Regional research capacity: what role in levelling up?

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Executive summary

This is a report about the distribution of research – funding, output and achievement – within countries, particularly but not only, the UK. Within the UK, research capacity has become concentrated in the areas around London, as has economic activity more generally. Policy initiatives have sought to shift this imbalance, which influences innovation capacity, as part of economic levelling up.

Experience in other countries points to a common challenge faced by industrialised economies in addressing the problems of a mismatch between population distribution and economic stimuli in a post-industrial environment. Germany has invested enormous sums post-reunification to boost the economy of Eastern regions. This has resulted in the emergence of new centres of research excellence, but only a limited generic shift in levelling up research capacity between regions. The US has had a decades-long programme of research investment (EPSCoR) targeting states that historically had least success in winning research grants. This has raised the average impact of research in those areas but has not greatly improved capacity.

OECD data show that there is an exceptional regional economic imbalance within the UK compared to the US, Germany and the Netherlands. Despite ongoing regional disparities in UK research activity that align with this, as previously observed in an earlier HEPI report, the average academic research performance of the regions – indexed by citation data and by the Grade Point Average (GPA) awarded in the Research Excellence Framework (REF2021) – is very similar. We present a series of new analyses based not on regional aggregations, but on linear distance from central London. These shift the focus from regional patches and make it clear that, although there is a correlation across the country between GDP and research activity, research capacity is not pervasive but concentrated – in line with observations on the economic influence of cities – in a relatively small number of bands corresponding to major conurbations.

The UK's investment is neither as large as that in Germany nor as sustained as that in the US. The science budget is a marginal part of government investment, and its primary purpose has been to support research excellence and promise. Nonetheless successive governments over many decades

have found it difficult not to tinker around the edges with diverse short-run initiatives. These adjustments detract from the underlying purpose while being insufficient to have a significant national effect. Furthermore, they miss the key connection to teaching in a knowledge-based environment.

We conclude that:

1. **The 'golden triangle' does not evidently deliver research that is – on average – much more highly rated nor does it enhance *relative* GDP beyond that achieved in other regions.** The regions around London lay an egg that is no more golden than any other part of the country's research base. More eggs are laid and more volume is sustained because more of the country's research investment is absorbed.

2. **Research quality is more evenly distributed across the UK than is funding or volume output.** Relatively less funded units are delivering outcomes that are nonetheless of a value equal to those better funded. They appear perfectly capable of using a better funding balance to deliver more. The disparity in funding therefore seems to be not simply regional over-concentration but a retained bias towards particular institutions.

3. **Regional analyses hide the concentration of research activity within regions.** The regional research networks in the West Midlands, the North West, Yorkshire and the Humber and in Scotland are not well-developed. Rather, it is the Birmingham concentration, the trans-Pennine M62 corridor and the Scottish central belt that have the capacity and deliver most benefit, and much of their research collaboration is international not intra-regional. Outside those bands there is less distributed capacity than in South East England, compromising training and development capacity as well as innovation.

4. **The purpose of the science budget is to support excellent and promising research as judged by experienced and expert peer review, wherever such research is found and not only in present regional concentrations.** It is not a large budget, however, and its use to address socio-economic policy purposes detracts from its prime objective without deploying the mass required to achieve significant change. Levelling up can be aided and enhanced by a more equitable national balance but not delivered by higher education and research alone.

Introduction

The research landscape is important.[1] Public investment in the research base underpins wealth creation and quality of life through the training of highly qualified people, the development of knowledge capacity and the delivery of innovation. How much can research investment contribute to a more equitable economic landscape?

The 1997 report of the Committee of Inquiry chaired by Lord Dearing noted that the role of the research base was not reserved solely for the purposes of wealth creation at a national level, but also existed to advance the contributions of individual institutions to regions and localities:

> *Higher education is now a significant force in regional economies, as a source of income and employment, in contributing to cultural life, and in supporting regional and local economic development*.[2]

A 2022 report from a Commission led by former UK Prime Minister Gordon Brown argues further that there is a link between constitutional and economic problems, such as stagnant productivity and high regional inequality. While such questions are often viewed as separate, the Brown report makes the case that many of the UK's economic and democratic problems can be explained by undue centralisation.[3] UK research has, historically, been concentrated around London and South East England.

Higher education research underpins the knowledge economy as an environment for educating highly skilled people with the capability to handle information and risk. Unintended variance in the distribution of research activity compromises the potential for future innovation, development and prosperity. This is important for nations, but it is equally important to regions and cities.

We argue that the geographic outcome of grant awards is a reflection of an inequitable spread of research capacity, research potential and knowledge capital. The Department of Science, Innovation & Technology (DSIT) believes that the science budget (the resources deployed by UK Research and Innovation, UKRI) should be used to facilitate socio-economic policy goals.[4] But there is a tension with another objective of public research investment, which is the promotion and sustenance of global excellence deemed to be essential to knowledge competitiveness.

This report cannot address the history of UK government science policy, but several issues stand out as perennial. First, there is a fundamental issue about the purpose and capacity of the science budget. The Haldane principle (1918, reaffirmed in the Higher Education and Research Bill, 2017) is that decisions on research programmes are best taken by researchers (usually through peer review) and by evaluating the excellence of researchers and the quality and likely impact of proposals. Ministerial input is limited to high-level allocations between bodies. Ministerial directives towards economic objectives cut through this principle. The science budget is also small: less than 1% of total government spend.[5] It could be argued that every investment made outside Haldane criteria is a resource lost to furthering the aims of supporting excellence and promise and that there is, in any event, insufficient resource to address existing priorities.

Secondly, few governments have been able to resist some degree of tinkering with the science budget to address socio-economic problems. Few politicians accept that the cycle times of research investment and policy ambition are fundamentally different. Following various attempts during the 1950s to build momentum for investment in a UK version of MIT, the often quoted invocation by Harold Wilson of 'the white heat of the technological revolution' was the classic example from the 1960s.[6] The inevitable failure of science alone to revive (or replace) the coal, steel and car industries by the mid-1970s led to Shirley Williams's verdict as Secretary of State for Education that 'for the scientists, the party is over'.[7] Examples continue to the present day.

Thirdly, while this report considers the regional distribution of research investment and activity, we would also draw attention to the association between the activity and outcome of institutional teaching and learning (T&L) functions, fortunately well covered in another recent HEPI report.[8] The T&L function is supported across more institutions and a more pervasive regional ecology than the research and development (R&D) function. However, regional equity and levelling up cannot succeed unless the support for teaching is as effective as that for research, not least because international research collaboration (accounting for more than two-thirds of UK research articles and reviews) means that much research has an extra-national outcome and impact.

