Department for Business Innovation & Skills

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Insights from international benchmarking of the UK science and innovation system

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Annexes

ANALYSIS

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Annex A: Mapping the science and innovation system

The UK's science and innovation system is complex and non-linear

1. As discussed in Chapter 2, the science and innovation system is highly complex, non-linear and has a large degree of interdependency. In order to better understand the system and its key elements, a system mapping exercise was carried out at the start of the project. System mapping offers a useful technique to determine the views of a large number of people, to determine the boundaries, components and relative dependencies within a system.[1]

2. The Systems map in Figure 2 was produced following literature reviews and consultation with experts and stakeholders, and illustrates the complexity of the science and innovation system. There are a large number of feedback loops within the system that span a wide variety of variables. The number of attempts at innovation – essentially, all types of experimentation – is at the centre of the system. Not all succeed but those that do drive the next iterations of the large feedback loop.

3. This systems map has implicit time-lags between causes and effects. For example changes in education policy may after a few years improve the system for a generation, whilst a change in tax levels will have much faster effects lasting a shorter time. Time lags are discussed against individual indicators where relevant.

4. Given the timescale of the project, it was not feasible to attempt to quantify and analyse all variables and their interactions in the systems map. A Six-Part Framework[2] was therefore devised (Figure 1) that reflects the key elements of the system, and allowed benchmarking of the UK against our key comparator countries.

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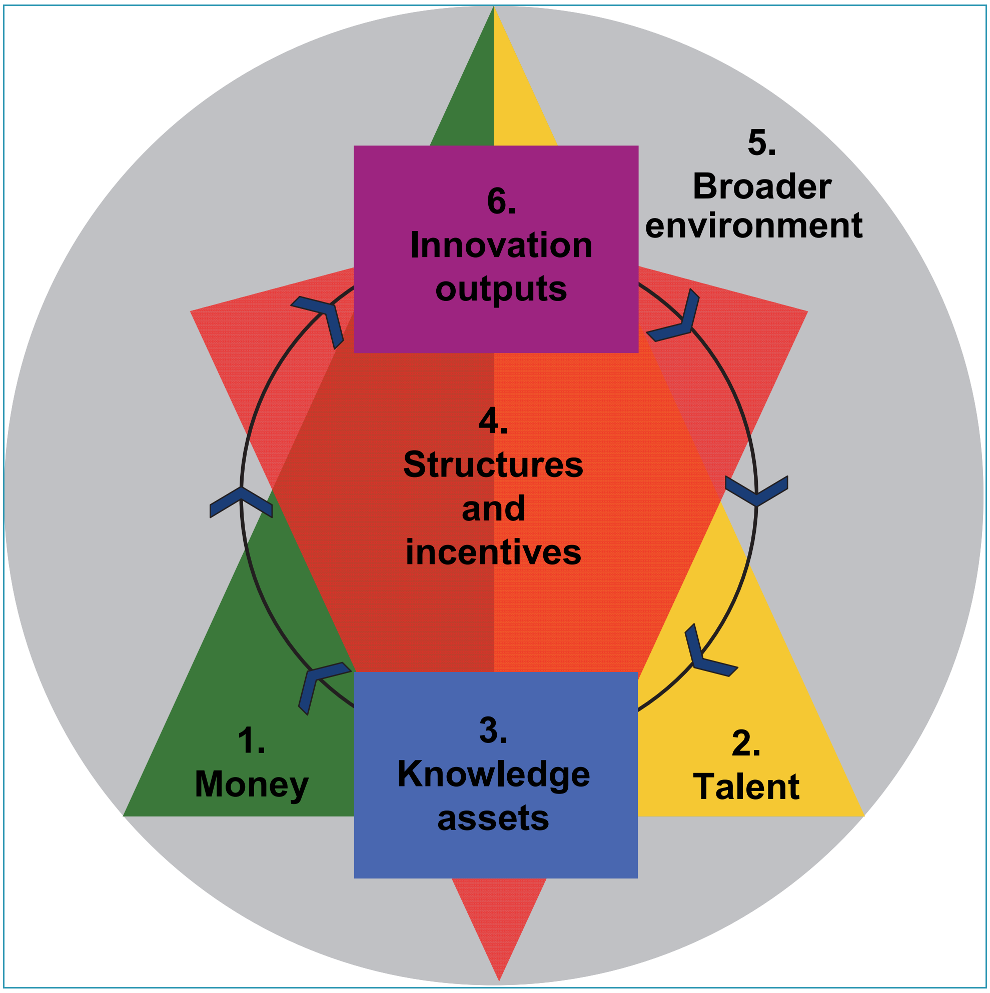
[1] For further details of the principles methodology behind systems mapping see Senge (1990)

[2] Any Systems mapping workshop reflects the views of its participants. Others may have different perspectives so feel that systems mapping variables may have been missed off, or categorised differently. Whilst the Six-Part Framework has also been tested extensively with stakeholders, readers may feel that there are alternative interpretations which we acknowledge.

Figure 1: The Six-Part Framework allows for comparisons with comparator countries



Source: BIS analysis

5. The key categories of the Six-Part Framework are:

- **Money:** A key input into all parts of the framework as it is used to invest in talent and the infrastructure necessary to generate and apply new knowledge. Money is also essential for innovative companies to grow. Money can come from investment in R&D and innovation by various sectors including public, private and third sector organisations, from both domestic and international sources.
- **Talent:** The people that generate, codify and apply science and innovation – the human capital of the system. This can include both domestic and international talent that contribute to the domestic talent pool. Talent also included those outside the science and innovation system that provide essential services which support it (managerial, legal, etc.), as well as those that teach the next generation. Talent is a key driver of both creating new knowledge and possessing the absorptive capacity to exploit new knowledge.
- **Knowledge Assets:** Intermediary outputs which provide a useful indicator of the system's potential and quality. Traditionally, knowledge assets include infrastructure, codified knowledge (in the form of academic papers, for example) and intellectual property. More intangible, but invaluable, knowledge assets include the reputation of the system and its cohesion and wider links to international systems.
- **Structures and incentives:** The institutions and interconnections that determine how effectively the actors in the system work together. The most effective systems include

strong individual components as well as strong collaboration between the various parts. This category captures institutional arrangements, collaboration and knowledge exchange and the degree of alignment of incentives between different actors.
- **Broader environment:** The factors that affect all companies and organisations within a state, such as tax and regulation. These play a key role in encouraging investment and entrepreneurship, both of which are crucial for innovation. The nature of the economy's underlying business population is also key: the drive for and uptake of innovation is, in part, determined by the economic structure of a country, and how complementary this is to its science and innovation system.
- **Innovation outputs:** Given that the ultimate goal, economic welfare,[3] depends on many other factors beyond science and innovation, this report concentrates on slightly more direct outputs of science and innovation. These include productivity growth, new products, services or processes, or exports derived from innovation.

6. The systems map and Six-Part Framework cover a large number of diverse actors who interact and have differing roles across the system. These include:

- **government**, with responsibility for overall policy, aspects of funding, some aspects of international frameworks and collaboration, regulatory framework and governance;
- **public services** (e.g. health and defence), which play a major role both in driving demand for science and innovation (through procurement) and in translating them into societal benefits;
- **Higher Education**, responsible for carrying out research, training the next generation, and acting as guardians of the inherited body of knowledge;[4]
- **Further Education**, which shares responsibility for training the next generation;
- **business**, which drives and creates demand, funds and carries out research, commercialises ideas and generates sales and exports;
- **capital markets**, which provide finance for start-ups and existing businesses to innovate and grow and an exit route that allows monetisation of successful innovations;
- **scientists and innovators** who carry out research and bring new innovation to market
- **non-STEM professionals**, who provide critical services to the science and innovation system from managerial and clerical to energy supply
- **customers and citizens**, who drive demand for solutions to problems that are solved by science and innovation and provide the pool for the future generation of scientists and researchers;
- **learned societies**, which monitor the health of the system, publish evidence and provide a framework for debate; and
- **charities**, which are important funders and policy partners, particularly in the life science sector.

[3] Increased consumer surplus, reduced resource costs, lower negative externalities or higher positive externalities.
[4] The UK is somewhat unusual in that higher education institutions do most of the research whereas in many other countries independent research organisations or institutes predominate.

7. The systems map and Six-Part Framework are based on discussions regarding the UK’s domestic system; systems and frameworks in other countries may differ from the UK’s. However, it is clear that the UK’s science and innovation system operates in a global context and it is important that the interaction of the UK system with other systems is given appropriate consideration.

8. The Six-Part Framework and underlying systems map helped to inform the identification of key indicators to compare the UK’s performance with the chosen comparator countries (See Annex G). Their use in identifying these indicators is described in more detail in the following chapter.

