

High correlation is not the whole story: a further cautionary note on the use of simple metrics to determine QR allocations

Peter Diggle and Amanda Chetwynd
(Lancaster University)

22 June 2006

1. Introduction

Section 4 of the government report, *Science and Innovation Investment Framework 2004-14: Next Steps*, henceforth SIIF, raised the possibility that the current method of allocating QR funding to universities, based on RAE grades, could be replaced by a so-called metrics approach, based on research grant income. The SIIF report demonstrated that at the institutional level, actual and metric-based 2002/03 QR allocations were strongly correlated ($r = 0.979$, $r^2 = 0.958$).

In our earlier report, dated 3 April 2006, we examined the relationship between institution-level 2002/03 QR allocations and two metrics-based allocations, one based on research grant income as in SIIF, and one based on numbers of PhD completions. Our conclusions at that time were:

1. the high correlation between QR and metrics-based allocations is largely an automatic consequence of the wide variation amongst different institutions in the volume of their overall research activity; the alternative metric based on numbers of PhD completions also produced a high correlation with actual QR, but with some very substantial changes in the the two metrics-based allocations to individual institutions;
2. a metrics-based allocation model would need to be much more sophisticated than the model used in the SIIF report if it were to have any credibility within the HE sector, both in terms of the inputs to the model and the ways that such inputs are used for different subject-areas.

Following the recent publication of the consultation document, *Reform of Higher Education Research Assessment and Funding*, we have examined the relationship between actual 2003/03 QR and five proposed metrics-based models, A to E, at the level of current RAE Units of Assessment. The consultation document covers only STEM subjects (Science, Technology, Engineering, Mathematics and Medicine), which equate to the current UoA's 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 (see Table A1).

2. Data analysis

Our data are taken from the HEFCE web-site, www.hefce.ac.uk/research). These data give actual and modelled 2003/03 QR for all individual returns which were graded 3b or above in RAE2001. From this source, we divided actual and modelled QR for each return by the corresponding volumen measure (staff FTE), on the grounds that that the RAE seeks to measure research quality rather than quantity, and that it is presumably this assessment of quality which the metrics-based models are intended to emulate. The resulting data-set consisted of six measures of QR per unit volume (actual and models A to E) for 707 individual UoA returns covering 98 Institutions.

We then carried out two simple analyses of the data as follows:

2.1 *Correlation matrices*

For each UoA, we calculated the correlations between all pairs of the six different allocations per unit volume. The resulting 6 by 6 matrices are shown in the Appendix, Table A2. Briefly, they show the following.

2.1.1 Correlations between pairs of modelled allocations are mostly very high.

2.1.2 Correlations between actual QR and *any* of the modelled allocations are typically of the order of 0.6 or less, and are even negative in some cases. This represents rather poor predictive performance; the proportion of the variation in actual QR which is captured by a model is given by the square of the correlation coefficient.

2.2. *Scatterplots*

For each UoA, we plotted each of the five modelled allocations against actual QR allocations. The results are shown in the Appendix, Figure A1, in which we have highlighted 94 Group universities in blue, and Lancaster University in red. The diagonal line on each plot is the line of equality. The plots confirm the poor performance of all five models as predictors of actual QR allocations at UoA level and underline the fact that many of the discrepancies between modelled and actual allocations are very large indeed.

As a not untypical example, consider the results for UoA 24 (Statistics and Operational Research) under model C. Figure 1 shows the scatterplot of actual against modelled QR per FTE. Note that the variation in actual QR within each RAE2001 grade is negligible. In contrast, the modelled QR values show very wide variation within RAE2001 grades as summarised in Table 1; for example RAE Grade 5 returns have modelled QR per unit volume varying between £3,669 and £42,998.

3. Conclusions

3.1. The Q in QR stands for quality, not quantity. Any replacement for the RAE should therefore stand up to scrutiny with regard to its implications for QR allocations per unit volume.

3.2. As already acknowledged implicitly by the restriction to STEM subjects in the HEFCE consultation document, different measures of quality are appropriate in different subject areas. Any replacement for the RAE should therefore stand up to scrutiny with regard to its implications for QR allocations *within* each UoA.

3.3. If the objective of a metrics-based model is to emulate the QR allocations currently determined by RAE results, all five proposed models fail spectacularly.

3.4. Whilst it is arguable that RAE results fall some way short of a “gold standard” for measuring research quality, a metrics-based system which, in a not untypical example, produces allocations per FTE which vary between £3669 and £42998 *within* RAE2001 grade 5 units is scarcely credible.

