

The Case for Growing STEMM Research Capacity in Wales

Yr Achos o Blaid Cynyddu Capasiti Ymchwil STEMM yng Nghymru

Stimulus paper

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Stimulus Paper Series

The Leadership Foundation is pleased to present this latest series of 'Stimulus Papers' which are intended to inform thinking, choices and decisions at institutional and system levels in UK higher education. The themes addressed fall into different clusters including higher education leadership, business models for higher education, leading the student experience and leadership and equality of opportunity in higher education. We hope these papers will stimulate discussion and debate, as well as giving an insight into some of the new and emerging issues relevant to higher education today.

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Foreword

A constant refrain in Wales over the past 20 years has been the claim that Welsh universities are underfunded in relation to their English or Scottish counterparts, especially since the rise of tuition fees (and hence income) in English universities.

Whatever the substance of that claim, there is no doubt that universities in Wales have gained a smaller proportion of research funding in relation to the size of its population over a number of years. Indeed, reading the regular accounts in the *Times Higher Education* of large grant allocations, one is struck by how few appear to be awarded to Welsh researchers. This new Leadership Foundation paper by Peter Halligan and Louise Bright analyses comparative data on research funding and seeks to understand the disparities, especially for STEMM (science, technology, engineering, medicine and mathematics) subjects.

Over the past two decades, fuelled by the disappointing results by Welsh universities in the first research assessment exercise in 1992, there have been successive attempts to create a policy framework through which Welsh research activity could be encouraged and intensified. There has been significant improvement since then, but despite a succession of initiatives, pump-priming and strong encouragement from government and the funding council, the Welsh share of research funding from STEMM subjects has remained stubbornly low. The authors of this paper offer some possible explanations; for example insufficient size of research units, staff deficits and a low concentration of researchers. Another reason, more difficult to explain, has been the low level of research applications. This in turn raises the issue of research leadership, and although this is not directly addressed, the findings seem to suggest the need for closer examination; indeed, it is noticeable that Wales gains much better research funding for the humanities and the social sciences, albeit on a small scale.

One question that inevitably follows is whether Welsh universities are generally too small, an argument often made by the Welsh Government. It is difficult to demonstrate a correlation between institutional size and research success as the evident success of relatively small institutions such as the LSE or St Andrews indicates, and it will take some time to discover whether recent institutional mergers, or partnership agreements in Wales, can deliver better outcomes.

It is important, as this paper argues, not to overstate the problem. While there is a demonstrable shortfall in research funding for Wales, it is misleading, according to the authors, to regard this as a proxy for overall research performance. The outcome of the research excellence framework in 2014 demonstrated a consistent level of improvement since 1992, and there are areas of outstanding performance.

Nevertheless, there is no doubt that Welsh universities generally could be in a better position. For example, Scottish universities have outperformed their benchmark by some distance and over many years; in 1991-92 Scotland gained 12.5% of research funding against Wales' 0.9% and has consistently gained more research funding than one would expect in relation to its population size. This may contribute to there being four Scottish universities in the world's top 200, according to the *Times Higher*, and none from Wales.

Given that Welsh universities have managed to improve their performance, despite the low level of research funding, one can only speculate how much better that performance might be if there were increased funding, together with enhanced research leadership, and how much greater the impact on the Welsh economy would be. While this paper raises important questions and encourages a much-needed debate, it also leaves us thinking, what next?

Leaders need access to good-quality data and analytics to understand the wider political context and to make informed strategic choices. Perhaps this historical and analytical study will provide the stimulus for policymakers, higher education leaders and the Leadership Foundation (among others) to consider these ideas within Wales and beyond.

Professor Sir Deian Hopkin

Rhagair

Un gân gyson yng Nghymru dros yr 20 mlynedd diwethaf yw'r honiad bod prifysgolion Cymru wedi'u tanariannu o'u cymharu â phrifysgolion Lloegr neu'r Alban, yn enwedig ers i ffoedd dysgu (ac felly incwm) gael eu codi ym mhrifysgolion Lloegr.

Beth bynnag yw sylwedd yr honiad, mae'n ddiau bod prifysgolion Cymru wedi ennill cyfran lai o'r cyllid ar gyfer ymchwil o'i chymharu â maint poblogaeth Cymru, a thros nifer o flynyddoedd. Yn wir, o ddarllen disgrifiadau rheolaidd y *Times Higher Education* o ddyraniadau grantiau mawr, mae'n drawiadol cyn lleied sy'n cael eu dosbarthu, i ymchwilwyr Cymru. Mae'r papur newydd hwn gan Peter Halligan a Louise Bright ar ran y Sefydliad Arweinyddiaeth yn dadansoddi data cymaradwy ar gyllid ymchwil ac yn ceisio deall yr anghysondebau, yn arbennig mewn pynciau STEM (gwyddoniaeth, technoleg, peirianeg, meddyginiaeth a mathemateg).

Dros y ddau ddegawd diwethaf, yn dilyn canlyniadau siomedig prifysgolion Cymru yn yr ymarfer asesu ymchwil cyntaf ym 1992, gwelwyd sawl ymgais i greu fframwaith polisi a allai hybu a dwysáu gwaith ymchwil yng Nghymru. Caed cryn welliant wedi bod ers hynny, ond er gwaethaf cyfres o fentrau, arian ysgogi ac anogaeth gref o du'r llywodraeth a'r cyngor cyllido, aros yn gymharol isel wnaeth cyfran Cymru o'r arian ymchwil mewn pynciau STEM. Mae awduron y papur hwn yn cynnig esboniadau posibl; er enghraifft maint annigonol unedau ymchwil, diffyg staff a diffyg crynodiad ymchwilwyr. Rheswm arall, sy'n anodd ei esbonio, yw lefel isel y ceisiadau am waith ymchwil. Mae hyn yn ei dro yn codi cwestiwn ynglŷn ag arweiniaeth ymchwil, ac er nad yw hyn wedi cael sylw uniongyrchol, yma, mae'r canfyddiadau fel petaen nhw'n awgrymu bod angen edrych yn fanylach; yn wir, mae'n amlwg bod Cymru'n sicrhau llawer gwell cyllid ar gyfer y dyniaethau a'r gwyddorau cymdeithasol, er ar raddfa lai wrth gwrs.

Un cwestiwn sy'n codi'n anochel yw a yw prifysgolion Cymru'n rhy fach yn gyffredinol, dadl sy'n cael ei chyflwyno'n aml gan Lywodraeth Cymru. Mae'n anodd dangos cydberthyniad rhwng maint sefydliad a llwyddiant mewn ymchwil, fel y gwelir yn llwyddiant amlwg sefydliadau cymharol fach fel yr LSE neu St Andrews, ac mae angen amser i ddarganfod a fydd yr uniadau diweddar ymysg y sefydliadau, neu gytundebau partneriaeth yng Nghymru, yn gallu sicrhau canlyniadau gwell.

Fel y dadleuir yn y papur hwn, mae'n bwysig peidio â gor-ddweud y broblem. Mae modd dangos bod yna ddiffyg cyllid at ymchwil yng Nghymru ond, yn ôl yr awduron, camarweiniol yw edrych ar hynny fel adlewyrchiad o'r perfformiad cyffredinol mewn ymchwil. Dangosodd canlyniadau fframwaith rhagoriaeth ymchwil 2014 lefel gyson o welliant ers 1992, a meysydd lle mae'r perfformiad yn eithriadol.

Serch hynny, mae'n sicr y gallai prifysgolion Cymru yn gyffredinol fod mewn sefyllfa well. Er enghraifft, mae prifysgolion yr Alban wedi perfformio gryn dipyn yn well na'u meincnod a hynny ers blynyddoedd lawer; ym 1991-92 enillodd yr Alban 12.5% o'r cyllid ymchwil o'i gymharu â'r 0.9% a gafodd Cymru, ac mae wedi sicrhau mwy o gyllid ymchwil yn gyson nag a ddisgwylid o'i gymharu â maint y boblogaeth. Mae'n bosibl bod hyn yn cyfrannu at y ffaith bod gan yr Alban bedair prifysgol yn y 200 gorau yn y byd, yn ôl y *Times Higher*, a dim un gan Gymru.

O gofio bod prifysgolion Cymru wedi llwyddo i wella'u perfformiad, er gwaethaf lefel isel y cyllid ymchwil, ni allwn ond dyfalu faint yn well fyddai'r perfformiad pe bai ganddi gyllid uwch, a gwell arweinyddiaeth mewn ymchwil, a faint yn well fyddai'r effaith ar economi Cymru. Er bod y papur hwn yn codi cwestiynau pwysig ac yn hybu trafodaeth y mae angen mawr amdani, mae hefyd yn ein gadael i bendroni, beth nesaf?

Mae ar arweinwyr angen data a dadansoddiadau o safon er mwyn deall y cyd-destun gwleidyddol ehangach a gwneud dewisiadau strategol gwybodus. Efallai y bydd yr astudiaeth hanesyddol a dadansoddol hon yn rhoi symbyliad i wneuthurwyr polisi, arweinwyr addysg uwch a'r Sefydliad Arweinyddiaeth (ymhlith eraill) ystyried y syniadau hyn yng Nghymru a'r tu hwnt.

Yr Athro Syr Deian Hopkin

Executive summary

Better metrics do not of themselves deliver better outcomes. You can't fatten a pig by weighing it. But if you don't have some means of weighing it, you may find yourself unable to persuade others that it's as fat as you believe.¹

In the early 1990s, concerns were raised about the performance of the Welsh research base when compared with that of other UK countries. Underlying these concerns was Wales's relatively poor showing in the early research assessment exercises (RAE) and its low capture of competitive UK research council (RC) funding. The Welsh Office and newly formed Higher Education Funding Council for Wales (HEFCW) placed particular emphasis on securing a greater proportion of the UK's highly competitive RC funding, and on improving the quality of research carried out by the higher education sector.

With this in mind, HEFCW and subsequently the new Welsh Assembly Government (WAG) adopted 5% (based on standard population share) of the UK's total RC income as one of the sector's stretching research targets and key indicators of Welsh sector performance. To increase RC income and overcome the perceived fragmentation of research efforts in Wales through better coordination and cooperation, WAG adopted a series of strategies directed at supporting research management and greater collaboration between institutions.

Improving RC grant capture became a key target for the Welsh Government and HEFCW during the first decade of devolution. The expectation was that increased research collaboration, better research management and strategic research leadership would help grow Wales's standard share of this competitive funding. Achieving this population share of RC income was also seen as an important step in stimulating economic growth.

This paper provides a selective, historical overview of the main reasons why, despite a range of initiatives over the past 20 years, this income target was never achieved. We argue that Welsh universities secured proportionally less research income from the high-spending science and medical research councils, in large part due to the historical shortfall of academic science and medical researchers working in science, technology, engineering, mathematics and medicine (STEMM) in Wales.

What would it take for Wales's standard share of total RC income to increase to 5%? The paper provides a current estimate of the STEMM staff shortfall in Wales. Compared with its standard academic population share, Welsh universities in 2012/13 show a collective research staff shortfall of some 0.5%, whereas Scotland has over 2.4% more than its standard share. Most of this staff deficit of 600 for Wales involved STEMM-related disciplines with the largest subject staff deficits being in clinical medicine, biosciences, physics, electrical and computer engineering, mechanical, engineering, and maths. We also show how reliance on Wales's UK share contributed to a misleading and reputationally damaging perception of the Welsh research performance. When one employs established bibliometric *output* measures of research productivity and citation impact, it is clear that the quality of Wales's research performance has improved significantly over the past decade when compared to similar-sized countries.

Recognising the need to address the STEMM capacity deficit, the Welsh Government launched the *Sêr Cymru* initiative in 2012, which contributed £50m towards building a stronger science base in Wales capable of supporting economic and national development. While welcome, further investment will be required if the critical mass required to build sufficient capacity to win greater and sustained competitive funding is to be achieved. Although all Welsh universities engage in research, only a small number have the research capability to grow their science base significantly.

Building on the 2012 *Sêr Cymru* initiative, the current chief scientific adviser for Wales is leading initiatives focused on building STEMM staff capacity. Ensuring that Wales has the future research capacity to win greater competitive (including RC) funding will require strong leadership and a long-term strategy that manages to balance sustainable research capacity with high-quality teaching provision.

In this paper, it has not been possible to cover all aspects of this story, including the political challenges surrounding the sector reconfiguration in Wales². However, it will (we hope) stimulate discussion and reflection for those charged with managing and leading large sectoral and institutional change. In particular, we hope it highlights the need to ensure sufficient research capacity before committing to outcome targets.

Crynodeb gweithredol

Nid yw metrigau gwell ar eu pen eu hunain yn sicrhau deilliannau gwell. Fyddwch chi ddim yn pesgi mochyn drwy ei bwysu. Ond os nad oes gennych y modd i'w bwysu, efallai na fyddwch yn gallu darbwyllo pobl eraill bod y mochyn mor dew ag yr ydych chi'n credu.³

Yn gynnar yn y 1990au, codwyd pryderon ynghylch perfformiad sylfaen ymchwil Cymru o'i chymharu â gwledydd eraill y Deyrnas Unedig. Sail llawer o'r pryderon hyn oedd canlyniadau cymharol wael Cymru yn yr ymarferion asesu ymchwil (RAE) cynnar a lefel isel yr arian cystadleuol yr oedd Cymru'n llwyddo i'w sicrhau gan gynghorau ymchwil (RC) y Deyrnas Unedig. Roedd y Swyddfa Gymreig a'r Cyngor Cyllido Addysg Uwch (CCAUC) a oedd newydd gael ei sefydlu yn gosod pwysais penodol ar sicrhau cyfran fwy o arian cystadleuol iawn cynghorau ymchwil y Deyrnas Unedig, ac ar wella ansawdd ymchwil sector addysg uwch.

O gofio hyn, mabwysiadodd CCAUC ac wedyn Llywodraeth newydd Cynulliad Cymru 5% (wedi'i seilio ar y gyfran safonol o'r boblogaeth) o gyfanswm incwm cynghorau ymchwil y Deyrnas Unedig yn un o dargedau ymchwil ymestynnol y sector ac un o ddangosyddion perfformiad y sector Cymreig. Er mwyn cynyddu incwm o'r cynghorau ymchwil a goresgyn yr argraff mai tameidiog oedd ymdrechion ymchwil Cymru drwy well cydlynu a chydweithredu, mabwysiadodd Llywodraeth Cynulliad Cymru gyfres o strategaethau wedi'u hanelu at gefnogi rheolaeth ymchwil a gwell cydweithredu rhwng y sefydliadau.

Daeth cynyddu'r gyfran o grantiau'r cynghorau ymchwil a enillid yn darged allweddol i Lywodraeth Cymru a CCAUC yn ystod degawd cyntaf datganoli. Disgwylid y byddai mwy o ymchwil gydweithredol, gwell rheolaeth mewn ymchwil ac arweinyddiaeth strategol ar gyfer ymchwil yn helpu i gynyddu cyfran safonol Cymru o'r arian cystadleuol hwn. Roedd sicrhau cyfran o incwm y cynghorau ymchwil a fyddai'n cyfateb i faint y boblogaeth yn cael ei weld fel cam pwysig at ysgogi twf yn yr economi.