Fourthly, research activity does not exist independently of broader economic activity. People, including researchers, want to live and work in thriving economic and cultural locations. Big cities drive half of global economic growth and development.[9] An analysis in the *Financial Times* showed that 'Removing London's output and headcount would shave 14% off British living standards', enough for the rest of the country to slip behind Mississippi, the poorest of the US states.[10]

The research-intensive civic universities founded in the nineteenth century are not spread across the UK because of a regional strategy but because pre-existing, commercially successful, local industrial and commercial interests recognised the value of a teaching and research institution in maintaining their competitiveness: ship-building and marine engineering in Newcastle; woollen textiles and dyeing in Leeds; cotton textiles and mechanical engineering in Manchester. Now, we are faced with a post-industrial distribution of cities, people and institutions without these natural links.

We consider investment deployed in Germany and in the US. Germany has had the challenge of rebalancing East and West to stabilise democracy post-unification. The US has the Established Program to Stimulate Competitive Research (EPSCoR) in states with lower levels of research capacity.[11] Evidence from the US suggests that addressing research inequities requires sustained and substantial long-term funding dedicated to this purpose. Evidence from Germany indicates that achieving 'sufficient magnitude' may involve the allocation of very large sums of money. Even so, in both countries, the outcome achieved is more partial than comprehensive in redressing the identified imbalances.

In this context, we conclude that the science budget is neither sufficient to achieve any significant degree of levelling up across the whole economy without broader economic investment nor the appropriate tool for such a policy purpose. It may be a driver, but we need a working car as well.

Regional trends in 2004

In 2004, we reported for HEPI on research and UK regions.[12] Nine of the 12 UK regions are in England, but the data analysed in our reports capture the UK as a whole.

The 2004 report was written at the time of interest in Regional Development Agencies (RDAs) as a tool for regionally focused development. We noted that staff, funding, PhD awards and research publications were highly concentrated in the three regions in the South East of England, in and around London. This 'concentration of excellence' accounted for about half of England's research, or about 40% of UK research staff and a rather greater percentage of funding and publications. Regional subject coverage was similar but South East England had an exceptional level of biological and medical research, and a concentration of private sector development in that sector, while strong engineering and physical sciences were found elsewhere.

We agreed that the issue of workforce knowledge skills, and the high-level development associated with research centres, was a critical factor in enabling further R&D to prosper in any city or region. However, we questioned the notion, advanced by RDAs, that there were particular regional strengths: most RDA research strategies were extremely similar in focus (biotech-pharma, communications and IT, leisure and media, advanced engineering); global competitiveness and the internet had reduced the significance of proximity in knowledge transfer; studies of research collaboration showed that the average distance between collaborators had increased; and an analysis of the research contacts of UK chemical firms showed that most links were inter-regional.[13] We also noted the risks of dispersal of research investment to regions, in spreading capacity and talent without achieving any new centres with critical mass.

Over the two decades since that report, rather than progressively evolving towards solutions to regional disparity, the realised focus on the national distribution of research capacity and outcomes has become ever more intense without actually changing the landscape to any evident extent. It has also become clear that the impetus for this agenda is not peculiar to the UK; rather, it is a consequence of the decline of important regional

industries such as coal, steel and shipbuilding. This challenge is common to most G7 economies, and it is unlikely that research awards alone will be sufficient to address it. John Huston Finley, Former Commissioner of Education in the State of New York, has written that:

> *Nations, like people, are freer to sketch and plan when institutions have yet to be built and resources are still uncommitted than at a later stage when the die has been cast and one must live with what one has chosen*.[14]

The G7 had 'cast the die' whereas developing nations such as China, Singapore and South Korea were fashioning bold plans for the future.[15]

Germany and reunification

Germany has spent €trillions since reunification in levelling the economic playing field between East and West. The Centre for Cities has estimated that this initiative has raised the average productivity of the former East from around 60% to around 85% of that of the West, at an annual cost that is an order of magnitude greater than that of the entire UK levelling up fund. The continuing costs of levelling up remain high but have evidently contributed to significantly higher economic capacity and resilience.[16]

The distribution of research funding across Germany remains uneven, with a large part of expenditure concentrated in a few research-intensive regions, contributing to unresolved regional structural differences, according to the Friedrich-Ebert-Stiftung (FES). A 2022 report from FES analysed regional differences in R&D pre-COVID and found inconsistencies in government research spending per inhabitant among Germany's 16 federal Länder. Funds were concentrated in Hamburg and Berlin and in the West German states of North Rhine-Westphalia, Baden-Württemberg and Bavaria. Only one eastern state, Saxony, received comparable levels of research spending.[17]

Generally, Northern and Eastern Länder continue to receive significantly less funding per capita, especially for direct project funding. For example, Bremen and Lower Saxony received less than a third of the per capita research funds spent on Berlin. Gross expenditure on R&D across all sectors, including business, government and higher education spending, is also higher in Western German states. In regions with research-intensive business clusters, such as Stuttgart and Upper Bavaria, business R&D expenditure forms a large part of total investment and appears to reinforce public funding for research.

Eastern Germany contains the historically poorer institutions but includes Berlin. While Dresden is also strong in R&D expenditure, it is the only Eastern German region among the five strongest R&D regions on the basis of regional GDP. The FES report expressed concern that regional socio-economic disparities were entrenched, hampering economic development.

The FES suggests that the patterns of R&D expenditure in Germany sustains a system of 'to him who has will be given' with the most R&D-intensive regions

attracting the highest levels of public funding. While the authors labelled this a 'blind spot' in German research policy, it is worth bearing in mind when considering parallel UK policy criteria directing funding to institutes and programmes of proven excellence rather than potential impact.

