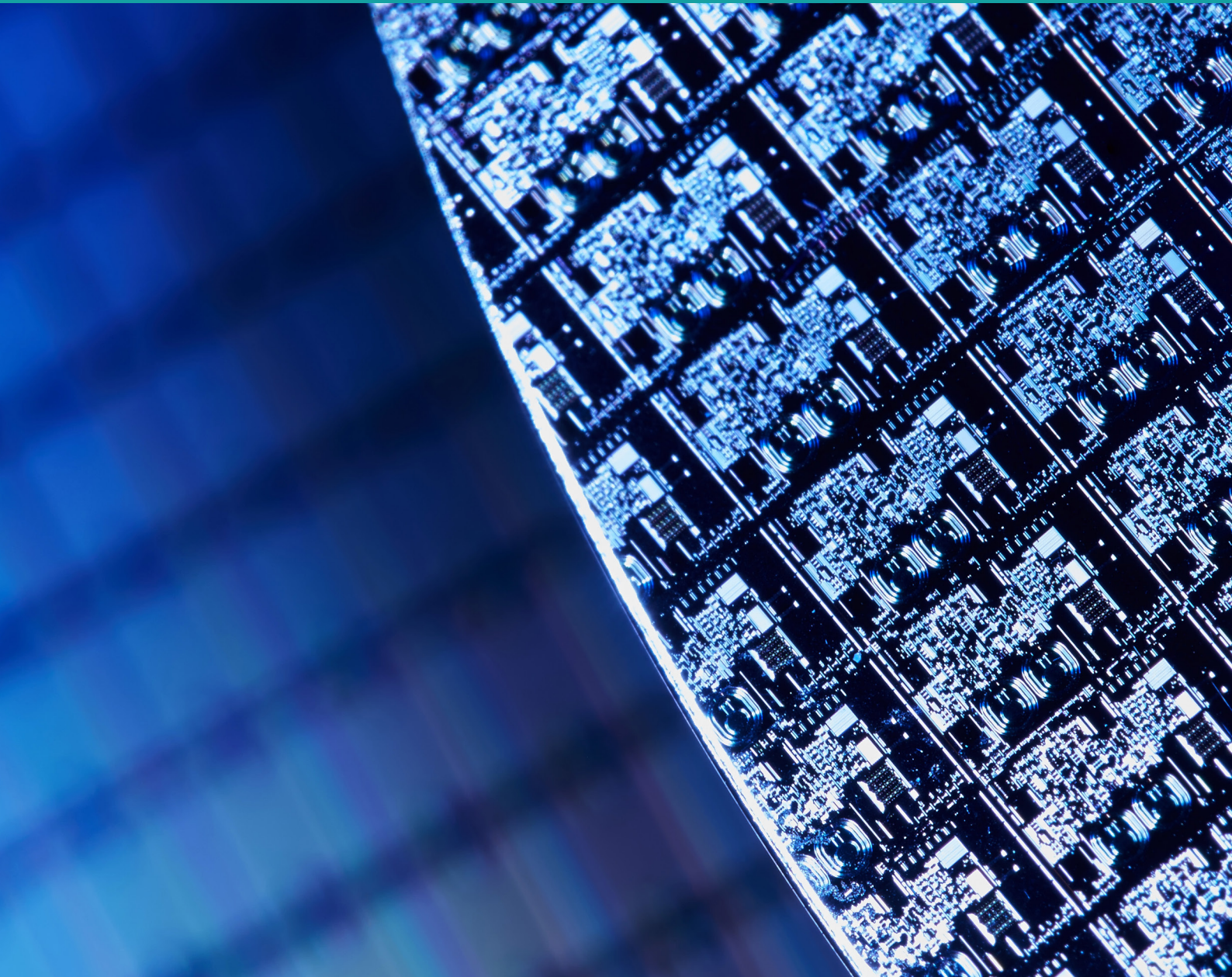


Research and Innovation in Wales

Research Briefing

July 2021



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Research Briefing

July 2021

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1. Executive Summary

Research and innovation is key to increasing prosperity in Wales.

Wales - like the UK - is in the midst of an **entrenched productivity problem**, with parts of the nation **trapped** in “a cycle of low-skill, low-wage and low productivity”.

Alongside investment in skills and infrastructure, research and innovation is considered a key driver of increasing productivity. Increases in productivity in turn drive economic growth and prosperity.

This link between research, innovation, skills and a stronger economy was a key theme within the previous Welsh Government’s Programme for Government: **Prosperity for All: the National Strategy**. It is also a key theme of the current UK Government’s economic strategy, and has been a theme identified in several Welsh Government Chief Economists reports, as well as OECD publications.

There are two main arguments for using public funding to invest in research and innovation (or research and development(R&D), which can be considered a sub-set of R&I).

First, whilst research and innovation can and does deliver substantial benefits to society, the private sector **may not be able to quickly capture enough of the value** of potentially valuable research to make it a viable investment. In these cases it is argued there is a role for state intervention.

Secondly, it is argued that state spending on R&D does not displace private investment, in fact it is argued it ‘crowds in’ private sector investment. This means that state funding can leverage in higher overall levels of R&D and innovation investment. This view is the basis of the latest UK Government economic development policy document **Build Back Better: our plan for growth**, which explains that: “Public investment in R&D crowds in private investment at a ratio of around two pounds on average for each pound of government funding”.

The overwhelming majority of UK public funding for research and innovation (**totalling £14.6bn for 2021-22**) is allocated by UK Government and UK level institutions as part of their drive to reach the UK Government’s **2.4% R&D investment target**. This means that R&D and innovation activity in Wales is fundamentally impacted by UK Government investment levels and allocation policies. The sums spent by Welsh Government are **comparatively modest**, but **have a relationship** with how much of the UK Government funding Wales is able to capture.

There remain some considerable “structural weaknesses” impacting research and innovation activity in Wales. Wales **spends less than its UK population share (5%) on R&D**, and also **wins less than its population share** of competitive external research and innovation funding (spending 2% on R&D and winning 3% of UK external funding respectively). At the same time, the higher education sector in Wales has been **very reliant on European structural funding** for its research and innovation activity, funding which will **cease altogether in the next few years**. Furthermore, because there is a positive relationship between the amount of core research grant universities have, and the amount of external funding they win, it is likely that Wales’ ability to win more external R&I funding will be limited by the relatively flat level of core grant they are provided.

As a result whilst the UK Government has set a target to invest 2.4% of GDP into R&D by 2027 and currently manages 1.7%, **Wales invests 1%**, far below the OECD average of 2.4%.

This all means that whilst Wales has a research base and R&D activity that has **high impact**, and can demonstrate **high quality, world-leading research**, the research and innovation system in Wales **lacks volume and mass** – it is impactful, but small.

Looking to the future, a **2018 report by Professor Graeme Reid** made recommendations to manage the end of EU funding, and to increase the research and innovation base in Wales by supporting institutions to win at least Wales’ population share of external competitive funding. Welsh Government has not yet fully funded the recommendations and the **sector continues to call on it to do so**.

Welsh Government also intends to introduce a Tertiary Education and Research (Wales) Bill in the first year of the current Senedd. In 2015 it commissioned Professor Hazelkorn **to report on** reforming the oversight of the post-compulsory education (PCET) sector in Wales. **Her report** (Beyond 2030) was published in 2016. The report recommended the creation of a new arms-length body encompassing the oversight, regulation, funding and governance of tertiary education providers. Taking this forward, **Welsh Government set out that**, despite bring primarily an education body, the new arms-length body would also fund and have oversight of research and innovation in Wales.

Whilst structural reforms in the guise of the new Tertiary Education and Research Commission are planned, the investment levels called for by Professor Reid (and **Professor Diamond in an earlier report**) have not yet materialised. This is likely to leave challenges for Wales’ small research base, and for R&D and innovation to contribute to increasing Wales’ prosperity.

2. Why spend public money on R&I?

This section sets out the debate for using public funding to invest in research and innovation.

Research and innovation / research and development, are often used interchangeably. However, broadly speaking research and innovation (R&I) is a more widely encompassing term than research and development (R&D). Research and development is very often tech and intellectual-property heavy. Innovation can occur as a result of the successful implementation of R&D activity, but crucially, innovation is generally considered to extend far beyond technology or science solutions. More information on these definitions can be found at Annex D.

The argument for spending public funding on R&I

In the UK there is a long history of public funding for research and innovation. This stems from the premise that whilst research and innovation can and does deliver substantial benefits to society, private individuals and companies **may not be able to capture enough of the value** of the research effort quickly enough to make it worth investing in.

Current UK Government policy is that in these instances state intervention is required both to directly fund R&D projects but to also 'crowd in' private funding.

In the **UK Industrial Strategy Report** the UK Government set out that increases in both public **and** private spending on R&D was required.

The strategy states that:

R&D is an example of public spending stimulating rather than displacing private spending: economies with high levels of public investment in R&D also typically have high levels of private investment. In the UK every £1 of public investment on R&D attracts around £1.40 of private investment.

This view is echoed in the latest UK Government economic development policy document **Build Back Better: our plan for growth**, which explains that: "Public investment in R&D crowds in private investment at a ratio of around two pounds on average for each pound of government funding".

That governments should fund some proportion of R&D and R&I activity is widely accepted in most developed countries. **Some 33 out of 35** OECD countries have national science, technology and innovation strategies; whilst a **2010 OECD report**

on innovation showed that OECD central countries invested 1% to 7% of their total budgets in R&D activities.