Mae'r papur hwn yn rhoi trosolwg hanesyddol, dewisol ar y prif resymau na chyrrhaeddwyd y targed incwm, er gwaethaf amryw o fentrau dros yr 20 mlynedd diwethaf. Rydym yn dadlau bod prifysgolion Cymru wedi sicrhau llai o gyfran incwm ymchwil gan y cynghorau ymchwil wyddonol a meddygol sy'n gwario symiau mawr i raddau helaeth oherwydd y diffyg hanesyddol o ran ymchwilwyr gwyddonol a meddygol academiaidd a oedd yn gweithio mewn gwyddoniaeth, technoleg, peirianeg, mathemateg a meddygaeth (STEMM) yng Nghymru.

Mae'r papur hefyd yn rhoi amcangyfrif cyfredol o'r prinder staff STEMM yng Nghymru. O'u cymharu â'r gyfran safonol o'r boblogaeth, mae prifysgolion Cymru yn 2012/13 yn dangos prinder staff ymchwil rhyngddyn nhw o ryw 0.5%, lle mae gan yr Alban dros 2.4% yn fwy na'i chyfran safonol. Rydym yn dangos hefyd sut mae'r ddibyniaeth ar gyfran Cymru o'r Deyrnas Unedig wedi cyfrannu at argraff gamarweiniol a niweidiol o sylfaen ymchwil Cymru. O ddefnyddio mesurau bibliometrig sefydledig o allbwn cynhyrchedd ymchwil ac effaith dyfyniadau, mae'n eglur bod ansawdd perfformiad ymchwil Cymru wedi gwella'n arwyddocaol dros y degawd diwethaf o'i chymharu â gwledydd o faint tebyg.

Gan gydnabod bod angen mynd i'r afael â'r diffyg capasiti mewn STEMM, lansiodd llywodraeth Cymru fenter Sêr Cymru yn 2012, gan gyfrannu £50m at greu sylfaen ymchwil cryfach yng Nghymru a all gynnal ei datblygiad economaidd a chenedlaethol. Er bod y buddsoddiad hwn yn dderbyniol, mae angen rhagor er mwyn sicrhau'r màs critigol sy'n angenrheidiol er mwyn creu digon o gapasiti i ennill mwy o gyllid cystadleuol cynaliadwy. Er bod holl brifysgolion Cymru yn gwneud ymchwil, nifer fach yn unig sydd â'r gallu mewn ymchwil i ehangu eu sylfaen gwyddonol yn arwyddocaol.

Gan adeiladu ar fenter Sêr Cymru, mae prif gynghorydd gwyddonol Cymru ar hyn o bryd wrthi'n arwain mentrau sy'n canolbwyntio ar adeiladu capasiti staff STEMM. Er hynny, i sicrhau bod gan Gymru y capasiti ymchwil yn y dyfodol i ennill mwy o arian cystadleuol (gan gynnwys arian y cynghorau ymchwil) a'r manteision ar gyfer ymchwil a fydd yn dilyn, bydd angen arweinyddiaeth gref, buddsoddi'n barhaus mewn ymchwilwyr yn y prifysgolion a strategaeth hirdymor yn y sector sy'n cydbwysu gallu ymchwil cynaliadwy â darpariaeth o safon mewn addysgu sy'n ateb galw cynyddol o du'r myfyrwyr.

Er nad yw wedi bod yn bosibl ymdrin â phob agwedd ar y stori, ac yn enwedig â'r heriau gwleidyddol ynglŷn ag ad-drefnu'r sector yng Nghymru⁴, gobeithio y bydd y papur hwn yn ysgogi trafod a myfyrion ymysg y rhai sy'n gyfrifol am reoli ac arwain newid yn y sector a'r sefydliadau, ac yn enwedig felly yr angen i asesu'r capasiti ymchwil yn ofalus cyn ymrwymo i dargedau ar gyfer allbynnau.

5
BIS 2014a

6
HM Treasury 2004; Health Economics Research Group, Office of Health Economics and RAND Europe 2008

7
Office of the Chief Scientist 2014

8
CaSE 2011

9
Evidence 2010

10
Altbach 2013

11
BIS 2014a p6

12
Evidence 2010

13
Scottish Government 2014

14
HM Treasury 2014

15
Million+ 2014, p3

Introduction: research universities and knowledge economies

The growth of knowledge-based societies built on research and innovation is widely regarded as a critical factor for global competitiveness and a key element of national government strategies intent on sustainable economic and social improvement⁵. In this regard, a vibrant research capacity in science, technology, engineering, mathematics (STEM) and medicine (STEMM) is considered imperative when growing a country's productivity and economic prosperity⁶.

In the US, scientific and technological advances produced roughly half of all economic growth over the last 50 years, and currently 75% of the fastest-growing occupations require STEM skills and knowledge⁷. STEM disciplines have been estimated to underpin at least a quarter of the UK's gross domestic product⁸. Investment in universities generally, and research in particular, has grown on the back of expectations about the transforming power that higher education can contribute to the economy through research-driven innovation⁹.

Although research-intensive universities constitute a minority of HEIs in most countries, they remain critical engines of the global knowledge economy¹⁰. Countries intent on seeking 'a competitive advantage in the global race for prosperity' consider the strength of their university research base as 'vital in pushing back the frontiers of human knowledge, supporting the wealth and welfare of the nation, [and] tackling current and future challenges'¹¹.

In addition to knowledge production, it is sometimes forgotten that the most pervasive aspect of this academic research base is the production of highly skilled people, trained in a knowledge-rich environment with relevant competencies and abilities across a diverse range of careers across the economy¹².

Not surprisingly, over the past decade, many large countries such as China, Canada, France, Germany and South Korea have strategically invested in their research-active universities with a view to accelerating the research and innovation cycle thought to be critical to economic growth and global competitiveness. Since the 1980s, there has been an increase in total gross expenditure on research and development (GERD) as a proportion of gross domestic product (GDP) across OECD countries, reflecting the increasing importance placed on R&D expenditure and innovation as key drivers of productivity and growth¹³.

In 2004, the UK's HM Treasury¹⁴ set a target to increase the UK's total R&D spend from 1.9% of GDP to 2.5% of GDP by 2014. Although successive UK governments 'have lauded the role of research in creating economic growth', the UK currently 'invests proportionately less in research and development than the OECD or European Union averages'¹⁵. Indeed, spending on R&D in the UK declined from 2.4% of GDP in 1981 to 1.7% of GDP in 2012. By contrast, many small European countries have been growing their R&D. Research intensity or GERD as a share of GDP provides a useful comparator for R&D investment between countries (Table 1).

Table 1: Comparison of GERD as a percentage of GDP in selected EU countries, 2012

EU country/region (population 2012)	GERD as a % of GDP 2012 (R&D intensity)
Finland (5.4m)	3.55
Sweden (9.5m)	3.41
Denmark (5.6m)	2.99
Austria (8.5m)	2.84
Slovenia (2.1m)	2.80
Estonia (1.3m)	2.18
England (53.5m)	2.00
Northern Ireland (1.8m)	2.00
Scotland (5.3m)	1.80
Ireland (4.7m)	1.72
Norway (5m)	1.65
Wales (3.1 m)	1.20

Source: Eurostat and ONS Statistical Bulletin 2012

In Wales, R&D investment is significantly below that of the UK and EU averages and has been for some time. Wales's average GERD was 1.1% between 2000 and 2008. Moreover, unlike England and larger EU countries where much of the R&D expenditure comes from business, the Welsh research base relies on its research universities to bring in nearly half of the country's R&D from higher education funding. At £569m in 2012, GERD in Wales amounted to 2.1% of the UK's total of £27bn.

Concentration of talented researchers

Although research income, league table rankings and bibliometric measures are all used to provide different forms of quantifiable, annual performance indicators that demonstrate the return on investment from research performance – the role played by research capacity (defined as the concentration of talented researchers) is not always recognised¹⁶:

Researchers are the engine that drives the progress of research, and so a country's research base is critically dependent on the individual contributions of the researchers affiliated with its research institutions. The prestige of individual researchers and laboratories, historic centres of research and top-ranking universities, serves not only to develop the next generation of researchers but also to attract excellent researchers from overseas.¹⁷

16

Evidence 2010; Russell International Excellence Group 2012

17

Elsevier 2013:20

18
Evidence 2010

19
The Royal Society 2010; Hooley, Kent, Williams, Hale, Oliver, Thompson, Mellors-Bourne, and Daley 2010; CST 2010; BIS 2014b

20
Salmi 2009

21
ibid:5

22
The Royal Society 2012

23
ibid:9

24
Economic Insights 2014:35

25
ONS 2014; Scottish Government 2013

26
Independent Commission on Funding & Finance for Wales 2010

27
Bruce 2012

The productivity of most research systems is delivered largely through the quality of the staff that make up that system: researchers, educators, postgraduate students, lab assistants and research managers. Without sufficient concentrations of intellectually active and creative individuals, research departments cannot perform competitively on a global scale. Equally, without sufficient funding, it is difficult to sustain world-class research¹⁸.

The need for a sufficient and sustainable number of qualified researchers with the ability to undertake, produce and disseminate scientific research outputs is well recognised¹⁹. Salmi²⁰ highlights the importance of researcher capacity when defining world-class research institutions, indicating that ‘the presence of a critical mass of top students and outstanding faculty’ is ‘the first and perhaps foremost determinant of excellence’. The capacity to carry out and produce research excellence at a level likely to bring in competitive, self-sustaining funding is largely determined by a ‘high concentration of talented faculty and students’²¹.

When discussing the key elements of research success, the importance of critical mass – defined in terms of the size of research units and concentration of talent capable of integrating international excellence, multidisciplinary capability and international collaboration – is typically considered to be a major driver by policymakers, funding councils and top-performing research universities²². While the literature examining the relationship between research outputs and critical mass remains mixed and shows differences according to discipline, there is evidence that supports critical mass thresholds, particularly in STEMM disciplines, which are more resource intensive and where physical proximity to others in their field is important²³. Notwithstanding differences in defining critical mass, there is ‘universal agreement that gathering together a “critical mass” of researchers in one place contributed to research excellence’²⁴.

Although sustained funding remains an obvious enabler for research excellence, growing the quality and volume of human talent that carries out the research, produces the publications (outputs), wins grant income (inputs), trains the next generation of researchers and contributes to economic and societal innovation, will always remain an essential element when growing a successful, sustainable university or national economy.

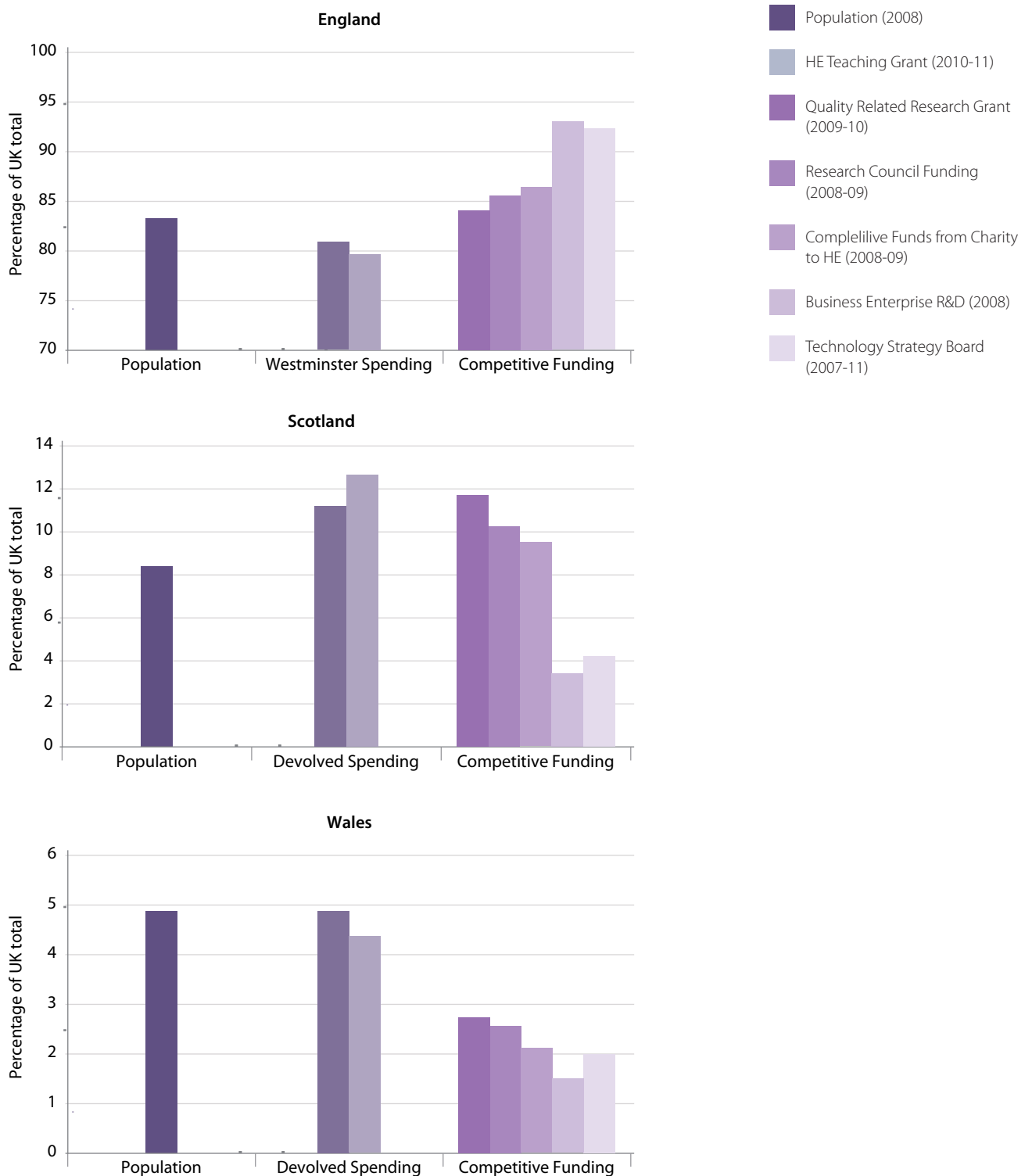
In search of Wales’s ‘standard share’ of UK research council funding

Population-based targets are commonly used when comparing the performance of the UK’s constituent countries in terms of share of public spending, employment, gross value-added (GVA), tax receipts and public sector net debt²⁵ (ONS, 2014; Scottish Government, 2013). Population is similarly an important factor when calculating the Barnett formula, used by successive UK governments to make changes to the funding allocations to Wales and the other devolved administrations²⁶. The approach is also commonly applied in government and public reports when comparing UK countries in terms of student numbers and research funding capture²⁷.

Below is an illustration from the 2011 CASE Policy report which shows (even allowing for the differential scaled range on the Y axis) the striking differences between Wales's relative capture of competitive funding and population.

28
CASE (2011)

Figure 1: Percentage of UK total for key STEM subjects for each of the UK nations with funding grouped as devolved spending, and competitive funding for R&D from public & private²⁸



29
CASE (2011) p8

30
Scottish Government, 2014;
British Council, 2013

31
Welsh Government (Jones
Report) 2009:9,14

32
Hughes 1999

33
National Assembly for Wales
2009:12

34
Welsh Assembly Government
2006:4

35
British Council 2013

36
Williams 2013:2

37
Jones 2011:7

Figure 1 shows that “Scotland invests well above its population share in HE teaching and in the research base” and secures “a high rate of competitive funding from the UK Research Councils, research charities and the EU”. Wales on the other hand “invests in HE at a proportionate rate for its population but “with public research funding slightly lower than expected. Unfortunately, it struggles to win its share of competitive funding and it has a relatively low level of private R&D investment”²⁹

Using this comparative approach, much has been made of the fact that Scottish universities secure a higher proportionate share of UK RC income than expected, based on its share of the population³⁰. By comparison, over the past decade, Welsh Government and media reports have raised concerns that Wales’s research output casts ‘an insufficient shadow on the world scene’ and that overall ‘Wales’s research base, particularly its science base, still lags behind the rest of the UK in terms of both quality and quantity’³¹. Behind such reports has been the tendency to focus on the sector’s inability to capture Wales’s ‘standard share’ (percentage of UK population) of competitive income from UK research councils³². Put simply, ‘Wales punches below its weight in terms of attracting research funding’³³, whereas ‘Scotland wins more than its share of UK Research Council funding and Wales wins less than its share of UK Research Council funding’³⁴.