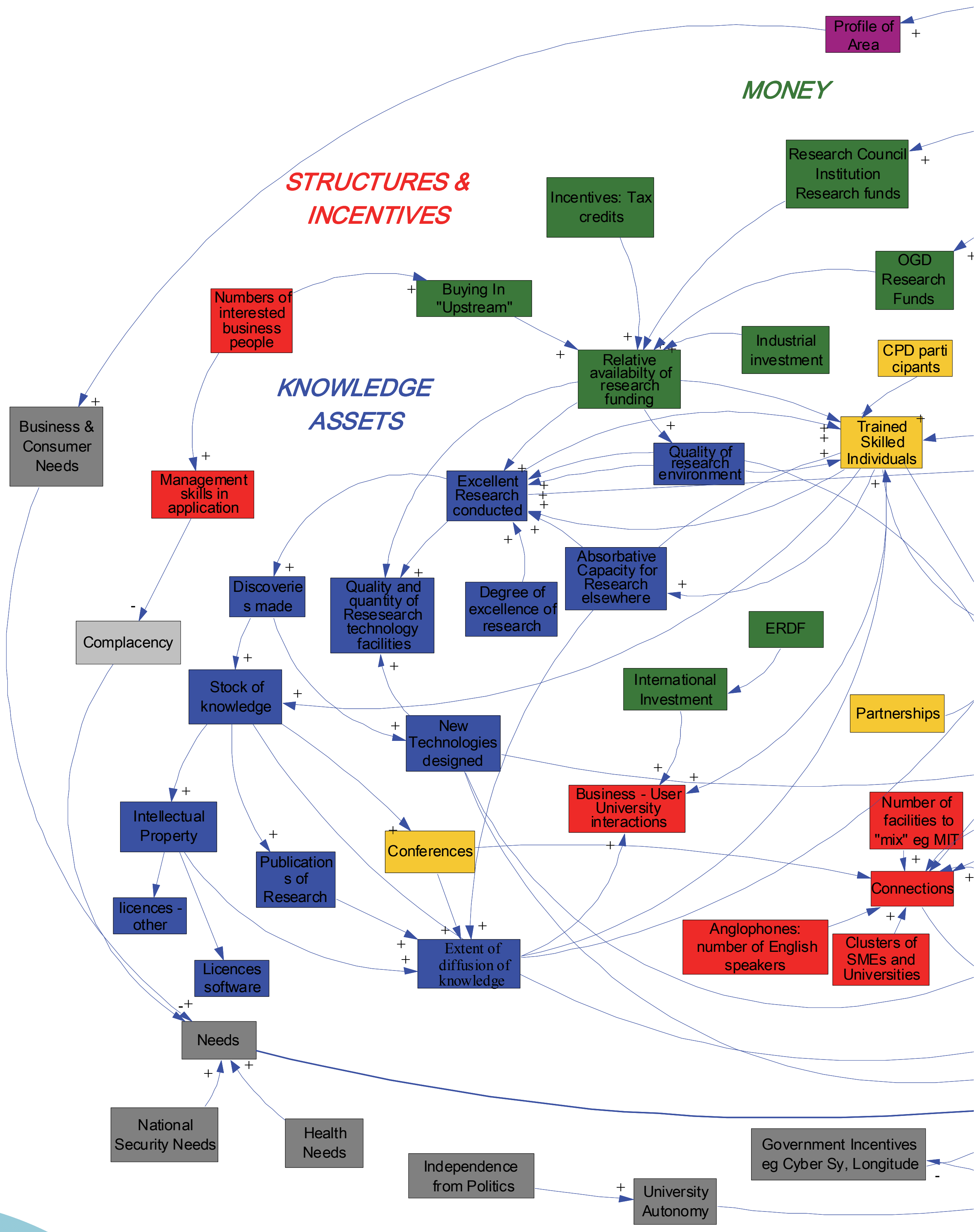
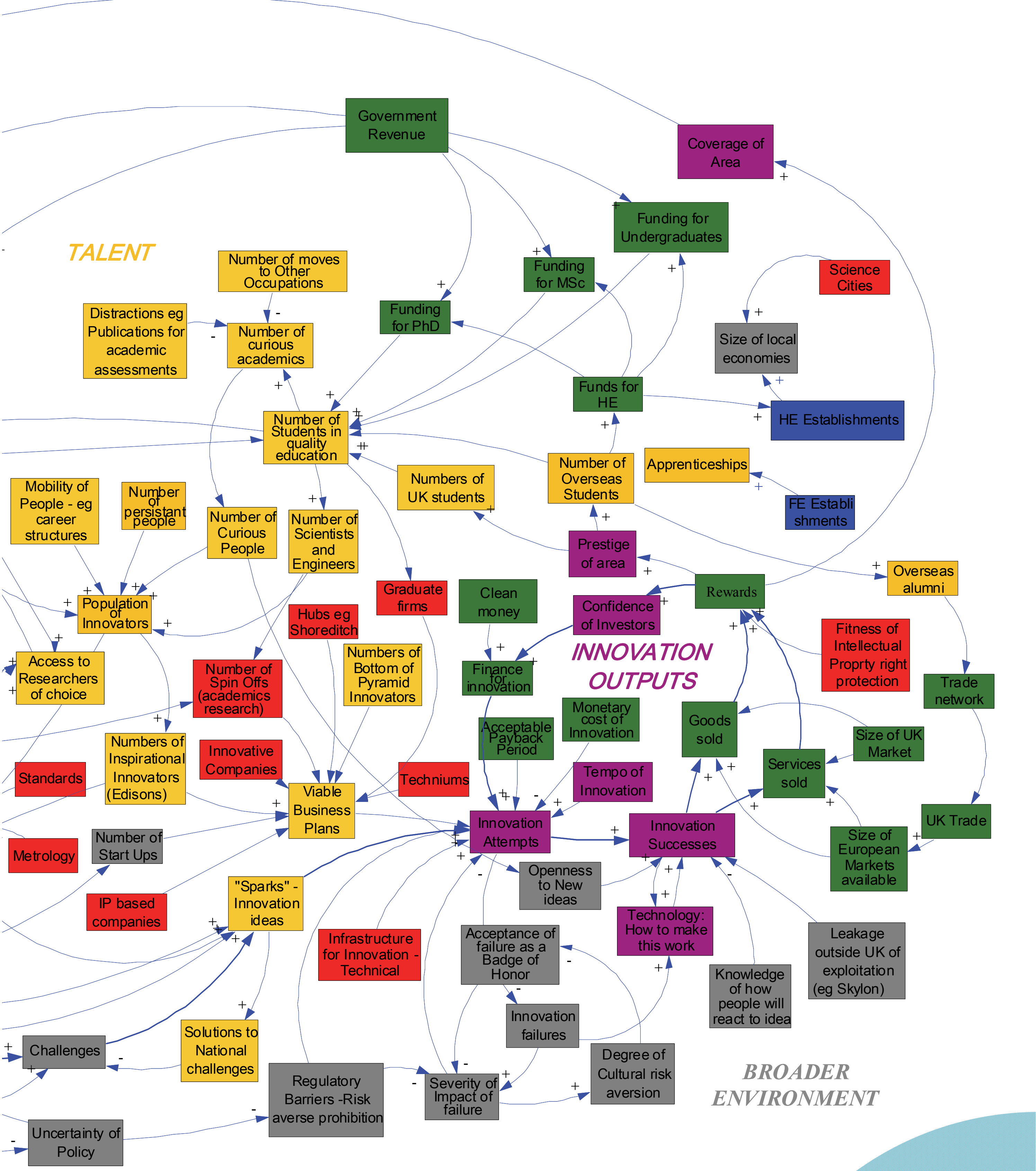

Profile of Area
MONEY
STRUCTURES & INCENTIVES
Research Council Institution Research funds
Incentives: Tax credits
OGD Research Funds
Numbers of interested business people
Buying In "Upstream"
Industrial investment
CPD participants
Relative availabilty of research funding
KNOWLEDGE ASSETS
Business & Consumer Needs
Management skills in application
Quality of research environment
Trained Skilled Individuals
Excellent Research conducted
Absorbative Capacity for Research elsewhere
Discoveries made
Quality and quantity of Resesearch technology facilities
Degree of excellence of research
Complacency
ERDF
International Investment
Stock of knowledge
New Technologies designed
Partnerships
Business - User University interactions
Intellectual Property
Number of facilities to "mix" eg MIT
Publications of Research
Conferences
Connections
licences - other
Anglophones: number of English speakers
Clusters of SMEs and Universities
Extent of diffusion of knowledge
Licences software
Needs
National Security Needs
Health Needs
Independence from Politics
University Autonomy
Government Incentives eg Cyber Sy, Longitude

Figure 2: Map of the UK's science and innovation system[5]



[5] See PDF of systems map on website for full details

Annex B: Identifying appropriate indicators

9. It is important to determine what 'good' looks like for a science and innovation system. This should include: how efficiently and effectively the system works to improve economic and ultimately societal outcomes; how responsive and adaptive the system is to changes in demand and practices; and the extent to which the various elements are appropriately coordinated to produce a cohesive system.

Specifying and quantifying what good looks like is complicated

10. A large number of metrics and datasets relevant to the science and innovation system are currently available. These indicators are published by numerous organisations, including the World Bank, the OECD, the World Economic Forum (WEF) and INSEAD and World Intellectual Property Organisation (WIPO).

11. In order to make a meaningful assessment of a science and innovation system it is necessary to identify and focus on those indicators which are judged to be the most informative. The choice of indicators was shaped by the systems mapping exercise described above and the resulting Six-Part Framework. It was also informed by previous studies, as well as discussions with experts in this area. More specifically, indicators were chosen against the following criteria:

- indicators should be based on high-quality statistics and robust analysis;
- indictors should be informative and relevant; and
- where possible, indicators should be available for all comparator countries and allow for consistent comparisons over time.[6]

12. The chosen set of indicators, and the rationale for their inclusion, is set out in Table 1.

13. Despite the approach taken to choosing indicators, some limitations remain, including:

- **inevitable inconsistencies in the data supplied**, given differing country methodology and interpretation;
- **historically focused** indicators with little reference to future trends;
- many available statistics are based **on old industrial models of manufacturing and traditional R&D** at the expense of the service sector and intangible assets;
- an **implied model of technology push** at the expense of demand factors that drive innovation;
- **inputs are generally easier to measure than outputs and outcomes**, and therefore tend to dominate data sets, and the contribution of multiple inputs to outputs and outcomes is hard to capture;

[6] One issue with the available indicators, particularly those relating to innovation performance, is that time-series are often not available. A second, and this particularly relates to output and outcome metrics, is that there are few robust indicators that allow for comparisons across all comparator countries.

- indicators often present countries in **a ranked-order** which can present a false picture for those countries that are highly performing and clustered towards the top of the rankings;
- the **sheer volume** of indicators can be overwhelming; and
- **time-series are not always available** or methodological changes makes comparison difficult.

14. While most of the selected indicators are based on hard economic data, we have also identified indicators that capture softer elements of the innovation system, such as reputation and trust. These soft indicators, which are typically (though not always) based on information from opinion surveys are highlighted in grey in the Table 1.

Table 1: Identified indicators

Indicator	Symbol	Comment	Source
Money			
GERD as a percentage of GDP	M1	Research & development spending, as defined by Frascati, is a widely agreed definition. Data available across all comparator countries and also over a long-time period (at least the early 1990s). Gives a good indication of the amount spent on 'typical' R&D (although the definition of R&D does not capture all types of innovation spending). There are three main sources of R&D spending that are considered: that financed from abroad; by businesses; and by government. Econometric evidence (e.g., Guellec and Van Pottelsberghe De La Potterie, 2004) shows that the overall level of R&D spend is positively correlated with productivity growth; and that this is true for both BERD and Government funded R&D.	OECD
BERD as a percentage of GDP	M2		OECD
Government financed GERD as a % of GDP	M3		OECD
Percentage of GERD financed from abroad	M4		OECD
Government financed BERD as a % of GDP	M5		OECD
Foreign Direct Investment (FDI) and technology transfer	M6	FDI is an important source of funds for investment in R&D, particularly in the UK. The extent to which this foreign investment brings new technology into the country is an important factor – the implication being that quantity of funds is not enough, but quality matters too. FDI can also be seen as a proxy for the overall effectiveness of the ecosystem, as investment can be expected to be located in the countries with the best overall environment for science and innovation.	WEF
Seed/start-up/early stage venture capital as a % of GDP	M7	Venture capital is an important source of funds for research and innovation, and growth investment for innovative companies. Venture capital investment often occurs once the business opportunity has shown itself to have a high enough probability of a sufficient rate of return. This might come as a later stage investment, but it is also important that businesses have adequate access to finance at an early enough stage that allows them to take forward an idea – early stage venture capital funding might give an indication of this, though there are other forms of finance that would not be	OECD
Later stage venture capital as a % of GDP	M8		OECD