The UK's 'productivity puzzle'

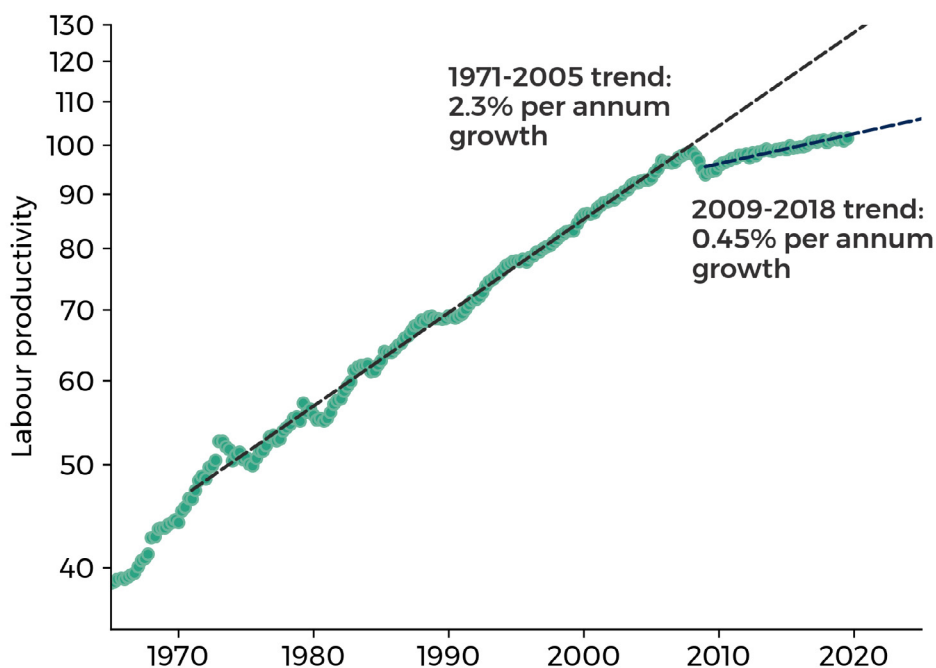
Wales - like the UK - is in the midst of an **entrenched productivity problem**, with parts of the nation **trapped** in "a cycle of low-skill, low-wage and low productivity".

Research and innovation is considered a key driver of increasing productivity (alongside investment in skills and infrastructure). Productivity increases in turn can drive economic growth and higher living standards. This link between research, innovation, skills and a stronger economy was a key theme within the previous Welsh Governments Programme for Government: **Prosperity for All: the National Strategy**.

Even prior to the pandemic, there was concern over a fall in the rate of productivity growth - in the decade following the 2008 financial crisis the estimated average annual increase in UK productivity **was 0.3%**. This is compared to a **2.3% annual rate of growth** between 1971 and 2005.

Recent **research** (prior to March 2020) suggests the decline in UK productivity growth is the worst it has been in the past 250 years, with productivity growth in 2019 being 19.7% below what would have been expected following the 2008 trend. This is shown in figure 1 below.

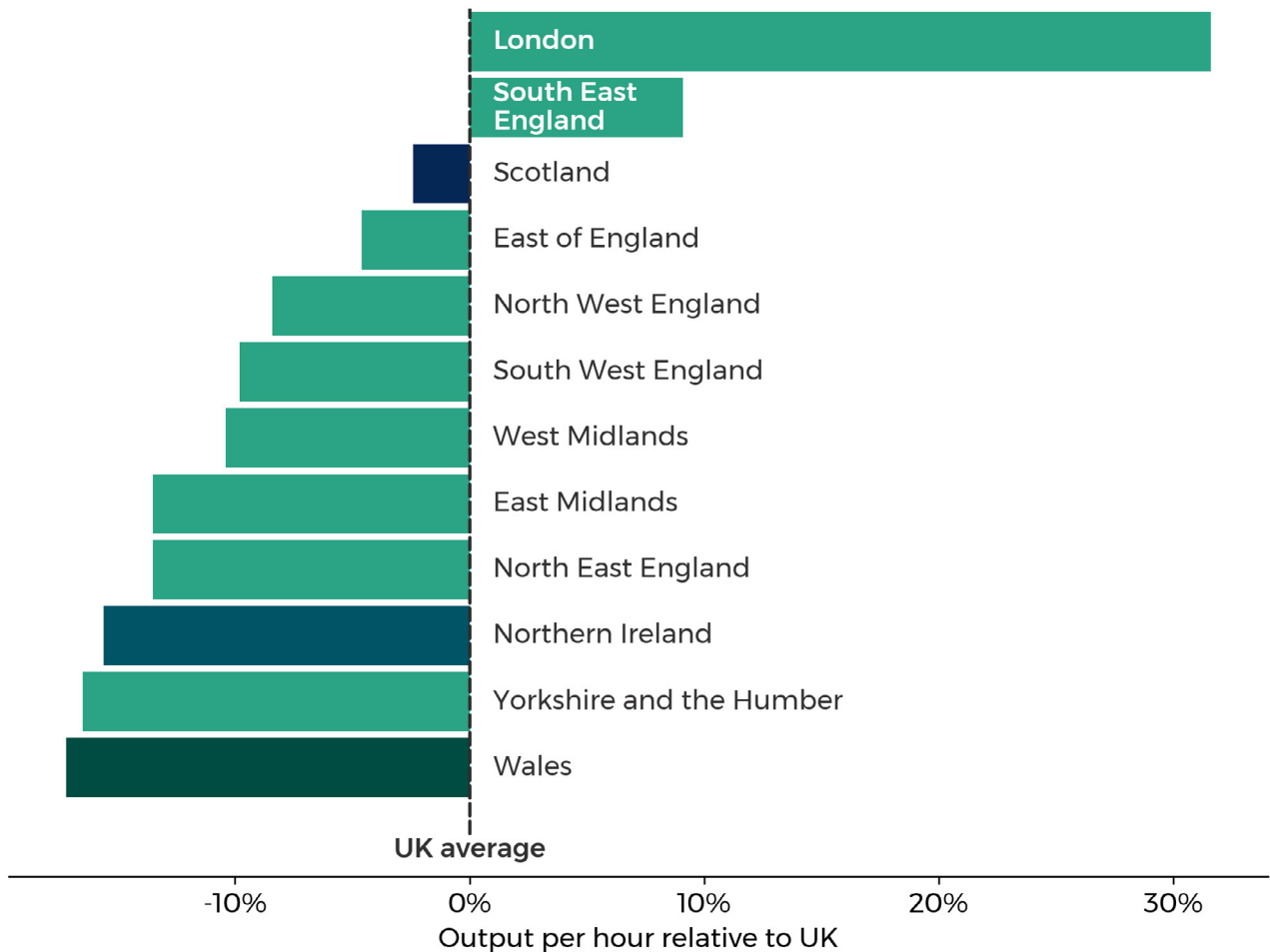
Figure 1: UK labour productivity growth trend



Source: **ONS**

Wales faces an arguably more challenging picture than the UK: in 2018 Wales had an average labour productivity (as measured using output per hour) 17% below the UK average. This is shown below in figure 2.

Figure 2: Output per hour, Wales v UK average



Source: [ONS](#)

This picture of comparatively low productivity is apparent under closer analysis. When the UK is broken down further into forty smaller NUTS2 sub-regions, none of the Welsh sub-regions are in the top 10. At an even more detailed level using the ONS' NUTS3 subregions (of which there are 140), all Welsh subregions have productivity levels below the UK average.

Inequality in economic performance and productivity between Wales and the UK's other regions and nations has been a longstanding issue. An **Industrial Strategy Council review** of UK regional productivity differences found that in 1901 the income per worker in Wales was 15% below the UK average and that despite some productivity convergence in the mid-20th century, pre-pandemic figures from 2017 show Wales was still 16% below the UK average.

3. UK Government research and innovation policy

Whilst Welsh Government has devolved powers to fund and conduct research and innovation, publicly funded Welsh research activity is in practice, and by policy intent integrated within the wider UK research and innovation system. As discussed below, Professor Graeme Reid in his review of Welsh Government funded research and innovation argued for Wales to have closer integration with and influence within the UK system.

The keystone of current UK Government policy is the commitment to increase R&D investment to 2.4% of GDP by 2027 (the OECD average). Currently, the UK is investing 1.7% of its GDP into R&D - a level that has been broadly stable since the mid-1980s, whilst **Wales invests 1% of its estimated GDP**.

Achieving this target will require significant additional UK public funding for R&D, which in turn will need to 'crowd in' significant private R&D funding. To achieve it, **the then Science Minister, Chris Skidmore estimated** that total UK research and development investment would need to more than double from 2017 levels, with an additional sum of £80 billion cumulatively invested each year from 2017. Kirsten Bound of **NESTA**, who gave evidence at a **UK Parliament inquiry** on the balance and effectiveness of research and innovation spending said that the target was "monumentally ambitious. It requires a sustained year-on-year increase that we have not seen in a generation".

This commitment has been restated by the current UK Government, which in its **March 2020 budget statement** has set a target of £22bn of public investment in R&D by 2024-25. In its **November 2020 Spending Review** the UK Government again re-stated the 2.4% ambition and set out that UK public funding for R&D would reach £14.6bn in 2021-22 (a rise from £10.6bn in 2018-19).