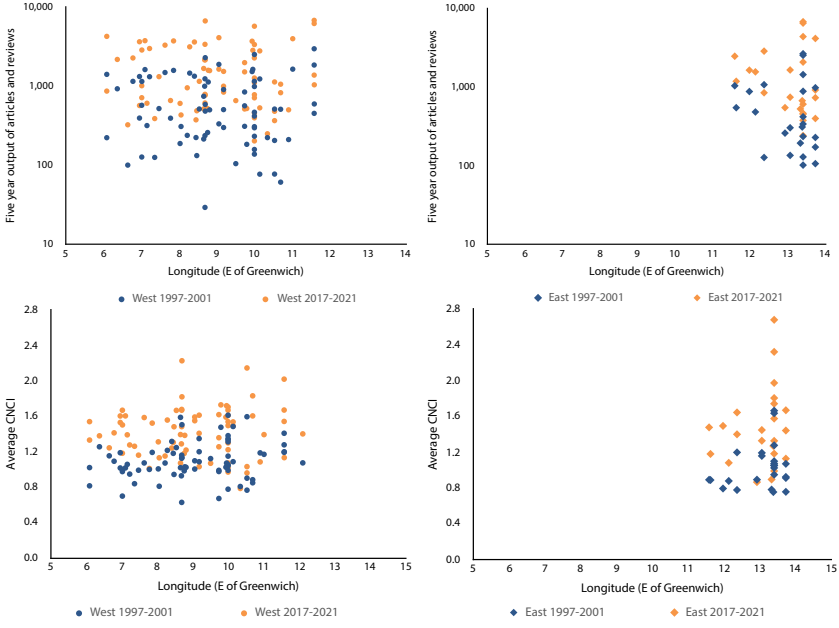
What has been the outcome from this level of investment and does the 'blind spot' actually play out in the research productivity and performance of the West and East German institutions? On this we need to exercise some caution, since the structure of the German research base has developed in a fundamentally different way to that in the UK. The overwhelming difference is the presence in the German system of a suite of public-sector research organisations (PROs) with multiple bases distributed across the country. The four largest are the Max Planck, Leibniz, Helmholtz and Fraunhofer – each with excellent international profiles – and they span a spectrum from basic to applied research and from public to private sector funding.

The four PROs account for slightly more than 20% of articles and reviews with a German address published in journals indexed in the Web of Science™ and this share has varied little over the last 25 years. The bulk of German research output is therefore attributable to higher education institutions (HEIs), although it is noteworthy that about 45% of Max Planck institute papers are cited more often than the world average (Category Normalised Citation Impact, CNCI), compared to about 35% of Germany's total output.[18] Many of these PROs are located on or are adjacent to a higher education institution and undoubtedly there is mutual benefit and interaction. The European Molecular Biology Laboratory is located just outside Heidelberg; it is excluded from this analysis but is likely to benefit the local university.

Focusing solely on the higher education institutions, we can track the output and citation impact of each institution from unification through to the present and thus observe whether there are differential signals of improvement across the state system. The data are reduced, for this analysis, to two comparable five-year periods: 1997 to 2001, slightly after the re-establishment of the single state; and 2017 to 2021, as for our later US analysis. Longitude is used as a convenient graphical axis for visual comparison between West and East (noting that the University of Regensburg lies slightly to the East of Friederich Schiller University in Jena).

The output of the higher education institutions has increased over 20 years in broadly the same proportions for these groups of institutions. In the early period, the average output of the 24 higher education institutions in the East was 646 papers over five years while the average for the 74 higher education institutions in the West was 729 papers. For the most recent period, these totals had risen to 1,772 in the East and 1,784 in the West. The East had therefore 'caught up' with the West in average output (upper graphs in Figure 1). The change in average citation impact was also rather similar. In the East, CNCI rose from 1.01 (just above world average) to 1.46 while in the West the average rose from 1.08 to 1.40. So, again, the East had caught up and – arguably – marginally bettered the West (lower graphs in Figure 1). Looking at the broad landscape, uniformity of change across the country might be the primary impression.

Figure 1. Distribution of volume (upper graphs) and citation impact (lower graphs) of articles and reviews published by German higher education institutions in 1997 to 2001 and 2017 to 2021, coded to show those in Länder originally in West and East Germany prior to unification. Data source: Web of Science, Clarivate



If there is a differential in funding between Länder, then that remains an issue of institutional capacity rather than equitable funding of research. Although the institutional averages and their citation recognition are similar, the overall volume is very different. The East produced a total of 15,510 papers in the early period rising to 42,518 in 2017 to 2021, while for the West the output was 53,936 rising to 131,996. The West is larger, has more institutions and produces three times as many outputs, so a variation in funding is inevitable. However, it is certainly true that an exceptional level of research investment has been made specifically in Berlin. In this analysis we have explicitly excluded *de facto* 'national' co-ordinating institutes in Berlin, founded relatively recently but to which exceptional numbers of publications are now attributed.

After a small but rapid post-unification rise in collaboration between universities in the previous Eastern and Western regions, from around 25% of output to about 30%, the level of collaboration has been essentially constant while volume has risen five-fold. As elsewhere, there is a premium on citation counts and indices of academic impact for collaboration and the benefits in Germany are equally shared.

Berlin's emergent research concentration, and perhaps that in Dresden, may in due course give rise to the same kinds of concern that have been frequently expressed in regard to the 'golden triangle' in the UK. For the present, however, the data suggest a markedly even distribution of higher education research activity and performance – and therefore capacity for highly-skilled education development – across a longitudinal transect through Germany. However, despite that evenness, major cities in the East continue to have lower higher education and research capacity and an 'osmotic' spread from Berlin and Dresden is not strongly evident.

The US and EPSCoR

It had been widely recognised in the US, not least by Congress, that there is a concentration of research capacity on the West and East coasts. Those research centres delivered a plethora of excellent research outcomes with international recognition, which unquestionably benefitted the country. The greatest benefit, however, emerged in the 'home' regions, enabling substantial economically advantageous technology development and pervasive enhancement of a knowledge-competent workforce. Benefit elsewhere, beyond the general economy, was less clear. The US National Science Foundation's (NSF) EPSCoR (Established Program to Stimulate Competitive Research) mission was established in 1978, to address Congress's concerns about research concentration. Its primary aim was to enhance research competitiveness in targeted states via investments in Science, Technology, Engineering and Mathematics (STEM) capacity and capability. This involved initiatives such as talent development programs and local infrastructure spending.[19]

Initially, funding started at around $1 million. But, over the years, EPSCoR and similar programmes have grown, not only within the NSF but also across four other agencies. The collective annual budget for these programmes has now surpassed $500 million. Agencies with active programmes include the Department of Energy (DOE – $10 million per annum in 2015), the National Aeronautics and Space Administration (NASA – $18 million), the US Department of Agriculture (USDA – $34 million) and the National Institutes of Health (NIH – $273 million). An EPSCoR Interagency Coordinating Committee (EICC), chaired by NSF, helps integrate these activities.

What has been the impact of EPSCoR? Some states have, through the historical foundation of major institutions and subsequent investment, been significantly more research productive than others. From 2017 to 2021, US researchers published around 2.5 million papers in journals indexed in the Web of Science. Around 465,000 of those had an author in California while fewer than 10,000 were published in five states (Table 1). There is an evident concentration of activity on the West and East coasts and a comparative paucity of research activity in the geographic middle of the nation.