Indicator	Symbol	Comment	Source
		captured by this measure.	
Financing through local equity markets	M9	Another way that firms might access finance is by issuing shares on the stock market. The ease with which firms can do this might give an indication of the opportunity for firms to grow beyond a certain scale. The existence of meaningful exit routes for growth companies makes it more likely that entrepreneurial activity to commercialise science and innovation takes place.	WEF
Investment in fixed and intangible assets as a percentage of GDP	M10	Traditional metrics of R&D and innovation might neglect investment in knowledge and intellectual capital – so called intangible investments. While this might be an important aspect of innovation investment - capturing investment in training, managerial capability, design and software development – there is a lack of data across key comparator countries over time, and definitions are less well agreed.	Corrado et al (2012)
Talent			
Literacy proficiency among adults	T1	Successful innovation processes not only require human capital that works at the high end of educational attainment but also, more generally, a well-educated population. This can be measured, in broad terms, by using indicators of numeracy, literacy and problem solving abilities among working age adults.	OECD
Numeracy proficiency among adults	T2		OECD
Proficiency in problem solving in technology-rich environments among adults	T3		OECD
Percentage of population that has attained tertiary education	T4	Highly-skilled labour is a key input to the innovation process in terms of generating, absorbing, and applying new knowledge. Tertiary education is the most commonly used proxy for highly qualified human capital.	OECD
Percentage of total first university degrees in science and engineering	T5	The evidence shows that high levels of science/engineering qualifications have a positive impact on innovation. Traditionally, these have been associated with the number of graduates obtaining first degrees in science and engineering.	IMD
International students as a % of total tertiary enrolment rate	T6	Students moving abroad to study are an important source of knowledge flows between countries. The ability to attract skilled individuals is also a good indication of the quality of the tertiary education system.	UNESCO

Indicator	Symbol	Comment	Source
Doctorate holders per thousand population	T7	Highly-skilled individuals with advanced research degrees are an essential element of modern science and innovation systems. They are not only the most qualified in terms of their educational attainment but also are specifically trained to conduct research.	OECD
Researchers per thousand employed	T8	Measuring the volume of human capital resources devoted to research in a country is another consideration when assessing talent. This can be proxied by looking at the number of researchers across all professions engaged in the creation and conception of new knowledge and products.	OECD
Individuals with tertiary-level STEM qualifications as % of total employment (excluding medical and biological sciences)	T9	The evidence shows that employees with high-level STEM skills are important for various aspects of the innovation process. For example, STEM skills are necessary to carry-out high level research and improve firms' absorptive capacity.	Eurostat: Human Resources in Science and Technology Database; The data is not available for Australia, Canada, Japan, South Korea and United States
Firms' leadership and management capabilities	T10	Management and leadership are important drivers of the ambition and successful implementation of business strategies, including R&D and innovation strategy. Evidence shows a clear link between management skills and productivity. Business building skills are also seen as a key bottleneck in many countries in moving from small-scale application of science and innovation into scale-up and exports.	CEPB
Knowledge assets			
Share of 1% most highly cited papers	K1	The number of citations of an article is a proxy for its quality and the significance of the work. Focussing on the share of the top 1% most highly cited papers gives a perspective on the quality of the research produced by a country.	SCOPUS
Patent application per million of population	K2	The number of patent applications gives an indication of how active researchers and businesses are regarding attempting to protect their intellectual property. Patents could be considered to be a proxy for the amount of commercially valuable innovations that are produced by a country. However, there are a number of caveats. First, a high number of patent applications does not tell us how many of those applications were successful. Second, there are a number of ways of commercialising knowledge and patenting is just one of them. A low score on patents might reflect a country's comparative advantage in sectors that are not suited to	WIPO

Indicator	Symbol	Comment	Source
		patenting.	
Academic/corporate co-authored publications	K3	This variable gives an indication of the amount of collaboration between research institutions and businesses. A high score does not necessarily mean that this collaboration results in high quality research. However, the extent to which a research base and businesses are appropriately linked is considered to be an important facet of a successful science and innovation system. While not ideal, this indicator attempts to proxy for the successful collaboration and linkage between research and business. In general, evidence shows that collaboration enhances the translation of knowledge into applications.	SCOPUS
Quality of scientific research institutions	K4	This indicator is based on a questionnaire asking how respondents would assess the quality of scientific research institutions in their country. This might be based on the quality of the facilities available to them, but also the quality of its outputs.	WEF
Structures and incentives			
Attractiveness to researchers and scientists	S1	Researcher migration is becoming an increasingly important feature of modern innovation systems, and as such, ability to attract scientists is important in ensuring the supply of highly-qualified researchers. As attractiveness could be influenced by a number of factors (the quality of research institutions, career prospects and the overall standard of living), comparing countries is not straightforward. As the proxy for these factors we use a measure of assessing business perceptions of countries' attractiveness to researchers and scientists.	WEF
Intellectual property protection	S2	Having a well-functioning intellectual property (IP) rights framework supports innovative activity and diffusion of new knowledge. Effective IP protection is particularly important for firms investing in generating new technology when the returns to technological investment are very long term, involve high risks and are easy to copy. Our assessment of IP regimes is based on business opinion surveys.	WEF
Cluster development	S3	A wide breadth of evidence suggests that there are strong productivity advantages of economic clusters. In the context of innovation systems, successful clusters allow companies (especially SMEs) to collaborate with research institutions, suppliers, customers and competitors located in the same geographical area, and thus lead to increased synergies between different innovation actors. To compare the state of cluster development between countries, the report uses qualitative data	WEF

Indicator	Symbol	Comment	Source
		capturing executive opinion surveys.	
Government procurement of advanced technology products	S4	Government procurement has the potential to drive innovation by demanding new products or technologies. However, measuring to what degree governments stimulate innovation and advanced technologies is difficult. In the absence of quantitative indicators, the report uses the data assessing business views on the impact of government procurement on innovations in different countries.	WEF
International collaboration on innovation by firms	S5	International collaboration can play an important role in the innovation process by allowing firms to gain access to a bigger pool of knowledge and resources. In addition, collaboration allows firms to share risks and costs.	OECD
SME collaboration with Higher Education institutions	S6	Given the sophistication and complexity of various fields of science and knowledge, collaboration with higher education or public research institutions could be an important source of knowledge transfer. We measure this using the proportion of innovative SMEs that collaborate with higher education or public research institutions. This reflects the existence of some sort of collaboration, but not the type, frequency or intensity of innovation collaborations	OECD
Broader environment			
Ease of doing business	E1	R&D decisions and innovative activities are influenced by the regulatory and policy environment. Well-functioning legal and administrative frameworks facilitate business creation and healthy competition. This, in turn, supports creation and application of new knowledge. We measure the quality of business environment using the Ease of Doing Business ranking produced by the World Bank.	World Bank
Total early-stage entrepreneurial activity	E2	The entry and growth of new firms are important to the innovation process. High levels of churn help speed up the process of reallocation of resources and reflect competitive and innovative pressures in a market.	Global Entrepreneurship Monitor
Intensity of local competition	E3	Higher levels of competition tend to increase the incentive to innovate, which will help firms gain a competitive advantage on their competitors. As a proxy of the degree of competition, we use the data on business perceptions on intensity of competition in local markets.	WEF
Firm-level technology absorption	E4	Absorptive capacity of firms is an important determinant of the speed and quality of technology diffusion. Given the lack of quantitative indicators, the report relies on business executives' assessment of firm-level absorptive capacity in	WEF

Indicator	Symbol	Comment	Source
		their own countries.	
Quality of demand conditions	E5	Innovation also depends on demand conditions such as customer orientation and buyer sophistication. More demanding customers force companies to provide better products and services, hence creating stronger incentives to innovate. This indicator is also based on business opinion survey.	WEF
Interest in science and technology	E6	Interest in science and technology is a measure of attitudes to new technologies. Consumers, who are interested in scientific discoveries, are likely to demand more technologically advanced products, and therefore create more incentives for firms to innovate.	Eurostat
Innovation outputs			
Labour productivity	O1	GDP per hour worked gives an indication of the level of productivity in a country. We have used a metric on the actual level rather than focusing on growth rates, which can be volatile from year to year.	OECD
Sales of new to market and new to firm innovations as % of turnover	O2	This gives an indication of the amount of product and process innovations that firms have implemented/utilised. A high percentage of turnover suggests a presence of highly innovative firms which also turn those innovations into commercial successes.	IUS* *Data availability only allows for comparisons between the UK, Germany, France and Finland
Economic complexity index	O3	Countries are scored based on the amount of productive knowledge that is implied in their export structures. A good score suggests that the country contains strong productive knowledge and that it manufactures and exports a large number of sophisticated goods.	The atlas of economic complexity - mapping paths to prosperity. Hausmann, Hildago et al
Knowledge-intensive services exports as % total service exports	O4	For advanced economies, knowledge intensive services is one of the areas they are likely to have a comparative advantage over other countries. Strength on this indicator would suggest that the country produces knowledge-intensive services that are demanded from abroad.	IUS* * Data only available for the UK, Germany, France and Finland
Technology balance of payments: surplus as % of GDP	O5	This indicator measures international transfers of technology, including licenses, patents, research and knowledge. The receipts represent payments for production-ready technologies. If a country exports more technology than it imports, it will have a technology balance of payments surplus. This might suggest that the country produces technologies that are demanded abroad,	OECD

Indicator	Symbol	Comment	Source
		suggesting a competitive science and innovation system and a resulting trade surplus. However, as the OECD point out, a technology balance of payments deficit does not necessarily equate to low competitiveness. A deficit might be a result of a country being effective at absorbing foreign technologies, as well as being able to export its own technologies.	
SMEs introducing product or process innovations as % of SMEs	O6	This attempts to assess how successful small and medium sized enterprises are at implementing and making use of innovations	IUS* * Data availability only allows for comparisons between the UK, Germany, France and Finland

Annex C: Indicators on the UK’s comparative performance

15. This annex considers each of the indicators identified in Table 1.

16. In order to compare the UK’s performance against the comparator countries a scoring system has been used. These scores (see formula below) use the maximum and minimum values from the sample to measure the performance of each country **relative** to the score of the best and worst performing countries in the sample.

$$\text{Score} = 9 \times \left(\frac{\text{(Country value- sample minimum)}}{\text{(sample maximum – sample minimum)}} \right) +1$$

17. The above formula scores the countries from 1-10. The country with the highest performance on a particular indicator scores 10 and the country with the lowest performance scores 1.

