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RAE Results And Research Funding in the UK : A Comparative Analysis

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Abstract

A considerable sum of money is allocated to UK universities on the basis of Research Assessment Exercise performance. In this paper we analyse the two main funding models and discuss their shortcomings. We propose an alternative model which uses a proxy for international quality to determine payouts. It is shown that the different models have quite different implications for the focus of UK research.

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I. Introduction

British academia has a very proud research record, whether it be in the physical sciences, the social sciences or the arts. Since the start of the 1990s there have been four British winners of the Nobel Prize for Chemistry, and four British winners of the Nobel Prize for Medicine. Since the creation of the Nobel Prize for Economics in 1969 there have been five British winners; John Hicks (1972), James Meade (1977), Richard Stone (1984), Ronald Coase (1991) and James Mirrlees (1996). Many of her top scientists have become household names, whether because of the contribution of their own research to science (e.g. Alexander Fleming's discovery of penicillin) or as a result of their work in bringing science to the attention and understanding of the general public (e.g. Stephen Hawking's "*A Brief History of Time*"). Britons have made countless other major contributions to scientific discovery.

The benefits that flow from this work are considerable. Dwarfing the academic and national pride that stems from being among the world's research elite, several of these advances – such as Alexander Fleming's discovery of penicillin or Tim Berners-Lee's invention of the world wide web - have had major impacts upon everyday life. The economic benefits to British industry of a strong research base are difficult to calculate, but research is a fundamental requirement for the jobs of millions of British workers and supports British export efforts. For a range of industries from defence equipment (e.g. British Aerospace) to pharmaceuticals (e.g. GlaxoSmithKline) Britain has achieved a global presence far in excess of that which one might expect for a middle-ranking country.

A major contributor to Britain's research effort is its academic sector. The extent of this effort

can be gauged by the fact that in the recent 2001 Research Assessment Exercise (RAE) the full-time equivalent of 48,021 researchers were submitted for this peer review process. The benefits of research excellence are perhaps felt most acutely in the academic sector itself, both by the individual academics themselves and by their institution. Promotions, and all that go with them, could very well depend on the academic's research record, whether that be measured in terms of the quantity and quality of their publications or the research funds they have brought into their institution[1]. And the 'recent journal publications' section of a job applicant's CV is often the basis on which prospective employers make their first impressions.

UK universities receive the bulk of their income from public funds administered by the four UK funding councils[2]. Much of this income is to pay for teaching. Nonetheless, a sizeable proportion of the total income universities receive from their respective funding council is to support research. In 2002-3 the UK's four funding councils provided more than £1bn support for academic research - £940m from HEFCE, £132m from SHEFC, £60m from HEFCW and £26m from DELNI – in the case of HEFCE this £940m constitutes 18.5% of the £5,076m it distributed to English universities (an increase of 5.9% on the figure for 2001-2).

For some British universities their attempts to acquire a greater share of these research funds is like the quest for the holy grail. Prior to 1992 they were classified as polytechnic colleges and as a result were seen largely as teaching institutions (with the lower esteem that went with that label). However, large numbers of these institutions became universities in 1992 and believe that increasing their share of research funding is the best way to enshrine their

[1] For example, the quality of their work environment is often heavily dependent on the research income that academics generate.
[2] These funding councils are the Higher Education Funding Council for England (HEFCE), the Scottish Higher Education Funding Council (SHEFC), the Higher Education Funding Council for Wales (HEFCW) and the Department of Employment and Learning for Northern Ireland (DELNI).

new status as a teaching *and research* university. The government's 2003 Higher Education White Paper indicated a desire to see a concentration of British academic research effort into a small number of centres of research excellence that would see these 'post-1992' universities revert back to a teaching-only status, even if they are allowed to retain their official university status[3]. The government has trumpeted a 30% real terms increase in research funding over the period from 2002-3 to 2005-6, but most of the additional funds will be given to departments classified as either nationally or internationally competitive in the 2001 RAE.

However, the financial rewards flowing to universities as a result of their research excellence do not stop there. Research excellence is a central determinant of an institution's international reputation, and hence the saleability of its courses in the international education marketplace[4]. Given that non-EU students typically pay fees of between £7,000 and £10,000 per annum this represents a potentially substantial relaxation of university budget constraints.

It is therefore clear that, more than ever, research excellence matters to British academia - the race for research funding is being ever more hotly contested. But the government has made it clear that extra funds from the taxpayer will only be provided to public services (including universities) in return for definite and specific *improvements* in quality and quantity. In his statements to the Treasury Select Committee on 19th July 2002 Chancellor Gordon Brown made it clear that these additional funds (£61bn over the period 2003-6) were being provided to fund *improvements* in the public sector, not to reward public sector workers with higher

[3] To quote the White Paper (p.23), "We propose to encourage the formation of consortia, provide extra funding for research in larger, better managed research units, and develop criteria to judge the strength of collaborative work. As part of this process, we will invest even more in our very best research institutions, enabling them to compete effectively with the world's best universities.

[4] Places in UK universities for UK / European Union (EU) undergraduate students are fixed by the funding decisions taken by the Funding Councils, and so universities are in effect playing a zero sum game with each other where the return to research reputation is seen only in the *quality* of students attracted, not the *quantity* of students attracted; however, for non-EU students no such arbitrary restrictions apply and therefore the attraction of such students is one way for universities to increase their total income.

wages for the work they already do[5].

In order to accurately evaluate improvement in the provision of public services (including the research efforts of British academics) there is a need for an effective measurement system. In primary and secondary education the government has introduced (controversial) league tables that focus on exam performance and other indicators of school performance, whilst in the National Health Service (NHS) the government awards NHS Trusts between zero and three stars depending on the extent to which they meet standards set by central government relating to performance indicators such as patient waiting lists, cancelled operations, clinical outcomes and cleanliness. The teaching component of the Funding Council's payment to a university depends on how closely it meets its negotiated student target for EU students and on assessments of its teaching quality.