The reason for focusing on UK research council funding is that all research universities compete with each other and with research institutes for this funding. Given the intense UK wide competition, income from research councils is used as a proxy to measure research quality³⁵.

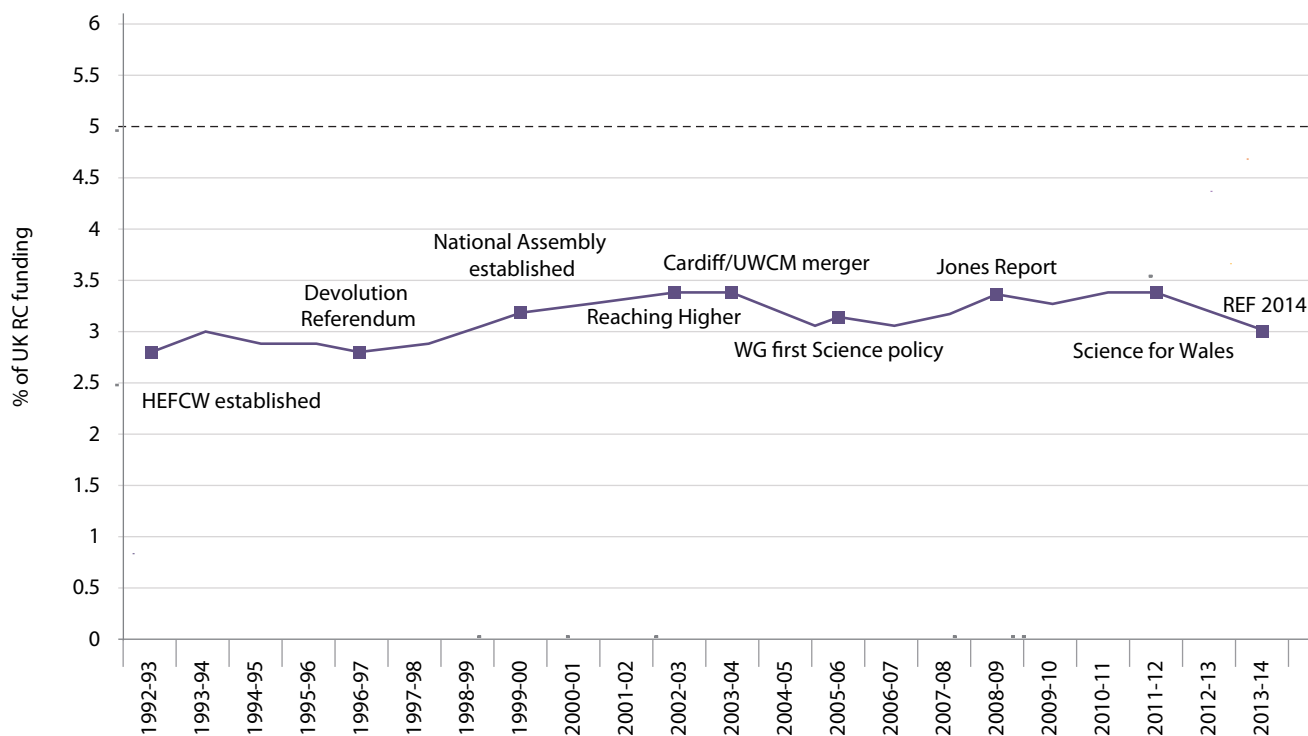
Securing Wales’s standard share of UK research council funding became a high-profile ambition and public target for the Welsh Assembly Government (WAG) soon after devolution, and the inability to achieve this target over the past decade has contributed in large part to the perception that Welsh universities were ‘under performing with regard to the quality and quantity of research’³⁶.

The origins of the Welsh Government’s ambition to secure Wales’s standard share of RC income can be traced back to the formation of HEFCW in 1993. A key element of the new funding council’s ambitious programme was to drive Welsh higher education research forward following poor performance in the 1989 and 1992 RAEs. Although the level of UK RC income comprised one of several higher education policy targets since devolution, it deserves attention for the following reasons:

1. Despite being a long-standing, high-profile priority in most education and science policy documents since devolution, this target was the cause of particular concern for successive Welsh government ministers and HEFCW since devolution. Increasing the level of RC income was also seen as an ‘important step in stimulating economic growth’³⁷.

- Notwithstanding a range of Welsh Office, HEFCW, Welsh Government and university initiatives designed to improve the overall quality of research, the RC income target has never been achieved in the past 20 years (Figure 2).

Figure 2: Percentage of UK RC funding won by Welsh HEIs, 1992-93 to 2013-14



- Over the past decade, this inability to reach the RC target has been used as a proxy for the sector’s overall research performance. This has resulted in a misleading and often one-sided picture of Wales’s university research base, which was reflected in the media and in public reports³⁸ suggesting that Welsh research was failing to reach its potential, particularly when compared with that of Scotland.
- The Welsh Government’s ambition to secure the standard share continues to be a high-profile target. In 2012, when Welsh Government³⁹ signalled its intention to accelerate efforts to create a more globally competitive and sustainable science-based economy for Wales, one of two key targets employed to judge the success of the new strategy (and substantial investment of £50m) was the ability of Welsh universities to achieve ‘at least parity in competitively funded research with the other UK nations’ and in particular to increase its share of UK research council funding from 3.3% in 2009/10 to 5% (Wales’s percentage of the UK population) by 2017⁴⁰.

38 Western Mail 2013; Times Higher Education 2012; Welsh Government (McCormick Report) 2009; Welsh Government (Jones Report) 2011; HEFCW 2011a

39 Welsh Government 2012

40 Science for Wales (2012) p12

41
Welsh Government 2010

42
HEFCW 2011a

43
Wales Audit Office 2009; Evans
2015

44
WAG 2002; Welsh Government
2009

45
Parken 2011:5

46
HEFCW 2009; 2011

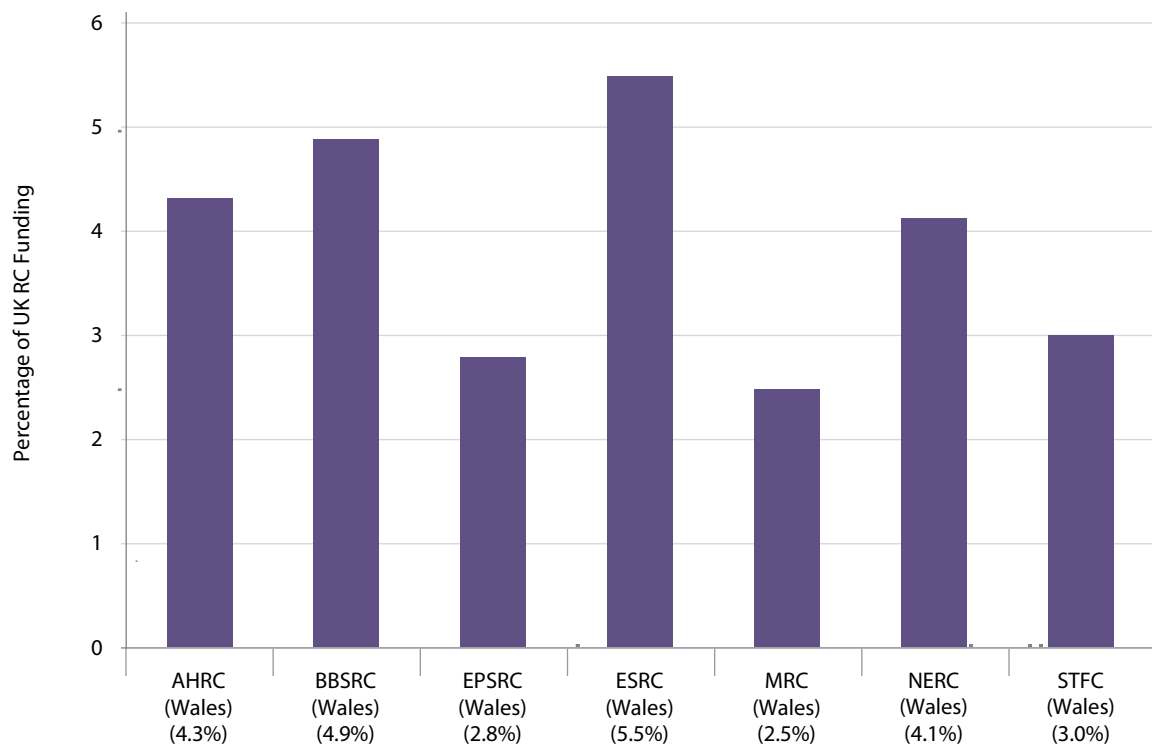
Notwithstanding the influence of historically low levels of R&D and Wales's relatively poor economic performance⁴¹, reasons put forward to explain the lack of success in winning more RC income have included (i) comparatively low levels of research council applications; (ii) poor research management; (iii) sector fragmentation and (iv) sub-optimal critical mass.

Wales was seen to have too many small-scale research units which collectively lacked the scale to compete successfully for research council and other sources of competitive external research income⁴². The recurrent issue of optimal size and shape of the higher education sector in Wales has a long history dating back to Welsh Office concerns in the early 1990s⁴³. As a result, since devolution, successive higher education strategies in Wales have pursued policies intended to encourage greater collaboration⁴⁴ on the assumption that this would also produce 'fewer, larger HEIs.. [and] a critical mass of expertise within subject areas, regional coherence in learning provision... Increased research income, greater international competitiveness, and a world class reputation as research intense universities⁴⁵.

While efforts by the Welsh Government and HEFCW over the past decade have resulted in a reduction of the number of HEIs in Wales from 13 to nine, the level of overall RC income has never achieved the standard share target.

Explaining the RC income shortfall

The main reason why Welsh universities were unable to secure their standard population share of total UK research council income over the past two decades was that Welsh universities secured proportionally less research income from the high-spending science and medical research councils⁴⁶. Figure 3 shows Wales's percentage of UK research council income based on a five-year average from the seven individual research councils. This shows that Wales is relatively good at securing funding from the AHRC, BBSRC and ESRC, but less so for income from the EPSRC, MRC and STFC.

Figure 3: Mean percentage of UK RC funding won by Welsh HEIs, 1992-93 to 2012-13

Accordingly, Welsh universities depend less on total RC funding for their research performance as an overall source of research income. On average, over the past eight years, UK RC funding amounted to 20% of the sector's total research income, with universities securing most of their research income from other sources including funding council quality-related (QR) funding, European Framework programmes, structural funds, Technology Strategy Board, National Health Service in Wales, European Union funds, charities and industry.

It is important however, to note that:

1. Welsh universities are relatively good at attracting research funding from the Economic and Social Research Council (ESRC) and the Arts and Humanities Research Council (AHRC). However, both of these councils distribute comparatively smaller proportions of the total RC funding.
2. In terms of overall success rates for RC grant applications (ie, the number of awards to applications made across all research councils), Wales's performance is not dissimilar to the UK average, suggesting that the quality of proposals was not a major contributing factor⁴⁷.

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Hughes 1999; HEFCW 2011a

48
Hughes 1999; Welsh Government
2006; HEFCW 2011b; LSW 2013

49
Williams 2013

50
ibid:6

51
Welsh Government 2013:28

52
Welsh Government 2013

The main reason for Wales's differential RC income capture was its comparatively small research base covering STEMM disciplines, all of which drew funding from the higher spending research councils. This was noted in several previous reviews and reports⁴⁸. According to Williams⁴⁹, one of the main reasons for the uneven distribution 'relates to the historical pattern of subject provision that evolved in Welsh universities primarily as a response to demand for degree courses'⁵⁰. Despite the university research base in Wales adopting a more strategic and efficient approach to research management over the past decade, Universities lacked sufficient STEMM capacity.

In 2012, recognising that Wales's significant science capacity shortfall was a key reason why Welsh universities had not achieved this long-standing income target, the Welsh Government provided a major investment of £50m. This was specifically to build a strong and dynamic science base that supports the economic and national development of Wales and had the explicit objective of raising Wales's share of the UK RC funding to 5%⁵¹ in support of the ambitious target articulated by the Welsh Government of building a world-class research system that would serve the interests of learners and the nation in the twenty-first century⁵².

Quest for the standard share: policy history (1993–2014)

The origins behind the quest for Wales's standard share of total UK RC income date back to the early 1990s and 'long-standing concerns over under-performance and weaknesses in the university and public sectors, obtrusively exposed in comparisons made with England and Scotland'⁵³. This need to bring about improved performance in the Welsh research base was highlighted at a major conference in Cardiff in 1993 organised by the newly formed Higher Education Funding Council for Wales (HEFCW), the Welsh Development Agency (WDA) and the University of Wales⁵⁴.

Conscious that Wales had not done well in the 1992 RAE, and was perceived to be falling some way short of its research potential, one of the over-riding motivations behind the 1993 Cardiff conference 'was the imperative to intensify and raise the level of research in Wales' so that Wales could 'be in the front rank of the United Kingdom'⁵⁵.

At the Cardiff conference, representatives from UK funding councils highlighted several areas of under-performance when compared with other regions of the UK. For example, Dr Dai Rees, secretary to the Medical Research Council (MRC), noted that in 1991/92, Wales secured only 0.9% of the UK total, whereas Scotland received above its population share at 12.5%. Although much was made of the disappointing 1992 RAE results, several good departments were also recognised. Nevertheless, Sir David Phillips, chair of the Advisory Board for the UK Research Councils, noted 'these were few in number and there is justifiable concern over the overall quality of research in the Principality'⁵⁶. Evidence of this poor performance included regional comparisons of RC grant expenditure covering the period 1987 to 1990, all of which showed that Wales did 'not do particularly well'⁵⁷.

Dr Anthony Hughes, presenting on behalf of the Science and Engineering Research Council (SERC), noted that despite a success rate in 1991/92 that was 'exactly that of the SERC average... one of the reasons why Wales was not as successful as England and Scotland in winning SERC funding was that investigators in Welsh HE institutions appeared to apply less often than their counterparts elsewhere in Britain'⁵⁸.

Another important historical difficulty identified by Professor John Andrews, incoming chief executive of HEFCW, were the 'structural problems' the sector had inherited from Wales's federal university system. This referred to the large number of small institutions compared with competitors in the UK, with less opportunity 'to develop major large scale research teams'⁵⁹. Andrews noted that this problem was further compounded 'by the fact that several of the colleges had increased their subject portfolios substantially in the '60s and early '70s with a number of departments or subject units dependent on a relatively small team of scholars'⁶⁰.