18. Although this method is a useful way to standardise a number of different measures (e.g. percentage of GDP, $ billion, WEF scores etc.), it does have its limitations. It is possible that all comparator countries perform very similarly on a particular indicator, however the country with the lowest value will have a score of 1. This might suggest a weakness against a particular measure when in fact, based on its raw value, this country might be judged as performing similarly to its rivals. It is also possible that one country has a much higher value than all other countries for an indicator. This might result in the country in second place having a low score when, compared to its rivals, it is actually relatively strong on this indicator (but is some way behind the lead country). While on balance we feel that it is still useful to present the data through this scoring system, it is important to consider these limitations, and the commentary for each indicator attempts to discuss each score with this in mind.

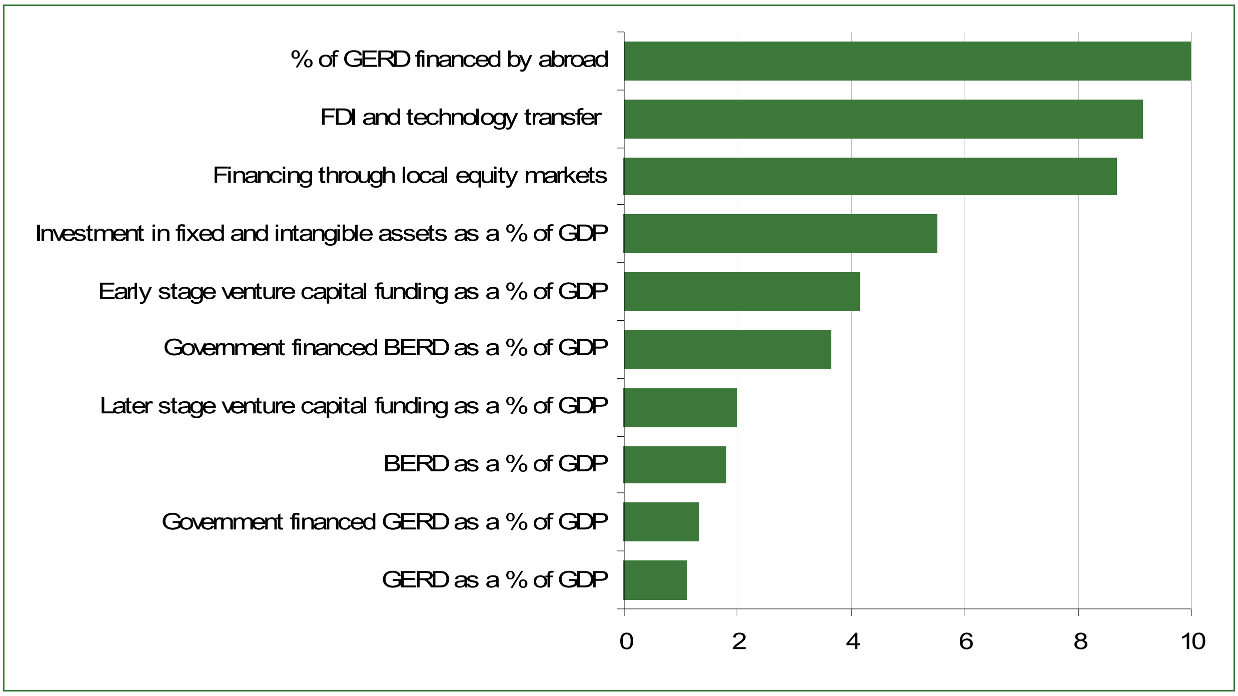
19. The indicator scores are presented in a common way throughout this section: at the beginning of each part (organised by the headings of the Six-Part Framework) there is a summary of how the UK performs for each section. This summary also includes a short discussion on data limitations and other issues regarding the assessment of the UK’s performance compared with other countries. Each indicator is then considered in turn, explaining the rationale for including the indicator, the source and a commentary regarding how the UK performs on each indicator. A chart showing the relative scores is then presented, followed by a table which includes the raw data behind the scores, and finally, where data availability allows, a time-series chart is included.

Money indicators

Overall, the UK scores poorly on key research and development (R&D) expenditure indicators - we have the lowest Gross Expenditure on R&D (GERD) as a percentage of GDP (Gross Domestic Product) of all comparator countries. Breaking down these GERD figures, the UK also has relatively low Business Enterprise R&D (BERD) and government financed GERD as a percentage of GDP.

However, the UK has the highest share of GERD financed from abroad. The UK also scores highly on some other measures of money. The UK is second (behind the US) for investment in fixed and intangible assets as a percentage of GDP. The evidence on intangible investment suggests that it is important to look beyond R&D data in order to understand total investment in science and innovation. The UK also scores highly for the ability of firms to gain access to finance through local equity markets, and the extent to which foreign direct investment (FDI) is associated with technology transfer.

Money indicators – UK scores (1-10)



Source: BIS analysis

Data availability

Measures of spending on R&D are well established and available for all of the comparator countries identified in this report. However, data on innovation spending are not widely available and proxies for such spending lack robustness. Comparable data across countries on innovation spending would significantly improve our ability to monitor and evaluate the UK's spending on innovation compared with other countries.

M1: GERD (Gross Expenditure on Research and Development) as a percentage of GDP

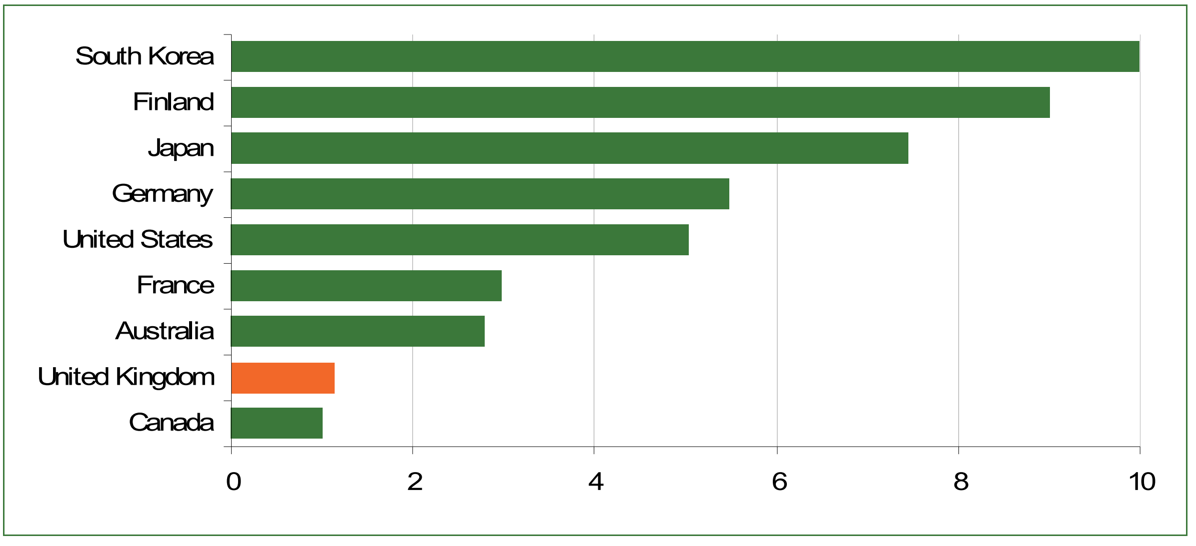
Definition: Gross domestic expenditure on research and development (GERD) is total intramural expenditure on research and development performed on the national territory during a given period.

Rationale: GERD as a percentage of GDP offers a good indication of total expenditure on R&D, as traditionally defined. R&D is a well defined and widely accepted concept. However, it does not capture all types of innovation expenditure.

Source: OECD (2013)

The UK's value of GERD as a percentage of GDP (1.8%) is low compared with most comparator countries. South Korea (4.0%), Finland (3.8%) and Japan (3.4%) are the leading countries according to this indicator. While over time the UK's GERD as a percentage of GDP has been relatively flat, most comparator countries have seen increases – most notably Finland and South Korea.

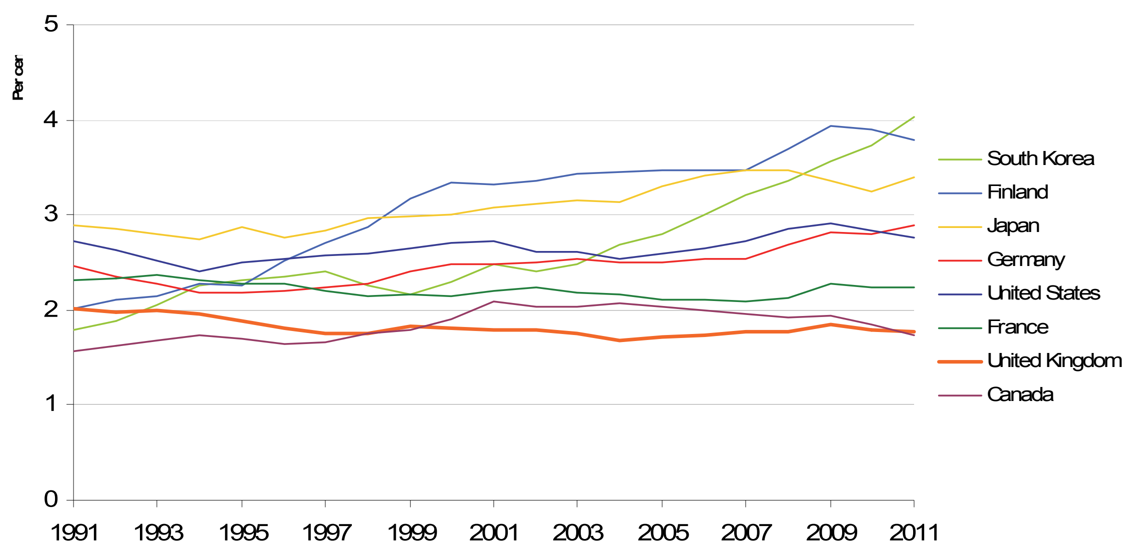
Relative country scores



Underlying data table

	Rank	Score	Value (% of GDP)	$ million PPP
South Korea	1	10.0	4.0	59,795
Finland	2	9.0	3.8	7,602
Japan	3	7.5	3.4	146,537
Germany	4	5.5	2.9	93,676
United States	5	5.0	2.8	430,218
France	6	3.0	2.2	51,891
Australia	7	2.8	2.2	21,668
United Kingdom	8	1.1	1.8	40,179
Canada	9	1.0	1.7	24,285

Time series



M2: BERD intensity (Business Enterprise Research & Development) as a percentage of GDP