For evaluating the research activities of Britain's academics the funding councils utilise the periodic RAE[6]. This exercise, most recently conducted in 2001 but covering the period 1996-2001, requires that all departments whose research output is to be evaluated are assigned to one of the sixty-nine 'units of assessment' (henceforth '*subject areas*') identified by the funding councils, such as 'Economics and Econometrics', 'History', 'Chemistry' and 'Pure Mathematics'. For each subject area a panel is constituted with the responsibility for attaching to each department submitted to its panel a qualitative assessment of that department's research output, using the ascending scale 1, 2, 3b, 3a, 4, 5 and 5*. It is for each university to decide to which subject areas it will make a submission, and which of its staff

[5] The importance of the views of the political paymasters to the decision-making by the four funding councils cannot be over-stated. Adopting an independently-determined set of objectives could well put at risk the large increases in public funding the government has promised. This acquiescence by the funding councils is apparent in their publications; for example, SHEFC (2002) stated the main influences affecting its decisions on resource allocation, and listed first of all "*Scottish Executive policies and priorities for Higher Education in 2002-03*".
[6] The RAE is owned and controlled by the four funding councils.

will be submitted in those submissions. In the 2001 RAE there were a total of 2,598 submissions from the 173 institutions taking part in the exercise.

Each of the four funding councils awards research funds largely on the basis of research performance as measured on this seven-point qualitative scale, though there are important distinctions between them in terms of the specific relationship between RAE performance and funding. In each case political considerations play a crucial role in determining the link between funding and performance[7].

It is this issue of how RAE performance – as measured by the RAE panels - is rewarded by research funding payments by the funding councils that is the focus of this paper. All funding councils insist on the principle of payment by quality. The purpose of this paper is to show that different methods of operationalising the 'payment by quality' principle can lead to very different payouts. In particular we will evaluate three alternative funding models – those used by HEFCE and SHEFC, plus a third that we propose – in terms of their advantages, disadvantages and funding implications for British academia. In Section 2 below we outline a general model which can be used to map RAE qualitative scores into monetary payouts. In Section 3 we discuss the HEFCE and SHEFC models as a special case of the general model. In Section 4 we outline an alternative special case which is radically different from both existing models. Section 5 concludes.

[7] Thus, for instance, SHEFC decided to remove all research funding from the pre-1992 departments scoring 3a or less in the 2001 RAE, though HEFCE decided that a large reduction (that still left some research funding for such departments) was a sufficient penalty.

II. A General Funding Model

The purpose of any funding model is to provide an unambiguous mapping from RAE qualitative scores to the consequent monetary payout. There are two dimensions of the payout which are of particular interest and concern. The first is the total payout to each institution for its research submitted across all the different subject areas. In response to government plans to concentrate research activity in just a few elite universities (set out in the White Paper on Higher Education) this matter has generated considerable debate within British academia and it has been extensively discussed in the press; this debate has included wider questions, such as whether or not the UK currently has too many universities, and whether the merger of certain universities would be desirable. The second dimension of the payout is the total payout across all universities to each subject area. Different funding models will deliver differing amounts of research funding to the different subject areas, even with a constant total funding pot; thus, the choice of funding model will help to determine which subject areas will flourish in the UK and which will be allowed to whither. From society's perspective this second dimension is clearly more important than the first. Curiously, it has received little attention in contrast to the university-level payouts. In this paper we redress this balance by focusing explicitly on the subject are level payouts, analysing the university level payouts *en passant*.

Any funding model which maps from raw RAE scores to payouts should satisfy a number of rather obvious criteria. These are:

1. The model should be transparent

2. The model should reward quality, thereby enhancing incentives to develop research excellence
3. The model should reflect the costs of research in different subject areas
4. The model should reward the volume of quality research

More contentiously, one may add a fifth criterion, namely that the model should reflect national priorities. In other words, if policymakers deem that research in Physics is more important than, let us say, research in Art and Design, this should be reflected in the payouts the funding model generates. Provisionally, then, we add this fifth criterion to the set of four listed above as:

5. The model should reward those subject areas deemed to be of special national importance

The raw data for the mapping exercise consists of the RAE qualitative ranking for each institution in each subject area together with the associated volume indicator – which broadly equals the number of research active staff submitted by the institution to the subject panel. Indexing institution by i and subject area by j, the raw data consists of the 2 tuple $\{Y_{ij}, V_{ij}\}$, i=1,2,3,…I and j=1,2,3,...J, where I is the total number of institutions and J is the total number of subject areas. In the 2001 RAE rankings I was 173 and J was 69[8]. Denoting as S_{ij} the payout to institution i for its submission to subject area j, we need to construct a mapping from $\{Y_{ij}, V_{ij}\}$ to S_{ij}. By aggregation, the university-level payout across all subject areas is given by $S_i = \sum_j S_{ij}$ and the subject-level payout for the whole of the UK is given by

[8] However, omitting from the analysis those universities submitting to only one subject area panel, and those subject area panels receiving submissions from only English universities (a problem in Section IV of the paper) we arrive at a subset of 145 institutions and 65 subject areas.

$S_j = \sum_i S_{ij}$.

The first step in the construction of such a mapping is to convert the RAE qualitative scores into cardinal numbers. This is a policy decision which cannot be avoided. The steepness of the cardinal scale must reflect the percentage of extra funding which should be the reward for a level improvement in RAE ranking, say from 5 to 5*. In principle the mapping from Y_{ij} to S_{ij} could be both subject and institution-specific resulting in I×J different single-valued functions $X_{ij} = G_{ij}(Y_{ij})$, i=1,2,3,...I and j=1,2,3,…J. Thus the policy function is:

$$X_{ij} = G_{ij}\left(Y_{ij}\right) \qquad \{1\}$$

Obviously, in line with criterion 2 above, the function $G_{ij}(\cdot)$ should be increasing. In practice the function $G_{ij}(\cdot)$ consists of little more than a table which maps the RAE's seven ranking categories on the ordinal scale Y={1,2,3b,3a,4,5,5*} to a scale consisting of seven cardinal numbers X={a,b,c,d,e,f,g}. Using this function, each ordinal Y_{ij} is converted into an equivalent cardinal X_{ij}.

The next set of policy decisions which need to be taken are to do with subject area-specific costs and national priorities. The simplest way to achieve this first task is for policymakers to attribute to those subject areas with the lowest research costs a cost factor of 1 and then to scale all other subject areas appropriately. This generates a set of cost factors C_j, j=1,2,3,…J. There is obviously considerable room for debate (and disagreement) here concerning relative research costs. However, even more contentious than research cost factors is attributing to a subject area a value in terms of national priorities. How does one decide that a particular subject area, A, is 10% more important than another subject area, B, and thus A deserves a

national priority rating of 1.1 if the rating of B is 1? Nonetheless, it is not an issue that can be ducked. We simply assume that these national priority ratings are assigned by policymakers with the least important subject areas getting a national priority rating of 1, and then all of the other subject areas being scaled appropriately. This leads to a national priority index for the N subject areas, N_j, j=1,2,3,…J.