53
Williams 2006:256

54
Higher Education Wales 1993

55
ibid:vii

56
Higher Education Wales 1993:34

57
ibid:41

58
ibid:67

59
ibid:122

60
ibid:123

61
Williams 2006

62
HEFCW 1994:16

63
Higher Education Wales 1993:28

64
ibid:121

65
HEFCW 1999:16

66
Andrews 2014 (personal communication)

67
HEFCW 1999:17

68
Andrews 2014 (personal communication)

69
HEFCW 1999:17

70
HEFCW 1999

Although size was not seen as guaranteeing quality, larger institutions with greater numbers of staff were viewed as better placed to achieve economies of scale and to maintain diversity of provision in the increasingly competitive market. Central to this process of quality enhancement was the objective of being able to compare the Welsh higher education system as a whole ‘with the other regions of the UK’ and the intention to fund the best units ‘at a level comparable with those in England and Scotland’.

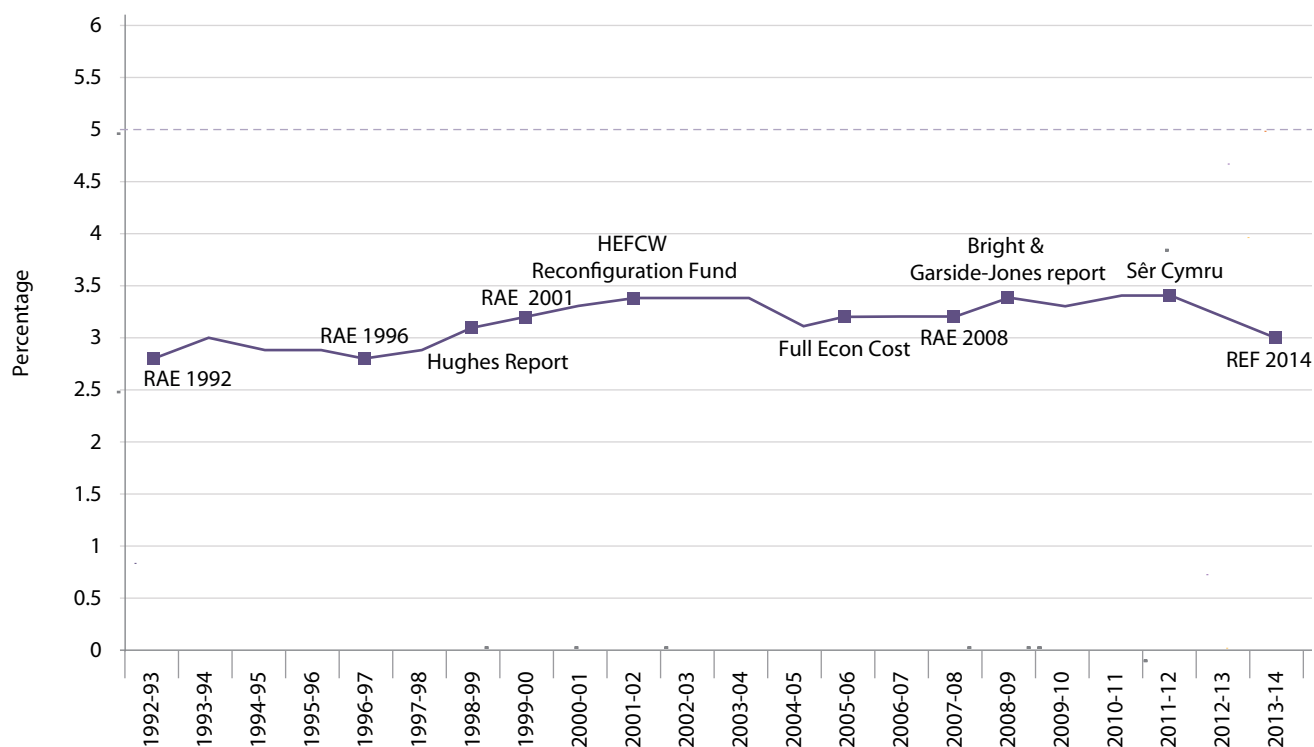
Established in May 1992, HEFCW was formed as a result of the Further and Higher Education Act 1992 and operated as a non-departmental public body sponsored by the Welsh Office with responsibility for funding higher education in Wales⁶¹. Before this, the University of Wales and its constituent institutions were funded by the University Funding Council (UFC), where much of the responsibility for the sector’s research planning lay with the constituent institutions of the University of Wales. Given Wales’s relatively poor standing in the 1989 and 1992 RAEs⁶², the Secretary of State for Wales made it clear that he wanted to see ‘very many more research centres of international standing in Wales’⁶³. In a letter to HEFCW’s chairman in May 1992, the Secretary of State indicated that he wanted HEFCW ‘to work with the higher education institutions in Wales to raise the quality of research in Wales’⁶⁴. With this in mind, HEFCW persuaded the Secretary of State to allocate an additional £2m to HEFCW for 1993/94 and subsequently a further annual £2m for research over the next two years – all with the intention of improving research quality.

This drive to improve the quality of research remained a key motivation behind much of HEFCW’s actions in relation to its responsibilities for funding research in Wales during the 1990s. However, a second and important driver was the aspiration for Welsh research to be seen to play an integral part in the UK’s world-class research community⁶⁵. With this in mind, HEFCW’s Research Committee was given considerable responsibility to take forward a programme of strategic incentives⁶⁶. Several of these were directed at increasing the low proportion of grants Wales attracted from the research councils, particularly given that Wales won ‘significantly less than that which might be expected on the basis of the size of the sector’⁶⁷. Demonstrating the ambition of the newly formed funding council for the Welsh sector, HEFCW agreed that 5% of total UK RC income based on Wales’s share of the UK population would provide a stretching target intended to drive Welsh performance up to a level comparable with other UK regions⁶⁸.

HEFCW and the pursuit of the standard share

Despite sector improvements in the 1996 RAE, Wales continued to win about 3% of total UK RC funding throughout much of the 1990s. Figure 4 provides a simple timeline of total RC income received by Welsh institutions between 1992–93 and 2013–14. The fact that Wales continued to secure ‘significantly less’ than its ‘standard share’ remained ‘a matter of concern for both for the Council and Welsh Office’⁶⁹, and so in 1998, HEFCW commissioned Dr Anthony Hughes⁷⁰ to investigate the reasons for the disparity.

Figure 4: Percentage of RC funding attracted by Welsh HEIs, 1992-93–2012-13



The Hughes Report

The Hughes Report⁷¹ provided a detailed analysis of the individual and collective performance of Wales's five largest research-active universities. It also offered reasons for Wales's failure to attract its standard share of research council funding. Relevant findings included:

1. Evidence of structural differences between the research activities in Welsh HEIs and those in the rest of the UK. The report noted that this included 'relatively less activity in Wales in medicine, science and engineering and relatively more in the social sciences and humanities'⁷². As the former group of subjects provided much of the research council income, the report concluded that the share Wales might be expected to win was 'somewhat less than the "standard share" figure of 5% based on the total higher education resource'⁷³.
2. Comparisons with other UK institutions confirmed that there was an overall shortfall in winning a share of overall research council income compared with that expected from the research quality ratings achieved by the five Welsh institutions, based on their 1996 RAE performance.

⁷¹ HEFCW 1999

⁷² *ibid*:2

⁷³ *ibid*:2

74
ibid:27

75
ibid:27

76
ibid:27

77
HEFCW 2001

78
Bright and Garside-Jones 2009

3. The overall success rates for proposals from Welsh institutions to the research councils were not, 'significantly different' from the average success rates of proposals from all UK HEIs. The ratio of funding won to funding sought was close to that for the totality of all proposals made to the research councils from all UK HEIs, suggesting that the main factor in the current situation was not quality but rather that researchers in the Welsh institutions were not submitting enough proposals to the Research Councils
4. Several departments and units of assessment (UoAs) in the Welsh institutions were perceived as small when compared with 'what are often considered to be critical masses for doing research of the highest impact'⁷⁴.

The main conclusion of the Hughes Report however, was that the shortfall in RC income stemmed from fewer grant applications being made 'by higher education academics in Wales'⁷⁵, and that this level of submission was less than might be expected given the quality of the research base. The report also noted the related obstacle that the average number and overall value of proposals submitted from Welsh institutions was lower than the average value of proposals to the research councils from all UK HEIs⁷⁶.

The main recommendations of the Hughes Report suggested increasing the number and value of proposals submitted to research councils, improving support for researchers throughout the application process and encouraging collaboration as a means of growing the critical mass of researchers involved in applying for and securing RC funding.

Responding positively to the review, Wales's five main research universities submitted action plans that addressed the report's main recommendations. A year later, a follow-up study by HEFCW of the performance of the five institutions against targets appeared encouraging, with the number and value of applications increasing along with the value of new awards and the value of RC income⁷⁷. The trend, however, did not continue. Although the percentage share of research council income showed a small increase moving from 3.1% (1998-99) to 3.4% (2003-04), it soon fell back to 1998/99 levels⁷⁸.

Government policy and HEFCW strategy

In May 1999, the National Assembly for Wales took over the functions of the Welsh Office, and HEFCW became a sponsored body of the National Assembly for Wales. Over the next decade, reference to Wales's standard share was included in many of the Welsh Government's higher education policy documents and commissioned reports (Table 2).

Table 2: Summary of Welsh government policies and HEFCW reports making reference to the standard share, 2001–12

Year	Policy and reports
1993	Higher Education Wales Research Conference, Cardiff
2001	Welsh Assembly Government (2001). <i>The Learning Country: A Comprehensive Education and Lifelong Learning Programme to 2010 in Wales</i>
2002	National Assembly for Wales (2002). <i>Policy Review of Higher Education by the Education and Lifelong Learning Committee</i>
2002	Welsh Assembly Government (2002). <i>Reaching Higher: Higher Education and the Learning Country</i>
2006	Welsh Assembly Government (2006a). <i>The Learning Country: Vision into Action</i>
2006	Welsh Assembly Government (2006). <i>A Science Policy for Wales: the Welsh Assembly Government's Strategic Vision for Sciences, Engineering and Technology</i>
2009	Welsh Government (2009). <i>Report of the Independent Review of Higher Education in Wales Part 2 (Jones Report)</i>
2009	Welsh Assembly Government (2009). <i>For Our Future: The 21st Century Higher Education Strategy and Plan for Wales</i>
2010	Welsh Government (2010a). <i>R&D Review Panel Report</i>
2011	HEFCW (2011). <i>Future Structure of Universities in Wales</i>
2012	Welsh Government (2012). <i>Science for Wales</i>

In 2001, the Welsh Assembly Government published *The Learning Country: A Comprehensive Education and Lifelong Learning Programme to 2010 in Wales*. Keen not to pre-empt the recommendations of the ongoing Education and Lifelong Learning (ELL) Committee's more comprehensive policy review on higher education, set up in October 2000, *The Learning Country* did not include specific targets for research council income. However, the policy did note that despite Wales having a 'substantial number of high rated research departments... income from the Research Councils amounts to only some 3.2 per cent of the UK total' and that what was wanted in the future was 'a significant effort to generate income for research and development, not least from the Research Councils themselves'⁷⁹.

79

Welsh Assembly Government
2001:58

80
National Assembly for Wales
2002:10

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ibid:32

82
ibid:32

83
ibid:2.39

84
ibid:32

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ibid:95

86
Wales 2002:10

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ibid 32

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ibid:32

89
ibid:32

90
Jones 2009

Policy Review of Higher Education

In January 2002, the Education and Lifelong Learning (ELL) Committee report *Policy Review of Higher Education* was published. Its aim was to develop a long-term strategic plan for higher education in Wales. The report explicitly considered the level of RC income expected. In describing a vision for 'a world class higher education system in Wales'⁸⁰, the ELL Committee recognised that 'World class research requires world class facilities, world class researchers and a steady supply of well trained postgraduates' and that 'in order to achieve this, a critical mass has to be reached'⁸¹. The ELL Committee's review also noted that while 'Wales had improved its research profile between the RAEs of 1992 and 1996', it was 'concerned to hear that, despite all the efforts to improve its research performance, the HE sector in Wales was not attracting its expected share of research funding'⁸². Another concern was the 'decrease in the number of research active staff put forward by Welsh institutions'⁸³. The ELL Committee observed:

Wales still does not attract the percentage of research funding that it might be expected to attain. Although total research income for Welsh HE has increased by 25% in recent years... it still only represents just over 3% of the UK total. We were told that 5% is the accepted pro-rata benchmark for Wales.⁸⁴

The ELL Committee noted that Scotland, with a population of approximately 9% of the UK, had managed to attract over 10% of UK research council grants: 'The committee was told that closing the gap between Wales and the rest of the UK was important, particularly if Wales wished to build a reputation for world class research'⁸⁵.

Reaching Higher

Incorporating many of the recommendations of the ELL Committee review, *Reaching Higher*⁸⁶ the Welsh Assembly Government's 10-year strategy to create a competitive, robust and sustainable higher education sector in Wales, articulated the ambitious vision for an inclusive and world-renowned sector and the steps required to achieve it. With respect to research, the strategy noted that Welsh HEIs had 'historically found it hard to generate the critical mass necessary to lift the number of successful applications for Research Council funding' and considered that 'if the sector achieved a percentage of Councils' funding equivalent to *population share*, Wales would benefit by a minimum of an extra £10 million annually'⁸⁷. Accordingly, *Reaching Higher* made a commitment to closing 'the existing gap in funding attracted by HE to Wales from the Research Councils by 2010'⁸⁸. This was one of several key target outcomes that it charged HEFCW with delivering by tying funding to its achievement⁸⁹.

Policy response to Reaching Higher

According to the Jones Report, published seven years later in 2009, the key message behind *Reaching Higher* was 'that Welsh HEIs did not possess the scale or scope to compete with institutions elsewhere in the UK (and beyond) in relation to leveraging money from external sources (e.g. the Research Councils) or in their capacity to take risks and innovate'⁹⁰. For *Reaching Higher*, the key strategy for ensuring a successful and internationally competitive sector in the future was reconfiguration and collaboration within the sector, given the capacity to 'bring

cost savings through economies of scale and provide benefits through creating institutions of greater critical mass⁹¹. The goal of reconfiguration identified in *Reaching Higher* (2002) was reaffirmed in the Welsh government's *Learning Country* (2006) and subsequently in *For our Future*⁹². The approach was also highlighted in HEFCW's 2001/02 annual report⁹³ and in the 2002-03 Remit Letter. In response to *Reaching Higher*, HEFCW launched the Research Capacity Development (RCD) and Reconfiguration and Collaboration (R&C) funding initiatives in 2002 to support the strategy of reshaping of the sector with the aim of achieving major performance gains and enhanced competitiveness (Table 3).

Table 3: Main HEFCW initiatives, 2002–11

Research Capacity Development Fund (RCDF) (2002–2006)
Aim: Strengthen research infrastructure and inject dynamism into the research portfolios of institutions
Funding: £8.5m supporting 10 projects at eight institutions
Outcome: Ten funded projects secured external research totalling £21.7m, of which £11.8m was from research councils
Reconfiguration and Collaboration Fund (R&C) (2002–2011)
Aim: To support the reshaping of the sector in the interests of achieving major performance gains and enhanced competitiveness
Funding: £67.3m allocated to support research initiatives out of a total allocation of over £131m
Outcome: A number of these research initiatives continue, including the Low Carbon Research Institute; the Biosciences, Environment and Agriculture Alliance between Aberystwyth and Bangor universities; the Research Institute of Visual Computing; and the Climate Change Consortium for Wales ⁹⁴

R&C funds were used to help encourage institutions to 'focus on collaboration as the most effective means of extending the research base to support the knowledge economy in Wales'⁹⁵. In addition, HEFCW set universities the research target of increasing their 'percentage of Research Council funding attracted by HEIs in Wales from 3.3% in 2000/01 to 4.5% by 2010/11'⁹⁶.