Prior to the current UK Government, UK R&D activity was driven by the 2017 **UK Industrial Strategy**. Under the current UK Government, the touchstones for R&D investment are:

- The **Build Back Better Plan for Growth** (which sets out R&D and innovation as being one of the three pillars which will act as the foundation for levelling up, with skills and infrastructure the other two). This plan sets out three further strategies which at the time of writing are not published:

- R&D Places Strategy;
- R&D People & Culture Strategy.
- Innovation Strategy.
- The Department for Business, Energy and Industrial Strategy's (BEIS) **UK Research and Development Roadmap policy paper** which aimed to begin discussions on a number of proposals for taking forward the increases in R&D funding planned. BEIS funds UKRI, and will be allocated £11.3bn of the total £14.6bn of public investment in R&D in 2021-22.

4. How R&I is funded in Wales

This section discusses both how R&D and innovation funding is distributed within Wales and the level of investment.

Research institutions in Wales, which include all Welsh universities and Amgueddfa Cymru – National Museum Wales, are able to access UK Government R&I funding. They are, in practice, embedded within the UK-wide, UK maintained, R&I funding system and their own Welsh Government public funding allocations are structured in part to enable them to continue to access UK funding.

The level of investment in R&I and R&D

Data from the ONS shows that most of the spending on R&D in Wales is by the business sector, accounting for 55% of all expenditure on R&D in 2018 (at the UK level, 68% of all R&D spending is by businesses).

A breakdown of expenditure on R&D across the UK in 2018 is outlined below in table 1. The table shows that in 2018, with 5% of the UK's population, Wales only spent 2% of the UK's total R&D investment, less than its population share.

Table 1: Country and regional breakdown of expenditure on R&D in the UK, 2018

	Government	Higher Education	Business	Private Non-profit	Total	UK Population Share	R&D spend share
UK	£2,460	£8,740	£25,048	£823	£37,072		
England	£2,249	£7,098	£22,738	£777	£32,862	84%	89%
Scotland	£181	£1,126	£1,356	£43	£2,706	8%	7%
Northern Ireland	£17	£174	£524	£-	£715	3%	2%
Wales	£14	£342	£430	£-	£786	5%	2%

Source: **ONS**

In evidence to the Senedd's EIS Committee during **scrutiny of the Welsh Government's 2021-22 draft budget**, Welsh Government officials set out that they were unable to provide the Committee with the full amount that Welsh Government spent on R&I. In its response to the Committee's report asking for the information, the Welsh Government **explained** that it accepted the recommendation "... and will work to provide the committee with a response once the information has been collated".

The university dual funding system

The UK and its constituent nations operate a so-called 'dual-funding system' for investing in university research.

The dual funding system sees two main streams of government funding being made available to research institutions, one at the nation level, and one at the UK level. These two streams are:

- core government grant funding allocated at the nation level. In Wales this is allocated and distributed by the Higher Education Funding Council for Wales (HEFCW); and
- competitive and other types of research funding allocated and distributed at the UK level. This is mainly made available from, but is not limited to, the UK wide research councils within the UK funding agency: United Kingdom Research and Innovation (UKRI).

These are discussed in turn below.

Core research grants

The first part of the dual funding system is the **core research grant funding** allocated to institutions by HEFCW. At the time of writing core research grant funding (with amounts for 2020/21 academic year in brackets) comprises:

- Quality Related (QR) funding (£71 million);
- Postgraduate Research funding (£6.5 million); and
- Research Wales Innovation Fund (RWIF) (£7.5 million).

Each year HEFCW decides on the overall level of QR funding it will allocate to institutions. The proportion of this total that each institution receives, is determined by the overall level of research excellence at each university.

The level of research excellence is currently measured using the outcome of a research audit exercise known as the **Research Excellence Framework**, or REF. The REF is undertaken every few years with the last complete REF exercise being REF 2014. The REF 2021 exercise is underway at the time of writing. The REF 2014 exercise assessed the quality of the research universities submitted to the exercise, giving an overall research quality profile for each university.

A significant feature of QR funding is that it is un-hypothecated. This means once the university has been given this funding it is broadly up to the university to decide how it uses that funding (as long as it stays within HEFCWs terms and conditions attached to the grant).

This funding stream is very important to the overall research base of universities as it allows universities to consistently fund researchers and research infrastructure from a predictable grant rather than being entirely reliant on winning competitive grants for specific projects. For this reason, and as discussed below, it helps make institutions more competitive when competing for external funding as it enables institutions to maintain their core research infrastructure in advance of winning bids.

QR funding was described in a Senedd Economy Infrastructure and Skills (EIS) **Committee inquiry** by Professor Chris Thomas, Pro Vice Chancellor for Research, Knowledge Exchange and Innovation at Aberystwyth University, as “forward look money”. It is more flexible than other streams of hypothecated funding and so can be used to fund cutting edge research and to grow the “critical mass” of research at a university by investing in key areas.

The second core research grant made to institutions is known as Postgraduate Research (PGR) funding. This is allocated by HEFCW to those universities receiving QR funding to fund the training of postgraduate research students.

The third core research grant is known as the Research Wales Innovation Fund. A significant difference between Wales and the other UK nations has been a recent lack of a core grant provided to universities to enable them to engage more closely with business. HEFCW previously provided approximately £8 million a year to universities for this purpose, but this grant was withdrawn in 2013/14 due **to budget constraints**.

However other UK nations continued to make Innovation and Engagement funding available; in 2020/21 **Research England** planned to allocate £230 million, **the Scottish Funding Council** £13.7 million and **Northern Ireland** £3.96 million.

The importance of engagement funding was highlighted **in multiple responses to the EIS Committee research and innovation inquiry mentioned above**. The Committee heard that Government engagement funding helped to support the “capacity [of universities] to engage with businesses” through the development of long-term partnerships as well as the ability of universities to respond to new opportunities.

In 2019 **HEFCW noted** a decrease in university income following the withdrawal of this engagement funding, calculating that there had been decrease of 24% in knowledge exchange income between 2013/14 and 2016/17.

In 2019, in light of the additional funding becoming available to HEFCW it **agreed that a Research Wales Innovation Fund** (RWIF) would be created and distributed from 2020/2021 with an in principle budget of £15 million a year. Welsh Government funding decisions allowed HEFCW to create an interim innovation and engagement fund a year early from 2019, prior to the RWIF being fully operational from 2020.

The **final funding allocation** for both 2019/20 and 2020/21 fell short of the initial in-principle £15 million at £7.5 million a year. **HEFCW explained its view that:**

Given falling performance in Wales the recent RWIF consultation [...] concluded that institutions required immediate investment funding to increase capacity and to support the ideals of [the] Reid Review of Government Funded Research and Innovation in Wales (2018). Reid noted that future I&E funding should incentivise and reward performance, particularly in relation to income capture. This has been the basis for the development of the RWIF funding model.

External funding

The second stream of funding comprises various external sources. This funding can derive from any external source including the UK Government, the EU, and charities such as the Wellcome Trust or Cancer Research UK. It is often awarded on a competitive basis or must be bid for.

In terms of the amount of funding, the single most significant source is the UK Government arms-length body **UK Research and Innovation** (UKRI).

UKRI was established in 2018 and operates across the whole UK. It holds a current research and innovation budget of approximately £8 billion a year, the vast majority of which is potentially accessible to Welsh universities. It brings together the seven formerly independent research councils and two other distinct bodies as follows:

- **Arts and Humanities Research Council** (AHRC);

- **Biotechnology and Biological Sciences Research Council** (BBSRC);
- **Engineering and Physical Sciences Research Council** (EPSRC);
- **Economic and Social Research Council** (ESRC);
- **Medical Research Council** (MRC);
- **Natural Environment Research Council** (NERC);
- **Science and Technology Facilities Council** (STFC);
- **Innovate UK** which is intended to “drive growth by working with companies to de-risk, enable and support innovation”; and
- **Research England** which is the body that provides research and business engagement funding to English universities in the same manner as HEFCW does for Welsh universities. The funding held by this body is not accessible to universities outside England.

In 2018-19 (**the latest data**) England received the largest proportion of research council spending, £2.1 billion or 86% of the total. This was followed by Scotland with £248 million or 10% of the total. Northern Ireland and Wales received much less funding from all research councils, accounting for 1% (£25 million) and 3% (£66 million) respectively. This means Wales receives less than its UK population share of overall research council funding, whilst Scotland and England receive more than their UK population share.

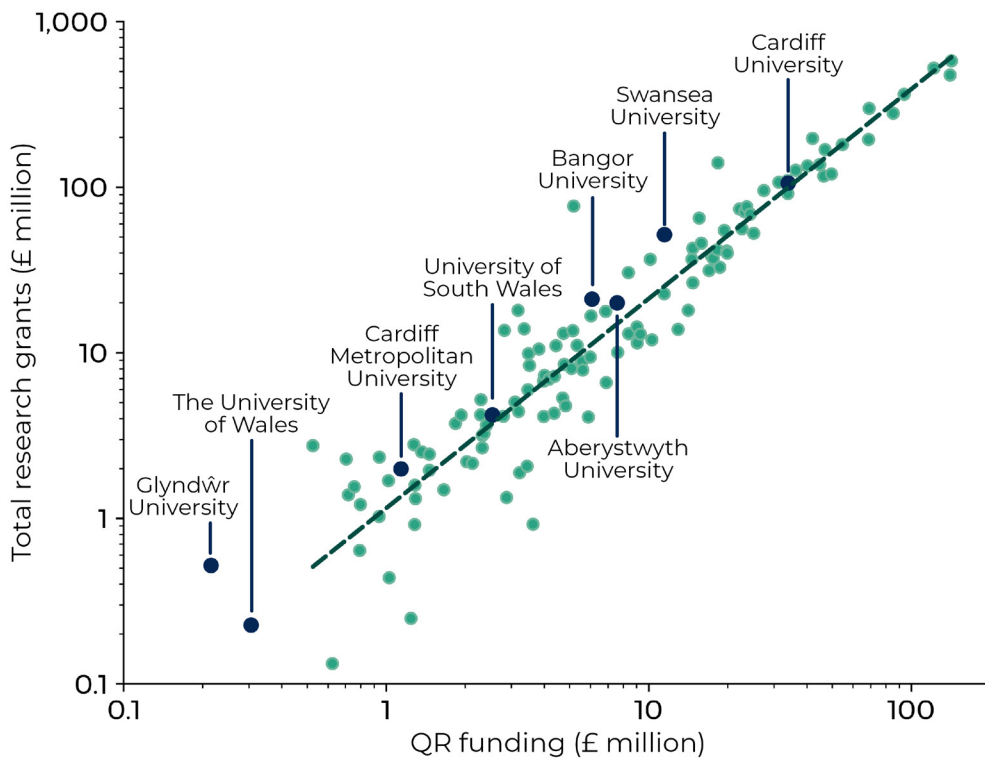
As well as the Research Councils, UKRI distributes funding via Innovate UK. Although most UKRI derived funding is devoted to academic research projects in the traditional academic sense, businesses and industry are able to apply for funds from Innovate UK.