The final policy decision to be taken. and quite probably the most important one, is how large the total payout figure, S, is to be. Benchmarking S against international standards of research funding may be one way forward here.

Given these four policy decisions – the $G_{ij}(\cdot)$ function, the cost factors C_j, the national priority index N_j, and the total payout S – and the raw data, the general form of the payout rule should be:

$$S_{ij} = F(X_{ij} , C_j , N_j , V_{ij}) \qquad \{2a\}$$

$$\sum_i \sum_j S_{ij} = S \qquad \{2b\}$$

where F(·) should be increasing in all of its arguments.

There are obviously many different ways in which this can be operationalised. The method we outline below has the virtues of both simplicity and transparency in line with criterion 1 above.

At the very outset we recognise that research quality is a relative concept. In other words, we

need a benchmark against which the X_{ij} can be properly compared. As we discuss later in this and the next section, the construction of this benchmark is a crucial policy decision. Denoting this benchmark by X_j^*, we define the average quality of research in subject area *j* as:

$$X_j = \frac{\sum_i X_{ij} V_{ij}}{V_j}, j=1,2,3,\ldots J \quad \{3\}$$

and the relative quality of research in subject area *j* as:

$$Q_j = \frac{X_j}{X_j^*}, j= 1,2,3\ldots J \quad \{4\}$$

The total number of staff submitted in subject area *j* is given by:

$$V_j = \sum_i V_{ij}, j=1,2,3,\ldots J \quad \{5\}$$

We allocate 'funding points' (P_j) to each subject area on the basis of relative research quality, volume, cost and national priority index according to:

$$P_j = Q_j \times V_j \times C_j \times N_j, j= 1,2,3,\ldots J \quad \{6\}$$

Hence at the subject area level a simple mapping is:

$$S_j = k \times P_j, j=1,2,3,\ldots J \quad \{7\}$$

where k is a constant of proportionality which is determined by the total payout S since:

$$\sum_j S_j = S \text{ , } j=1,2,3,\ldots \text{J} \qquad \{8\}$$

The proportionality constant k measures the monetary value of each funding point, and it is given by:

$$\text{k} = \frac{S}{\sum_j P_j} \text{ , } j=1,2,3,\ldots \text{J} \qquad \{9\}$$

In effect we are assuming that the function determining subject area payouts exhibits constant returns to scale in all of its arguments.

Once all of these J subject area-level payouts have been determined, the distribution of funds within a particular subject area (between institutions making a submission in that subject area) can be determined. The relative research quality in institution *i* in subject area *j* is defined as:

$$q_{ij} = \frac{X_{ij}}{X_j} \text{, } i=1,2,3\ldots \text{I and } j=1,2,3,\ldots \text{J} \qquad \{10\}$$

Following prior reasoning we can choose the funding points function at this micro level to be:

$$P_{ij} = q_{ij} \times V_{ij} \text{, } i=1,2,3,\ldots \text{I and } j=1,2,3,\ldots \text{J} \qquad \{11\}$$

Analogously with {7}, we then set the payout function as:

$$S_{ij} = \mathrm{k}_j \times P_{ij},\ i=1,2,3\ldots\mathrm{I} \text{ and } j=1,2,3,\ldots\mathrm{J} \qquad \{12\}$$

where $\mathrm{k_j}$ is a *subject area-specific* constant of proportionality. Each of these J constants is determined by the subject area payouts S_j determined in {7} since:

$$\sum_i S_{ij} = S_j,\ i=1,2,3,\ldots\mathrm{I} \text{ and } j=1,2,3,\ldots\mathrm{J} \qquad \{13\}$$

In other words, each $\mathrm{k_j}$ is given by:

$$\mathrm{k}_j = \frac{S_j}{\sum_i P_{ij}},\ i=1,2,3,\ldots\mathrm{I} \text{ and } j=1,2,3,\ldots\mathrm{J} \qquad \{14\}$$

Once the S_ij are known simple aggregation yields the university-level payouts S_i as:

$$S_i = \sum_j S_{ij},\ i=1,2,3,\ldots\mathrm{I} \text{ and } j=1,2,3,\ldots\mathrm{J} \qquad \{15\}$$

This completes the description a general funding model which meets all of the criteria listed above.

III. The Battle of Existing Models: HEFCE v SHEFC

In the previous section we described the construction of a general funding model which maps from RAE data to payouts. Policymakers need to make key policy decisions (C_j, $G_{ij}(\cdot)$, N_j and S). Together with the raw RAE data, these policy decisions constitute the inputs to the funding model. Payouts are then automatically generated endogenously by the model. The simplest and most useful way to compare the main funding models used (i.e. the HEFCE and SHEFC ones) is to illustrate how they determine the key policy decisions. In this section we will compare and contrast the HEFCE and SHEFC models in precisely this way. We will also examine the different payouts that would prevail under each of these models.

The two models are identical with respect to the policy variable N_j – the national priority index. Both opt out by setting the value of N_j equal to unity for every subject area. In a sense this unwillingness to discriminate between the 69 subject areas may well reflect the British government's own neglect of this issue. The question of which subject areas should receive research priority is of clear national concern, but it is obviously contentious. On the Occam's razor principle setting N_j equal to unity for all subject areas apparently finesses the question by effectively removing N_j from the model. Indeed there is no discussion of this question in either HEFCE or SHEFC documentation. But this 'solution' is illusory since the decision to fund different subject areas (e.g. Sports Related Subjects and Clinical Medicine) at the same rate, *ceteris paribus*, needs justification by the policymakers.