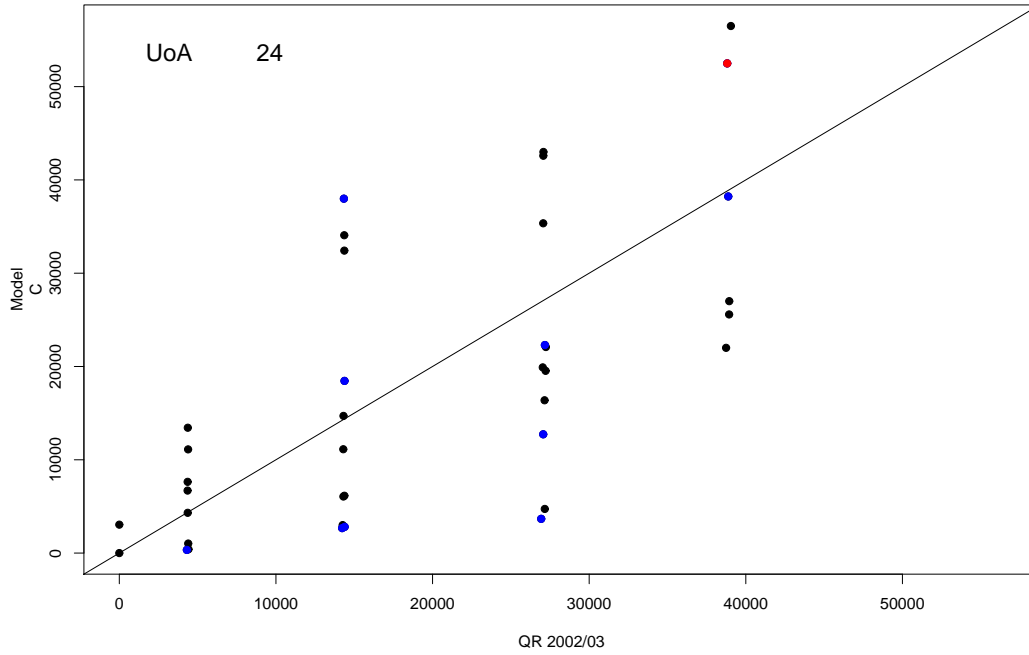


Figure 1: Actual against modelled (model C) 2002/03 QR allocations for UoA 24 (Statistics and Operational Research). Lancaster University is highlighted in red, other members of the 94 Group in blue.

Table 1: Ranges of modelled allocations (model C) within each RAE2001 grade, for UoA 24 (Statistics and Operational Research).

RAE2001	Range of modelled QR	
3b	0	3046
3a	340	13436
4	2675	37990
5	3669	42998
5*	21999	56497

Appendix

Table A1. List of UoA's included in the HEFCE data-set.

UoA	Subject area
1	Clinical Laboratory Sciences
2	Community-based Clinical Subjects
3	Hospital-based Clinical Subjects
4	Clinical Dentistry
5	Pre-Clinical Studies
6	Anatomy
7	Physiology
8	Pharmacology
9	Pharmacy
10	Nursing
11	Other Studies and Professions Allied to Medicine
14	Biological Sciences
15	Agriculture
16	Food Science and Technology
17	Veterinary Science
18	Chemistry
19	Physics
20	Earth Sciences
21	Environmental Sciences
22	Pure Mathematics
23	Applied Mathematics
24	Statistics and Operational Research
25	Computer Science
26	General Engineering
27	Chemical Engineering
28	Civil Engineering
29	Electrical and Electronic Engineering
30	Mechanical Aeronautical and Manufacturing Engineering
31	Mineral and Mining Engineering
32	Metallurgy and Materials

Table A2. Correlation matrices for actual and five modelled 2002/03 QR allocations within each UoA included in the HEFCE data-set. Note that the results for UoA 17 (Veterinary Science) and for UoA 31 (Mineral and Mining Engineering) are meaningless: for UoA 17, all units were given RAE2001 Grade 5; for UoA 31, only two units were submitted.