Table 1. US states: upper and lower output quartiles, i.e., those publishing the most and fewest papers in journals indexed in the Web of Science (2017 to 2021). State short codes are included for cross-reference to Figure 2. Data source: Web of Science, Clarivate.

	Most prolific	Papers in journals		Least prolific	
CA	California	463,120	17,165	Arkansas	AR
NY	New York	310,768	14,767	Delaware	DE
MA	Massachusetts	284,219	14,210	Nevada	NV
TX	Texas	238,618	13,316	West Virginia	WV
PA	Pennsylvania	204,120	12,032	Idaho	ID
MD	Maryland	192,598	10,493	Montana	MT
IL	Illinois	161,567	10,162	Maine	ME
FL	Florida	142,576	9,848	Vermont	VT
NC	North Carolina	139,564	7,919	North Dakota	ND
OH	Ohio	137,730	7,072	Alaska	AK
MI	Michigan	126,125	6,604	South Dakota	SD
GA	Georgia	105,772	6,026	Wyoming	WY

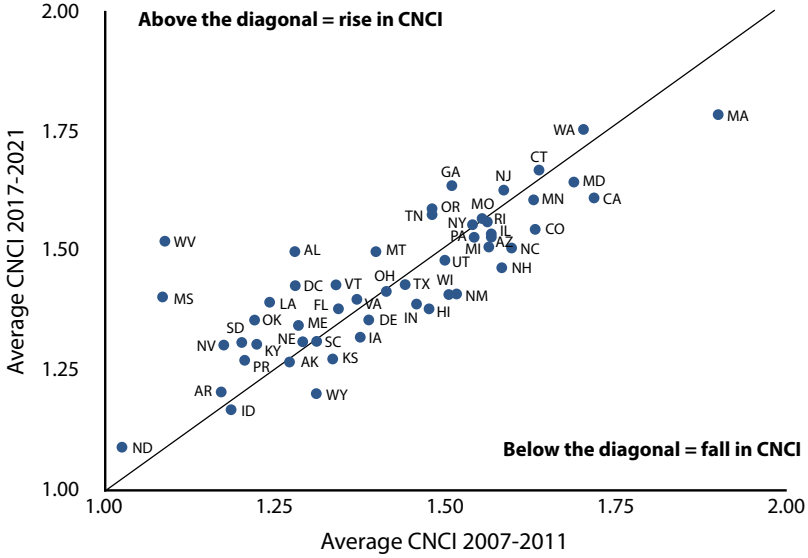
NSF's EPSCoR program funding is limited to jurisdictions that receive 0.75% or less of total NSF research and related activities funds over the most recent three-year period. Currently 25 states and three territories are eligible for EPSCoR funding, which include all the states in the 'Least prolific' column in Table 1. Of these 25 states, Alaska received the highest percentage of funding from NSF from the financial years 2018 to 2022 at 0.7%.

The manifestation of increased output takes time as capacity gradually builds. It is essential that this growth should not be merely in terms of volume but founded on and sustained by quality ideas, projects and outcomes. What changes can be detected at this stage in the relative quality of both past and current research publications?

We analysed citation data for two five-year periods: 2007 to 2011 and 2017 to 2021. We use five-year windows to smooth out annual perturbations. The analysis shows that the least well-cited quartile of states, with an average CNCI of 1.19 in 2007 to 2011, saw their citation impact rise to 1.33 in 2017 to 2021 whereas the most cited saw a marginal drop from 1.64 to 1.60 over

the same period. So, some states that have been prolific in their historical publishing patterns have plateaued in their relative CNCI, whereas a spread of states with smaller outputs have evidently improved in average citation performance.

Figure 2. Ten-year change in Category Normalized Citation Impact (CNCI, world average = 1.0) for U.S. States. CNCI reflects the attention given to these publications by later researchers. The short codes for states with highest and lowest prior funding are indicated in Table 1. Data source: Web of Science Clarivate



It is worth bearing in mind that interpreting change presents challenges. Some observed changes could be attributed to statistical variations and others may be a result of universities consolidating research efforts and creating pockets of excellence. Nonetheless, it appears that the cumulative effect of EPSCoR over several decades has been to enable a modest positive shift in the relative research outcomes for the less productive states. However, some other factors could be taken into account, including the effects of research collaboration.

Recently, funding agencies have been been placing a greater emphasis on achieving geographical and demographic diversity within the research teams they fund. This trend aligns with criteria similar to those found in European Framework Programmes). Consequently, reseachers in EPSCoR states are now engaging in collaborations with researchers who have a strong track record of receiving funding from federal agencies. The effect of this is likely to be a citation boost to the less well funded, potentially at some marginal cost to partners. Since the 1980s, papers from leading universities in the less prolific states have become more collaborative with the nationally recognised leading universities. A sample from 10 such universities indicates that collaboration with Harvard, Columbia, Yale, CalTech and Berkeley has risen from around 2% to rather more than 10% of output. These papers have tended to be more highly cited than average.

Other analyses have shown that internationally collaborative research also tends to be better cited than institutional research, so the relationship between targeted funding such as the EPSCoR program and international engagement might be revealing. Certainly, international collaboration has risen and now makes up about 35% to 40% of US institutional output with an average CNCI for 10 'regional' universities or university systems of 2.07 compared to their baseline average of 1.44.

The UK and levelling up

The level of regional investment in the UK has never approached that of Germany, and there is no programme akin to that of EPSCoR.

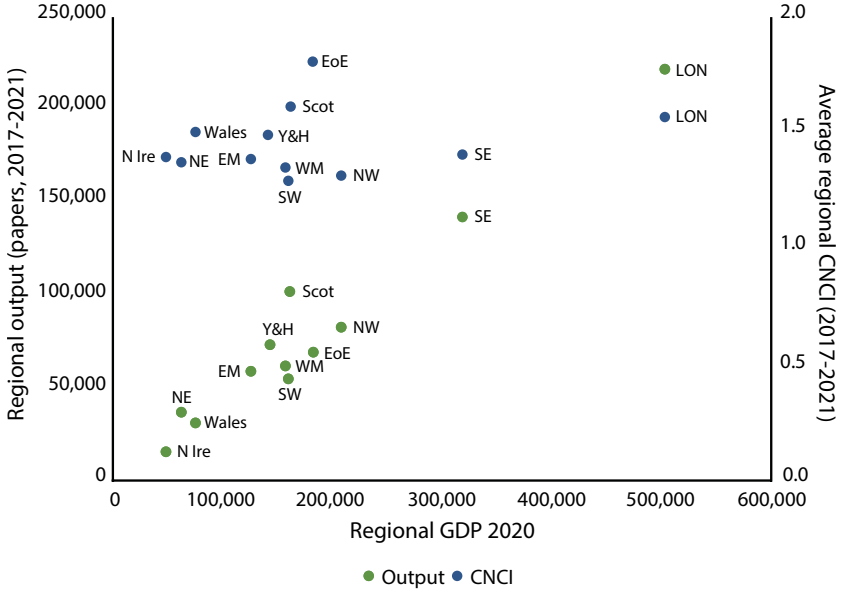
The present UK administration spoke extensively of the need for regional redistribution of investment and support for economic development and regeneration in the Conservative Party's 2019 election manifesto. The goal was to reduce the imbalances, primarily economic, between areas and social groups across the United Kingdom without detriment to prosperous areas, such as South East England. A white paper for the policy was published by then Prime Minister Boris Johnson's Government on 2 February 2022.[20] The policy position has been continued by subsequent Conservative leaders, particularly via the Department for Levelling Up, Housing and Communities (DLUHC) reconstituted in September 2021 from Housing, Communities and Local Government. The Levelling-up and Regeneration Act received Royal Assent in October 2023.