Link between core grant funding and winning external competitive funding

In his review of Welsh Government funded research and innovation in Wales (discussed in detail below), Professor Reid explored the relationship between the two funding streams in the dual funding system model. In doing so he presented a view as to why Wales consistently receives less than its UK population share of competitive external R&I funding.

Professor Reid presented evidence for a strong link between levels of QR funding / core grant funding, and the levels of success in securing other competitive research grants and contracts. Figure 2 shows this relationship between levels of QR funding and levels of competitive funding won for all UK universities with Welsh universities in red.

Figure 3: relationship between research grants and level of QR funding



Source: **Reid Review 2018**

Professor Reid argued that:

The low level of this un-hypothecated [QR] funding relative to the rest of the UK has been a structural weakness in Wales for around two decades and is reflected in relatively low levels of funding secured in competitions at UK-wide and EU levels and fragile levels of business income in Welsh universities.

In an **evidence session** to the 5th Senedd EIS Committee’s inquiry, Dr David Bembo of Cardiff University explained that QR funding “put the pounds on the table in order to back the money that comes in externally”.

During the same inquiry Professor Paul Harrison of the University of South Wales also remarked that:

QR funds for long term, it allows us to fund PhD students, fund early career researchers, give them time for academic pursuits. It allows all researchers to do the blue skies research that’s unfunded to try out new ideas, to build prototypes, et cetera that are not near-market. And these, further downstream, then can be translated into new products and services that help grow the economy.

The Haldane principle

The management of public funding for research and innovation in the UK is guided by the **Haldane Principle**. The principle sets out that decisions about which research projects to fund should be made through independent evaluation by experts, based on the quality and likely impact of that research – not politicians. The principle is enshrined in **UK legislation**, and the Welsh Government proposes to do similar in the **Tertiary Education and Research Bill**.

In practice the principle means that specific funding decisions and research projects are generally protected from political influence. However UK governments can and do set policy with regards to the overall priorities, objectives and means of allocating government research and innovation funding (for example, creating specific funds such as the **Global Challenges Research Fund**, or creating agencies such as UKRI).

EU funding for R&I

EU funding has been a significant source of funding for research and innovation in Wales.

Professor Reid, in his review, found that:

At a UK-wide level, most EU funding for research and innovation is won in competitions under the Horizon 2020 programme. In Wales, however, most EU funding for research and innovation comes through structural funds. That difference means that Brexit has distinctive implications for Wales .

At the time of writing it is not clear to what extent the £56 million of annual EU structural funds for R&I will be replaced as projects come to an end by 2023.

The overall picture of EU funding for research and innovation in Wales is shown below **in table 2**.

Table 2: EU funding (€ms and £ms) for R&I projects (approved projects up to 2020)

EU funding source	Total Investment (£ms)	Annual Average 2014-2020 (£ms)
Horizon 2020 EU contribution (up to 23/06/21)	€147.30m	€21.04m
EU (ESF + ERDF) funding contribution	£376.12m	£55.73m

Source: Welsh Government

EU structural funding for R&I

Some £376 million of EU structural funding has been contributed by the EU through the Wales European Funding Office (WEFO) for research and innovation projects between 2014 and 2020 – representing an average annual investment figure of £56 million.

Along with Northern Ireland and the South West of England, Wales has been described as being one of the places in the UK most reliant on European structural funding. Indeed, in Wales, the majority of EU funding for research and innovation came from EU structural funds as opposed to the Horizon 2020 programme. This reliance on structural funds (as opposed to Horizon 2020 funds) is not the case in Scotland and England, with both nations receiving a greater proportion of funding from Horizon 2020.

The foreword to the Welsh Government report on protecting research and innovation after EU exit explains that: “Nearly 80 per cent of our total EU funding for research and innovation come from Structural funds and we can have no confidence that the UK Government will make up this deficit.”

Horizon 2020 and its successor

The primary source of EU funding for research and innovation in Europe and the UK has been the Horizon 2020 programme. It has now been superseded by a new Horizon Europe programme, to which UK Government has confirmed the UK will take part.

To date **Wales has received** €144.8 million from Horizon 2020 participation, some 0.25% of the EU total. The Horizon 2020 programme is not restricted to just universities and academic institutions, and in many cases projects have to be collaborative with multiple partners in order to qualify for funding.

The top five Welsh research organisations **receiving Horizon 2020 funds** are shown below in table 3:

Table 3: Top 5 Welsh research bodies receiving Horizon 2020 funding

Research body	Net EU Contribution (€m)
Cardiff University	€57.06m
Swansea University	€17.63m
Aberystwyth University	€10.58m
Bangor University	€10.25m
Welsh Government	€9.71m

Source: **EU (accessed 23 June 2021)**

Medical research funding

Whilst medical research funding can be accessed via the UKRIs Medical Research Council (MRC), it is also funded through **Health Care and Research Wales**.

Health and Care Research Wales is the body which funds and oversees Welsh medical research centres, research units, clinical trials units, infrastructure support groups as well as support and delivery within the organisation and the Wales School for Social Care Research. Between 2015 and 2019 it awarded £37.9 million worth of direct funding in the form of postdoctoral fellowships, PhD studentships, research time awards and research capacity awards. Its funding allocation from Welsh Government in the 2021-22 **Final Budget** is £42 million.

5. The big debates in R&I funding policy

This section discusses the different debates over how funding should be distributed and what ‘counts’ as research and innovation. It addresses three broad research and innovation policy debates: first, the choice of funding ‘pure’ or ‘applied’ research; second, which institutions should have access to public research funds; and third, whether funding should be allocated on the basis of a record of past success, or allocated based on economic need.

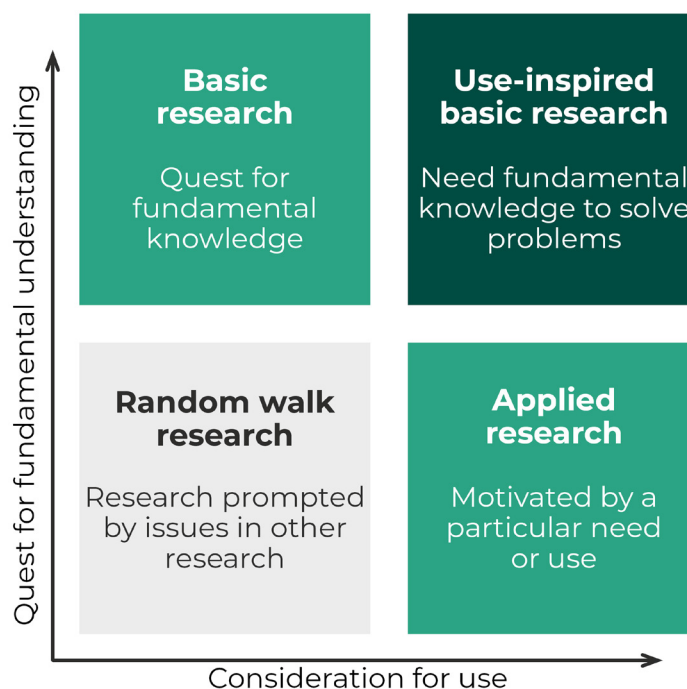
Should we fund ‘pure’ or ‘applied’ research?

In the debate over what types of research should be funded, a distinction is often drawn between ‘pure’ research, and ‘applied’ research, with the broad understanding that ‘applied’ research results in quicker, more tangible impacts for society.

Whether research can truly be divided into this binary black and white choice is **debated**.

Professor Donald Stokes, a political scientist, set out a more nuanced picture instead. A modified version of his ideas is shown in figure 4 below where he categorised research based on whether there was a quest for fundamental understanding and/or a particular use or problem was being addressed.

Figure 4: a way to categorise types of research



The diagram above sets out his four types of research:

- applied research: this is where there is no quest for fundamental understanding, the research is instead motivated by a particular need or use in mind;
- basic research: this is where there is a quest for fundamental knowledge, rather than any particular use being in mind, it is instead driven by curiosity, mystery or interest;
- user-inspired basic research: this is where there is a need for fundamental understanding to solve practical problems; and
- random-walk research: this is where further research is prompted by problems and issues in another piece of research.