UoA 1

	QR	A	B	C	D	E
QR	1.000	0.578	0.578	0.578	0.688	0.565
A	0.578	1.000	1.000	1.000	0.822	0.982
B	0.578	1.000	1.000	1.000	0.822	0.982
C	0.578	1.000	1.000	1.000	0.822	0.982
D	0.688	0.822	0.822	0.822	1.000	0.830
E	0.565	0.982	0.982	0.982	0.830	1.000

UoA 2

	QR	A	B	C	D	E
QR	1.000	0.378	0.379	0.378	0.292	0.332
A	0.378	1.000	1.000	1.000	0.898	0.987
B	0.379	1.000	1.000	1.000	0.897	0.987
C	0.378	1.000	1.000	1.000	0.898	0.987
D	0.292	0.898	0.897	0.898	1.000	0.872
E	0.332	0.987	0.987	0.987	0.872	1.000

UoA 3

	QR	A	B	C	D	E
QR	1.000	0.623	0.623	0.623	0.579	0.563
A	0.623	1.000	1.000	1.000	0.938	0.977
B	0.623	1.000	1.000	1.000	0.938	0.977
C	0.623	1.000	1.000	1.000	0.938	0.977
D	0.579	0.938	0.938	0.938	1.000	0.898
E	0.563	0.977	0.977	0.977	0.898	1.000

UoA 4

	QR	A	B	C	D	E
QR	1.000	0.580	0.580	0.580	0.471	0.657
A	0.580	1.000	1.000	1.000	0.842	0.937
B	0.580	1.000	1.000	1.000	0.842	0.937
C	0.580	1.000	1.000	1.000	0.842	0.937
D	0.471	0.842	0.842	0.842	1.000	0.711
E	0.657	0.937	0.937	0.937	0.711	1.000

UoA 5

	QR	A	B	C	D	E
QR	1.000	0.126	0.127	0.126	0.249	0.190
A	0.126	1.000	1.000	1.000	0.832	0.995
B	0.127	1.000	1.000	1.000	0.832	0.995
C	0.126	1.000	1.000	1.000	0.832	0.995
D	0.249	0.832	0.832	0.832	1.000	0.874
E	0.190	0.995	0.995	0.995	0.874	1.000

UoA 6

	QR	A	B	C	D	E
QR	1.000	0.683	0.683	0.683	0.728	0.725
A	0.683	1.000	1.000	1.000	0.714	0.992
B	0.683	1.000	1.000	1.000	0.714	0.992
C	0.683	1.000	1.000	1.000	0.714	0.992
D	0.728	0.714	0.714	0.714	1.000	0.686
E	0.725	0.992	0.992	0.992	0.686	1.000

UoA 7

	QR	A	B	C	D	E
QR	1.000	0.288	0.288	0.288	0.177	0.218
A	0.288	1.000	1.000	1.000	0.859	0.967
B	0.288	1.000	1.000	1.000	0.859	0.968
C	0.288	1.000	1.000	1.000	0.859	0.967
D	0.177	0.859	0.859	0.859	1.000	0.809
E	0.218	0.967	0.968	0.967	0.809	1.000

UoA 8

	QR	A	B	C	D	E
QR	1.000	0.747	0.747	0.747	0.711	0.713
A	0.747	1.000	1.000	1.000	0.899	0.982
B	0.747	1.000	1.000	1.000	0.899	0.982
C	0.747	1.000	1.000	1.000	0.899	0.982
D	0.711	0.899	0.899	0.899	1.000	0.920
E	0.713	0.982	0.982	0.982	0.920	1.000

UoA 9

	QR	A	B	C	D	E
QR	1.000	0.493	0.493	0.493	0.504	0.528
A	0.493	1.000	1.000	1.000	0.896	0.963
B	0.493	1.000	1.000	1.000	0.896	0.963
C	0.493	1.000	1.000	1.000	0.896	0.963
D	0.504	0.896	0.896	0.896	1.000	0.956
E	0.528	0.963	0.963	0.963	0.956	1.000

UoA 10

	QR	A	B	C	D	E
QR	1.000	0.494	0.463	0.494	0.258	0.509
A	0.494	1.000	0.996	1.000	0.877	0.994
B	0.463	0.996	1.000	0.996	0.910	0.985
C	0.494	1.000	0.996	1.000	0.877	0.994
D	0.258	0.877	0.910	0.877	1.000	0.846
E	0.509	0.994	0.985	0.994	0.846	1.000