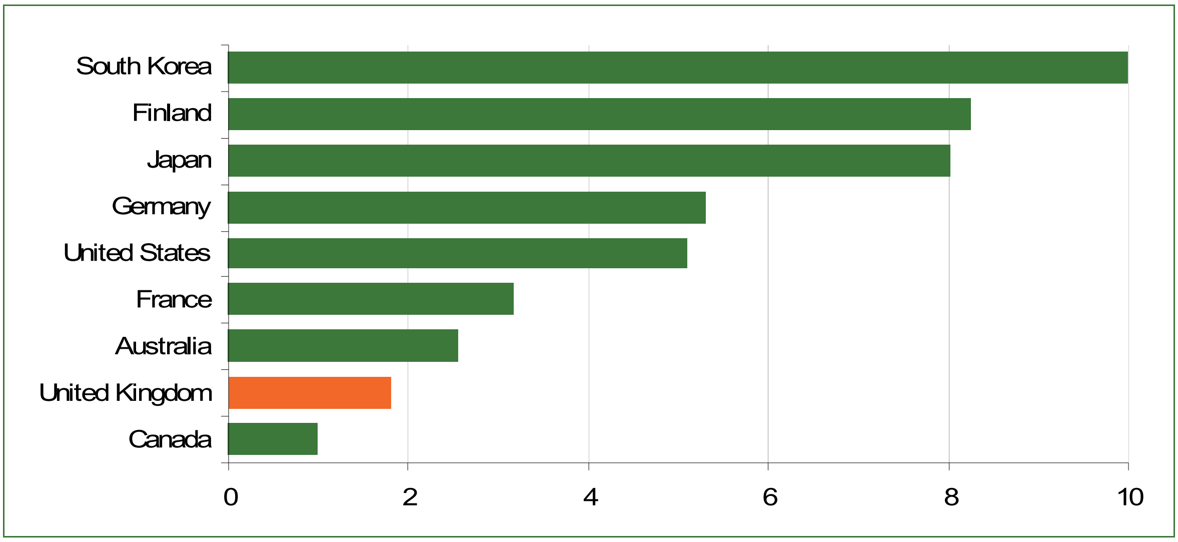
Definition: Business Enterprise R&D refers to R&D performed in the business sector.

Rationale: BERD as a percentage of GDP offers a useful indicator of the amount of R&D performed by businesses. R&D is a well defined and widely accepted concept. However, it does not capture all types of innovation spend.

Source: OECD (2013)

The UK's BERD intensity is low compared with comparator countries. South Korea, Finland and Japan are the leading nations on this measure. While most countries have increased their BERD intensity over time, the UK has not, meaning that the UK has fallen further behind key comparator countries.

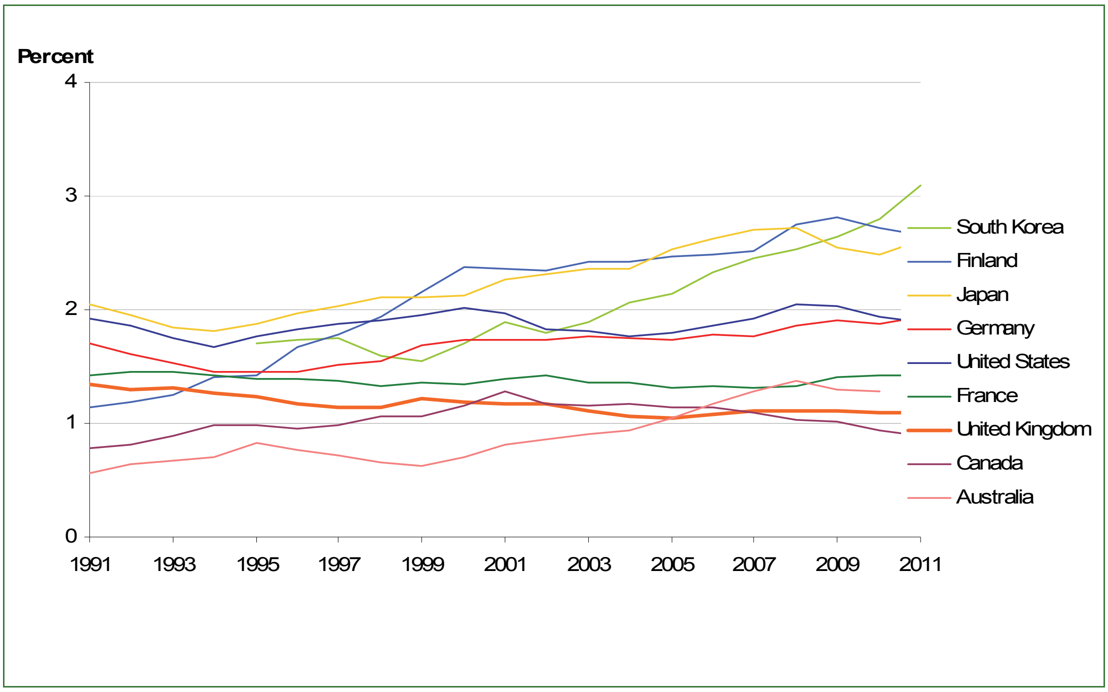
Relative country scores



Underlying data table

	Rank	Score	Value (BERD Intensity)	$ million PPP
South Korea	1	10.0	3.1	45,764
Finland	2	8.3	2.7	5356
Japan	3	8.0	2.6	112,779
Germany	4	5.3	1.9	63,069
United States	5	5.1	1.9	294,053
France	6	3.2	1.4	32,918
Australia	7	2.6	1.3	12,567
United Kingdom	8	1.8	1.1	24,697
Canada	9	1.0	0.9	138,709

Time series



M3: Government financed GERD (Gross Domestic Expenditure on Research and Development) as a percentage of GDP

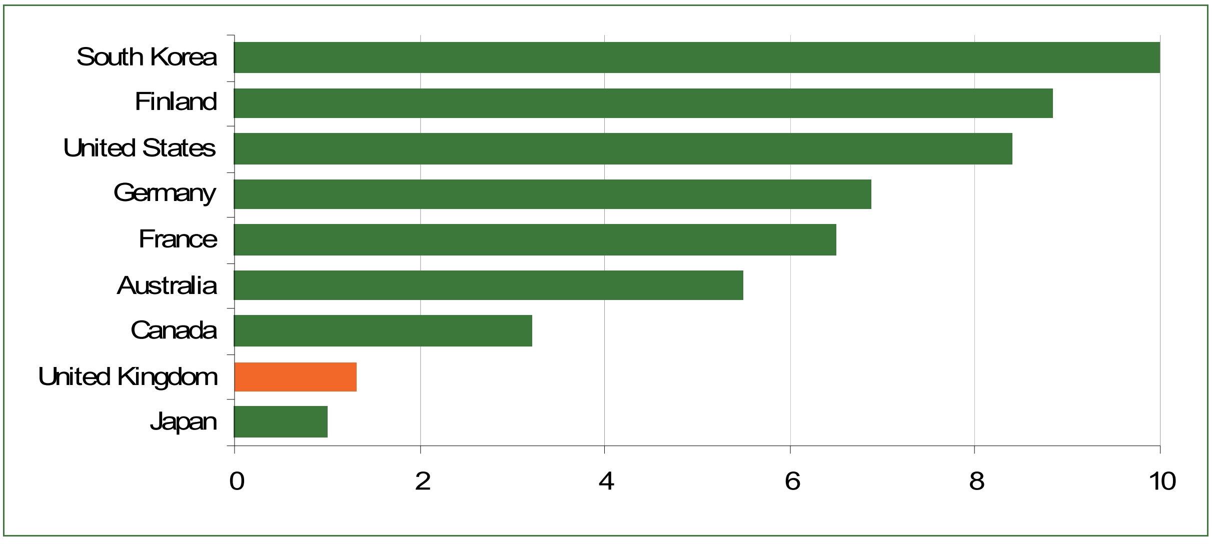
Definition: This measures public sector funding of total R&D, measured as a percentage of GDP.

Rationale: The public sector is an important source of funds for R&D. This indicator considers government financed R&D in each comparator country.

Source: OECD (2013)

Government financed GERD as a percentage of GDP was 0.6% of GDP in 2011 – only Japan was lower of the key comparator countries. The leading countries according to this indicator are South Korea, Finland and the US.

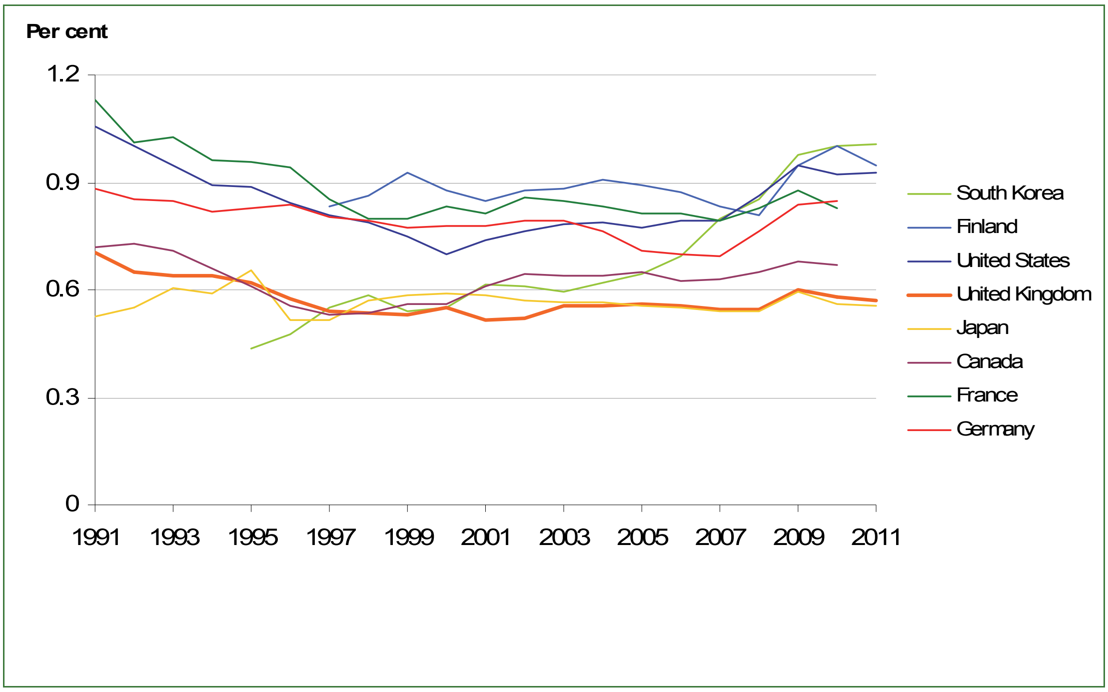
Relative country scores



Underlying data table

	Rank	Score	Value (% of GDP)	$ million PPP
South Korea	1	10.0	1.0	14,891
Finland	2	8.8	0.9	1,903
United States	3	8.4	0.9	143,658
Germany	4	6.9	0.8	27,581
France	5	6.5	0.8	19,184
Australia	6	5.5	0.8	7,702
Canada	7	3.2	0.7	9,302
United Kingdom	8	1.3	0.6	12,957
Japan	9	1.0	0.6	24,044