With respect to the policy variables $G_{ij}(\cdot)$ and C_j, the two funding councils take slightly different views. Turning first to the $G_{ij}(\cdot)$ function, we show in Table 1 below the functions

used by HEFCE and SHEFC:

Table 1 : The RAE ordinal rating to cardinal score functions used by HEFCE and SHEFC

RAE ordinal rating	HEFCE score	SHEFC score
1	0	0
2	0	0
3b	0	0
3a	0.31	0 / 1 [a]
4	1	1.55
5	1.89	2.80
5*	2.71	3.20

[a] SHEFC awarded a score of 1 to those departments from post-1992 institutions who achieved an RAE rating of 3a

Whilst both models use functions that are uniform with respect to subject area, SHEFC uses a function that does discriminate between institutions in that it sets the cardinal value of a 3a in the RAE rating equal to zero for old institutions but equal to one for new institutions[9]. The HEFCE function is simpler in that it does not discriminate between new and old institutions. HEFCE provides a greater reward for the movement from 5 to 5* (a 43% premium compared to 14% for SHEFC) whilst for older institutions SHEFC penalises 3a performance in a much more draconian manner than HEFCE (a 100% penalty compared to 69% for HEFCE)[10]. In short the differences mainly concern the steepness of the G(·) function. There is no obvious way to claim that one of these functions is more appropriate than the other. Similarly, both models use slightly different values for the cost index C_j. In effect C_j takes only three distinct values; each subject area is assigned to one of three cost groups – low, middle and high. The value of the cost index assigned to the low group is set at 1 with appropriate scaling for the middle and high cost groupings.

[9] SHEFC's justification for this discrimination is its desire to encourage the development of research excellence in the newer institutions that were, until quite recently, almost exclusively concerned with teaching. Whether the concession to the newer institutions is retained may well depend on whether the government's desire (set out in the White Paper) to see concentration of research in fewer but larger research centres becomes accepted policy throughout the UK.

[10] Though its 35% penalty for newer institutions is less punitive.

However, the main difference between HEFCE and SHEFC lies in their construction of the quality benchmark, X_j^*. HEFCE's approach to this is wonderfully simple, if not simplistic – they set X_j^* equal to the average research quality in all subject areas. That is:

$$X_j^* = X_j, j=1,2,3,\ldots J \qquad \{16a\}$$

In effect this assumes that, *ceteris paribus*, every subject area receives the same payout since each subject area has a relative quality index (Q_j) value of one. This method at least has the virtue of being consistent with setting N_j equal to one for all subject areas. If each subject area is assumed to be equally important then why not assume as well that they are all of equal quality in terms of their research? In effect, HEFCE assumes that the research quality of UK researchers in Sports Related Subjects is exactly the same as that in Clinical Medicine. Can this strong assumption be justified?

SHEFC follows a radically different approach. They assume that there is some notion of the average quality of research across all subject areas in Scotland and treat this as the relevant benchmark. In other words they determine X_j^* as:

$$X_j^* = \frac{\sum_j \left(X_j V_j\right)}{\sum_j V_j}, j=1,2,3\ldots J \qquad \{16b\}$$

This policy decision can only be justified if all the RAE panels were using exactly the same standards. Can such a construction have any useful meaning? Does a 5 rating in, for example, Sports Related Subjects imply the same research quality as a 5 rating in Clinical Medicine?

The impact of this policy decision is that SHEFC sets X_j^* as subject-independent. Denoting this subject-independent benchmark of research quality as X^*, we see from {4} that Q_j is proportional to X_j for every subject area with a constant of proportionality equal to $(1/X^*)$. But the multiplicative nature of research funding points P_j as given by {6} means that setting X_j^* to be invariant across subject areas has the same impact on funding as setting X_j^* equal to unity and hence $Q_j=X_j$.

We can summarise this discussion by noting that the fundamental difference between HEFCE and SHEFC lies in their implied policy choice of Q_j. For HEFCE, $Q_j=1$ for all subject areas, whilst for SHEFC $Q_j=X_j$ for all subject areas. This major difference should have, indeed does have, a significant impact on the payouts. We investigate this impact by suppressing all other differences between HEFCE and SHEFC. Thus, we calculate the payouts using actual 2001 RAE data, setting $N_j=1$ for all subject areas, using the HEFCE G(·) function and the HEFCE cost indices C_j[11]. The HEFCE values of G(·) were given in Table 1, and their C_j values are shown in Table 2 below. These values remain unchanged throughout the rest of our analysis.

Table 2 : The HEFCE research cost index

Research cost	HEFC cost factor
Low	1.0
Medium	1.3
High	1.6

We calculate the payouts from the model using the HEFCE policy decision of $Q_j=1$, and then

[11] For comparative purposes we use the HEFCE values of G(.) and C_j on the grounds that HEFCE is by far the largest provider of research funds in the UK and its G(.) function is simpler.

repeat the calculations using the alternative SHEFC policy decision of $Q_j=X_j$. In both cases we use the policy variables from Appendix Table 1. As the institutions in the four constituent parts of the UK are separately funded by their own respective funding council, we calculate the payouts for each separately. The total payouts for England, Scotland, Wales and Northern Ireland are set equal to, a, b, c and d respectively. In order to focus on the impact of the crucial policy difference between the benchmarks used by HEFCE and SHEFC, we aggregate all the 117 institutions in England into one single entity called *English Universities* whilst the remaining 28 institutions are aggregated into one single entity called *Rest of the UK (RUK) Universities*. The results showing the subject level payouts are shown in Appendix Table 2.

In column (a) of Appendix Table 2 we report the subject area payouts for the set of English Universities using the HEFCE benchmark which implies $Q_j=1$ for all subject areas. Column (b) shows the same payouts using the SHEFC benchmark which implies $Q_j=X_j$. Columns (c) and (d) are analogously defined for RUK. When comparing the payouts from the HEFCE and SHEFC models we can see that the differences are large and significant. In England the main beneficiaries of the HEFCE method (compared to the SHEFC method) were Art and Design (£11.9m), Education (£6.8m), Other Studies and Professions Allied to Medicine (£5.1m) and Business and Management Studies (£4.9m). Within the RUK the main beneficiaries of the HEFCE method were Business and Management Studies (£2.5m), Art and Design (£2.1m), Chemistry (£2.1m) and Education (£1.7m). That Business and Management Studies, Art and Design and Education were amongst the top four beneficiaries for both the English and RUK universities suggests that across the whole of the UK submissions to these three panels tended to achieve a lower RAE rating than submissions to other panels. In short, these subject areas had a lower value of Q_j by the SHEFC benchmark.