Although the applications of pure research are rarely immediately obvious, they can nonetheless still clearly result in highly significant and lucrative technologies and products. The value of basic / fundamental research was **summarised** by Nobel Prize winner Dr Andre Geim who said:

There is no such thing as useless fundamental knowledge. The silicon revolution would not have been possible without quantum physics. Abstract maths allows internet security and computers not to crash every second. Einstein's theory of relativity might seem irrelevant but your satellite navigation system would not work without it. The chain from basic discoveries to consumer products is long, obscure and slow – but destroy the basics and the whole chain will collapse.

It is also argued that fundamental research is more in need of public funding because there is often no immediate return on investment, as explained by Ben Bernanke, former chairman of the US federal reserve, who said that:

The primary economic rationale for a government role in R&D is that, absent such intervention, the private market would not adequately supply certain types of research. The argument, which applies particularly strongly to basic or fundamental research, is that the full economic value of a scientific advance is unlikely to accrue to its discoverer, especially if the new knowledge can be replicated or disseminated at low cost.

On the other side of the debate, given the purported link between research, innovation and the growth in productivity, it is argued that in order for society to derive the most benefit from research, the types of research funded by the public purse should result in innovation and solve 'real-world' problems sooner rather than later.

In reality the debate is more nuanced and revolves around the balance of funding between applied research, and basic research with most of the position that all types should be **funded to some degree**.

The translation of research into real-world uses, and supporting and enabling this to occur is another dimension of this debate. Several of the witnesses in the 5th Senedd’s Committee **inquiry** into research and innovation felt that whilst much ground-breaking fundamental research was taking place in the UK, the lack of applied and translational funding (where research is translated into real-world uses) led to the final technological breakthroughs and associated economic benefits occurring in other countries.

This concern over the UK’s ability to hold onto and commercialise its research is highlighted in a 2013 House of Commons Select Committee report **Bridging the valley of death: improving the commercialisation of research**. Here the Committee argued that ‘a troubling feature of technology companies in the UK is how many are acquired by foreign owners where the subsequent jobs and wealth are generated outside the UK.’

Should we fund R&I via business, or via universities?

Another area of debate is the balance of funding allocated to research that takes place in universities, versus research that takes place outside universities – either in other publicly funded research institutions, charities or private enterprise.

In funding terms most funding for R&D in the UK is provided by businesses and is spent by businesses.

Table 4: Flows of research and development funding in the UK, 2018

	Government & UKRI	Higher Education	Business Enterprise	Private Non-Profit	Total (£m)
Sector providing the funds:					
Government	£1,446m	£380m	£1,190m	£113m	£3,129m
UKRI	£677m	£2,600m	£530m	£189m	£3,996m
HEFCs	-	£2,492m	-	-	£2,492m
Higher Education	£22m	-	£179m	£10m	£211m
Business Enterprise	£70m	£389m	£19,832m	£25m	£20,315m
Private Non-Profit	£72m	£1,318m	£67m	£402m	£1,860m
Overseas	£172m	£1,562m	£3,250m	£84m	£5,069m

Source: **ONS**

The above table also shows that the vast majority of public funding for research in the UK is used by the public / university sector for conducting R&D. Comparable data for Wales is not available, but Welsh Government funding for research and innovation is largely allocated to the health sector and higher education.

During the previous Senedd's EIS Committee inquiry into research and innovation, evidence showed that within businesses, particularly small businesses, there was some concern about this imbalance of funding, and what was seen to be the differences between university, and business research and development. David Notley, at the time sitting on the Innovation Advisory Council for Wales, **told the Committee** that:

I think there's the potential to change the dynamic here. So, at the moment a lot of funding goes in via higher education institutions and then it flows out to SMEs. There's the potential to pivot that, so that it flows into SMEs and then, through collaboration with universities, follows a route in that way. So, I should say I think universities play an extremely important part in innovation, and obviously in research, but it's just one part of the spectrum, and innovation is a really broad spectrum that runs from TRL—technology readiness levels—1 and 2 and so on, right through to more market-led, as opposed to technology-push, innovation, and it's in that area where SMEs are being neglected at the moment

Should we focus on centres of excellence or places in need?

A final significant debate regards which institutions, and which places receive research and innovation funding.

The debate is broadly framed along the lines of: should governments give research funding to well established, highly-research intensive institutions with strong records of success and excellence, or should they distribute public funding for research and innovation based on other criteria such as regional economic performance.

Whilst the first model may look intuitively appealing as there can be more confidence that the funding will produce impact, it has given rise in practice to a concentration of research intensity in certain areas through a positive feedback loop known as the **Matthew effect**. This is where better funded universities produce better research which leads to them being judged more highly and therefore being allocated more money.

The latter approach of investing research and innovation funding on a 'place' basis in one sense can carry more risk. However, the current UK Government economic policy is centred on UK regional disparity, a policy encapsulated in the term 'levelling up', a policy intended to reduce the regional disparities. Given the role R&D can play in driving productivity and improving economic outcomes, R&D and innovation

funding has become a key element in the 'levelling up agenda' referred to within the **UK Government Plan for Growth**.

An **IMF report** suggests that "reducing regional disparities [in the UK] by boosting labour productivity in underperforming regions would promote faster and more inclusive growth." In **Professor Richard Jones' blog** on reducing regional inequality he argues for the development of 'place-based' research policy as opposed to the current 'place-blind' model to help deal with regional economic inequalities.

This has meant a focus on 'place based outcomes' in the **UK Government's R&D Roadmap**. The roadmap explains:

We are challenging ourselves to consider how a greater focus on place outcomes in decision-making and new, proactive and coordinated approaches with devolved administrations and key funders could address regional imbalances in R&D intensity as part of our levelling up ambition.

One benefit of funding universities and research and innovation projects on a place basis is that these activities tend to 'crowd in' further investment and prosperity and create 'industrial commons'. The **industrial commons concept**, as explained by Professor Gary Pisano, an economist at Harvard Business School, is the R&D and manufacturing infrastructure, know-how, process-development skills, and engineering capabilities" that result from the clustering of universities, suppliers and manufacturers. Although digitisation and the internet has made knowledge global to some degree, the exchange of ideas and technology still mostly takes place over short geographic distances, with certain types of knowledge seen to be more efficiently communicated face-to-face.

6. The future for R&I in Wales

This section explores the future of research and innovation in Wales. It discusses the Tertiary Education and Research (Wales) Bill expected during the 6th Senedd, and two major Welsh Government commissioned reviews into research funding and policy.

Welsh Government research and innovation policy

The **Programme for Government 2021-26** sets out that Welsh Government will:

- Take the Tertiary Education and Research (Wales) Bill through the Senedd;
- Consider establishing a Creative Industry Research and Development Fund;
- Argue for closer economic and research ties with the EU; and
- Support innovation in new renewable energy technology.

Previous Welsh Government policy on R&I was similar to the current UK Government's in that it recognised R&D and innovation as being a key driver of productivity and economic growth (along with skills and infrastructure). However, the previous Welsh Government **declined to set an equivalent R&D investment target**, rejecting the 5th Senedd's EIS Committee recommendation to establish one on the basis that a large proportion of Welsh funding is derived from sources beyond the control of the Welsh Government.

In policy documents such as the **Prosperity for All: economic action plan** and the **Science for Wales** report, the previous Welsh Government outlined its ambition to maintain and increase funding for research and innovation. Both policy documents emphasised the importance of securing UK wide and international funding and proposed policies to help increase Wales' visibility and competitiveness when bidding for these funds – a policy that was in-line with the main argument the Reid review discussed above.

Tertiary Education and Research (Wales) Bill

Welsh Government commissioned Professor Hazelkorn **to report on** reforming the oversight of the post-compulsory education (PCET) sector in Wales. **Her report** (Beyond 2030) was published in 2016.

The report recommended the creation of a new arms-length body encompassing the oversight, regulation, funding and governance of 6th Forms, higher and further education providers, adult community learning, and work-based learning providers.

Taking this forward, Welsh Government set out that despite bring primarily an education body, the new arms-length body would also fund and have oversight of research and innovation in Wales.

The Welsh Government issued a **consultative White Paper** in 2017, followed by a further **technical consultation** in 2018. It then launched the **PCET strategic vision** in autumn 2020, after the publication of the draft bill.

The Tertiary Education and Research (Wales) Bill was expected to be introduced in the summer of 2020, however Welsh Government announced it would prioritise other legislation due to pandemic pressures, and it instead **published the Bill** as a draft for consultation.

The Explanatory Memorandum to the draft bill sets out the research function of the proposed arms-length Commission:

The Commission will take a whole system approach to research and innovation funding across the tertiary education sector, with an ability to provide research and innovation funding to a wide range of institutions, such as HE and FE institutions and organisations working in collaboration with a provider registered with the Commission. This will allow the Commission to have oversight of funding to ensure value for money as well as for better coordination of research and innovation in Wales. This will be delivered and coordinated by the Research and Innovation Wales (“RIW”) Committee.

The 5th Senedd’s EIS Committee explored the research and innovation proposals of the Welsh Government’s initial 2017 and 2018 consultations **in an inquiry**. The Committee recommended that:

If the final remit and scope of Research and Innovation Wales (RIW) includes organisations outside the post-compulsory education sector such as NHS Trusts, technology organisations and businesses, then the Welsh Government could consider the case for making RIW independent of the proposed Commission for Tertiary Education and Research (CTER), an organisation which will primarily be a strategy planning body for post-16 education.

The Welsh Government **rejected this recommendation**.