Five years after *The Learning Country*, the Welsh Government published a progress review, *The Learning Country: Vision into Action*⁹⁷. This outlined the strategy and priorities to be taken forward over the following years to make the 2002 vision a reality. This policy reaffirmed the need 'to grow further the research base of the higher education sector in Wales' and specifically to raise 'the percentage of Research Council funding attracted by HEIs in Wales from 3.3% to 4.5% by 2010'⁹⁸. Although by the time HEFCW's 2006/07 annual report was published, the percentage of research council funding attracted by HEIs in Wales was still around

91
Wales 2002;95

92
WAG 2009

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HEFCW 2002

94
Parken 2011

95
HEFCW 2003:9; 21

96
HEFCW 2004:37

97
WAG 2006a

98
Ibid:25

99
HEFCWE 2007:4

100
WAG 2006b

101
ibid:4

102
ibid:4

103
ibid:4

104
ibid:14

105
ibid: 5

106
ibid:4–5

107
Bruce 2012

108
Welsh Government 2009

109
ibid:9

110
ibid:9

111
ibid:12

3.3%, HEFCW remained 'optimistic that a number of research-related investments through the Reconfiguration and Collaboration Fund would soon lead to further progress'⁹⁹.

Wales's First Science Policy

In November 2006, the First Minister and Minister for Science launched Wales's first overarching science policy, *A Science Policy for Wales*¹⁰⁰. The opening page of the policy stated that 'Wales may be said to have inherited a science deficit' that would not be 'an easy inheritance to change radically'¹⁰¹. While Welsh universities 'produce thousands of excellent science graduates and postgraduates' and 'offer employment in research and teaching', the same universities were considered 'far less successful'... compared to their Scottish counterparts... in winning Research Council funding¹⁰². The policy went on to point out that compared with 'the total size of the higher education base or to the total population... Scotland wins more than its share of UK Research Council funding and Wales wins less than its share of UK Research Council funding'¹⁰³.

The potential effects of Wales's relatively 'below par success rate in securing funds from the Research Councils'¹⁰⁴ provided the authors of the report with a possible solution for 'correcting the existing science deficit.' They stated that 'If Welsh HEIs won the same share of Research Council funding, relative to its population, as Scottish HEIs do... there would be hundreds more scientists employed in Wales [and]... Welsh HEIs' science mass and revenue streams would be much improved'¹⁰⁵. Although the report considered the situation in Wales as 'improving' with 'different HEIs' having 'different degrees of success', the general conclusion was that a 'general improvement' by universities in winning more research council funding was 'an obvious high priority'¹⁰⁶. Reiterating the case that Wales had too many small HEIs, the policy confirmed support for the ongoing R&C strategy outlined in *The Learning Country* as the way for Wales to generate 'critical mass' in research.

Jones Report

In 2008 seven years after *Reaching Higher*, the new Minister for the Department for Children, Education, Lifelong Learning and Skills (DCELLS) commissioned a two-stage review of higher education, undertaken by a group chaired by Professor Merfyn Jones. The Jones Review was to influence the new national higher education strategy that appeared the following year¹⁰⁷. The second part of the Jones review¹⁰⁸, published in April 2009, proposed a wider 'high-level and long term Review' that focused on the 'mission, purpose, role and funding for higher education in Wales'¹⁰⁹. Having considered information and submissions from a range of stakeholders, the review concluded that while 'there were many examples of international excellence in Wales', collectively its higher education sector 'casts an insufficient shadow on the world scene'¹¹⁰. With respect to research specifically, the review felt that while 'Wales has steadily increased its market share of non-Research Council income from 3.7% of the UK total in 2001/02 to 4.3% in 2006/7'¹¹¹, overall, the Welsh 'research base, particularly its science base, still lags behind the rest of the UK in terms of both quality and quantity' and that 'while research funding won from the UK Research Councils by Welsh HEIs has risen from £23m in 2000/01 to £35.6m in 2006/07, the proportion of total available funds won by the Welsh sector

has remained around 3%, despite the target to achieve a higher proportion¹¹². The ongoing problems with research council income were also confirmed by a report by Bright and Garside-Jones¹¹³ that came out in the same year. This noted that while the percentage share of research council income had increased for a number of years (up to 2003-04), it had fallen back and had effectively flat-lined.

Commenting on the HEFCW strategy, the Jones Review¹¹⁴ noted that while 'substantial measures to improve scale and scope and achieve critical mass have taken place in recent years, through the creation of research collaborations... funded through the HEFCW Reconfiguration and Collaboration Fund... the insufficient *scale of many research units and funding for research*... [were] quite probably the two most significant causes of failure to obtain a larger percentage of Research Council funds'¹¹⁵. While noting that the HEFCW reconfiguration strategy provided 'one powerful means of helping the HE sector to deliver the benefits sought for Wales', the Jones Report felt 'equally that this alone is unlikely to deliver benefits for higher education capacity and quality'¹¹⁶. In particular, the report felt that 'critical mass [was] crucial to research performance, especially in science' where there was 'a lack of critical mass in many research units in Wales and a weakness in the size and depth of the overall science base'¹¹⁷.

Recognising that Wales was not closing the gap in terms of its research performance 'and that more needed to be done to achieve critical mass and raise levels of investment in research', the Jones Report recommended 'accelerating the consolidation and capacity building needed to enhance Wales's Research Performance'¹¹⁸.

For our Future

The conclusions of the Jones Review significantly informed the Welsh Government's new Higher Education Strategy and Plan for Wales, published in November 2009. On research, the policy specifically referred to the Jones Report and indeed included direct quotes from it. The new policy indicated the need to 'see strategic funding targeted on areas of existing strength', with the aim of growing the Welsh research base where we are 'best placed to do so'¹¹⁹. By adopting this selective allocation, the Welsh research base was expected to 'play a stronger role in stimulating business growth and development, promoting a globally recognised Welsh leadership in key fields, underpinning teaching and learning quality, and nurturing a future higher education community in Wales through the presence of a strong postgraduate community'¹²⁰.

For our Future provided the basis for the Welsh Government's subsequent remit letters to HEFCW between 2010 and 2012 and further impetus for HEFCW to deliver several key priorities, including progress towards Wales having fewer, but stronger institutions and a priority 'to increase the Welsh share of UK research funding by further focusing developments on national research priorities, encouraging more collaborative scholarship across subject specialisms and promoting cross-institutional working particularly across Wales's research intense institutions'¹²¹. This agenda gathered further pace with the appointment of Leighton Andrews as Minister for Education in December 2009, who considered the failure to collaborate as part of the reason for Wales's continued inability to

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ibid:14

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Bright and Garside-Jones 2009

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Welsh Government 2009

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ibid:14

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ibid:33

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ibid:33

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ibid:15

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WAG 2009:15

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ibid:13

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Remit Letter 2010

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Andrews 2014:287

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Remit Letter 2011

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HEFCW REMIT LETTER 2011\12

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Welsh Government 2012:4

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ibid:3

win a sufficiently large share of research council funding¹²². This research priority was highlighted in the subsequent year's Remit Letter¹²³, which indicated that the new strategy 'recognized that leaving the present research base unchanged would pose a significant risk to Wales's future economic success' as 'Wales has too many small and dispersed research units' and 'produces too many small scale and individual bids for UK research funding'¹²⁴.

Science for Wales

In March 2010, the Welsh Government appointed Professor John Harries as Wales's Chief Scientific Adviser. Following a detailed consultation and review of the Welsh science base, Professor Harries oversaw the publication of the Welsh Government's second science strategy, *Science for Wales*, in March 2012.

This set out the case to build a strong science base in Wales that would support the country's economic and national development. The strategy came with a significant investment of £50m to help boost the university's science research base and attract new scientific talent to Wales. A central and unambiguous target of this new investment, and strategy, remained Wales's ability to secure a quantifiable uplift to 5% in the share of research council funds by 2017, in addition to sector improvements in the 2014 REF. The new policy argued that the previous situation whereby universities in Wales won 'relatively low levels of competitively-awarded research funding compared to the UK' was 'unacceptable'¹²⁵ and researchers were encouraged to 'create a step change in activity... to build a strong and dynamic science base that supports the economic and national development of Wales'¹²⁶.

Recognising and estimating the shortfall

The 1999 Hughes Report¹²⁷ considered that low institutional critical mass in the science disciplines was one of the contributing factors for Wales's inability to secure the 5% research council target. However, its main conclusion was that fewer, smaller grant applications were being made from Wales. In 2002, a joint Working Group on Research, one of four established in September 2002 by Higher Education Wales (HEW) and HEFCW to consider the implications of the Welsh Assembly Government's Reaching Higher policy¹²⁸, argued that the higher education sector in Wales needed to build more capacity in research across a wider range of institutions, including increasing the number of world-class researchers in departments that are already out-performing their counterparts in other parts of the UK. This group considered the main conclusions of the Hughes Report, indicating that the lack of success in securing the standard share of research council funding was due to lack of applications, was too simplistic and that Wales lacked sufficient infrastructure to support the preparation of successful bids.

In 2004, HEW, in its submission to the Welsh Government's spending review¹²⁹, reported that an analysis of the 2001 RAE showed that in STEM subjects, Scottish departments scoring 5 or 5* had 3.5 times as many staff (standardised per million population) compared with Welsh HEIs. In this submission HEW argued that the focus on the reconfiguration and collaboration agenda in Wales had 'diverted attention from the need to address weaknesses in Wales's research base at a critical time'¹³⁰, and that what was needed was a 'funding injection' involving 'significant funding for recruiting and retaining excellent research staff... to turn around the deficit with respect to England and most notably Scotland in top quality research in Wales'¹³¹.

This problem of insufficient capacity in STEM also prompted the heads of Wales's two largest research-intensive universities to speak out publicly on the issue. In providing evidence to the Select Committee on Welsh Affairs in 2004, Dr David Grant, Vice Chancellor of Cardiff University, noted that 'within Wales we obviously have not got an adequate number of people who will attract those funds... The factor is the number of academics in 5 and 5* departments. It is simply down to... not enough people in Wales are bidding for research funding'¹³².

In an interview with the *Times Higher* in 2010, Professor Richard Davies, Vice Chancellor of Swansea University, used evidence from his own analysis of Wales's 2008 RAE performance to make a similar case arguing that the gulf between Scotland and Wales was 'attributable in part to the fact that Wales has done less STEM research in the past and in part to a relative underperformance in the existing research'¹³³. According to Professor Davies, 'The real issue is our research strength, particularly in STEM, because we haven't got enough... We have to grow STEM'¹³⁴.

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HEFCW 1999

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WAG 2002

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HEW 2004

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HEW 2004:5

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ibid:5

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UK Parliament 2005

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Times Higher Education 2010

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ibid

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HEFCW 2009a:2-3

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HEFCW 2011b

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ibid:2

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HEFCW 1999

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WAG 2006b

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Welsh Government 2009

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Welsh Government 2014b

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Elsevier 2014

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Welsh Government 2014b

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145Welsh Government 2014b
(Delivering Science for
Wales.2013-14)**146**

ibid:23

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ibid:23

At the first meeting of HEFCW's Research, Innovation and Engagement Committee (RIEC) in April 2009, the committee noted the issue of critical mass and confirmed that the 'historic deficit in the number of STEM researchers in Wales compared with other parts of the UK [was] a factor in the sector's relatively low share of UK Research Council funding, the majority of which is provided for STEM subjects'. The committee also noted that 'addressing the historic deficit in STEM subjects would be expensive, and should not be at the expense of other disciplines, but it would significantly boost the sector's capacity for Research Council grant capture, knowledge transfer and international collaboration'¹³⁵.

Two years later, in 2011, a subgroup report from RIEC chaired by Professor Robin Williams¹³⁶ investigated the reasons why research council income for Wales had not moved closer to the target set in Reaching Higher back in 2002. Using the 2008 RAE results, the subgroup determined that the critical factor was 'the proportion of staff among UoAs in Wales' was 'anomalously low in those disciplines relating to the highest spending Research Councils' and that there 'appeared to be a deficit in the numbers of STEM researchers when compared with number of researchers per million population elsewhere in the UK'¹³⁷. Although similar points regarding the STEM shortfall had been made before, in the Hughes Review¹³⁸, the Welsh Government's first science policy¹³⁹ and the Jones Review¹⁴⁰, this 2011 review provided a formal estimate of the scale of the numbers involved. The same STEM staff deficit was also considered responsible for the relatively poor levels of Technology Strategy Board, charity and European Framework programme funding.

Three years later in June 2014, the Minister for Economy, Science and Transport confirmed that the STEM capacity deficit was the main reason for Wales's low level of research council income in an update to the National Assembly for Wales on Welsh science¹⁴¹. Commenting on the findings of the recently published international comparison of Welsh research provided by Elsevier¹⁴², the Minister indicated that the main problem for Welsh research, was that 'we have too few scientists in Wales'. The Minister indicated that the Science for Wales strategy would therefore focus 'on increasing the numbers of scientists working in Wales and also on creating the environment for those already here to succeed and grow in future'¹⁴³. 'The Sêr Cymru appointments and the research networks' directors have the central aim of significantly increasing our research capacity and gaining greater success in securing the competitively awarded funding that we need to expand research portfolios in our universities and elsewhere'¹⁴⁴.

In keeping with the Minister's statement, the Welsh Government's annual report on the Science for Wales strategy in June 2014¹⁴⁵ went further, admitting that achieving the standard share of competitively-awarded research funding had been ambitious, because 'the research base in Wales is too small' and that 'the problem... is that there are too few researchers within Wales in medicine, engineering and the physical sciences'¹⁴⁶, all subjects that are supported by the highest spending research councils. This was 'a key reason why Wales does not win the "population equivalent" share of UK Research Council grant funding which Science for Wales aspires to achieve'¹⁴⁷.

Quantifying the deficit

The main, long-standing reason for Wales's not securing its standard share from STEM-relevant research councils was the small size of Wales's STEM researcher base. However estimates of the extent and range of subject areas involved have varied depending on the methods used.

When the HEFCW subgroup¹⁴⁸ compared the number of academic staff (Category A: all academic staff on the payroll with research and/or teaching as their primary function) submitted to the 2008 RAE with the number Wales might have submitted given its notional 5% share in each UoA, they calculated overall 'shortfalls of around 90 staff in the UoAs covered by the Medical Research Council and around 106 staff in those covered by the Engineering and Physical Sciences Research Council'¹⁴⁹. Translated into financial terms (and based on average per-capita grant income), these figures suggest that, in 2008/09, Wales lost out on research council income of some £7.5–£8m 'because of staff deficits in these areas – equivalent to around 20-25% of the sector's current total Research Council income'¹⁵⁰.