To see the overall impact of the decision between the HEFCE and the SHEFC benchmark we use the HEFCE benchmark as the norm and compute the gains / losses to each subject area arising as a result of a move to the SHEFC benchmark As we are allocating a fixed sum using two different benchmarks, the total of the gains must equal the total of the losses. In order to avoid double counting we compute the sum of gains only (i.e. ignoring losses) and express this number as a percentage of the total payout. This represents the overall impact of moving from a universal UK-wide application of the HEFCE benchmark to a universal UK-wide application of the SHEFC benchmark; the results are shown in Appendix Table 2. Although the impact of a move from the HEFCE benchmark to the SHEFC benchmark would, in percentage terms, be larger for the RUK institutions, the effect for the English institutions would obviously be much greater in absolute terms – for English institutions the potential transfer of £61.7m (6.63% of HEFCE's £940m of research funds) amounts to a very considerable reallocation indeed.

IV. An International Benchmark

Thus, the differences in payouts generated by the use of two very different benchmarks is considerable. Despite the difference between the HEFCE and SHEFC benchmarks, they do share a common property, namely that they are both wholly inward-looking in character. Neither benchmark makes any attempt at looking outward to the rest of the world. Ideally one might wish to use a fully international subject area benchmark such that the quality of each subject area in the UK was judged against that of the rest of the world. If the RAE exercise was conducted on a world-wide basis, we would have the data with which to construct this benchmark. Since the UK would, in a world context, be the 'classic' small open economy, we could define the benchmark as:

$$X_j^* = \frac{\sum_i \sum_j X_{ij} V_{ij}}{\sum_i \sum_j V_{ij}}, \; i=1,2,3\ldots I \text{ and } j=1,2,3\ldots J \qquad \{17\}$$

where the summation included institutions in all countries other than those in the UK.

We don't have the data needed to construct the benchmark defined in {17}. However, we can take the opportunity offered by the fact that each of the four constituent parts of the UK is funded separately, but assessed in the RAE in a consistent manner, to define four separate quasi-international benchmarks, one for each of the four constituent parts. Thus, for English institutions we define the benchmark as in {17}, but include in the summation only Scottish, Welsh and Northern Irish institutions. Similarly for each of the UK's other constituent parts. Thus, we construct the four benchmarks as:

X_j^* (England) = $\frac{\sum_i \sum_j X_{ij} V_{ij}}{\sum_i \sum_j V_{ij}}$, where the summation includes non-English institutions only

X_j^* (Scotland) = $\frac{\sum_i \sum_j X_{ij} V_{ij}}{\sum_i \sum_j V_{ij}}$, where the summation includes non-Scottish institutions only

X_j^* (Wales) = $\frac{\sum_i \sum_j X_{ij} V_{ij}}{\sum_i \sum_j V_{ij}}$, where the summation includes non-Welsh institutions only

X_j^* (N. Ireland) = $\frac{\sum_i \sum_j X_{ij} V_{ij}}{\sum_i \sum_j V_{ij}}$, where the summation includes non-N. Irish institutions only

These benchmarks are international in character and they are subject area-specific. For Scotland, Wales and Northern Ireland (by population size the smaller constituent parts of the UK) they do represent a reasonable approximation to an international benchmark. But for England they are somewhat problematic since non-English institutions constitute a relatively small sector compared to English institutions. Despite this limitation they do represent a genuine indicator of an external quality benchmark against which internal quality can be judged. The implication of using a slightly modified version of {17} to compute a benchmark is that Q_j, the relative research quality of subject area *j*, is computed only by reference to the measured quality in the same subject area in the rest of the UK. There is no attempt made at defining spurious constructions like the average quality of overall research in Scotland as SHEFC does. Our benchmark only compares like with like. The impact of RAE grade inflation is therefore eliminated since we are only comparing scores within a given subject area panel. A proportional raising of all UK scores within a given subject area will not alter the relative quality indices and hence will not distort the payout.

The results of this exercise are shown in Appendix Table 3 (this third benchmarking system is referred to as 'International'). For ease of comparison we also report the payouts under the HEFCE and SHEFC benchmarks in the same table (previously-discussed). Once again we can see that there are considerable differences that arise from using the new benchmarks. One pattern that does stand out strongly from the results is that the subject areas that are winners amongst the English universities tend to be losers amongst the Rest of the UK universities, and vice-versa. This is only to be expected given the nature of the International benchmark,

as payouts are determined by comparing English and Rest of the UK research and therefore if there is deemed to be better quality research in England (compared to that in the Rest of the UK) then it follows that there is deemed to be poorer quality research in the Rest of the UK (compared to that in England).

The final two columns in Appendix Table 3 indicate those subject areas that benefit and those that lose out from a switch from the HEFC benchmark to the new international benchmark. Thus, amongst the Rest of the UK universities, the Other Studies and Professions Allied to Medicine, Computer Science, Psychology and Town and Regional Planning subject areas are the major beneficiaries from a move to the international benchmark (and major losers in the English universities), whilst Social Policy and Administration, Economics and Econometrics, Business and Management Studies and Chemistry would be major losers (and consequently major beneficiaries in the English universities).

Using the HEFCE benchmark as the norm, we calculate the transfer implied by moving to the international benchmark. We find that for the English universities the transfers amount to £94.5m (10.16% of the total £940m budget) whilst for the Rest of the UK universities there is a transfer of £16.8m (7.71% of the total £218m budget)[12]. Comparing these transfers to the earlier comparisons (HEFCE vs. SHEFC) we see a greater effect on the English universities (10.16% vs. 6.63%) and a lesser effect on the Rest of the UK universities (7.71% vs. 9.63%). However, the combined effect across all universities in the UK is much greater (£111.3m vs. £82.5m). And once again we can argue that such transfers constitute a significant proportion of the research funds available to UK academia, and would significantly change the focus of UK academic research.

[12] Though not shown in Appendix Table 3, moving from the SHEFC benchmark to the international one would result in transfers of £108.9m for the English universities and £14m for the Rest of the UK universities.

V. Conclusions

We have shown that the policy choice of an appropriate benchmark is of crucial importance in determining the allocation of research funds through the funding model. Considerable sums of money are reallocated across different subject areas depending on which benchmark is used. If one was indifferent to the fate of a particular subject area, these reallocations might not be of great significance. However, if policymakers intend that the funding model should generate incentives to research excellence then payment by quality is of fundamental importance. Our proposed international benchmark achieves this objective at the subject area level itself. Since the subject area payouts then form the basis of allocations to universities, the incentive effect 'trickles down' to the next level of funding too.