Universities and their research activity are not distributed uniformly across the UK. The patchiness influences the possibilities for innovative opportunities and their spillover into research training and transferable knowledge, just as it had done in Germany and the US. Typically, research and industrial distributions have been considered in terms of 12 standard NUTS1 regions, which enables a wide range of economic and other statistics to be linked.[21]

Regions are convenient economic units but have less significance for the organisation of research. For example, it is obvious that the South East region stretching around London from Canterbury to Southampton and up to Oxford would not be meaningful in terms of university, industry and public body collaborations.

The data show that the volume of higher education research activity in the UK regions increases with regional GDP: wealthier economic units are associated with greater volumes. However, there is no such association with the indexed quality of the research. Regions with greater GDP are not supporting better research. The smaller research output in regions with lower GDP is as innovative on average as that in regions with higher GDP.[22]

Figure 3. Research capacity (counts of academic research papers, 2017 to 2021) is distributed in proportion to GDP across regions, but the indexed performance of those papers (CNCI) is unrelated to GDP. Data source: Web of Science, Clarivate



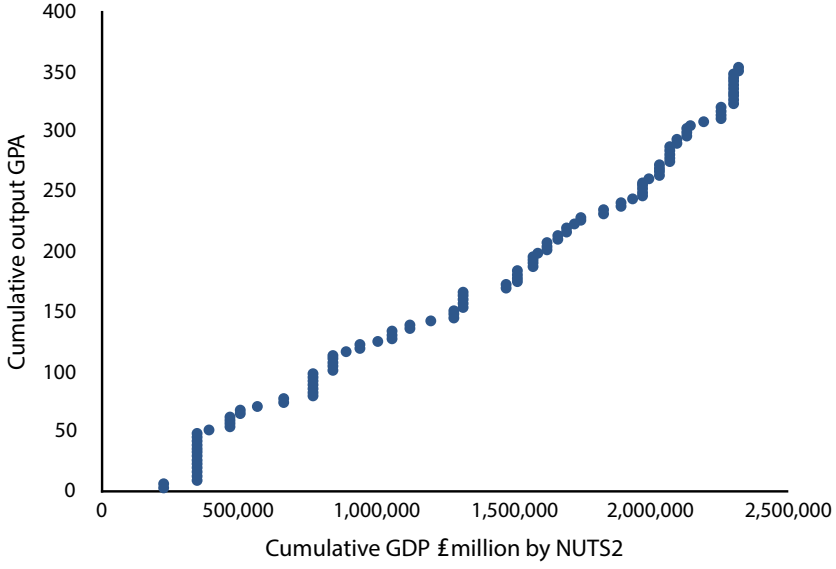
A regional focus presents a lumpy picture of research concentration, and the shape of UK regions disguises the strength of London-centrism. The core of UK research activity concentrated in the South East region of England is often referred to as a 'golden triangle' linking Cambridge, Oxford and central London. The image of a 'golden triangle' is unhelpful since it associates this area with the idea of a haven of knowledge linked to ancient universities. The data suggest that this is inaccurate and, perhaps, pejorative to newer institutions.

As a complement to regionalism, we can examine the same data at the level of the more finely grained NUTS2 sub-regions and then plot this against the radial distance from central London, using the actual distance (in kilometres) to each institution from Westminster. This London-centricity is of course less appropriate to Wales and Scotland, which share the same

UKRI project grant and fellowship system, but have their own core research funding systems. However, the outcomes remain of general interest.

Beyond the initial inner-London spike, the analysis produces what is essentially a straight-line distribution of research and economic activity. The distributions for the Grade Point Average (GPA) awarded in REF2021 and profiled by either cumulative GDP or cumulative population look very similar to this graph. That suggests that GDP is benefitting from research excellence at about the same rate throughout the country.

Figure 4. Correlation between cumulative GDP as distance from central London increases and the cumulative Grade Point Average (GPA) awarded in the Research Excellence Framework 2021. Increasing radial distance from London encompasses greater area and cumulative area can be estimated by aggregating NUTS2 sub-regional data.

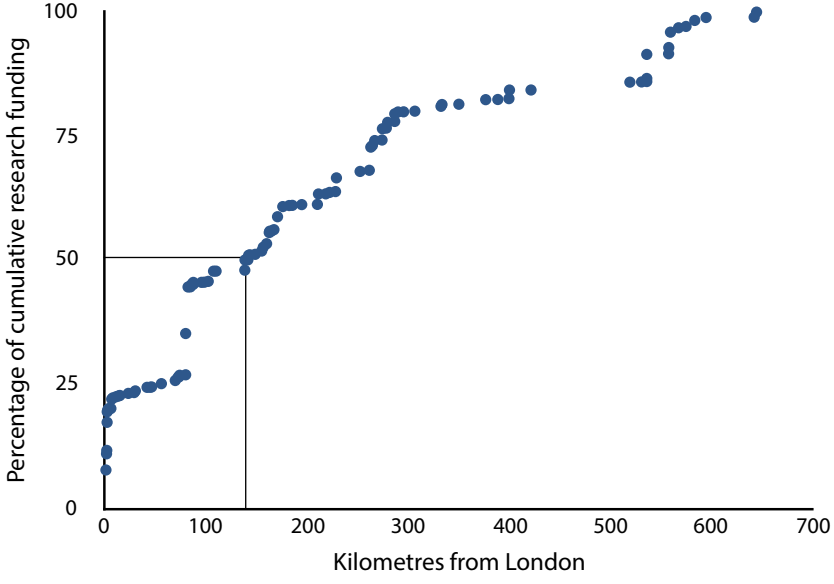


The amount of research that is supported and knowledge generated are likely contingent on the volume of resources available. The data collated at REF2021 for each institution constitutes a comprehensive and audited guide to the distribution of research project grants and of total research funding, including centrally allocated block QR (Quality Related) funding.