UoA 11

	QR	A	B	C	D	E
QR	1.000	0.536	0.535	0.536	0.484	0.470
A	0.536	1.000	1.000	1.000	0.944	0.987
B	0.535	1.000	1.000	1.000	0.944	0.987
C	0.536	1.000	1.000	1.000	0.944	0.987
D	0.484	0.944	0.944	0.944	1.000	0.941
E	0.470	0.987	0.987	0.987	0.941	1.000

UoA 14

	QR	A	B	C	D	E
QR	1.000	0.688	0.688	0.688	0.675	0.638
A	0.688	1.000	1.000	1.000	0.949	0.982
B	0.688	1.000	1.000	1.000	0.949	0.982
C	0.688	1.000	1.000	1.000	0.949	0.982
D	0.675	0.949	0.949	0.949	1.000	0.943
E	0.638	0.982	0.982	0.982	0.943	1.000

UoA 15

	QR	A	B	C	D	E
QR	1.000	-0.182	-0.181	-0.182	0.166	-0.184
A	-0.182	1.000	1.000	1.000	0.805	1.000
B	-0.181	1.000	1.000	1.000	0.807	1.000
C	-0.182	1.000	1.000	1.000	0.805	1.000
D	0.166	0.805	0.807	0.805	1.000	0.801
E	-0.184	1.000	1.000	1.000	0.801	1.000

UoA 16

	QR	A	B	C	D	E
QR	1.000	-0.361	-0.377	-0.361	-0.228	-0.361
A	-0.361	1.000	1.000	1.000	0.887	1.000
B	-0.377	1.000	1.000	1.000	0.885	1.000
C	-0.361	1.000	1.000	1.000	0.887	1.000
D	-0.228	0.887	0.885	0.887	1.000	0.895
E	-0.361	1.000	1.000	1.000	0.895	1.000

UoA 17

	QR	A	B	C	D	E
QR	1.000	0.700	0.700	0.700	1.000	0.693
A	0.700	1.000	1.000	1.000	0.700	0.999
B	0.700	1.000	1.000	1.000	0.700	0.999
C	0.700	1.000	1.000	1.000	0.700	0.999
D	1.000	0.700	0.700	0.700	1.000	0.693
E	0.693	0.999	0.999	0.999	0.693	1.000

UoA 18

	QR	A	B	C	D	E
QR	1.000	0.789	0.789	0.789	0.725	0.782
A	0.789	1.000	1.000	1.000	0.929	0.998
B	0.789	1.000	1.000	1.000	0.929	0.998
C	0.789	1.000	1.000	1.000	0.929	0.998
D	0.725	0.929	0.929	0.929	1.000	0.933
E	0.782	0.998	0.998	0.998	0.933	1.000

UoA 19

	QR	A	B	C	D	E
QR	1.000	0.644	0.644	0.644	0.537	0.643
A	0.644	1.000	1.000	1.000	0.929	1.000
B	0.644	1.000	1.000	1.000	0.929	1.000
C	0.644	1.000	1.000	1.000	0.929	1.000
D	0.537	0.929	0.929	0.929	1.000	0.931
E	0.643	1.000	1.000	1.000	0.931	1.000

UoA 20

	QR	A	B	C	D	E
QR	1.000	0.383	0.382	0.383	0.351	0.371
A	0.383	1.000	1.000	1.000	0.897	1.000
B	0.382	1.000	1.000	1.000	0.897	0.999
C	0.383	1.000	1.000	1.000	0.897	1.000
D	0.351	0.897	0.897	0.897	1.000	0.892
E	0.371	1.000	0.999	1.000	0.892	1.000

UoA 21

	QR	A	B	C	D	E
QR	1.000	0.359	0.359	0.359	0.335	0.363
A	0.359	1.000	1.000	1.000	0.934	1.000
B	0.359	1.000	1.000	1.000	0.935	1.000
C	0.359	1.000	1.000	1.000	0.934	1.000
D	0.335	0.934	0.935	0.934	1.000	0.935
E	0.363	1.000	1.000	1.000	0.935	1.000

UoA 22

	QR	A	B	C	D	E
QR	1.000	0.491	0.492	0.491	0.411	0.490
A	0.491	1.000	1.000	1.000	0.781	1.000
B	0.492	1.000	1.000	1.000	0.781	0.999
C	0.491	1.000	1.000	1.000	0.781	1.000
D	0.411	0.781	0.781	0.781	1.000	0.773
E	0.490	1.000	0.999	1.000	0.773	1.000