The role of international benchmarking might be usefully extended to another policy variable. Perhaps the most crucial variable that determines the fate of future academic research in the UK is the total size of the payout. At present the four funding councils set their total payout in accordance with the imperatives of their paymaster – the Treasury. There is no evidence that the size of the total payout is any way influenced by what international rivals in the race for national research excellence are doing. This is clearly a factor which the government needs to consider carefully, not least because under-funding of research in the UK will inevitably accelerate a brain drain. If enhancing research excellence in the UK is a policy objective, then policymakers who ignore international benchmarks do so at their own peril, and (sadly) at considerable cost to the nation.

Appendix Table 1 : Notation

Policy decision variables

C_j	research cost factor for subject area *j*
$F(\cdot)$	general form of the payout rule
$G_{ij}(\cdot)$	mapping from RAE qualitative score to a cardinal score
N_j	national priority rating for subject area *j*
S	total research funds to be distributed
X_j^*	benchmark quality of research in subject area *j*

Raw data

i	institution
j	subject area
V_{ij}	volume indicator (number of staff) for submission *ij*
V_j	volume indicator (number of staff) for subject area *j*
X_{ij}	cardinal scale score for submission *ij*
X_j	cardinal scale score for subject area *j*
Y_{ij}	RAE qualitative score for submission *ij*

Endogenous variables

P_{ij}	funding points for institution *i* in subject are *j*
P_j	funding points for subject area *j*
q_{ij}	relative quality of research in institution *i* in subject area *j*
Q_j	relative quality of research in subject area *j*
S_{ij}	payout for submission *ij*
S_i	sum of all payouts to institution *i*
S_j	sum of all payouts to subject area *j*

Appendix Table 2 : HEFCE and SHEFC payouts by subject area

Subject Area	(HEFCE) England (a)	(SHEFC) England (b)	(HEFCE) Rest of UK (c)	(SHEFC) Rest of UK (d)	Winners and losers (b) - (a)	(d) - (c)
Business and Management Studies	34,507,662	29,600,660	8,669,503	6,150,960	-4,907,002	-2,518,542
Art and Design	32,758,125	20,884,082	7,303,589	5,175,555	-11,874,043	-2,128,034
Chemistry	33,421,721	35,626,017	8,579,992	6,479,624	2,204,296	-2,100,369
Education	28,824,172	22,024,977	5,115,767	3,460,883	-6,799,195	-1,654,884
Social Policy and Administration	15,524,235	11,871,801	2,816,904	1,283,999	-3,652,434	-1,532,905
Economics and Econometrics	19,193,095	18,464,894	2,954,231	1,659,295	-728,201	-1,294,937
Community-based Clinical Subjects	26,684,951	25,035,321	4,796,700	3,753,244	-1,649,631	-1,043,456
Environmental Sciences	7,687,165	8,256,144	2,367,028	1,384,143	568,979	-982,885
General Engineering	24,113,986	26,186,168	2,601,534	1,736,575	2,072,182	-864,959
Clinical Dentistry	8,885,182	9,850,388	2,497,321	1,632,947	965,205	-864,374
Agriculture	9,885,111	7,127,764	5,246,861	4,429,893	-2,757,346	-816,968
Library and Information Management	4,613,216	4,449,207	1,150,722	482,944	-164,009	-667,778
Nursing	7,321,097	4,512,631	1,397,652	773,011	-2,808,466	-624,641
Geography	23,501,479	21,238,126	4,442,653	3,838,531	-2,263,353	-604,121
Mech, Aero & Manufacturing Engineering	27,490,588	30,260,016	5,524,465	5,131,721	2,769,428	-392,744
Food Science and Technology	1,958,894	2,087,381	1,105,420	749,724	128,487	-355,696
Chemical Engineering	8,241,300	9,163,568	1,159,454	834,377	922,268	-325,077
Archaeology	10,463,835	11,295,001	2,430,657	2,122,298	831,166	-308,358
Sports-related Subjects	5,132,780	4,402,112	1,835,627	1,556,273	-730,668	-279,354
Philosophy	7,783,076	8,840,306	1,563,822	1,303,292	1,057,230	-260,530
Classics, Anc History, Byzantine & Modern	5,864,854	7,246,392	1,069,137	820,592	1,381,538	-248,545
Pharmacology	5,325,536	5,539,696	544,870	357,598	214,160	-187,272
Metallurgy and Materials	11,693,934	12,637,524	531,097	359,458	943,591	-171,639
Drama, Dance and Performing Arts	4,708,609	3,362,509	834,636	673,940	-1,346,100	-160,696
Physiology	6,602,469	5,833,156	1,259,092	1,118,800	-769,313	-140,292
Russian, Slavonic & E European Langs	1,334,289	1,584,585	239,301	140,382	250,296	-98,920
Iberian and Latin American Languages	3,335,515	3,721,649	828,467	747,035	386,134	-81,432
Italian	1,793,094	2,184,775	237,932	162,827	391,681	-75,105
Anthropology	4,761,939	5,457,320	1,091,024	1,026,690	695,381	-64,334
Built Environment	9,604,101	7,626,183	2,739,817	2,689,988	-1,977,918	-49,829
German, Dutch & Scandinavian Langs	4,199,379	4,836,893	890,055	840,854	637,514	-49,201
French	7,096,011	7,763,240	1,810,737	1,796,551	667,229	-14,187
Asian Studies	2,436,374	2,882,894	184,078	171,067	446,520	-13,010
Statistics and Operational Research	8,613,261	8,198,457	1,276,671	1,267,695	-414,804	-8,976
Music	7,690,319	7,275,542	1,001,486	1,007,240	-414,777	5,754
Linguistics	4,173,233	4,147,672	682,368	692,261	-25,561	9,893
History of Art, Architecture and Design	4,983,144	3,659,509	784,539	817,243	-1,323,635	32,703
Middle Eastern and African Studies	2,509,210	2,600,674	151,522	234,306	91,464	82,784
Communication, Cultural & Media Studies	4,790,783	3,007,062	856,305	946,538	-1,783,721	90,233
Politics and International Studies	19,202,557	17,135,132	3,313,177	3,407,222	-2,067,425	94,045
Accounting and Finance	2,525,396	3,284,770	1,750,260	1,869,319	759,374	119,059
Social Work	4,885,822	3,351,614	1,325,820	1,448,412	-1,534,208	122,592
History	27,410,614	27,584,522	6,371,754	6,661,459	173,908	289,705
Sociology	13,549,571	12,860,600	2,553,510	2,845,946	-688,971	292,436
European Studies	8,588,215	7,928,727	1,680,030	2,028,125	-659,488	348,095
Applied Mathematics	16,162,308	17,780,933	2,529,853	3,008,994	1,618,625	479,140
Earth Sciences	13,125,918	14,524,524	3,266,804	3,758,278	1,398,606	491,474
Computer Science	36,199,698	32,306,188	10,995,960	11,512,645	-3,893,510	516,685
Pure Mathematics	10,925,400	12,517,956	2,505,394	3,038,459	1,592,557	533,066
Pharmacy	10,902,075	11,294,908	2,818,934	3,363,052	392,832	544,119
Mineral and Mining Engineering	1,905,772	2,491,134	712,749	1,267,676	585,362	554,927