Time series



M4: Percentage of GERD (Gross Domestic Expenditure on Research and Development) financed by abroad

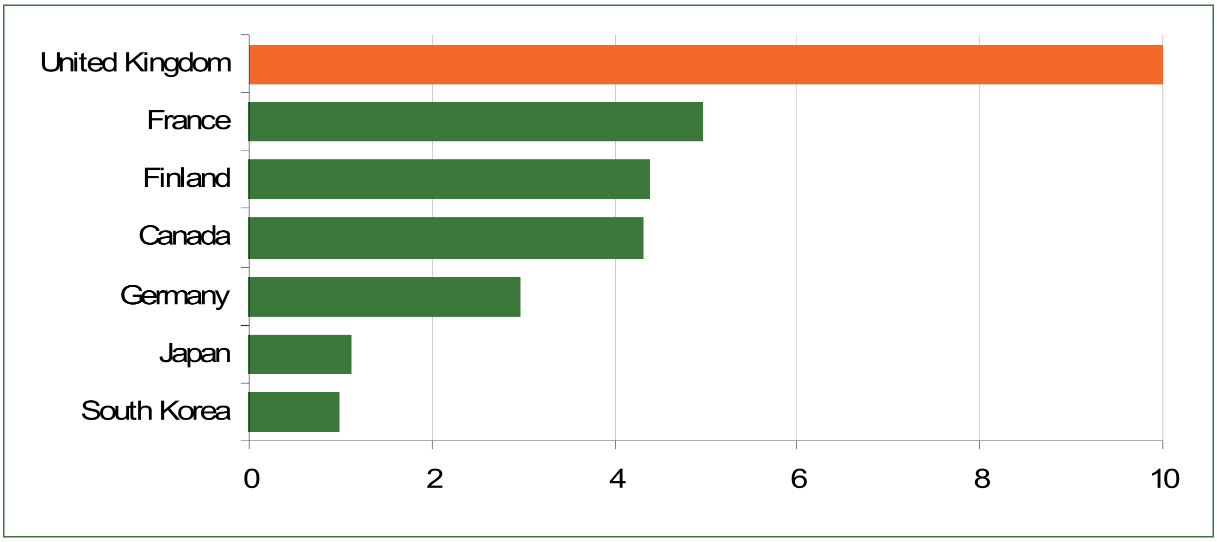
Definition: This measures how much of a country's GERD is financed by abroad.

Rationale: Foreign investment is an important source of funds for R&D, particularly so for some countries.

Source: OECD (2013)

The UK has the highest percentage of GERD financed from abroad compared with its key comparator countries. The extent to which this is an indicator of strength is ambiguous. On the one hand, it suggests that the UK is a place where foreign-owned companies are willing and able to invest. This might indicate that the UK performs strongly regarding its facilities, human capital and technological capabilities compared to other economies. However, it might also be a risk given that foreign-owned firms might be more likely to shift investment to other countries, leaving the UK's R&D spending quite dependent on factors outside of its control.

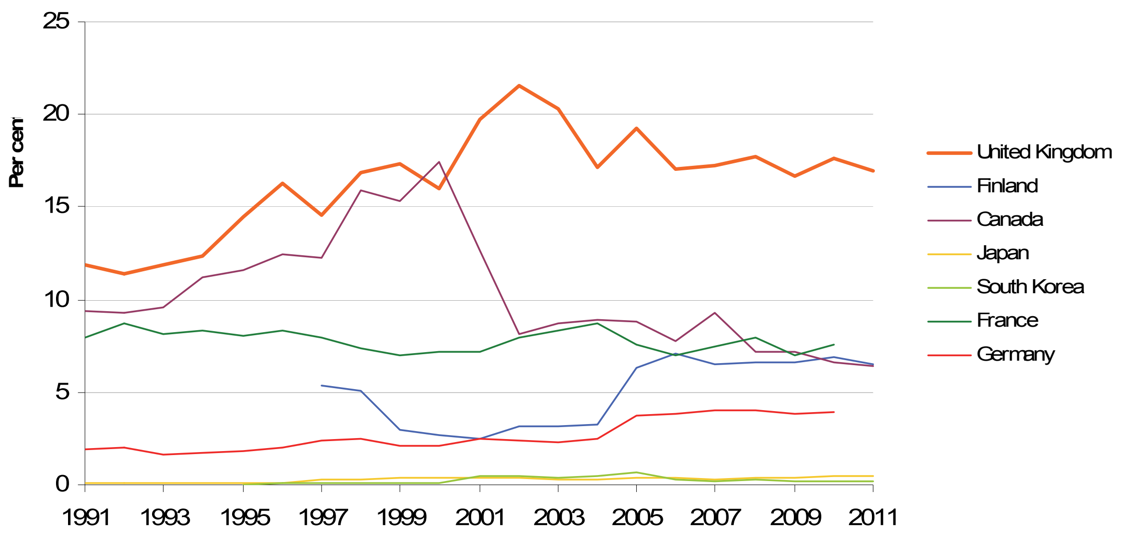
Relative country scores



Underlying data table

2011	Rank	Score	Value (% of GERD)	$ million PPP
United Kingdom	1	10.0	17.0	6727
France	2	5.0	7.6	3799
Finland	3	4.4	6.5	500
Canada	4	4.3	6.4	1562
Germany	5	3.0	3.9	3351
Japan	6	1.1	0.5	702
South Korea	7	1.0	0.2	134

Time series



M5 Government financed BERD as a percentage of GDP

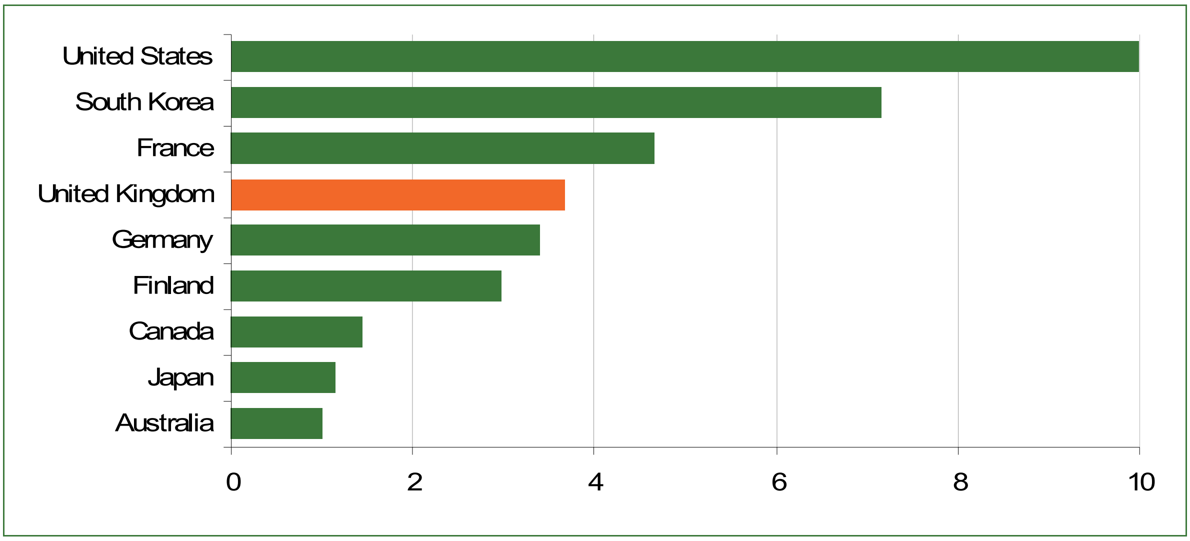
Definition: This shows the amount of BERD financed by government, measured as a percentage of GDP.

Rationale: The extent to which the government supports business spending on R&D is an important factor. Such support might be important in helping to achieve R&D activity that might not have otherwise taken place.

Source: OECD (2013)

The UK is a middle-ranked country according to this measure (0.09% of GDP), similar to Germany (0.09%) and Finland (0.08%). The US is the clear leader on this indicator with public sector financing of BERD standing at 0.26% of GDP.

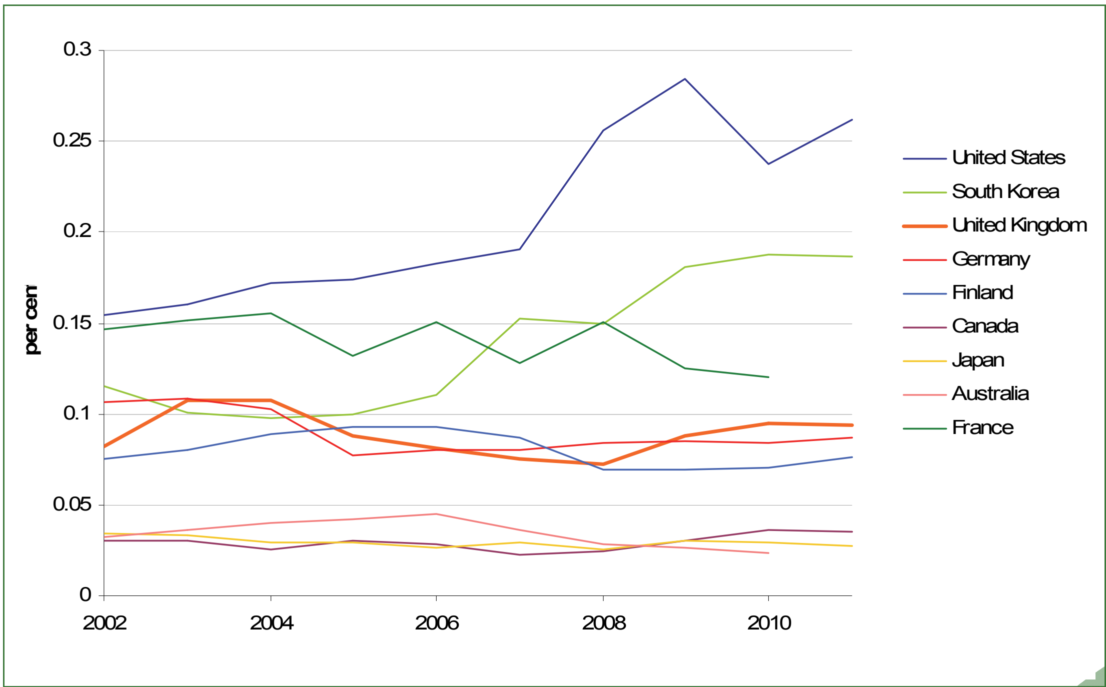
Relative country scores



Underlying data table

	Rank	Score	Value (% of GDP)	$ million PPP
United States	1	10.0	0.26	40,695
South Korea	2	7.2	0.19	2,771
France	3	4.7	0.12	2,683
United Kingdom	4	3.7	0.09	2,128
Germany	5	3.4	0.09	2,815
Finland	6	3.0	0.08	153
Canada	7	1.5	0.04	489
Japan	8	1.2	0.03	1,183
Australia	9	1.0	0.02	216