The ‘Diamond’ review (2016)

The Review of Higher Education Funding and Student Finance Arrangements in Wales was published by Professor Sir Ian Diamond in September 2016. The report focused on funding higher education, but made some significant recommendations on funding R&I within higher education.

The report noted that “for the decade leading up to 2015/16 the rate of QR funding in Wales [...] was consistently lower than all other UK nations.” The report describes QR funding as being essential given its impact on a university’s overall research capacity and the way in which it acts “as leverage for external research”.

The report made several key R&I related recommendations, including:

- That a Welsh Postgraduate Research Scholarship Scheme should be created to fund the fees and maintenance of 150 students per year;
- That QR funding should be maintained in real terms at its (then) current level of £71 million per annum; and
- That the Welsh Government, through HEFCW, develop a dual support system to fund knowledge exchange through knowledge transfer hubs and a project based funding stream.

The **Welsh Government response** to these recommendations was mixed, fully accepting only one: the creation of the Postgraduate Research Scholarship scheme. At the time of writing it has not been established.

The 5th Senedd’s Children, Young Person and Education (CYPE) Committee conducted on-going scrutiny on the implementation of the Diamond review. **In response to this scrutiny**, Welsh Government in June 2019 confirmed that:

- Discussions on the development of the Research Scholarship Scheme were to begin;
- That it agreed Welsh QR funding should be maintained at £71 million; and
- That the recommendations concerning knowledge transfer would be considered in light of future budget settlements for the Welsh Government.

As discussed above, QR funding levels **have remained cash-flat** since the publication of the Diamond Review at £71m per academic year (with a one-off-one-year increase in 2019/20 of £4.7m as a result of Welsh Government releasing additional funding in-year). This means that the amount of QR funding available to Welsh universities has fallen in real-terms since the publication of the review.

The 'Reid' review (2018)

The **Review of Government Funded Research and Innovation** (introduced above) was published by Professor Graeme Reid in June 2018. The review builds on the work and recommendations of the Diamond review, with Professor Reid endorsing all the Diamond report recommendations relating to research and innovation.

Professor Reid went on to set out the central problem as he sees it for research and innovation in Wales, writing that:

I encountered long-standing structural weaknesses in the research and innovation ecosystem that put Wales at a disadvantage compared with other parts of the UK in funding competitions. That disadvantage has been masked by the availability of EU structural funds, whose future remains unclear.

To replace EU funding, he argued that Welsh universities would need to become better at winning external funding from bodies such as UKRI, and that there was a relationship between the amount of core grant funding provided to institutions, and the amount of external funding they win (see figure 3 above).

As a result, he recommended that Welsh Government strengthen the Welsh research base and enable Welsh researchers to attract a greater share of UK-wide funding by implementing Professor Diamond's recommendation for maintaining levels of QR funding and creating an additional £30 million Future of Wales Fund. The purpose of the Future of Wales Fund was to be to incentivise Welsh researchers to win funding from outside Wales by rewarding institutions able to win more external funding with a greater allocation from the £30 million fund.

Professor Reid also made two further recommendations:

- That Welsh Government increase the visibility and influence of Welsh research by creating a new Welsh Research and Innovation London Office (WRILO).
- That Welsh Government increase the visibility, coherence and impact of research and innovation in Wales by creating a single overarching brand for its innovation activities: the St David's Investment Fund. This should be worth some £35m yearly in the first instance but with the potential to grow to £100m yearly or more after the UK exits the European Union.

The total additional funding required to implement these recommendations in full, which have not yet been fully funded by Welsh Government, would have been £85 million in 2018 cash terms.

Welsh Government response to the Reid review

At the time of writing, HEFCW has re-established (albeit at a smaller scale than recommended by the review) the knowledge exchange fund (RWIF, discussed above). But neither the Future of Wales Fund nor the St David's Investment Fund has been established. The 5th Senedd's EIS Committee recommended that Welsh Government implement these remaining recommendations in both its annual draft budget scrutiny reports and its inquiry on research and innovation; Universities Wales have also continued to call on Welsh Government to implement these recommendations fully.

HEFCW research vision for Wales

HEFCW has produced a **Research and Innovation: Vision for Wales**, publishing it in 2019. In it HEFCW outlines its key short, medium and long-term aims.

Shorter term aims include:

- Establish Research Wales – a fit-for-purpose Committee which will be recognised as the voice of Welsh R&I and enterprise (this has been established);
- Maintain QR funding in real terms (this has not yet been achieved at the time of writing);
- Establish the Research Wales Innovation Fund (as discussed above, this has been established);
- Work with Welsh Government to establish the St David's Investment Fund and support Innovation Hubs (as discussed above, the fund has not yet been established);
- Work with Welsh Government to establish the Future of Wales Fund – additional QR funding to incentivise and reward grant capture (as discussed above, this has not yet been established); and
- Strengthen engagement with UKRI – ensuring Wales' voice is heard and increasing sector's competitive success in securing funding

Business support

Within the previous Programme for Government 2016, Welsh Government argued that:

Economic resilience underpins our ambitions for Wales. It is only through innovation that businesses can adapt and improve their productivity and sustainability.

This was to be achieved both through raising skills levels and using the Government’s business support infrastructure to “to build capacity and innovation within our home grown businesses including local supply chains, to enable more to be procured from businesses in Wales”. Key elements of Welsh Government’s business support infrastructure are the **Innovation Advisory Council for Wales** (IACW) and the **SMART programme**:

- The role of the IACW is set out as advising Welsh Government “on a broad range of innovation matters to help grow and sustain Wales’ economy and improve the wealth and wellbeing of the people of Wales”.
- The SMART suite of programmes is intended to be accessed by businesses looking to innovate and offers support and access to “a team of highly experienced Innovation Specialists, Research Development Managers, Manufacturing and Design Specialists, Commercialisation Managers and Intellectual Property Specialist”. This intervention is part funded from EU funding and at the time of writing it was unclear what the future of the programme will be.

7. Annex A: R&I - places and people

This annex sets out what the R&I and R&D landscape looks like in Wales – it addresses where R&I and R&D is conducted and examines the workforce and training pipeline.

University based R&I

Wales is home to eight universities as well as the Open University in Wales.

The universities are shown in the map below, whilst table 5 provides some key information on the research profile of each. The largest Welsh university in terms of both staff and research income is Cardiff University: in 2019/20 it had a total of 1090 staff engaged only in research and **declared £112 million** of external research grants and contracts for year ended 31 July 2020.

Figure 5: map of universities in Wales

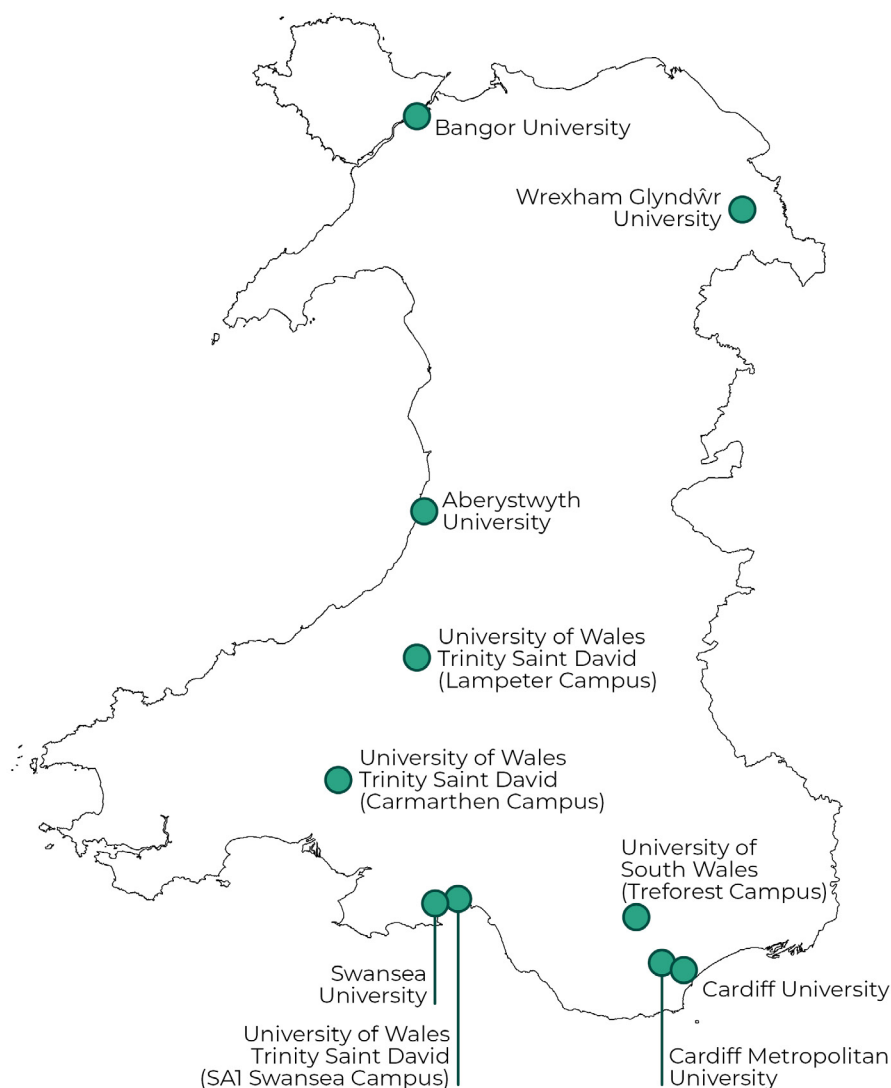


Table 5: selected research metrics, universities in Wales

University	Number of Researchers (2019/20)		Research Excellence Ranking by GPA (REF2014)	Research Intensity Ranking (REF2014)
	Research only	Teaching and research		
Cardiff University	1090	1270	6	50
Swansea	470	600	26	42
Cardiff Metropolitan University	25	460	41	123
Bangor University	220	285	42	51
Aberystwyth	140	280	58	46
University of South Wales	75	730	93	113
University of Wales Trinity Saint David	15	320	97	123
Glyndŵr University	5	175	112	119

Source: [Higher Education Statistics Agency \(HESA\)](#); [THE](#); [THE](#)

In addition to the universities there are a small number of public research institutes in Wales, many of which are now run in conjunction with a university.