Theology, Divinity and Religious Studies	5,936,860	6,055,413	2,162,295	2,775,741	118,553	613,446
Town and Country Planning	4,796,593	3,424,550	1,950,905	2,564,872	-1,372,043	613,967
Law	22,068,685	26,613,243	5,360,088	6,176,980	4,544,558	816,892
Celtic Studies	269,763	311,291	1,575,732	2,438,480	41,528	862,748
Civil Engineering	11,520,953	12,745,816	4,680,419	5,643,587	1,224,863	963,168
Other Studies & Profs Allied to Medicine	17,319,321	12,246,388	3,981,178	5,086,415	-5,072,933	1,105,237
Veterinary Science	6,128,350	7,003,364	4,766,582	5,912,504	875,014	1,145,921
Physics	44,449,962	52,850,991	9,810,464	10,999,426	8,401,029	1,188,962
Hospital-based Clinical Subjects	56,389,899	63,355,600	9,698,112	10,892,517	6,965,701	1,194,405
Biological Sciences	58,144,624	64,194,089	17,967,485	19,205,002	6,049,465	1,237,517
Clinical Laboratory Sciences	29,754,273	34,898,828	6,334,596	7,792,955	5,144,556	1,458,359
Electrical and Electronic Engineering	20,419,312	21,737,456	6,547,316	8,130,343	1,318,143	1,583,027
English Language and Literature	24,047,915	26,851,410	5,921,000	7,689,563	2,803,495	1,768,564
Psychology	23,862,422	23,908,259	6,846,548	8,671,674	45,837	1,825,126
Totals	930,000,000	930,000,000	218,000,000	218,000,000	61,678,755* (6.63%)	20,984,048* (9.63%)

Subject areas are sorted in ascending order according to the values in the final column

* Given the zero-sum nature of moving from one funding model to the other, these two totals are the sum of the positive values in the columns above (and the negative of the sum of the negative values in those columns). These numbers indicate the aggregate gains of the winners and the aggregate losses of the losers.

Appendix Table 3 : HEFCE, SHEFC and International payouts by subject area

	HEFCE England (a)	SHEFC England (b)	International England (c)	HEFCE Rest of UK (d)	SHEFC Rest of UK (e)	International Rest of UK (f)	Winners and Losers (c) - (a)	Winners and Losers (f) - (d)
Chemistry	33,421,721	35,626,017	42,524,786	8,579,992	6,479,624	6,283,997	9,103,065	-2,295,995
Business and Management Studies	34,507,662	29,600,660	40,672,047	8,669,503	6,150,960	7,310,771	6,164,385	-1,358,732
Economics and Econometrics	19,193,095	18,464,894	29,690,025	2,954,231	1,659,295	1,755,303	10,496,931	-1,198,928
Social Policy and Administration	15,524,235	11,871,801	24,046,091	2,816,904	1,283,999	1,681,064	8,521,856	-1,135,840
Environmental Sciences	7,687,165	8,256,144	13,576,560	2,367,028	1,384,143	1,368,702	5,889,394	-998,326
General Engineering	24,113,986	26,186,168	34,480,061	2,601,534	1,736,575	1,609,738	10,366,075	-991,796
Clinical Dentistry	8,885,182	9,850,388	14,191,106	2,497,321	1,632,947	1,560,962	5,305,924	-936,358
Mech, Aero & Manufacturing Engineering	27,490,588	30,260,016	30,078,704	5,524,465	5,131,721	4,628,092	2,588,116	-896,373
Community-based Clinical Subjects	26,684,951	25,035,321	29,059,816	4,796,700	3,753,244	4,031,178	2,374,865	-765,522
Physics	44,449,962	52,850,991	44,236,072	9,810,464	10,999,426	9,104,140	-213,890	-706,324
Library and Information Management	4,613,216	4,449,207	9,151,173	1,150,722	482,944	535,607	4,537,957	-615,115
Education	28,824,172	22,024,977	30,557,482	5,115,767	3,460,883	4,534,702	1,733,310	-581,065
Archaeology	10,463,835	11,295,001	12,767,927	2,430,657	2,122,298	1,949,249	2,304,092	-481,408
Chemical Engineering	8,241,300	9,163,568	12,272,193	1,159,454	834,377	730,218	4,030,894	-429,236
Classics, Anc History, Byzantine & Modern	5,864,854	7,246,392	8,717,981	1,069,137	820,592	675,264	2,853,126	-393,873
Philosophy	7,783,076	8,840,306	9,213,933	1,563,822	1,303,292	1,187,051	1,430,856	-376,772
Food Science and Technology	1,958,894	2,087,381	2,958,826	1,105,420	749,724	742,359	999,932	-363,060
Law	22,068,685	26,613,243	21,355,946	5,360,088	6,176,980	5,080,220	-712,738	-279,868
Accounting and Finance	2,525,396	3,284,770	2,755,967	1,750,260	1,869,319	1,473,946	230,571	-276,314
Metallurgy and Materials	11,693,934	12,637,524	19,989,739	531,097	359,458	293,683	8,295,806	-237,414
Geography	23,501,479	21,238,126	22,425,627	4,442,653	3,838,531	4,242,848	-1,075,852	-199,805
Pharmacology	5,325,536	5,539,696	7,418,969	544,870	357,598	346,049	2,093,433	-198,821
Anthropology	4,761,939	5,457,320	5,281,769	1,091,024	1,026,690	895,357	519,830	-195,667
Nursing	7,321,097	4,512,631	8,414,302	1,397,652	773,011	1,212,078	1,093,206	-185,575
Iberian and Latin American Languages	3,335,515	3,721,649	3,889,635	828,467	747,035	678,710	554,119	-149,757
German, Dutch & Scandinavian Langs	4,199,379	4,836,893	4,736,834	890,055	840,854	743,243	537,455	-146,812
French	7,096,011	7,763,240	7,039,792	1,810,737	1,796,551	1,674,544	-56,219	-136,193
Russian, Slavonic & E European Langs	1,334,289	1,584,585	2,374,161	239,301	140,382	118,990	1,039,872	-120,311
Italian	1,793,094	2,184,775	2,925,932	237,932	162,827	136,360	1,132,838	-101,572
Asian Studies	2,436,374	2,882,894	2,726,610	184,078	171,067	145,528	290,236	-38,550
Biological Sciences	58,144,624	64,194,089	52,719,441	17,967,485	19,205,002	17,955,728	-5,425,183	-11,758