In practice, the distributions are almost identical, allowing us to focus on just one of them.

If we compare the cumulative volume of research funding with increasing distance from Westminster, then we can see that about half of total UK research funds are found within a radius of 140 kilometres, which is roughly the distance to the Universities of Gloucestershire or Warwick. It includes no Welsh institutions and is less than one-quarter of the distance to the University of Aberdeen (about 640 kilometres).

Figure 5. Correlation between cumulative research funding reported to REF2021 and institutional distance from London. About half of UK research funding is concentrated within a 140km radius



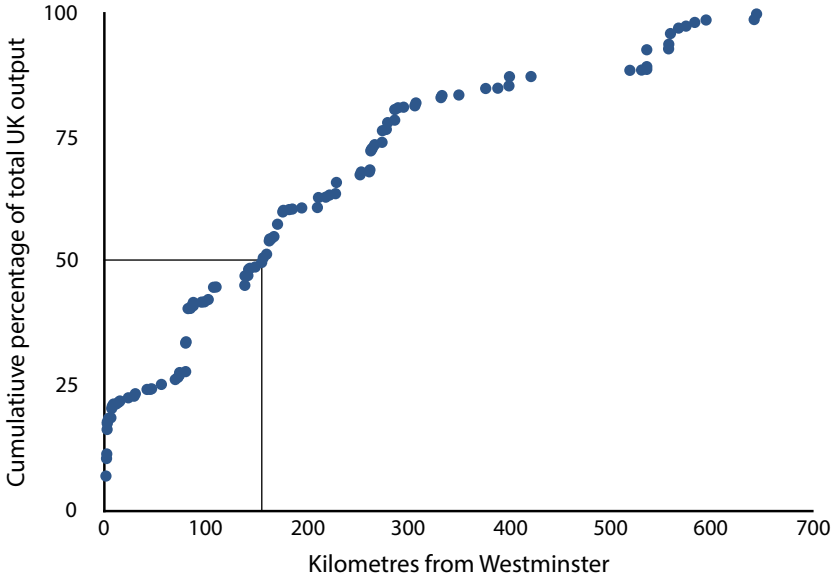
These data also show no continuous distribution. It is one that is concentrated at the origin and then steps upwards at major conurbations (such as the West Midlands around Birmingham) and bands (such as the Lancashire-Yorkshire corridor across the Pennines marked by the M62). This clarifies the true distribution of research activity: it is not regional but tightly urban. It is also evident that research activity thins out significantly beyond 270 kilometres (Manchester, Swansea) and there is then a 100-kilometre northwards 'gap' with no research institutions until the next concentration is reached in the Scottish Midland valley and broad periphery linking Glasgow and Edinburgh.

Funding leads to research activity and thence to publication. Publication rates vary between subjects. It is, for example, much lower in the performing and visual arts and much higher in life sciences. If we exclude the specialist arts institutions, concentrated in London, from the analysis then there is no strong pattern of subject distribution nationally. We can therefore take total institutional publication output as a reasonable proxy for activity and, perhaps, productivity.

The comparison between the cumulative output of papers published in journals indexed on the Web of Science and the distance from Westminster of the publishing higher education institutions follows a similar pattern to that seen in the funding data. It is perhaps marginally less concentrated, due to London weighting. In fact, the 50% threshold is met at about 155 kilometres, the distance from Westminster to the Universities of Bath and East Anglia.

The discontinuous step-wise distribution seen in funding is repeated in output. It is particularly concentrated in a region near London and across the country in relatively concentrated bands: London; an 80 kilometre ring with Cambridge and Oxford; a Midlands ring at 160 kilometres; the M62 band at 260-280 kilometres; and the Midland valley and central belt in Scotland at around 550 kilometres from Westminster. The geography of Wales spreads research institutions thinly over 100 kilometres from Cardiff to Bangor with challenging communication links.

Figure 6. Correlation between cumulative count of research papers published in journals indexed in the Web of Science (2012 to 2021) and the distance of the authors' institutions from London. About half of UK research publication output was within 155 km of Westminster. Data source: Web of Science, Clarivate

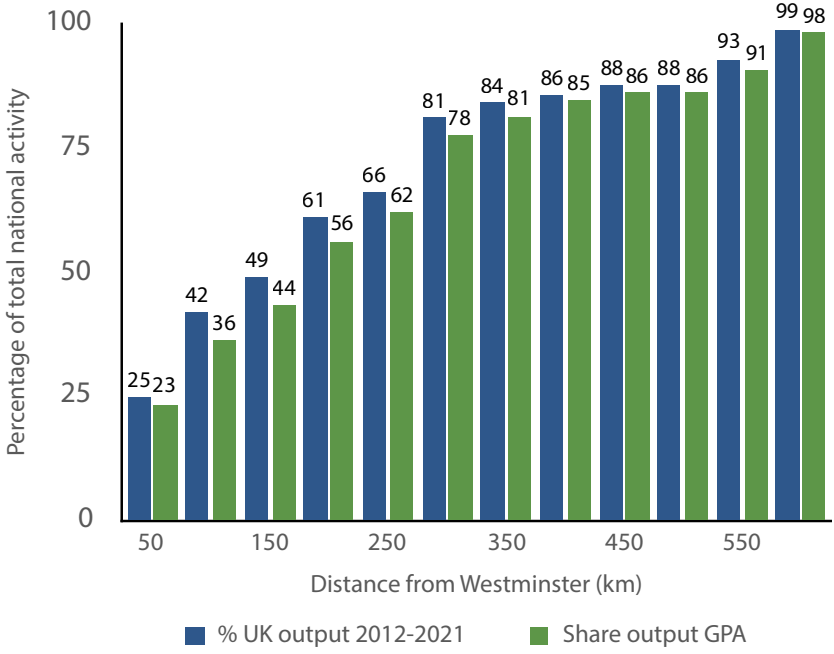


If funding and output are concentrated close to Westminster, is the outcome in terms of peer evaluation and / or academic impact similarly concentrated? Citation impact is dimensionless and not readily 'accumulated', although we could construct a combination of output and impact as 'research power'. However, to create an index of research impact not based on citations, we can consider the cumulative total GPA scores awarded by peer panels in REF2021 (which also affirms the relationship between peer evaluation and citation impact).