For example the [UK Centre for Ecology and Hydrology](#) is owned and funded by the Natural Environment Research Council (NERC), but has one of its four sites based in the Environment Centre Wales at Bangor University. As well, Cardiff University is home to the Medical Research Council's (MRC) [Centre for Neuropsychiatric Genetics and Genomics](#).

In addition to government research institutes there is also intended to be two research and innovation centres in Wales backed by the Innovate UK’s **Catapult network**. The Catapults are a network of “world-leading technology centres designed to transform the UK’s capability for innovation in areas of strength and drive innovation to promote productivity and economic growth”.

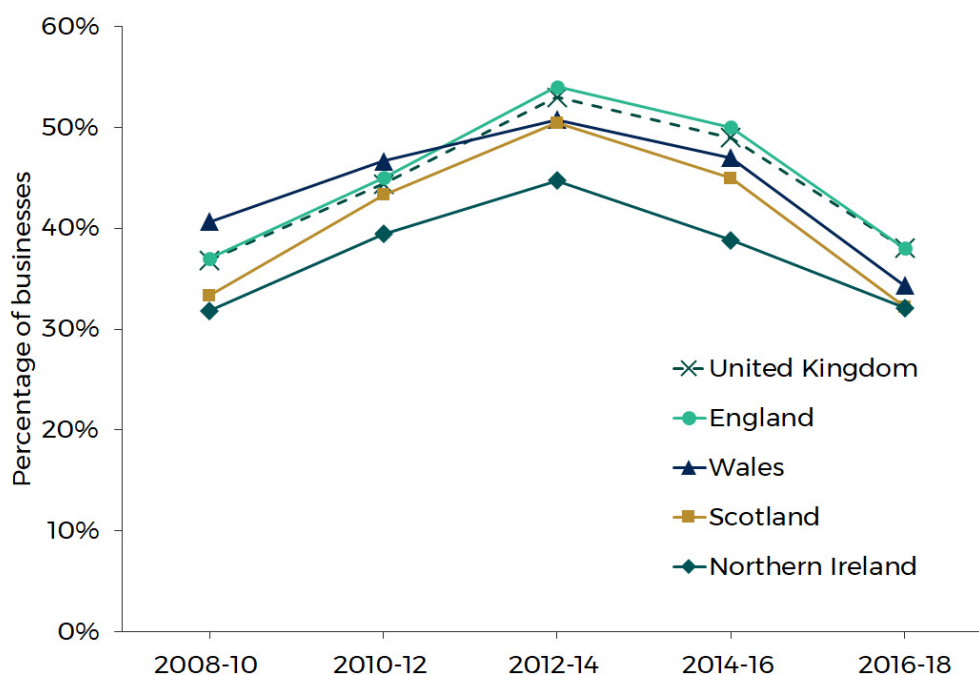
The first catapult is the **Compound Semiconductor Applications Catapult** Innovation centre which is to be built in South Wales; the second is the **Advanced Manufacturing Research Centre (AMRC) Cymru** in Deeside, North Wales. AMRC Cymru operates as part of the University of Sheffield AMRC and is a member of the **High Value Manufacturing Catapult**.

Non-university R&I

Considerable R&D and innovation activity occurs outside academic research centres like universities.

A sense of the level of innovation occurring in enterprises in Wales can be gained from exercises such as UK Innovation’s survey, the **overall results of which** are shown in figure 7. From this survey we can see that a relatively low proportion of Welsh businesses are innovation active, less than in England and the UK overall, although marginally higher than the other devolved nations.

Figure 6: proportion of innovation active business in the UK 2008-10 to 2016-18



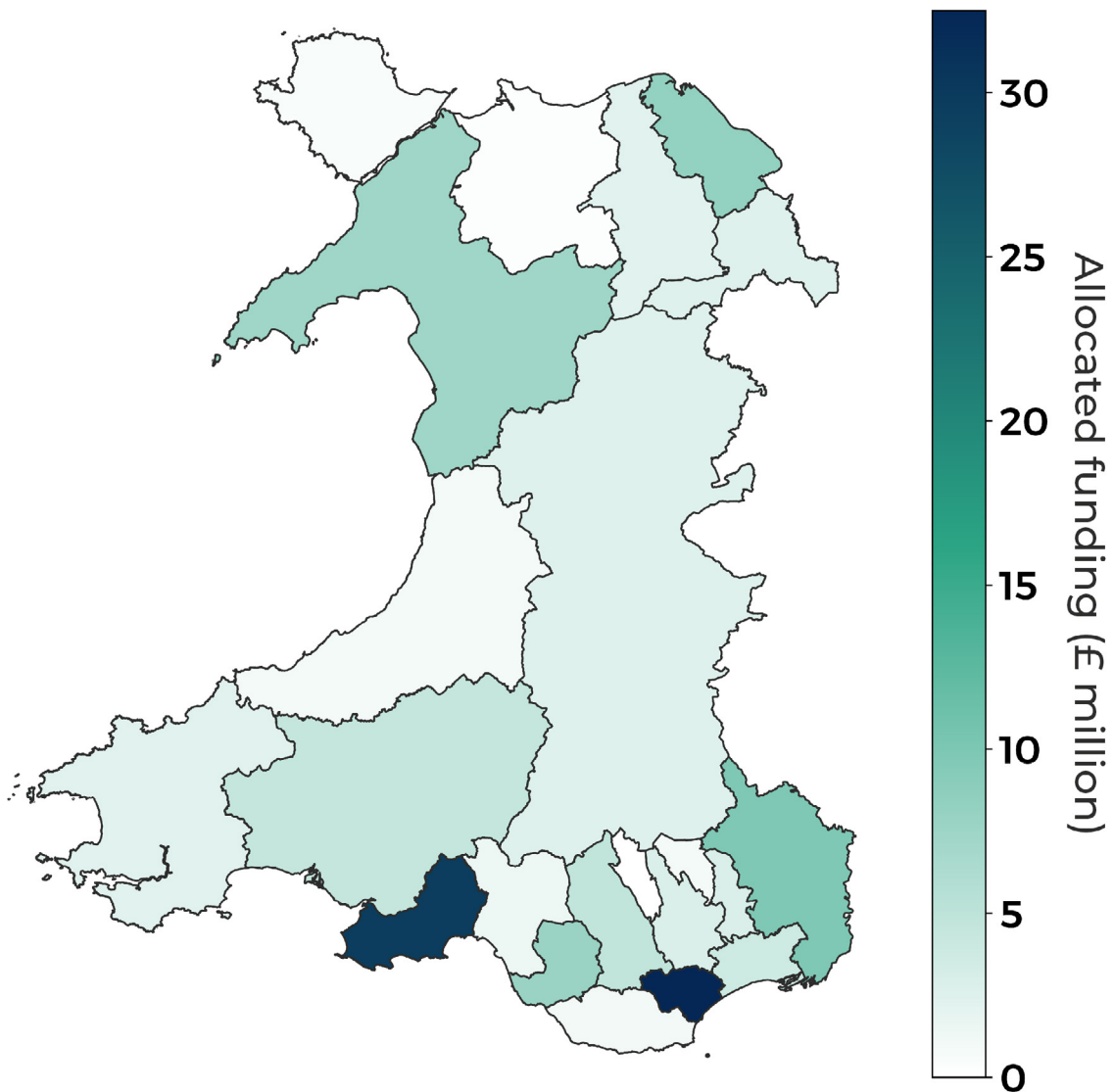
Source: **StatsWales**

UK Government innovation funding

Another way in which to measure innovation activity in non-academic institutes is to look at how **grants from Innovate UK are spread across Wales**.

This data shows that funding in Wales is geographically concentrated in South East and South West Wales. Figure 6 shows how innovate UK funding is distributed across Wales.

Figure 7: Geographical concentration of Innovate UK spending in Wales



Source: **Innovate UK**

Across all types of organisation, 66% of the funding was allocated to organisations in Cardiff and Swansea. Looking at only funding allocated to businesses, almost half (48%) was allocated to businesses within Cardiff and Swansea.

Other measures of innovation activity

In the **EU's Regional Innovation Scoreboard 2019** Wales ranks as a 'strong innovator'. Although Welsh performance is below the UK average (by 9.5%) it is still 6.3% above the EU average and has increased by 16.6% between 2011 and 2019. The scoreboard however also highlights that Wales underperforms in terms of public and private R&I expenditure.

R&D workforce

In 2018 the total number of people employed in research and development in some form in Wales was 12,220 taking into account those **employed by Welsh companies and universities**. Whilst Wales has a relatively small public and private research and innovation base, the size of this base has been increasing. Between **1995 and 2016** the research base increased by 5% per year compared to a UK average of 2%.

In the UK there are more people employed in research and development in businesses than in higher education, whilst in Wales an almost equal number of people are employed by both sectors. In terms of investment, in 2018 businesses accounted for just over half (54%) of **expenditure on R&D** that was done in Wales.