Sports-related Subjects	5,132,780	4,402,112	4,763,965	1,835,627	1,556,273	1,828,113	-368,814	-7,514
Physiology	6,602,469	5,833,156	5,769,906	1,259,092	1,118,800	1,274,734	-832,563	15,643
Music	7,690,319	7,275,542	7,273,664	1,001,486	1,007,240	1,028,354	-416,655	26,868
Linguistics	4,173,233	4,147,672	3,631,367	682,368	692,261	717,283	-541,866	34,916
Statistics and Operational Research	8,613,261	8,198,457	7,256,988	1,276,671	1,267,695	1,340,649	-1,356,273	63,977
Middle Eastern and African Studies	2,509,210	2,600,674	1,445,195	151,522	234,306	228,709	-1,064,015	77,187
Drama, Dance and Performing Arts	4,708,609	3,362,509	4,163,019	834,636	673,940	943,447	-545,589	108,811
Earth Sciences	13,125,918	14,524,524	11,596,204	3,266,804	3,758,278	3,386,663	-1,529,714	119,858
Pure Mathematics	10,925,400	12,517,956	9,407,957	2,505,394	3,038,459	2,664,689	-1,517,442	159,296
History	27,410,614	27,584,522	24,209,581	6,371,754	6,661,459	6,545,838	-3,201,033	174,084
Hospital-based Clinical Subjects	56,389,899	63,355,600	49,538,788	9,698,112	10,892,517	9,895,278	-6,851,111	197,166
Applied Mathematics	16,162,308	17,780,933	13,119,029	2,529,853	3,008,994	2,759,605	-3,043,279	229,751
Mineral and Mining Engineering	1,905,772	2,491,134	1,231,077	712,749	1,267,676	976,218	-674,694	263,469
Clinical Laboratory Sciences	29,754,273	34,898,828	26,003,178	6,334,596	7,792,955	6,632,006	-3,751,095	297,410
Sociology	13,549,571	12,860,600	11,161,318	2,553,510	2,845,946	2,873,870	-2,388,252	320,360
History of Art, Architecture and Design	4,983,144	3,659,509	3,087,782	784,539	817,243	1,120,202	-1,895,363	335,663
Civil Engineering	11,520,953	12,745,816	10,294,350	4,680,419	5,643,587	5,022,404	-1,226,603	341,986
Pharmacy	10,902,075	11,294,908	8,996,376	2,818,934	3,363,052	3,175,779	-1,905,699	356,846
Politics and International Studies	19,202,557	17,135,132	16,008,209	3,313,177	3,407,222	3,686,353	-3,194,348	373,176
European Studies	8,588,215	7,928,727	6,572,122	1,680,030	2,028,125	2,055,832	-2,016,093	375,802
Built Environment	9,604,101	7,626,183	7,731,421	2,739,817	2,689,988	3,175,877	-1,872,680	436,060
Veterinary Science	6,128,350	7,003,364	4,962,523	4,766,582	5,912,504	5,208,023	-1,165,828	441,441
Theology, Divinity and Religious Studies	5,936,860	6,055,413	4,303,875	2,162,295	2,775,741	2,653,404	-1,632,985	491,109
Celtic Studies	269,763	311,291	200,447	1,575,732	2,438,480	2,070,279	-69,316	494,547
Art and Design	32,758,125	20,884,082	27,773,568	7,303,589	5,175,555	7,798,773	-4,984,557	495,185
Communication, Cultural & Media Studies	4,790,783	3,007,062	2,631,575	856,305	946,538	1,402,767	-2,159,208	546,461
Social Work	4,885,822	3,351,614	2,862,819	1,325,820	1,448,412	1,980,624	-2,023,003	654,804
Agriculture	9,885,111	7,127,764	7,965,798	5,246,861	4,429,893	5,934,465	-1,919,313	687,604
English Language and Literature	24,047,915	26,851,410	19,181,372	5,921,000	7,689,563	6,716,735	-4,866,543	795,736
Electrical and Electronic Engineering	20,419,312	21,737,456	16,028,591	6,547,316	8,130,343	7,468,689	-4,390,721	921,373
Town and Country Planning	4,796,593	3,424,550	2,517,728	1,950,905	2,564,872	3,247,231	-2,278,865	1,296,325
Psychology	23,862,422	23,908,259	17,992,713	6,846,548	8,671,674	8,460,311	-5,869,708	1,613,763
Computer Science	36,199,698	32,306,188	28,336,525	10,995,960	11,512,645	12,727,752	-7,863,173	1,731,793
Other Studies & Profs Allied to Medicine	17,319,321	12,246,388	9,731,462	3,981,178	5,086,415	6,313,364	-7,587,859	2,332,186
Totals	930,000,000	930,000,000	930,000,000	218,000,000	218,000,000	218,000,000	94,488,145* (10.16%)	16,810,655* 7.71%)

Subject areas are sorted in ascending order according to the values in the final column

* Given the zero-sum nature of moving from one funding model to the other, these two totals are the sum of the positive values in the columns above (and the negative of the sum of the negative values in those columns). These numbers indicate the aggregate gains of the winners and the aggregate losses of the losers.

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The data utilised in this analysis was provided in electronic form as part of the SHEFC circular letter above.