Size of research units

The insufficient number of research-active staff in some of the science units in Wales was considered by Hughes¹⁵¹ as a contributing factor for Wales's inability to secure the 5% standard share of RC funding. This was in keeping with the main conclusion of this report, namely that not enough (large) proposals were being submitted from Wales. Hughes also noted that 'Some of the departments and UoAs within the study institutions [were] relatively small compared with what are often considered to be critical masses for doing research of the highest impact'¹⁵². His 1999 report provided a compelling example in the case of physics, where the collective total for physics at Cardiff, Swansea and Aberystwyth universities comprised 'over 40 research active staff, comparable with many of the departments considered to be the strongest in the UK'. In Wales 'two of the institutions have only about 10 research active staff, which is only half the size considered by some to be a minimum critical mass for this discipline'¹⁵³. The report went on to note that the 'same could be said for some of the engineering disciplines, and also for some other subjects such as Economics and Econometrics.'¹⁵⁴

Although there are several examples of small units achieving excellent results in the UK¹⁵⁵, Toivanen and Waterson¹⁵⁶ using data from the three UK RAEs (1996, 2001 and 2008) showed that the size of science departments had an independent positive and causal effect on research quality. Converging evidence in favour of Hughes's observation can also be found in the REIC's subgroup report¹⁵⁷, which noted that Wales, for its size, had submitted too many small research units in the 2008 RAE. Table 4 shows the number of full-time equivalent (FTE) staff submitted per institution in Wales for a selection of STEM subjects in 2008, confirming the association between low critical mass in relevant UoAs and grade point average (GPA) performance when compared with Scotland.

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HEFCW 2011b

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ibid:26

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ibid:26

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HEFCW 1999

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ibid:26

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University Alliance 2011

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Toivanen and Waterson 2013

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HEFCW 2011b

Table 4: Composition of FTE staff from HEIs in Wales and Scotland in terms of GPA, RAE (2008)

RAE 2008 unit of assessment (UOA)	Wales (1) Total FTE (2) No.of HEIs (3) Av GPA	Wales No of FTE per HEI (GPA)	Scotland (1) Total FTE (2) No of HEIs (3) Av GPA	Scotland No of FTE per HEI (GPA)
Biological sciences (UoA 14)	90.5 4 GPA 2.01	53.9 (2.6) 16.6 (2.1) 16.0 (1.9) 4.0 (1.45)	358.6 5 GPA 2.64	65.0 (2.8) 122.7 (2.65) 46.8 (2.6) 78.6 (2.6) 45.5 (2.55)
Physics (UoA 19)	71.4 3 GPA 2.28	32.3 (2.35) 20.7 (2.55) 18.3 (1.95)	193 6 GPA 2.5	32.2 (2.85) 60.5 (2.8) 45.7 (2.75) 19.5 (2.65) 3.7 (1.8)
Chemistry (UoA 18)	48.6 2 GPA 2.57	36.57 (2.7) 12.00 (2.45)	159.3 6 GPA 2.68	43.89 (3.0) 33.0 (3.0) 26.4 (2.75) 25.0 (2.75) 19.0(2.6) 12.0 (2.4)

(Hefce 2008 RAE 2008 The Outcome; SOMIS 2008 RAE Dundee)

Analysis using HESA cost-centre database

Over the past decade, many accounts describing Wales's research performance have interpreted the inability to secure the standard share of RC funding as evidence of the sector's relative under-performance. However, this claim would be misleading and unfair if Wales had significantly fewer research academics than its population share, particularly in STEMM subjects which typically secure the largest share of total RC funding.

To derive a current estimate of the STEMM shortfall for Wales, it is important from the outset to secure a reliable estimate of the total number of academic researchers in the four UK nations engaged in producing the UK's academic research. This can be done by securing the academic staff figures from HESA's cost-centre database and establishing Wales's population share of total UK academics contracted to engage in research. Notwithstanding different organisational and academic structures within institutions, HESA considers that cost-centre data 'permits "in theory"... meaningful comparisons between different types of data at a more granular level than the total institution'¹⁵⁸.

Table 5. lists the overall academic HEI-contracted staff for the four UK regions using a full-time equivalent (FTE) count for 2012/13. This shows that Scotland has a large surplus (2.1) compared to that of Northern Ireland (0.9) and Wales (0.2).

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ONS 2013

Table 5: Total HEI academic staff (FTE) by UK country, 2012/13UK

UK nation	Regional % of total UK HEI (FTE) staff *	UK population share** (Est mid-2012)
England	83.7%	83.9%
Scotland	10.4%	8.3%
Northern Ireland	2.0%	2.9
Wales	5.0%	4.8%

Source: * HESA 2012; ** ONS

Table 6, however, shows that despite having it's population share for the total number of HEI or academic staff, Wales has *substantially fewer* staff engaged in research than any other UK country and the UK average.

Table 6: Breakdown of academic staff (teaching v research) by UK nation, 2012/13

UK nation	Total HEI staff per UK nation	Total staff (FTE) with T&R or R contracts	% of staff (FTE) covered by T&R and R contracts	% of total HEI staff covered by T&R and R three-year average(2010–13)
England	120,553	103,518	85.9%	86.7%
Scotland	15,185	13,386	88.2%	89.2%
N. Ireland	2,975	2,326	78.2%	88.8%
Wales	7,225	5,399	74.7%	78.3%
UK	145,938	124,629	85.4%	86.6%

Source: HESA 2002

Notes: The distinction between 'teaching' and 'research' staff refers to staff who are engaged either only in research (R), or in teaching and research (T&R). The HESA Staff Record covers all academic staff with a contract of employment with an HEI in the UK. Figures are based on FTE staff numbers employed on an R or T&R contract, and exclude atypical contracts.

FTEs are calculated for each cost centre within a contract as the FTE for the contract, multiplied by the proportion the cost centre contributes to the contract (excluding atypical contracts). Of the 145,938 academic staff FTEs employed by UK HEIs, 122,555 (84%) were FT and 23,383 (16%) PT.

The population of the UK was estimated to be 63.7m in mid-2012: 53.5m (England), 5.3m (Scotland), 3.1m (Wales), 1.8m (Northern Ireland)¹⁵⁹.

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Paterson 2013

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ibid:2013:2-3

Size of research base

Using the FTE staff count from HESA data, Table 7 shows that Wales's academic research population (i.e. HEI staff with R and T&R contracts) is 4.3%, some 0.5% (646 FTEs) below Wales's population standard share of 4.8%, whereas Scotland has over 2.4% above its country population share (3,263 FTEs). While the Welsh academic sector remains below its standard proportion for research-contracted staff and Scotland above, much of the research capacity deficit difference for Wales involves STEMM disciplines (96%; 621 FTE) while approximately two-thirds of the surplus for Scotland's involved STEMM disciplines (72%; 2,339 FTEs).

Table 7: Number of staff (FTEs - R and T&R) as a proportion of total in UK HEIs and country population, 2012/13

UK nation	Researcher (FTE)	% of UK R&T and R staff	UK nation pop % (est mid-2012) /disparity	% of UK RC income 2012/13 (HEFCW method using HESA data)
England	103,518	83.1%	(84%) -0.9	79.9%
Scotland	13,386	10.7%	(8.3%) +2.4	15.7%
Northern Ireland	2,326	1.9%	(2.9%) -1.0	1.3%
Wales	5,399	4.3%	(4.8%) -0.5	3.0%
UK	124,629	100%	–	–

Source: HESA cost-centre data

One reason Scotland secures higher than its standard share for research council income is its healthy surplus of research staff, particularly in STEMM disciplines. As noted by Paterson¹⁶⁰, 'Scotland receives more than its population share... because it has more academics than its population share would warrant. According to Paterson

"the reason for Scotland's relatively large number of academics is historical... "Scotland had an above-average provision of university education when the UK state took over its funding in 1919 and the position has simply drifted forward without any explicit decision by any policy maker to sustain it. It is certainly not something for which any recent policy decisions of either the UK or the Scottish governments can claim credit." (p3)¹⁶¹.

The relevant STEM subject deficit areas for Wales are shown in Table 8.

Table 8: Number of staff (FTEs - R and T&R) as a proportion of total in UK HEIs for STEM disciplines by country population, 2012/13

HESA cost centres for individual STEM disciplines	Wales: % of UK share (FTEs)	Wales: Diff from % UK pop share (4.8%)	Wales: No of staff required to bring Wales up to pop share	Scotland: (% of UK share) (FTEs)	Scotland: Diff from % UK pop share (8.3%)
Clinical medicine (101)	3.6% (653)	-1.3%	242	10.3% (1,882)	+1.9%
Clinical dentistry (102)	10.5% (72)	+5.6%	–	14.8% (102)	+6.4%
Biosciences (112)	4.3% (436)	-0.6%	62	16.8% (1,725)	+8.5%
Chemistry (113)	4.8% (155)	-0.1%	2	13.8% (499)	+5.5%
Physics (114)	2.7% (104)	-2.1%	84	14.1% (537)	+5.8%
General engineering (115)	10.9% (256)	+6.1%	–	5.9% (137)	-2.5%
Civil engineering (118)	4.5% (60)	-0.4%	5	12.3% (166)	+3.9%
Electrical, electronic & computer engineering (119)	2.9% (94)	-1.9%	65	13.2%(427)	+4.9%
Mechanical, aero & production engineering (120)	2.6% (88)	-2.2%	78	10.1%(340)	+1.8%
IT, systems sciences & computer software engineering (121)	5.0% (238)	+0.2%	–	13.8% (658)	+5.5%
Mathematics (122)	2.4% (74)	-2.4%	76	9.7% (296)	+1.4%
Architecture, built environment & planning (123)	4.5% (110)	-0.3%	7	11.8% (285)	+3.5%
Total STEM as % of UK	4.1 (2339)	-0.7	621	12.3% (7003)	+4.0%

Source: HESA cost-centre data

The lighter blue rows highlight where the figure is at or more than the standard share.

The darker blue show those, mainly STEM, subjects that are below their standard share.

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HEFCW 2011a; HEFCW 2011b

Much of the staff deficit for Wales involves STEMM-related disciplines, with the largest staff deficits being in clinical medicine, biosciences, physics, electrical and computer engineering, mechanical, aero and production engineering, and maths.

Collectively, the findings suggest that the Welsh academic STEMM research base, lacks critical mass based on its standard share of UK academic researchers which if grown would be likely to contribute to securing the long standing Welsh Government's RC target.

Using the findings from Table 8, it is possible to map Wales's STEMM staff deficit onto the UK distribution of research council funding allocated for 2012/13. In Table 9, it can be seen that Wales's lowest RC income comes from key STEMM dependent councils most of which receive the largest funding.

Table 9: Capacity shortfall in Welsh HEIs related to research council performance, 2012/13

UK research council	Subject/ disciplines	Wales % of UK RC income	2012/13 Wales staff deficit (FTEs)	BIS 2012/13 Total UK % funding allocation (Dec 2010)
AHRC		4.3%		3.6%
BBSRC	Biosciences	4.9%	-0.59 (62)	13.9%
EPSRC	Electric and computer engineering	2.6%	-1.9 (65)	29.1%
	Mechanical engineering		-2.2 (78)	
	Maths		-2.4 (75)	
ESRC		3.6%		5.9%
MRC	Medical	2.0%	-1.29 (242)	21.2%
NERC		4.9%		11.5%
STFC (Core and Cross Facility)	Physics	2.7%	-2.1 (84)	9.7%

The bold text above indicates the large STEMM resourced councils.

Collectively, these findings are consistent and extend previous estimates of the STEMM shortfall¹⁶² in Wales and confirm that the Welsh academic research base lacks critical mass (based on standard share) in several key STEMM disciplines. The HESA data analysis suggest that Wales requires in the region of some 600 additional academic STEMM research staff from a range of research career stages if it wants to bring the number of academic staff working in Wales up to the equivalent for its population share in the UK.

Producing more with less: Wales's research performance

One of the problems of not achieving the high-profile 5% standard share of RC income was its wider use as a more general indicator and commentary on Wales's overall poor research performance compared with other nations of the UK¹⁶³. To secure a better appreciation of Wales's university research sector performance since devolution one needs to examine a wider range of input and output indicators including the five yearly RAEs, together with normalised bibliometric indicators such as research productivity (publications per researcher), efficiency (publications per unit of GERD) and research impact (average number of citations received per paper relative to rest of the world). The following summary shows that the Welsh research base has managed to be both efficient and productive despite this STEM deficit and historical low spending on R&D.

RAE and REF performance

According to the 2013 Learned Society of Wales report¹⁶⁴, Wales showed a substantial improvement on the 2008 RAE over the past two decades compared with its relatively poor showing in the first two RAEs of 1986 and 1992. In 2003, the Roberts Report¹⁶⁵, commissioned by the UK funding bodies to review the 2001 RAE, concluded that the quality of research in Wales 'has improved substantially since the 1992 RAE, and the outcomes of the 2001 RAE confirmed that it now stands comparison with that in the rest of the UK'¹⁶⁶. In 2008 Wales showed a credible performance, albeit with percentages of scores of 4* and 3* lower than elsewhere in the UK (Table 10).

Table 10: Summary of RAE results for UK nations, 2008

Quality level	% of research activity				
	Wales	England	Scotland	N Ireland	UK
4*	14	18	15	14	17
3*	35	37	37	36	37
2*	36	32	34	37	33
1*	14	11	13	12	11
u/c	1	1	2	1	1
4* + 3*	49	55	52	50	54

Source: Welsh Government : Science for Wales 2012

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Welsh Government 2009; Western Mail 2011; 2013; Welsh Government 2011; Williams, 2013

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Williams 2013

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Roberts 2003

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Halligan (2012)

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Williams 2013

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LSW 2015

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Research Fortnight, 18/10/14

The performance of Welsh HEIs in the 2008 RAE was achieved, with only 3.6% of all competitively-awarded research funding available to both England and Scotland during the six-year RAE assessment period¹⁶⁷. A close examination of these UK RAE results also show that:

- In a number of subject areas, Wales performed among the best in the UK, with world-class achievement in civil/electrical engineering, computer science and informatics, psychiatry, neuroscience, psychology, art and design and Celtic studies.
- In terms of the proportion of research rated 'world-leading' and 'internationally excellent', Wales had some 20 units of assessment that out-performed the UK average. These were mainly located in the social sciences (7) and arts/humanities (6), but also in health/ medicine (4) and engineering/science (3).

Employing the quality-related (QR) research funding allocated by the various UK research councils, the ratio of the percentage of scores 4* and 3* normalised for the percentage share of QR funding for each UK nation also shows that Wales out-performs other UK countries, suggesting that in terms of volume of the highest quality of research (measured by the addition of scores 4* and 3*) per £ of investment (measured by QR), Wales was the most efficient of the home nations¹⁶⁸.

The 2014 REF results also confirmed that the Welsh Higher education sector is capable of producing high levels of world-leading research despite years of under-resourcing. More than 75% of research submitted was rated as world leading (4*) or internationally excellent (3*). Moreover Welsh universities scored particularly well on the new impact measure, with nearly half of the research submitted by Welsh universities rated world-leading and above the UK average. However, while Wales produced the highest overall quality index of all UK nations, (Table 11), it nevertheless achieved this by submitting 28% fewer staff (3.6% share of all staff across the UK) with the result that its proportion of the UK's 4* and 3* outputs were 3.6% and 3.7% respectively, down from 4.0% and 4.7%¹⁶⁹ when compared with 2008

Table 11: Research Fortnight summary of REF, 2014¹⁷⁰

Rankings per nation , including staff numbers									Staff FTE	
Nation	Power rating	Quality Index	Market Share	4*	3*	2*	1*	Unclassified	2014	% change 2008-14
England	100	45.5	81.88%	30.3	45.7	20.1	3.2	0.6	42,491	1.24%
Scotland	14.9	45.0	12.17%	29.2	47.5	20.1	2.8	0.4	6,390	-2.81%
Wales	4.4	46.4	3.64%	30.7	47.0	19.3	2.6	0.4	1,855	-28.04%
Northern Ireland	2.8	41.1	2.30%	24.4	50.2	22.4	2.6	0.5	1,325	5.41%

Bibliometrics: Elsevier Report

The first wide-ranging, international overview of Wales's research performance was produced by Elsevier in 2014¹⁷¹. This independent report (commissioned by Welsh universities, the Welsh Government and HEFCW) had the advantage over REF of comparing Wales with similar-sized countries over a longer period and also evaluating a larger amount of research published by academics in Welsh HEIs. By linking research output productivity to economic metrics, the report provided the first comprehensive picture of Wales's research efficacy and international standing.