UoA 23

	QR	A	B	C	D	E
QR	1.000	0.479	0.481	0.479	0.531	0.482
A	0.479	1.000	1.000	1.000	0.849	0.999
B	0.481	1.000	1.000	1.000	0.849	0.999
C	0.479	1.000	1.000	1.000	0.849	0.999
D	0.531	0.849	0.849	0.849	1.000	0.848
E	0.482	0.999	0.999	0.999	0.848	1.000

UoA 24

	QR	A	B	C	D	E
QR	1.000	0.641	0.641	0.641	0.657	0.626
A	0.641	1.000	1.000	1.000	0.935	0.999
B	0.641	1.000	1.000	1.000	0.935	0.999
C	0.641	1.000	1.000	1.000	0.935	0.999
D	0.657	0.935	0.935	0.935	1.000	0.930
E	0.626	0.999	0.999	0.999	0.930	1.000

UoA 25

	QR	A	B	C	D	E
QR	1.000	0.576	0.576	0.576	0.516	0.577
A	0.576	1.000	1.000	1.000	0.954	1.000
B	0.576	1.000	1.000	1.000	0.954	1.000
C	0.576	1.000	1.000	1.000	0.954	1.000
D	0.516	0.954	0.954	0.954	1.000	0.954
E	0.577	1.000	1.000	1.000	0.954	1.000

UoA 26

	QR	A	B	C	D	E
QR	1.000	0.540	0.545	0.540	0.622	0.504
A	0.540	1.000	1.000	1.000	0.908	0.994
B	0.545	1.000	1.000	1.000	0.914	0.994
C	0.540	1.000	1.000	1.000	0.908	0.994
D	0.622	0.908	0.914	0.908	1.000	0.897
E	0.504	0.994	0.994	0.994	0.897	1.000

UoA 27

	QR	A	B	C	D	E
QR	1.000	0.763	0.763	0.763	0.586	0.764
A	0.763	1.000	1.000	1.000	0.935	1.000
B	0.763	1.000	1.000	1.000	0.935	1.000
C	0.763	1.000	1.000	1.000	0.935	1.000
D	0.586	0.935	0.935	0.935	1.000	0.931
E	0.764	1.000	1.000	1.000	0.931	1.000

UoA 28

	QR	A	B	C	D	E
QR	1.000	0.639	0.639	0.639	0.656	0.638
A	0.639	1.000	1.000	1.000	0.938	1.000
B	0.639	1.000	1.000	1.000	0.938	1.000
C	0.639	1.000	1.000	1.000	0.938	1.000
D	0.656	0.938	0.938	0.938	1.000	0.939
E	0.638	1.000	1.000	1.000	0.939	1.000

UoA 29

	QR	A	B	C	D	E
QR	1.000	0.793	0.793	0.793	0.740	0.794
A	0.793	1.000	1.000	1.000	0.912	1.000
B	0.793	1.000	1.000	1.000	0.912	1.000
C	0.793	1.000	1.000	1.000	0.912	1.000
D	0.740	0.912	0.912	0.912	1.000	0.910
E	0.794	1.000	1.000	1.000	0.910	1.000

UoA 30

	QR	A	B	C	D	E
QR	1.000	0.345	0.345	0.345	0.358	0.342
A	0.345	1.000	1.000	1.000	0.948	0.999
B	0.345	1.000	1.000	1.000	0.948	0.999
C	0.345	1.000	1.000	1.000	0.948	0.999
D	0.358	0.948	0.948	0.948	1.000	0.946
E	0.342	0.999	0.999	0.999	0.946	1.000

UoA 31

	QR	A	B	C	D	E
QR	1	1	1	1	1	1
A	1	1	1	1	1	1
B	1	1	1	1	1	1
C	1	1	1	1	1	1
D	1	1	1	1	1	1
E	1	1	1	1	1	1

UoA 32

	QR	A	B	C	D	E
QR	1.000	0.735	0.735	0.735	0.624	0.739
A	0.735	1.000	1.000	1.000	0.942	1.000
B	0.735	1.000	1.000	1.000	0.942	1.000
C	0.735	1.000	1.000	1.000	0.942	1.000
D	0.624	0.942	0.942	0.942	1.000	0.943
E	0.739	1.000	1.000	1.000	0.943	1.000

Figure A1. Scatterplots of modelled against actual 2002/03 QR allocations for each UoA included in the HEFCE data-set, and for each of the proposed models A to E

Lancaster University is highlighted in red, other members of the 94 Group are highlighted in blue.

See overleaf for scatterplots.