A breakdown of employment in research and development and how it compared to the other UK nations is given in Table 6.

Table 6: Number of workers carrying out research, and R&D

Region	HE Academic Staff 2019/20				
	People employed in R&D by UK Businesses 2019	Engaged in research only	Engaged in both teaching and research	Total academics engaged in any sort of research	Total number of people engaged in any sort of R&D
England	232000	42420	82505	124925	356925
Wales	7000	2050	4125	6175	13175
Scotland	15000	6055	9725	15780	30780
Northern Ireland	9000	990	1730	2720	11720
United Kingdom	263000	51515	98085	149600	412600

Source: **HESA; ONS**

In its **response to the call for evidence** for the House of Commons inquiry on **improving the commercialisation of research**, the Royal Academy of Engineering emphasised the importance of skills levels in the wider workforce.

The skills set of the UK workforce is heavily influenced at school as students start to specialise relatively early in the UK compared to many countries around the world, initially at GCSE and then again at A level. There have been several UK and Welsh initiatives aimed at increasing uptake of STEM subjects amongst students and there has been a very **slight increase over the past decade across the UK**.

Welsh Government **commissioned research** shows that for 2018/19 48% of GCSE entries were for STEM academic subjects, a 7.3% increase amongst girls and 10.9% for boys in the decade since 2008/09.

In 2019 43% of all A level entries in Wales were in STEM subjects. This was up from 40% in 2010. A noted feature of the uptake of STEM subjects has been the higher proportion of male entries, with 37% of female entries in STEM subjects compared to 51% of males in 2019, a 14% gap. Subjects in which there is a particularly strong split are mathematics and physics.

The picture is similar when looking at the **uptake of science subjects at university**: 48% of all undergraduates at Welsh universities were enrolled in a science subject in 2019/2020. At postgraduate level, 45% of students at a university in Wales were enrolled in science subjects.

Ser Cymru I and II

A **2015 report** contended that whilst the research base in Wales produced high quality outputs (as discussed below), it lacked “power” and mass – particularly in the area of STEMM research capacity where it identified a deficit of 600 researchers.

This lack of capacity the report argued, was a contributing factor to Wales’ poor performance capturing external competitive funding and its inability to win its 5% UK population share (the same matter addressed again by the Diamond and Reid reviews discussed above).

Whereas the later report by Professor Reid would recommend the creation of a fund to incentivise winning external funding, Professor Halligan’s 2015 report focussed on increasing the STEMM research base. The report stated that:

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 councils

In 2012 the Welsh Government established the £50 million **Ser Cymru programme**. This programme's objectives were focussed on building capacity in the then 'grand challenge' areas of UK Government industrial policy by creating three research networks and appointing four 'star' researchers in related disciplines.

An **evaluation of the original Ser Cymru programme** explained that in 2018 it was too soon to come to a view on the ultimate success of the programme. However it went on to say that "it had performed well in terms of outputs, with targets exceeded in advance of the end of the funding period" – having supported 350 researchers, 600 published papers and 1,000 conference abstracts. However, with regard to Wales achieving the 5% UK population share of research council funding, **in 2019-20** Wales met this metric for one research council, and achieved an average across all research councils of 3%.

In 2018, a follow on programme, Ser Cymru II was launched. This programme focusses on attracting early to mid-career "research excellent" researchers. **Welsh Government explains** that this programme has so far recruited 12 such Fellows.

Immigration and the workforce

In 2019/20 some 31% of academics in **UK universities were not UK nationals**. Subject areas with particularly high numbers of non-UK academics are engineering and technology with 47% non-UK academics, and biological, mathematical and physical sciences with 40% non-UK academics.

Wales overall has a much smaller proportion of non-UK academics than all other UK nations with 21% coming from overseas compared to 31%, 47% and 37% for England, Northern Ireland and Scotland respectively. Within Wales, engineering and technology, architecture and planning, and biological, mathematical and physical sciences also have relatively high proportions of non-UK academics, around 30% in each.

Because of the relatively high proportion of overseas academic staff, the UK immigration rules for researchers and scientists will have a significant impact on the workforces of universities and research organisations. This was explored in a recent UK Parliamentary report titled, **“An immigration system that works for science and innovation.”**

There have been some concerns over how the newly introduced post EU-exit points-based immigration system would impact the recruitment of academic staff, in particular the salary threshold requirement. This matter was raised in the **Welsh Government position paper** published after the points based system was proposed. Early career researchers and technicians can receive relatively low salaries. This has led to **calls from universities** and **research institutes** for the UK Government to ensure that the immigration rules took this into account.

The current rules of the new points-based **system** do include a salary threshold that is slightly lower if the applicant has a PhD relevant to their job – a policy which has been welcomed by **universities** and **researchers**. In addition to the salary thresholds, the **UK government has announced** a fast-track visa scheme, the Global Talent route with no immigration cap and expanded eligibility to allow top scientists and researchers to come to the UK. The UK Government has also made changes to the immigration rules to allow PhD graduates to remain in the UK longer to look for positions on completion of their studies.

8. Annex B: Measuring the quality of research

This annex sets out how research quality and impact is measured. Research quality and impact influences the amount of core research funding HEFCW allocates, which as discussed above, has a relationship with how much external research funding institutions win.

Quantity of university research

A Welsh Government **report** on research and development estimates that despite having 0.04% of the global population and 0.08% of the research funds, Wales is home to 0.13% of the global full time equivalent researchers. It states that from this resource pool, Wales produces 0.3% of the worlds research articles, representing 0.6% of the global citations and 0.8% of the world's most highly cited papers.

The Welsh Government report argues that these figures indicate that Wales “punches above its weight” in terms of research and development, producing a higher quantity and quality of research despite its relatively small absolute capacity. A HEFCW commissioned **Elsevier report** states that the average publications per year per researcher in 2014 was just over 9.6. This was second among the UK nations behind Scotland.

The Research Excellence Framework (REF)

As discussed above, core grant research funding (termed QR) is allocated by the funding bodies in the UK based on the research excellence profiles of institutions. The research excellence profiles are derived from the **Research Excellence Framework (REF)**. The REF is the “system for assessing the quality of research in UK higher education systems”. It has three purposes:

- To provide accountability for public investment in research and produce evidence of the benefits of this investment;
- To provide benchmarking information and establish reputational yardsticks, for use within the HE sector and for public information; and
- To inform the selective allocation of funding for research

Each cycle of the framework is colloquially known as a REF. The last REF was completed in 2014 and the next is due complete and be published in 2022. The results of **REF 2014** showed that 77% of all Welsh research was assessed as world-leading or internationally excellent. The overall figure for the UK was 76.1%.

Measuring impact

Another method for measuring research impact is known as the field-weighted citation impact (FWCI) method. This is where the average number of citations per paper is weighted in relation to the subject field, article type and year of publication.

Using the FWCI method, the same Elsevier report mentioned above compares the research base in Wales to other countries. This shows that Wales was 68% above the world average. When compared to the other constituent UK countries this ranked Wales second with Scotland. The report at the time showed a high growth trend in Welsh FWCI with Wales surpassing the UK average in 2010/11.

When broken down into the six main subject groupings used by the OECD, Wales has an above average FWCI in all areas, with strengths in engineering and technology (68% above average), the natural sciences (67% above average) and medical and health sciences (64% above average). In 2016 Wales' FWCI was above the EU 28 average, with Wales outcompeting similarly sized nations such as Denmark, the Netherlands, Finland and New Zealand.

9. Annex C: ARIA

Funding for a UK high-risk research agency, ARIA, modelled on the US DARPA and focusing on blue-skies research was announced in **the 2020 UK budget**, with an investment of at least £800 million over the course of this Parliament. Whilst the funding level set out is relatively modest in the context of circa £15bn of R&D spend a year, the proposal has attracted considerable attention and so is briefly addressed here.

DARPA (the Defense Advanced Research Projects Agency) is a research agency within the US Department of Defense that has been responsible for some of the key scientific and technological breakthroughs and inventions of the 20th century. Particularly high profile **outputs and contributions** include GPS, microprocessors and computer networking.

The UK Government has now published **a policy statement** on what is now called the Advanced Research and Invention Agency (ARIA) and has introduced the necessary primary legislation to establish it. At the time of writing it is making its way through Parliament, being introduced via the Lords.

The mission of ARIA as described by UK Government will be to:

...exclusively focus on projects with potential to produce transformative technological change, or a paradigm-shift in an area of science. While it is anticipated that most programmes may fail in achieving their ambitious aims, those which succeed will have profound and positive impact on society.

10. Annex D: Definitions

Research and innovation / research and development, are often used interchangeably. However both terms have established meanings – broadly speaking research and innovation (R&I) is a more widely encompassing term than research and development (R&D). Research and development is arguably tech and intellectual-property heavy. Innovation can occur as a result of the successful implementation of R&D activity, but crucially, innovation is generally considered to extend far beyond technology or science solutions.

The **Oslo Manual** defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. This definition includes product / service innovations, marketing innovations, process innovations or wider organisational innovations.

A standard definition of R&D is that of the **Frascati Manual** which defines research and experimental development (R&D) as comprising “creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.”

Another useful definition of research and development comes from the OECD which breaks research and development down into three stages:

1. Basic research. This is experimental or theoretical work with no particular application in mind;
2. Applied research. This is similar to the above in that you are aiming for new knowledge, but there is also a potential application in mind;
3. Experimental development. This draws on the knowledge from the above stages them and focuses on developing technology, processes, materials with a defined purpose, ready for use.

