College London
University of Leeds
University of Liverpool
London School of Economics
University of Manchester
Newcastle University
University of Nottingham
University of Oxford
Queen's University Belfast
University of Sheffield
University of Southampton
University College London
University of Warwick.

The 1994 Group: The '1994' Group was also formed in 1994, its membership comprising smaller research-intensive universities that had not been invited to join the Russell Group. This group disbanded in 2012.

The University of Bath
University of Durham
The University of East Anglia
The University of Essex
The University of Exeter
The University of Lancaster
The University of Leicester
Birkbeck College
Queen Mary University of London
Royal Holloway and Bedford New College
The School of Oriental and African Studies
Loughborough University
The University of Reading
The University of Surrey
The University of Sussex
The University of York
The University of St Andrews

"New" Universities: This group comprises institutions which were given status as universities from 1992 onwards. Prior to that time most of the members of this group were known as 'polytechnics' delivering post-high school technical education.

Anglia Ruskin University
Birmingham City University
University of Brighton
Bournemouth University
University of Central Lancashire
Coventry University
De Montfort University
University of East London
University of South Wales
University of Greenwich
University of Hertfordshire
University of Huddersfield
Kingston University
Leeds Beckett University
University of Lincoln
Liverpool John Moores University
London Metropolitan University
London South Bank University
Manchester Metropolitan University
Middlesex University
Northumbria University
Nottingham Trent University
Oxford Brookes University
University of Plymouth
University of Portsmouth
Sheffield Hallam University
Staffordshire University
University of Sunderland
Teesside University
University of the West of England
University of West London
University of Westminster
University of Wolverhampton
Ulster University
University of the Arts London
The Arts University Bournemouth
Bath Spa University
University of Bedfordshire
Bishop Grosseteste University
University of Bolton
BPP University
Buckinghamshire New University
Canterbury Christ Church University
Cardiff Metropolitan University
University of Chester
University of Chichester
Cranfield University
University for the Creative Arts
University of Cumbria
University of Derby
Edge Hill University
Falmouth University
University of Gloucestershire
Glyndŵr University
Harper Adams University
University of the Highlands and Islands
Leeds Trinity University
Liverpool Hope University
Newman University
University of South Wales
University of Northampton
Norwich University of the Arts
University of Roehampton
Royal Agricultural University
Southampton Solent University
St Mary's University, Twickenham
Swansea Metropolitan University
University of Winchester
University of Worcester
York St John University
University of Abertay Dundee
Edinburgh Napier University
Glasgow Caledonian University
Queen Margaret University
The Robert Gordon University
University of the West of Scotland.

Specialists: This group comprises a set of high specialised universities offering a limited

range of subjects including, in some cases, universities offering only a single subject.

Royal College of Art
University of the Arts, London
Royal Academy of Music
Royal College of Music
Royal Northern College of Music
Glasgow School of Art
London School of Hygiene and Tropical Medicine
London Business School
The Royal Veterinary College
St George's Hospital Medical School
Norwich University of the Arts
Royal Agricultural University
Courtauld Institute of Art
University for the Creative Arts

Others: Universities not included in any of the above groups are assigned to this 'other' group.

The Open University
Cranfield University
The University of Central Lancashire
The University of Huddersfield
The University of Westminster
Aston University
The University of Bradford
Brunel University London
The City University
The University of Hull
The University of Keele
The University of Kent
Goldsmiths College
The University of Salford
The University of Strathclyde
The University of Aberdeen
Heriot-Watt University
The University of Dundee
The University of Stirling
Aberystwyth University
Bangor University
Swansea University
Guildhall School of Music and Drama