Time series



M6: FDI (Foreign Direct Investment) and technology transfer

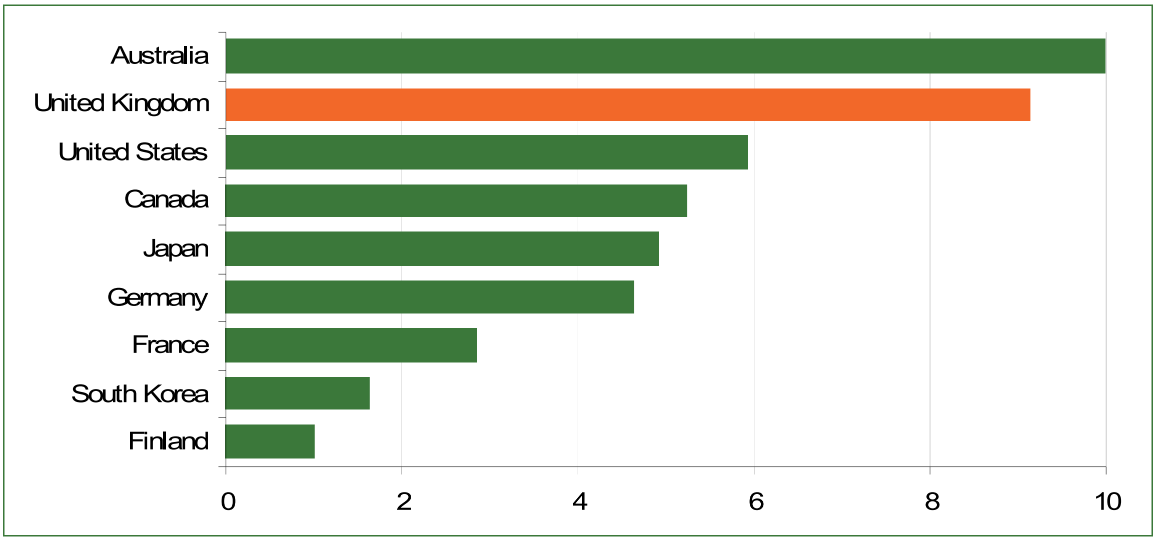
Definition: This indicates the extent to which foreign direct investment (FDI) brings new technology into a country [1 = not at all; 7 = to a great extent—FDI is a key source of new technology].

Rationale: FDI is an important source of funds for investment in R&D, particularly in the UK. The extent to which this foreign investment brings new technology into the country is an important factor – the implication being that quantity of funds is not enough, but quality matters too. FDI can also be seen as a proxy for the overall effectiveness of the ecosystem, as investment can be expected to be located in the countries with the best overall environment for science and innovation.

Source: WEF (2013)

The UK scores highly on this measure. It suggests that FDI (which is a key component of the UK's total investment in R&D, as shown in M4 above) is important in bringing new technology to the UK. The actual values for each country are reasonably close together, but the UK and Australia score highest. This might suggest that for other countries, the type of FDI is less likely to bring new technologies. However, it could also suggest that other countries are less reliant on FDI bringing new technology to their country, perhaps because they invest more heavily domestically.

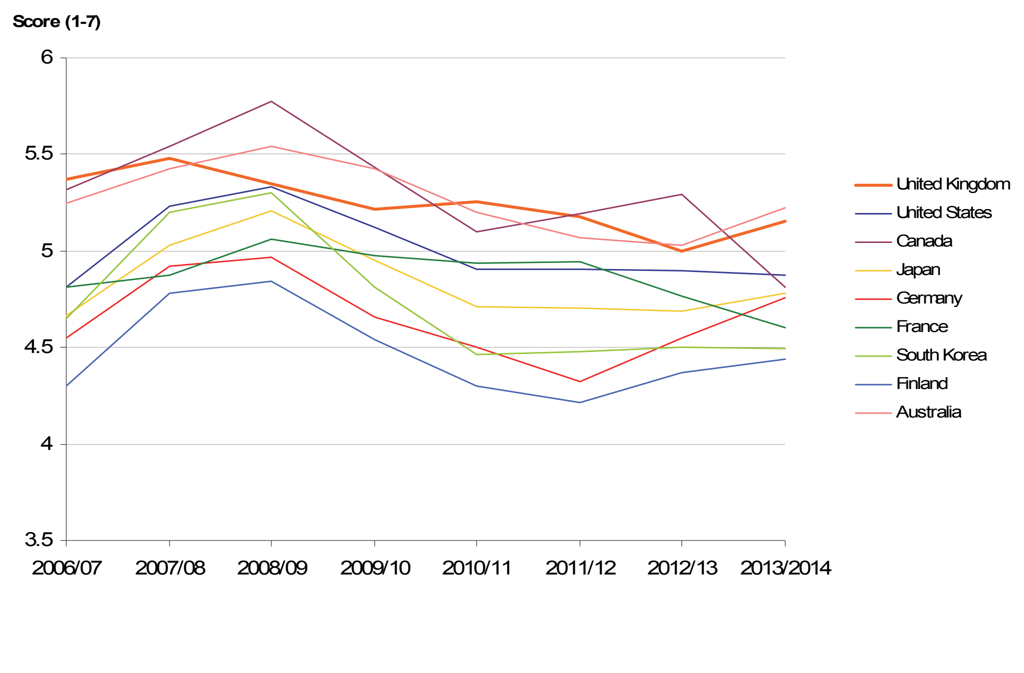
Relative country scores



Underlying data table

	Rank	Score	Value (1-7)
Australia	1	10.0	5.2
United Kingdom	2	9.2	5.2
United States	3	5.9	4.9
Canada	4	5.2	4.8
Japan	5	4.9	4.8
Germany	6	4.6	4.8
France	7	2.9	4.6
South Korea	8	1.6	4.5
Finland	9	1.0	4.4

Time series



M7: Seed/start-up/early stage venture capital as a percentage of GDP on Research and Development

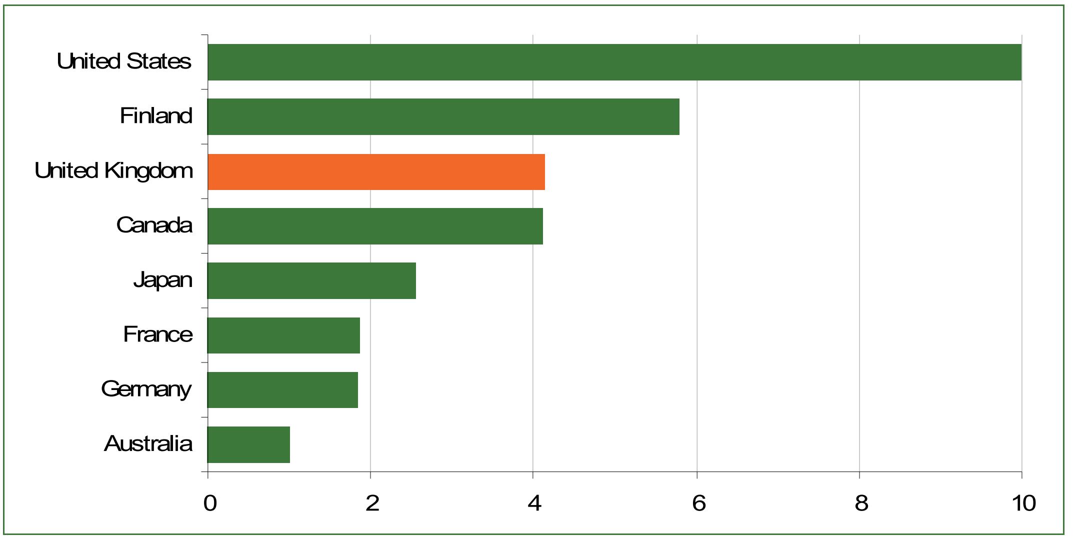
Definition: This provides a measure of access to finance in the form of venture capital funding.

Rationale: Venture capital is an important source of funds for research and innovation, and growth investment for innovative companies. Venture capital investment often occurs once the business opportunity has shown itself to have a high enough probability of a sufficient rate of return. This might come as a later stage investment, but it is also important that businesses have adequate access to finance at an early enough stage that allows them to take forward an idea – early stage venture capital funding might give an indication of this, though there are other forms of finance that would not be captured by this measure.

Source: OECD - Entrepreneurship at a Glance 2013

The US has the highest share of early stage venture capital funding (as a percentage of GDP) out of the comparator countries. The UK has the third highest share. In absolute terms, early stage venture capital funding is higher in the UK ($570 million PPP) than in countries of a similar size, such as France ($312 million PPP) and Germany ($436 million PPP). It is possible, however, that in these countries businesses have access to other types of finance not captured by this measure.

Relative country scores



Underlying data table

	Rank	Score	Value (% of GDP)	$ million PPP
United States	1	10.0	0.055	8,568
Finland	2	5.8	0.034	68
United Kingdom	3	4.1	0.025	570
Canada	4	4.1	0.025	348
Japan	5	2.6	0.017	737
France	6	1.9	0.013	312
Germany	7	1.9	0.013	436
Australia	8	1.0	0.009	89

M8: Later stage venture capital as a percentage of GDP

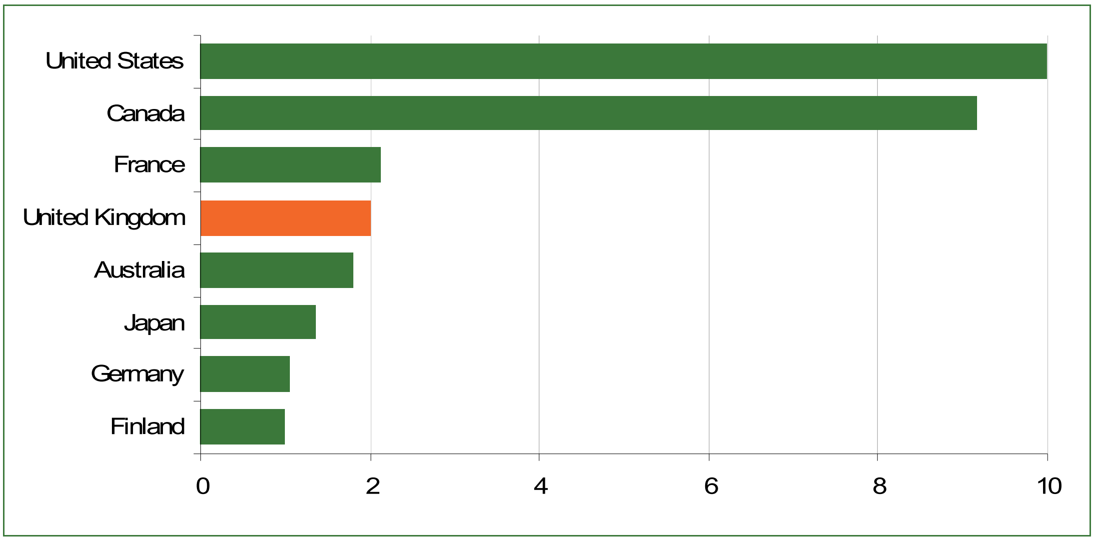
Definition: This provides a measure of access to finance in the form of venture capital funding.