Using a range of input and output research indices, the Elsevier report showed that Wales's research impact (defined by field-weighted citation) for Welsh research had grown significantly over the past 10 years, closing the gap on England and Scotland, and in the process out-performing many European and international countries of similar size¹⁷².

The main findings of the report showed that, collectively, the Welsh research base accounted for a disproportionately high share of the world's published academic articles, global citations and highly cited articles, despite having a relatively small researcher base. In particular it showed that:

- With just 4.9% of the UK population and 0.14% of the world's researchers, Welsh research accounted for 4.4% to the UK's total research output and 4.3% of the UK's total citations.
- Wales's share of the top 1% of highest-cited articles was 0.7%, twice as high as might be expected based on the overall publication share of 0.3%. Wales's percentage of cited publications is higher than that of the UK and also higher than that of the world average.
- In terms of productivity (publications per researcher), Wales performed above the UK average, out-performing England and coming a close second to Scotland.
- In terms of efficiency (publications per unit of GERD), Wales was the most efficient constituent country of the UK for converting GERD into publications, out-performing both Scotland and England, and making it one of the most efficient in the world for countries of a similar size in terms of population.
- Although Wales published a relatively small volume of publications, its field-weighted citation impact (measured by mean citations per article, normalising for subject field, article type and year of publication) was greater than that of New Zealand and the Republic of Ireland and comparable to that of Norway, Finland or Sweden.

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Elsevier 2014

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Halligan 2014

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Elsevier 2014

- I The field-weighted citation impact for Wales grew from 28% above (in 1996) to 61% above the world average in 2012 and in the process secured parity with the UK average in 2012. One concern identified in the report is the low number of researchers per head of population, low levels of funding and slow growth in the number of researchers compared to similar sized countries. Indeed one of the reasons Wales performs so highly on research efficiency is due to both a decline in GERD – gross expenditure on research and development – in Wales, and the slow growth in numbers of researchers.

The Elsevier report¹⁷³ identified international research collaboration and mobility as two of the key factors behind Wales's impressive research performance. Wales occupies a central position in global networks for research collaboration and has the *highest percentage of international collaboration* of all UK constituent countries. The percentage of Welsh articles resulting from international collaboration increased from 44.7% in 1997–01 to over 60% in 2007–11. It also confirmed that the Welsh researcher base has grown the least among comparator countries over the last five years.

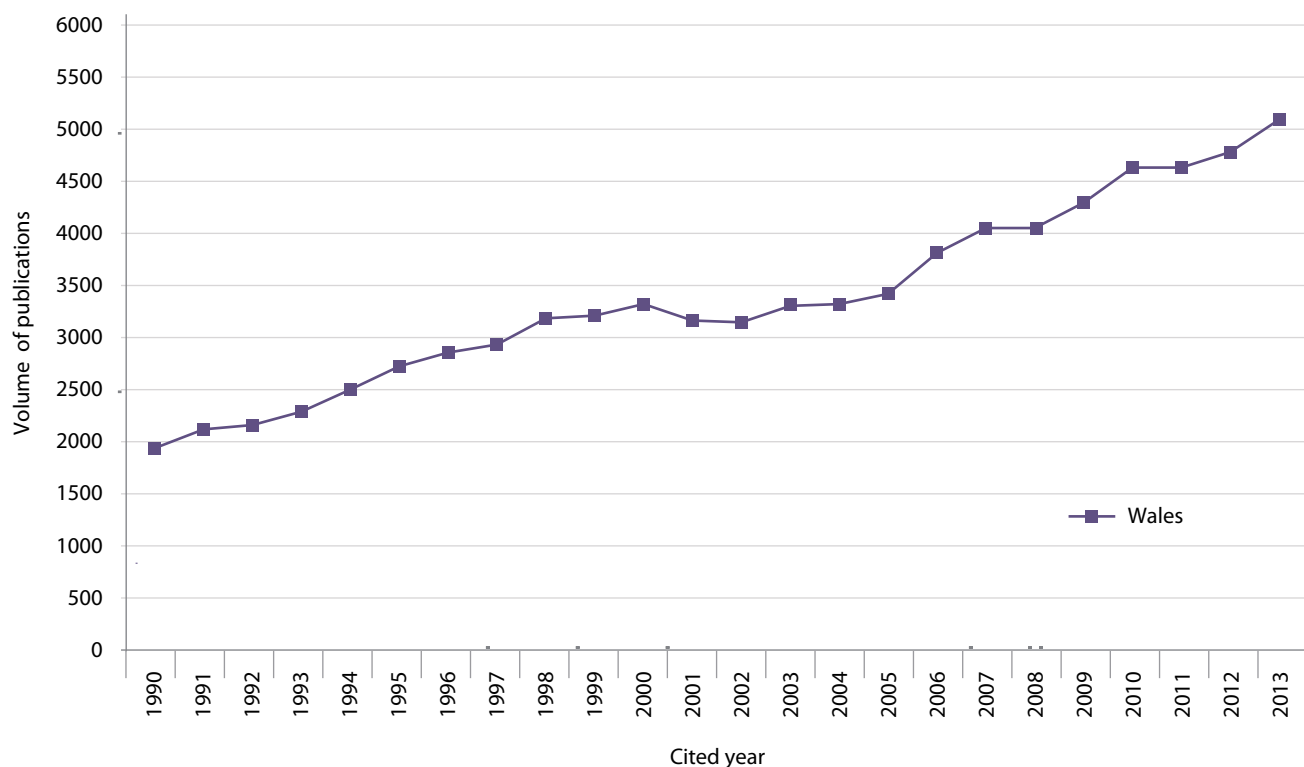
Improving performance but missing the target

Despite the relatively low share of total RC income and UK academic staff, employing a variety of established output measures showed that Wales has managed to punch above its resource base in terms of research productivity and impact. It is possible to capture the journey that the Welsh research base has made over the past 20 years both in terms of the (i) volume of research documents; and (ii) number of citations for these documents over time. Using the Thompson database¹⁷⁴, Figure 5 shows that Wales's research outputs grew from 1,943 research documents in the 1990s to over 5,000 by 2013, an increase of some 38%.

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Web of Science: InCites incites.
thomsonreuters.com

Figure 5: Growth of research publications from Wales, 1990–2013



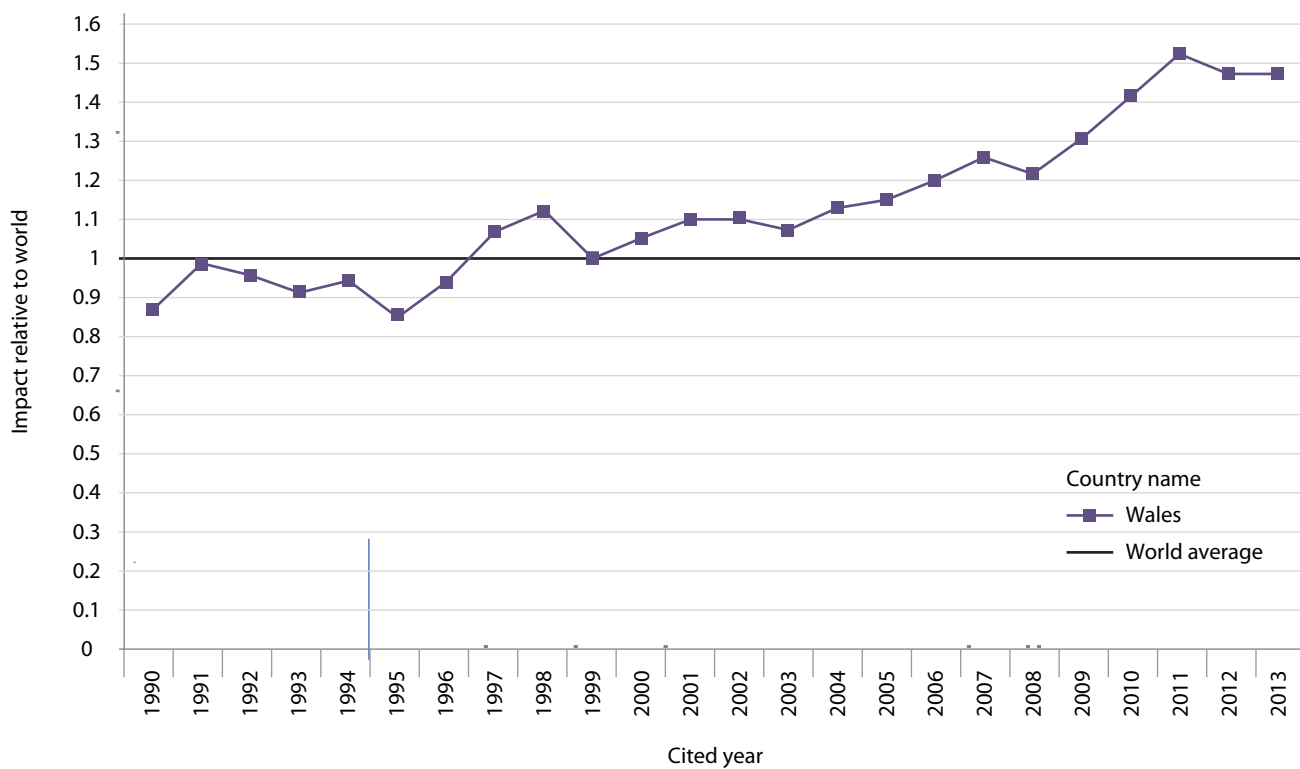
Source: Web of Science InCites 2013

More telling, however, is the data shown in Figure 6, which shows Wales's research impact compared with that of the world average since 1990. The 'Impact relative to world' means the mean citations per paper of all Wales-authored papers divided by the mean citations per paper of all the world's papers.

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Eurostat 2012

Figure 6 shows that for much of the early 1990s, Wales's research performance was below the world average, lending support to the concerns raised by HEFCW and the Cardiff Conference in 1993. By 1999, however the citation impact of Wales's papers had become equal to the global average. From 2000, we can see a gradual and steady improvement in Wales's citation impact covering the period when Welsh Government policies were being put into operation by HEFCW. Over the past 15 years, Wales's research impact has exceeded the world average, and by 2011 its level of citations relative to the rest of the world had progressed to 50% above average.

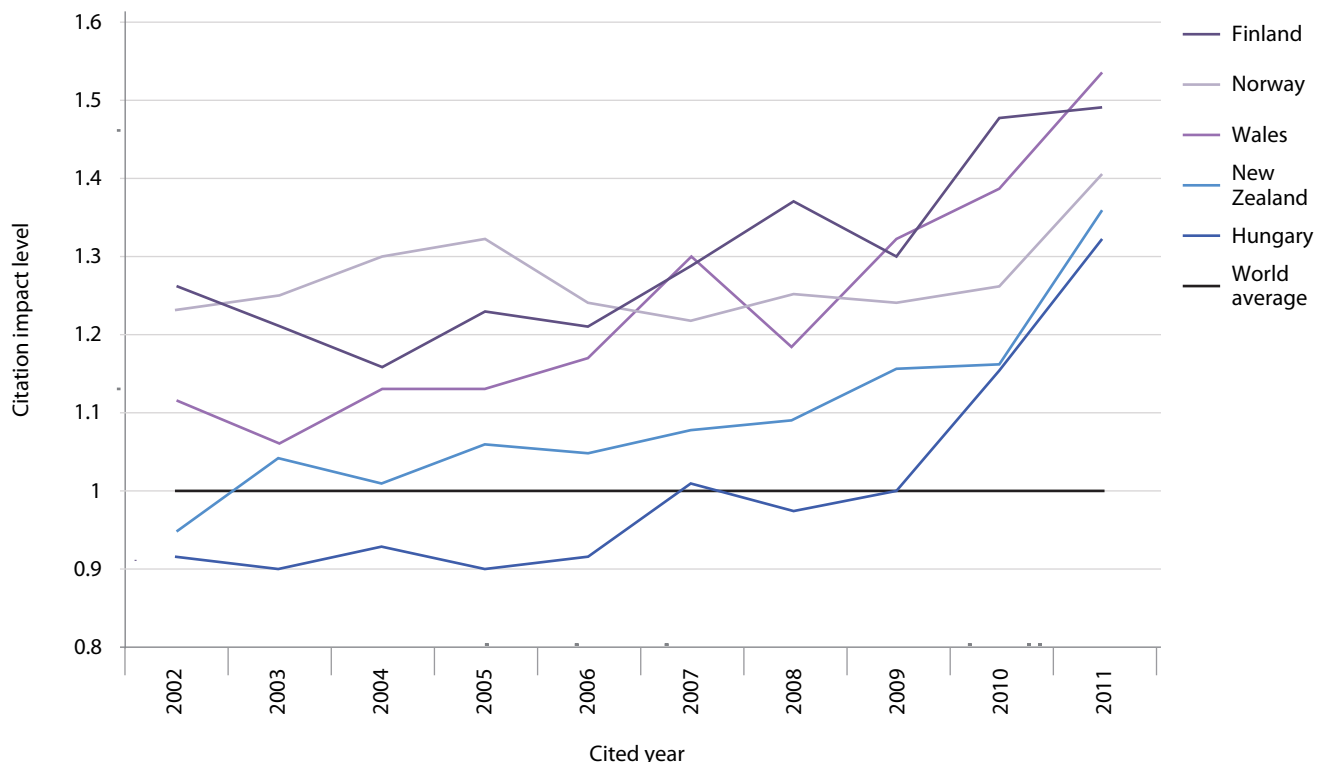
Figure 6: Impact (citations per paper) relative to the world average, 1990–2013



Source: Web of Science InCites, November 2014
Note: Baseline = 1.0

In summary, until the late 1990s, the impact of Welsh research was below the world average; from 2000 onwards, Wales's research impact grew steadily, exceeding the world and EU averages and in the process overtaking several well-performing but similar-sized countries, (see Figure 7) many of which had spent a greater percentage of their GDP on R&D (Finland, 3.55; Norway, 1.66; New Zealand, 1.41; Hungary, 1.3¹⁷⁵).

Figure 7: Impact relative to the word for selected countries, 2002–11



Source: Web of Science InCites
 Note: Baseline = 1.0

Wales’s performance remains particularly impressive when one considers that from 2003 onwards, and with productivity and citation impact growing rapidly, the size of the Welsh academic research base remained relatively unchanged (Table 12). Despite the relatively low share of total RC income and UK academic staff, the 2014 Elsevier and REF results show that that Wales managed to ‘punch above’ its resource base in terms of research productivity and impact. Given that much of the credit for this was due to Wales’s Univeristies, Sir John Cadogan, the first President of the Learned Society of Wales reflected, “Just think what they could have done or would do with funding equivalent to that in England - or just half of that available in Scotland”.¹⁷⁶

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 Williams (2013)

Table 12: All R&T and R staff (FTEs) for Wales, 2003/04–2012/13

Wales	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
R and T&R staff	5,151	5,215	5,354	5,486	5,653	5,694	5,402	5,456	5,457	5,399

Source: HESA staff record

Note: FTEs are calculated for contracts active within the academic year and atypical contracts are excluded. The FTE for each contract is apportioned across cost centres using the proportion of the contract activity in each cost centre. FTE is defined by the contract(s) of employment and is proportioned to each activity’s cost centre. FTE indicates the proportion of a full-time year being undertaken over the course of the reporting period 1 August to 31 July. The FTE is therefore counted using a population of staff who were active during the reporting period, not just on a given snapshot date.