The concentration of research output close to Westminster leads, unsurprisingly, to a concentration of cumulative GPA scaled across the same area. However, the panel judgments are that the spread of research quality is not proportional to volume but is somewhat more widely distributed than the underlying activity. The 155-kilometre ring accounted for about

50% of volume output but only 43.5% of cumulative GPA. The ring must be extended to 175 kilometres to reach GPA-50% and adds the Universities of Birmingham and Bristol.

Figure 7. The GPA scores (which demonstrably correlate with citation impact) are more evenly distributed with distance from Westminster than is output.



The dissemination of research knowledge is not only via publication but also via collaboration. Collaboration between researcher and research user is the most effective way of engaging a user's full understanding and therefore accelerating knowledge development by feedback, knowledge transfer by direct involvement and thus making the process more complete. This 'new production of knowledge' has been discussed in the context of 'Mode 2' research.[23]

The trend towards greater collaboration has grown considerably over the last 20 years and continues to rise.[24] Centres of research capacity and high-indexed impact primarily collaborate with other elite research institutions

outside their own economy. A significant channel for knowledge transfer is therefore not into the region or even into the national research base but into an international network. For 2016 to 2020, about 52% of UK research papers had international co-authors and the most internationally collaborative UK regions, on average, were Scotland (57%) and Northern Ireland (64%). Within England, however, Cambridge and Oxford universities, Imperial and University College London all had international co-authors on more than two-thirds of their publications. Thus, the core of the 'golden triangle' is the part of the research base most externally orientated and least regional.

Discussion

The distribution of research capacity in the UK, essential to innovation and economic growth, remains extremely uneven and the overall pattern has changed little since our previous HEPI report in 2004. OECD data show the distribution of economic activity is equally uneven – more so in the UK than other comparable economies. However, additional data make it evident that, while funding capacity outside South East England is less than elsewhere, the regional distribution of research quality is more even.

Our new analysis by distance from a point shows that conventional regional summaries obscure the degree of concentration within regions. Consequently, many communities disrupted by post-industrial decline – particularly in the coal and steel sectors – have little local access to training opportunities associated with high-quality research despite being in regions with excellent research institutions.

This problem is shared by other post-industrial economies with a strong national research base. The German investment in reunification has achieved some balancing of research capacity in East and West but the cost has been extremely high. The US EPSCoR experience has enhanced research in deficit states but only via a programme sustained over decades. Their experience suggests that some improvement in levelling up is achievable, and their economies are more evenly distributed, but change is neither quick nor sufficiently low cost to be done by leveraging the science budget.

The UK can redistribute its research capabilities to great regional benefit but it will not do it by tinkering with science allocations over a short policy cycle. Nor is a 'regional' analysis a sufficiently informed approach.

First, the golden triangle around London lays an egg that is no more golden than any other part of the country's research base. It may lay more eggs but that is because it absorbs more of the country's research investment and sustains more volume, but it does not evidently deliver research that is – on average – much more highly rated nor enhance the *relative* GDP of the region beyond that achieved elsewhere. It also has stronger collaborative links outside the UK than into the national economy and, given its average indexed citation impact, the 'golden triangle' must include a concentration of relatively weak units in addition to its recognised research performers.

Secondly, research quality is more evenly distributed across the UK than is funding or volume output. Relatively less funded units are delivering outcomes that are nonetheless of a value equal to those better funded. The disparity in funding is therefore more problematic than simply regional over-concentration and may reflect a retained and somewhat toxic historical and cultural bias towards particular institutions.

Thirdly, while regional analyses have a long economic history and therefore engage with a sound database, they hide the concentration of research activity within regions. It would be a misinterpretation to assert that the West Midlands, the North West, Yorkshire and the Humber and Scotland have well-developed regional research bases. Rather, it is the Birmingham concentration, the M62 corridor and the Scottish central belt that benefit. The rest of these regions outside those bands has far less distributed capacity than South East England, and this compromises training and development capacity as well as innovation.

Several issues follow from this:

i. Current innovative capacity in the UK outside South East England is not an outcome of weaker research quality but of lower relative investment and therefore output capacity.

ii. Research quality is not affected by volume but the discontinuous, step-wise and banded distribution results in *de facto* cold spots that lack innovative capacity.

iii. Cold spots in the distribution of research inevitably lead to cold spots in education and training.

Innovative capacity will be affected not only by the present distribution of research activity, but also in the future by the knowledge environment that is contributed by research through spill-over into education and training. The data confirm a skewed concentration of research funding, hence volume, but not of quality. From this we conclude that constraints in regional economic development arise through both a reduced regional volume of innovative research and knowledge development and a reduced regional access to a skilled and innovative workforce to exploit innovative opportunities.

The absorption of research funding in London, East and South East England leads to gaps in resourcing and activity elsewhere. Banding of research around major UK conurbations is revealed by distance analysis but those bands still lack the critical mass of investment that would enable dissemination of skills and knowledge into their surrounding regions.

A highlight of analysis of German post-unification investment by Katherin Enenkel at the Centre for Cities is the critical role of larger cities. Outside Berlin and Dresden, those in former East Germany, such as Jena and Leipzig, still struggle to attract higher skilled jobs and have lower shares of employment in high-value added industries than, say, Frankfurt or Düsseldorf, which makes them less productive. The data indicate this has implications not only for the cities themselves but also for the jobs they can offer to people living in nearby towns and villages.

The German experience has implications for the spread of knowledge and innovation capacity within as well as across regions. For example, the resources required to boost activity along the M62 corridor cannot be limited to further concentration in the larger institutions along that band. It will need to spread to the network of other higher education institutions and enhance links into colleges that contribute to overall development. That cannot all be driven by the science budget since it is focussed on restructuring of present economic and societal imbalances, not on research centres.

A legitimate shift of research funding across UK areas, retaining existing criteria of excellence and promise, should have led to investment in research of equal quality judged by both national assessment and international citations. It appears not to have done so because of concentration on conventional centres of excellence close to London. A more transparent redistribution would boost early innovative research outcomes in other regions and enhance innovative capacity through improvements in the research environment and in training. This would lead in turn to an increase in regional economic innovation through enhanced processes, and new products and a greater and more distributive growth in GDP.

This report focuses on data drawn from the public sector research base, which is supported by the UKRI science budget. The budget is already stretched, faces multiple additional demands including international

opportunities, and cannot be the prime lever to shift the levelling-up agenda. The entire agenda is meaningless without very substantial, sustained and targeted funding. The Brown Commission recommendations on devolved regional government, associated with devolved spending powers, may very well be an important component in answering such a requirement.

Endnotes

1 The research landscape is discussed in this report in terms of institutional and regional input and output variables with a primary focus on research activity and achievement. Research that is seen by peers as being of greater significance is likely to be innovative in itself and lead to or be associated with innovation in new processes and products of economic, health or societal benefit. We rely primarily on bibliometric analysis for an indicator of achievement, and a strong association is found between such indicators and peer assessment. Publication and citation indicators provide a useful and accessible common currency across jurisdictions where a broad relationship between normalised citation counts and peer judgments has been demonstrated.

2 National Committee of Inquiry into Higher Education, *Higher Education in the learning society*: The Dearing Report. London: Her Majesty's Stationery Office, 1997. Related quotes can be found in the Foreword paras 9 and 61.

Jonathan Adams and David Smith, Higher education and the knowledge economy: from Robbins to 'The Gathering Storm', pp 81-108, in, *The Dearing Report: ten years on*, ed. David Watson and Michael Amoah, 2007. Institute of Education, London. ISBN 0 85473 780 4.

3 The 'Brown Report'. The Labour Party, *A new Britain: Renewing our democracy and rebuilding our economy. Report of the Commission on the UK's Future*, December 2022. https://labour.org.uk/wp-content/uploads/2022/12/Commission-on-the-UKs-Future.pdf

4 Specific guidance to UKRI from the Department of Science, Innovation & Technology (June 2023): 'Research England's ongoing attention to the levelling up agenda and supporting the UKRI organisational objective to "Deliver economic, social, and cultural benefits from research and innovation to all of our citizens, including by developing research and innovation strengths across the UK in support of levelling up" is encouraging. Research England has already demonstrated this through increased QR distributed outside the greater Southeast and the delivery of the UKRI Strength in Places Fund. The Expanding Excellence in England programme also supports this goal, and we welcome the second round of this programme.' https://www.ukri.org/wp-content/uploads/2023/06/RE-13062023-DSIT-GuidanceForResearchEngland-2023-24.pdf

5 The UKRI science budget for 2022/23 was slightly less than £8 billion compared to total UK government departmental spend of slightly more than £1,000 billion.

6 Prime Minister Harold Wilson delivered his speech to a Labour Party conference in October 1963.

David Smith, Lewis Baston, Jean Bocock and Peter Scott, 'Americanisation and UK higher education: towards a history of transatlantic influence on policy and practice', *Journal of Education Policy*, Volume 17, Issue 4, pp.443-461, 2002 https://www.tandfonline.com/doi/abs/10.1080/02680930210140266

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7 Shirley Williams, 'The responsibility of science', *The Times Saturday Review*, 27 February 1971.

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8 Nicola Dandridge, *The relationship between teaching and research in UK universities – what is it and does it matter?* HEPI Report 162, July 2023 https://www.hepi.ac.uk/wp-content/uploads/2023/07/The-relationship-between-teaching-and-research-in-UK-universities-what-is-it-and-does-it-matter.pdf

9 Valentina Romei and Alan Smith, 'Big cities drive half of global economic growth', *Financial Times*, 7 December 2022 https://www.ft.com/content/24dbcc0f-7974-48d7-9824-ab86b58a3a29

10 John Burn-Murdoch, 'Is Britain really as poor as Mississippi?', *Financial Times*, 10 August 2023 https://www.ft.com/content/e5c741a7-befa-4d49-a819-f1b0510a9802

11 UK: https://www.gov.uk/government/speeches/the-prime-ministers-levelling-up-speech-15-july-2021); Germany: https://www.centreforcities.org/levelling-up/; US: EPSCoR https://beta.nsf.gov/funding/initiatives/epscor

12 Jonathan Adams and David Smith, *Research and regions: An overview of the distribution of research in UK regions, regional research capacity and links between strategic research partners,* HEPI Report 9, March 2004 https://www.hepi.ac.uk/2004/03/29/research-and-regions-an-overview-of-the-distribution-of-research-in-uk-regions-regional-research-capacity-and-links-between-strategic-research-partners/

13 David Charles, 'Universities and Territorial Development: Reshaping the Regional Role of UK Universities', *Local Economy*, Volume 18, Issue 1, pp.7-20, 2003 https://www.researchgate.net/publication/24085324_Universities_and_Territorial_Development_Reshaping_the_Regional_Role_of_UK_Universities

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David Smith and Sylvan Katz, *Collaborative approaches to research*, A report to the Higher Education Funding Council for England, Centre for Policy Studies in Education, University of Leeds, 2000.

14 John Huston Finley, *Four Stages of Greek Thought*, Stanford University Press, pp. 114, 1966.

15 The G7 is a group of advanced economies accounting for about half of global wealth: the US, UK, Canada, France, Germany, Italy and Japan.

16 https://www.centreforcities.org/levelling-up/

17 https://library.fes.de/pdf-files/a-p-b/19553.pdf

18 Citation counts to academic papers are a conventional route to identifying more and less influential work. Such counts rise over time at a rate that is discipline dependent. The citation count of each is 'normalised' to account for this and to provide a standardised index by calculating the ratio of a specific count to the world average for the appropriate publication year and journal subject category. This is referred to as Category Normalised Citation Impact (CNCI).

19 EPSCoR programme awards over the past five years include: outreach engaging around 7,000 faculty in universities and colleges, almost 20,000 teachers in schools and over 300,000 school students; involvement of around 500 under-represented minority graduate and undergraduate students in EPSCoR projects relevant to their degrees, which they attained; projects leading to 64 new patents and leveraging around $1.5 billion in new awards.

20 https://www.gov.uk/government/publications/levelling-up-the-united-kingdom

21 NUTS1 as defined in UK statistics and international NUTS (nomenclature des unités territoriales statistiques), a geocode standard adopted in 2003 for referencing administrative divisions for statistical purposes.

22 Note that, EMBL was excluded from the German analysis, and so institutes such as the Crick are excluded from the UK analysis.

23 Helga Nowotny, Peter Scott and Michael Gibbons, '"Mode 2" Revisited: The New Production of Knowledge, *Minerva*, Volume 41, pp.179–194, 2003 https://link.springer.com/article/10.1023/A:1025505528250

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This report compares the UK's policies intended to 'level up' the research and innovation capacity of regions with those in Germany after unification as well as in the US. The report concludes that investment has been too small and poorly linked to boosting research capacity.

The report also confirms there is exceptional regional economic imbalance in the UK. Yet despite disparities in the scale of UK regional research activity, the average academic research performance of the regions is similar. For example, the 'golden triangle' around London does not deliver research that is on average much more highly rated than that achieved in other regions.

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