Some caveats

The focus of this paper has been on competitive RC income, which remains a UK responsibility where funds are allocated competitively to institutions in all four devolved countries. It does not claim to provide a comprehensive guide to all research incomes, including the NIHR or recurrent funding distributed to the universities as a block grant by HEFCW.

Although Welsh universities have done well despite their low research income, it is important when making comparisons with other UK countries to bear in mind the scale and historical differences. Wales has one of the lowest regional GDP per capita and one of the lowest levels of research intensity (measured in terms of GERD as a share of GDP) for similar population sized countries. Differences in the scale of funding allocations, together with historical patterns of subject provision, institutional diversity and size, all need to be kept in mind when making sector comparisons between the UK's different university sectors. Some brief examples serve to illustrate.

The *total* amount of research income secured in 2012/13 by all Welsh universities (excluding QR) was £175m spread unevenly across eight institutions. Put in perspective, this level of funding is equivalent to about 4.5% of the total research income for England, and about 52% of University College London's total research income for the same year.

Wales's research income for 2012/13 is equal to just 27% of the total research income for the whole of Scotland, and only 87% of the research income secured by the University of Edinburgh.

Within-sector disparity

While the distribution of research income among the four UK nations remains significant, it is also important to appreciate within-sector differences between HEIs in Wales with regard to their research income. Like other nations, Wales has a diverse range of pre- and post-1992 universities, with different missions and discipline mixes, all of which determine the extent of their research intensity. Table 13 provides a snapshot of the distribution across Wales's eight HEIs for 2012-13.

Table 13: Welsh university sector: research income, 2012/13

University	Total research funding £K/ (% of sector total)	Total recurrent income £k (% of uni total)	UK RC income £k (% of uni total)	% of Welsh RC sector income
1.Cardiff	130,891 (52%)	42,680 (33%)	22,685 (17%)	49%
2. Swansea	49,784 (20%)	12,590 (25%)	9,819 (20%)	21%
3. Bangor	28,018 (11%)	7,669 (27%)	4,219 (15%)	9.2%
4. Aberystwyth	26,137 (10%)	7,715 (30%)	8,011 (31%)	17.2%
5. University of South Wales*	8370 (3.3%)	3,116 (36%)	601 (7%)	1.3%
6. Cardiff Metropolitan	3,709 (1.5%)	1,232 (33%)	39 (1%)	0.08%
7. University of Wales: Trinity St. David & Centre for Advanced Welsh and Celtic Studies	2,186 (0.9%)	1,245 (57%)	565 (26%)	1.21%
8. Glyndŵr University	1,943 (0.8)	0	374 (19%)	0.8%
Total	251,398	76,247	46,565	
% of UK	3.7%	3.9%	3.0%	

Source: HEFCW 14/41 Sources of research income of HEI in Wales, 2012/13: extracted from HESA Resources for Institutions of Higher Education 2012/13

Note: Recurrent research funding consists of QR and PGR (or equivalent) * Combined University of Glamorgan and University of Wales Newport

Table 13 shows that some institutions are more research intensive than others, with Cardiff University securing more than half the total research funding for the sector, followed by Swansea, Bangor and Aberystwyth universities. In terms of RC funding, Cardiff secures most at 49%, followed by Swansea, Aberystwyth and Bangor. Consequently, although all Welsh universities engage in research, only a small number will have the research capability to grow their STEMM science base significantly.

While research council funding clearly remains a prestigious and important source of research income, a breakdown of total research income for 2012/13 shows that Welsh HEIs rely less on research council funding as a source of overall research income. Over the past eight years, the average UK research council funding amounted to some 20% of the total Wales sector's research income, with universities securing most of their research income from a variety of other sources including European Framework programmes, structural funds, Technology Strategy

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LWS (2015)

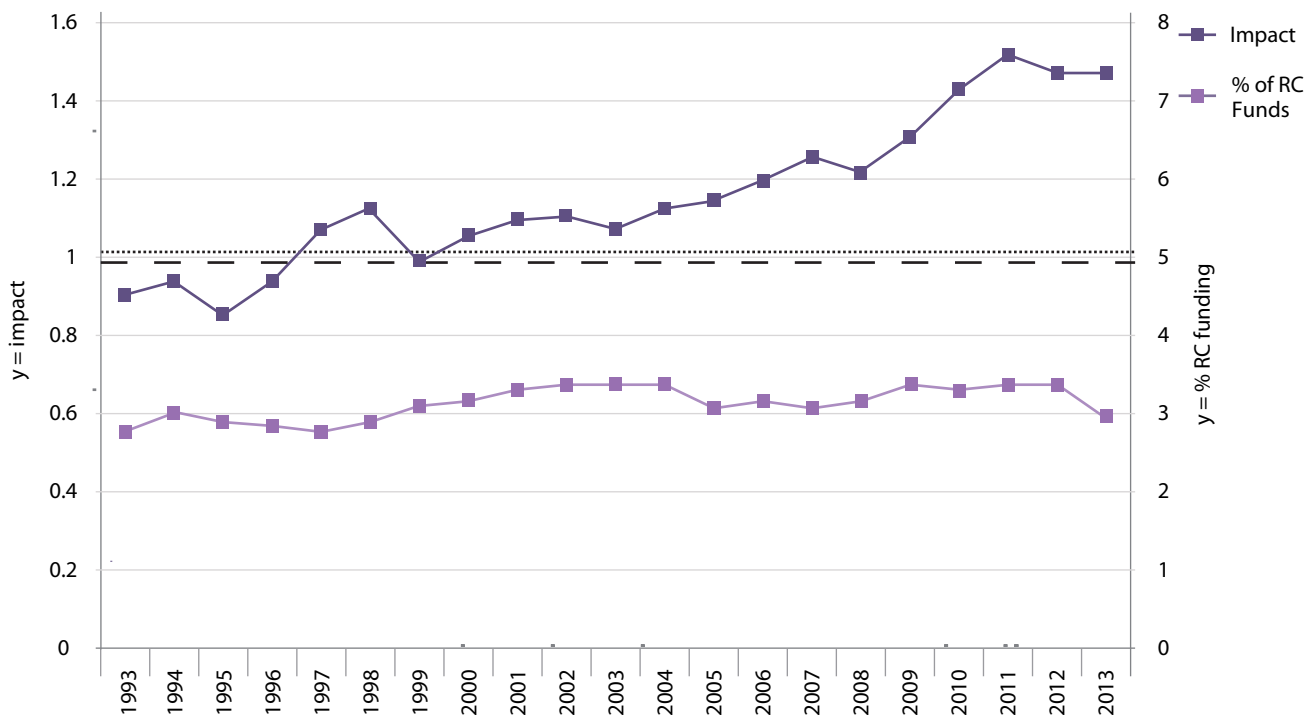
Board, National Health Service in Wales, National Institute of Social Care and Health Research, European structural funds, charities and industry.

The importance of HEFCW's QR grant for Welsh universities should not be underestimated as it has remained the largest single source of research income of the sector's total research income. Despite this sizable contribution, the Welsh percentage of the UK's QR funding has been steadily falling to 3.9% in 2013, significantly below the 4.8% share that might be expected on the basis of its share of the UK population¹⁷⁷.

Redressing the balance

The strategic decision to fund reconfiguration and collaboration over the past decade was intended to improve the quality of research conducted by Welsh HEIs and was largely directed at countering the effects of the sector’s historical *fractionation*. Although this produced little effect on the Welsh Government’s high-profile target of growing research council funding, the initiatives were associated with impressive improvements in Welsh research performance (as measured by published research impact) over the last decade and particularly from 2003 onwards (see Figure 8).

Figure 8: Comparison of Wales’s RC performance and research citation impact, 1993–2013



Note: Welsh Government’s RC target = 5% (..... right X axis); World average for research impact (— ; left X axis)

While the Welsh Government’s collaboration and reconfiguration policies were not able to compensate for the low levels of STEMM staff required to secure a greater volume of RC income capture, it seems reasonable to conclude that the collective initiatives over the past two decades contributed to improving Wales’s research output performance.

While always difficult to attribute specific outcomes to discrete causes, it seems reasonable to argue that the substantial improvement in Wales's research impact and productivity over the past decade was due to a combination of factors, including HEFCW initiatives, raised university ambition and strategic improvements in institutional research management, all of which helped encourage research-intensive institutions to pay closer attention to their research productivity, quality, and interdisciplinary and international collaboration. The role played by the QR grant, administered by HEFCW and controlled by individual universities, was also very important.

The quest to secure Wales's 'standard share' of research council income proved elusive due in the main to Wales's historic shortfall in STEMM research capacity. The Welsh Government and universities are now working to address this deficit using the major investment provided by Sêr Cymru funding . Building upon the Sêr Cymru ,investment, Wales's current chief scientific adviser is currently planning how future initiatives can improve the Welsh research community's ability to win greater competitive funding.

Conclusion

- It is apparent that Wales has some catching up to do. The Welsh Government's 2012 contribution of £50m towards building a stronger science base was a start that demonstrated the need to address the longstanding STEMM capacity deficit in Wales and support for the economic and national development of Wales.
- While all Welsh universities engage in research, only a small number of Wales's HEIs have the research capability to grow their science base significantly.
- Like all large complex change projects, it will take several years to fully capture the impact of Sêr Cymru and new planned initiatives.
- It is important that any future investment is not secured at the expense of other important subject disciplines such as social sciences, arts and humanities, where Wales has already an established record of research excellence.
- It also seems clear that any remedial action to compensate for the historical shortfall in STEMM in Wales needs to be worth the investment for the size of gain to be realised and maintained.
- Ensuring that Wales has the future research capacity to win greater competitive funding to build a strong and sustainable science base will require ongoing investment and a long-term strategy that provides a future roadmap where Universities can manage to balance their research and educational missions with the growing demand to operate in an internationally competitive higher education sector.

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Abbreviations

AHRC: Arts and Humanities Research Council
 BBSRC: Biotechnology and Biological Sciences Research Council
 BIS: Department for Business, Innovation and Skills
 CSA: chief scientific adviser
 DCELLS: Department for Children, Education, Lifelong Learning and Skills
 ELL Committee: Education and Lifelong Learning Committee
 ESRC: Economic and Social Research Council
 EPSRC: Engineering and Physical Sciences Research Council
 FPE: full-person equivalent
 FTE: full-time equivalent
 HEIs: higher education institutions
 HEFCW: Higher Education Funding Council for Wales
 HEW: Higher Education Wales (Universities Wales from September 2014)
 GERD: gross domestic expenditure on research and development
 GDP: gross domestic product
 GPA: grade point average
 GVA: gross value-added
 MRC: Medical Research Council
 NERC: Natural and Environmental Sciences Research Council
 NI: Northern Ireland
 OECD: Organisation for Economic Cooperation and Development
 PGR: postgraduate research
 QR: quality research (income based on formula funding distributed post-RAE/REF)
 R&T: research and teaching
 RAE: research assessment exercise
 RC: research council
 RCF: Reconfiguration and Collaboration Fund
 REF: research excellence framework
 RIEC: Research, Innovation and Engagement Committee (HEFCW)
 SDF: Strategic Development Fund
 SERC: Science and Engineering Research Council
 STEM: science, technology, engineering and mathematics
 STEMM: science, technology, engineering, mathematics and medicine
 STFC: Science and Technology Facilities Council
 TSD: Trinity St David's
 UFC: University Funding Council
 UoA: unit of assessment
 USW: University of South Wales (resulting merger of University of Glamorgan and the University of Wales, Newport)
 UWIC: University of Wales Institute, Cardiff (formerly Cardiff Metropolitan University)
 WAO: Wales Audit Office
 WAG: Welsh Assembly Government (WG since May 2011)
 WG: Welsh Government (formerly WAG)

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Peter W Halligan and **Louise Bright**

Biographies

Professor Peter W Halligan

Peter W Halligan is currently Chief Executive of the Learned Society of Wales, Wales's first national scholarly academy. During 2013-14, he was Head of Strategic Futures at Universities Wales.

Professor of Neuropsychology and Dean of Interdisciplinary Studies at Cardiff University until 2014, Professor Halligan joined the School of Psychology in Cardiff as Distinguished Research Professorial Fellow in 2000. He had previously worked at Oxford University as a Research Fellow and subsequently as a Medical Research Council Senior Research Fellow in the departments of Clinical Neurology and Experimental Psychology.

At Cardiff, Professor Halligan played a central role in establishing the Cardiff University Brain Research Imaging Centre (CUBRIC), Wales Research and Diagnostic Positron Emission Tomography Imaging Centre (PETIC), Wales Institute of Cognitive Neuroscience (WICN), the UnumProvident Centre for Psychosocial and Disability Research, Cardiff Cognitive Neuroscience Seminar Series, School of Psychology MindArt project, the Haydn Ellis Distinguished Lecture Series, and Cardiff's first University Research Institutes.

His research has been reported widely in the national and international media, including the *New York Times*, *Economist*, *New Scientist*, *Guardian*, *Western Mail*, BBC, Channel 4, Channel 5 and BBC Radio 4. Co-editor of the international journal *Cognitive Neuropsychiatry*, Professor Halligan has published over 200 papers including papers in *Nature*, *BMJ*, *The Lancet* and *Nature Reviews Neuroscience* and has also edited 10 books.

Professor Halligan is a Fellow of the British Psychological Society, Irish Psychological Society and Academy of Medical Sciences. In 2005, he was awarded the British Psychological Society Presidents' Award for outstanding contributions to psychology. In 2010, he was appointed Chair and Academic Lead of Welsh Crucible, a unique all-Wales staff leadership programme for early career researchers. This flagship researcher development programme, which was showcased at the European Commission in Brussels, won the Times Higher Education Award for Outstanding Contribution to Leadership Development in 2013.

Dr Louise Bright

Dr Louise Bright is Deputy Director of Research and Business Engagement at the University of South Wales. While previously seconded to the Welsh Government, Louise undertook a study on how the government might work with Welsh universities to increase the levels of research council income. The outcomes of the study formed the basis for a ministerial-approved report with policy implications. During her secondment, Dr Bright was also responsible for drafting a proposal to establish a National Science Academy for Wales. This was approved and Dr Bright now works with the Welsh Government on a consultancy basis to help it deliver the National Science Academy and to inform the Welsh Government's Innovation Policy.

Dr Bright is the Associate Director of the Leadership Foundation for Higher Education with responsibility for Wales. This role builds on her experience of developing research students and academics to become effective researchers. She is a peer reviewer for the HR Excellence in Research Award and a member of the Chief Science Adviser for Wales Task and Finish Group, which is considering the role and contribution of women in science, technology, engineering and medical research in Wales.

Before moving into management, Dr Bright's research focused on freezing oocytes from patients whose fertility is threatened by chemotherapy or radiotherapy. This work was funded by the Leukaemia Research Appeal for Wales and involved the use of many novel techniques such as cryopreservation and double-immuno fluorescent staining. Following her PhD, she successfully established a new group that explored the pathogenesis of endometriosis. She now uses her own experience of being a research-active academic to help others fulfil their potential.

Notes



Notes

Stimulus paper

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