Rationale: Venture capital is an important source of funds for research and innovation, and growth investment for innovative companies. Venture capital investment often occurs once the business opportunity has shown itself to have a high enough probability of a sufficient rate of return. This might come as a later stage investment, but it is also important that businesses have adequate access to finance at an early enough stage that allows them to take forward an idea – early stage venture capital funding might give an indication of this, though there are other forms of finance that would not be captured by this measure.

Source: OECD - Entrepreneurship at a Glance 2013

The US also leads on the amount of later stage venture capital investment (in absolute terms and percentage of GDP). The UK is a middle ranking country on this measure, still ahead of Germany but below France in terms of later stage venture capital funding.

Relative country scores



Underlying data table

	Rank	Score	Value (% of GDP)	$ million PPP
United States	1	10.0	0.060	9,338
Canada	2	9.2	0.055	770
France	3	2.1	0.014	317
United Kingdom	4	2.0	0.013	294
Australia	5	1.8	0.012	116
Japan	6	1.4	0.009	402
Germany	7	1.0	0.007	239
Finland	8	1.0	0.007	14

M9: Financing through local equity markets

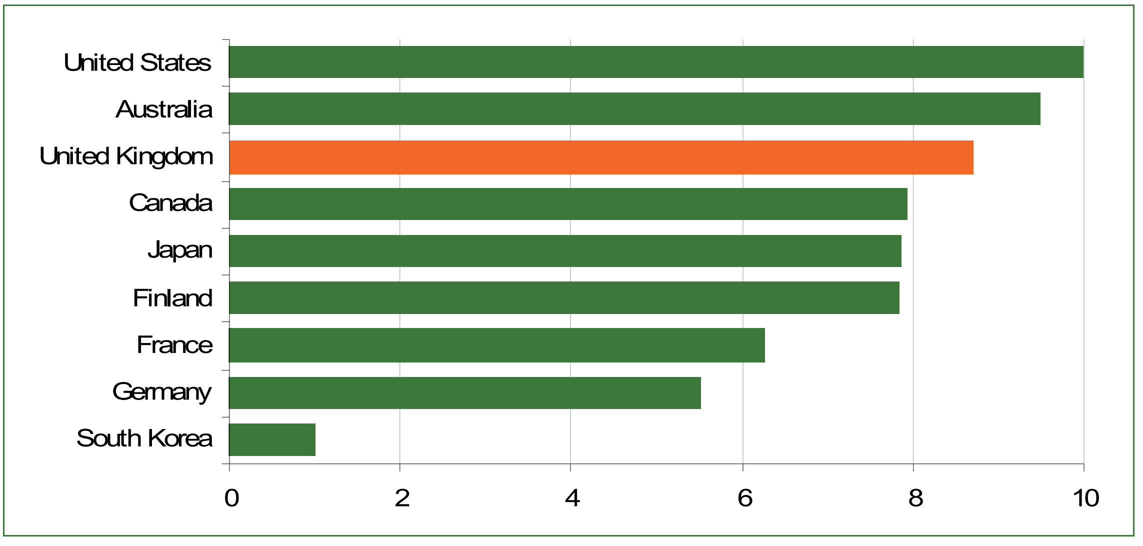
Definition: This measures the extent to which, in a country, it is easy for companies to raise money by issuing shares on the stock market? [1 = extremely difficult; 7 = extremely easy]

Rationale: Another way that firms might access finance is by issuing shares on the stock market. The ease with which firms can do this might give an indication of the opportunity for firms to grow beyond a certain scale. The existence of meaningful exit routes for growth companies makes it more likely that entrepreneurial activity to commercialise science and innovation takes place.

Source: WEF (2013)

The UK performs relatively well on this indicator, ranking third of the comparator countries. The United States leads the way, as it generally appears to on access to finance (e.g. venture capital funding). There has been a general downward trend in ability to access finance through local equity markets among the countries over the period. This is likely to be, at least in part, due to the global financial crisis which began in 2007/8.

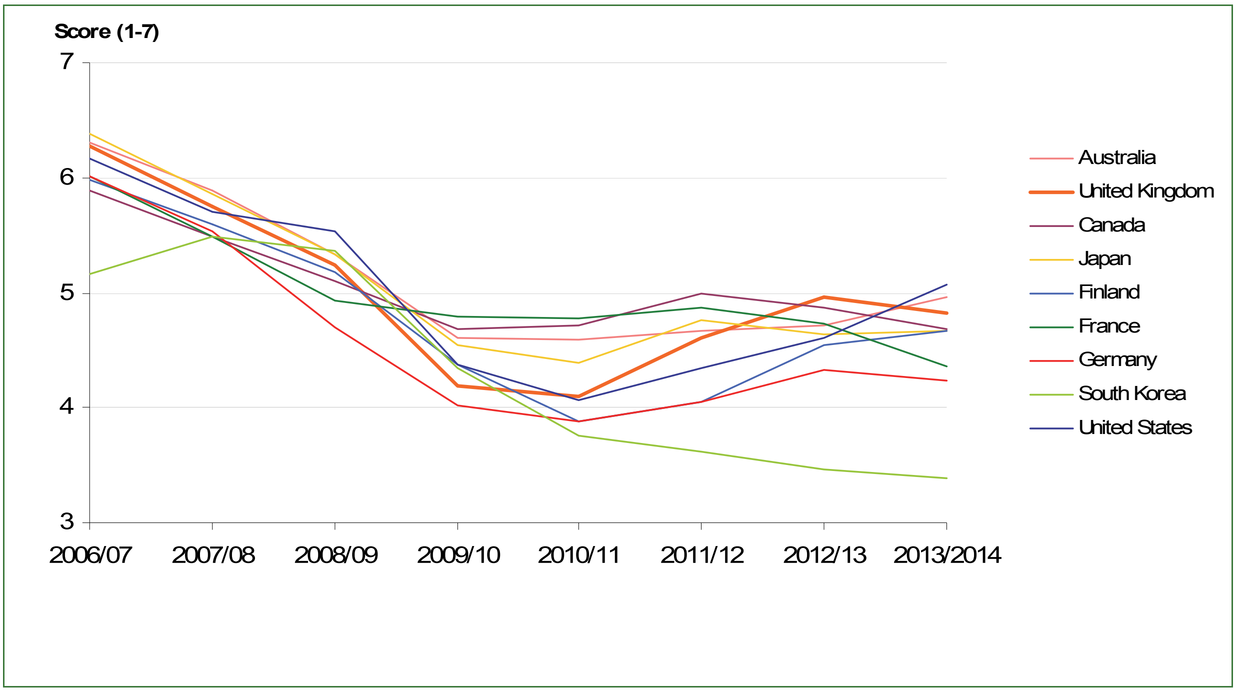
Relative country scores



Underlying data table

	Rank	Score	Value (1-7)
United States	1	10.0	5.1
Australia	2	9.5	5.0
United Kingdom	3	8.7	4.8
Canada	4	7.9	4.7
Japan	5	7.9	4.7
Finland	6	7.9	4.7
France	7	6.3	4.4
Germany	8	5.5	4.2
South Korea	9	1.0	3.4

Time series



M10: Investment in fixed and intangible assets, 2010 as a percentage of GDP

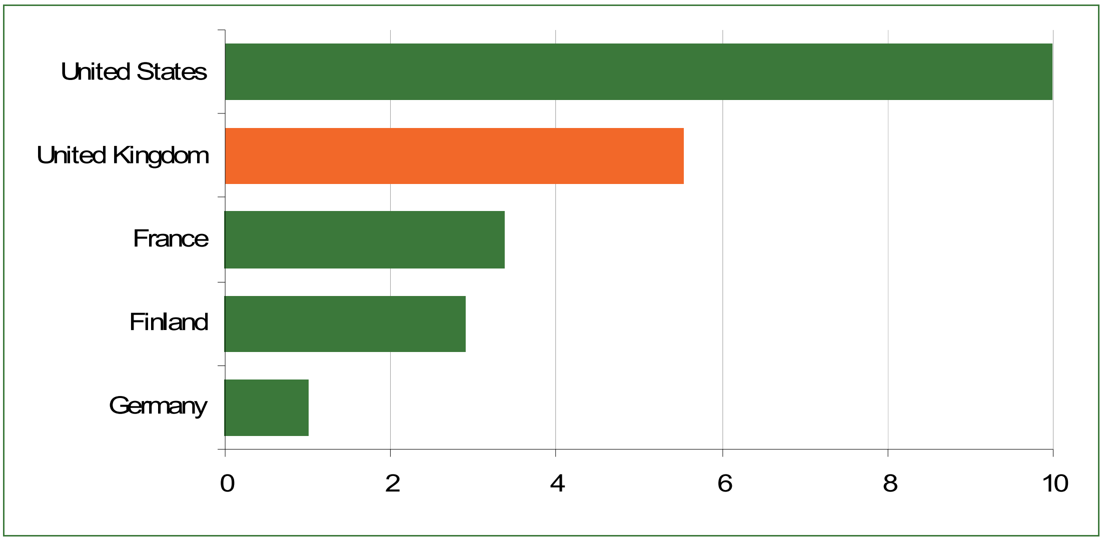
Definition: Gross fixed capital formation (GFCF) - brand equity, firm-specific human capital, organisational capital; R&D and other intellectual property products; and software

Rationale: Traditional metrics of R&D and innovation might neglect investment in knowledge and intellectual capital – so called 'intangible' investments. While this might be an important aspect of innovation investment - capturing investment in training, managerial capability, design and software development – there is a lack of data across key comparator countries over time, and definitions are less well agreed.

Source: Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible capital and growth in advanced economies: Measurement methods and comparative results", Imperial College Business School Discussion Papers, No. 2012/06, available at www.INTAN-Invest.net

Data was only available for a smaller set of countries. The UK performs relatively strongly on this indicator. It might be that R&D, as traditionally defined, only tells part of the story and that the UK invests more in intangibles than comparator countries. It is also possible that the UK's industrial structure might account for some of the difference compared with Finland, France and Germany, but it would be necessary to control for economy structure in order to answer this.

Relative country scores



Underlying data table

2010	Rank	Score	% GDP
United States	1	10.0	11.9
United Kingdom	2	5.5	9.4
France	3	3.4	8.3
Finland	4	2.9	8.0
Germany	5	1.0	7.0

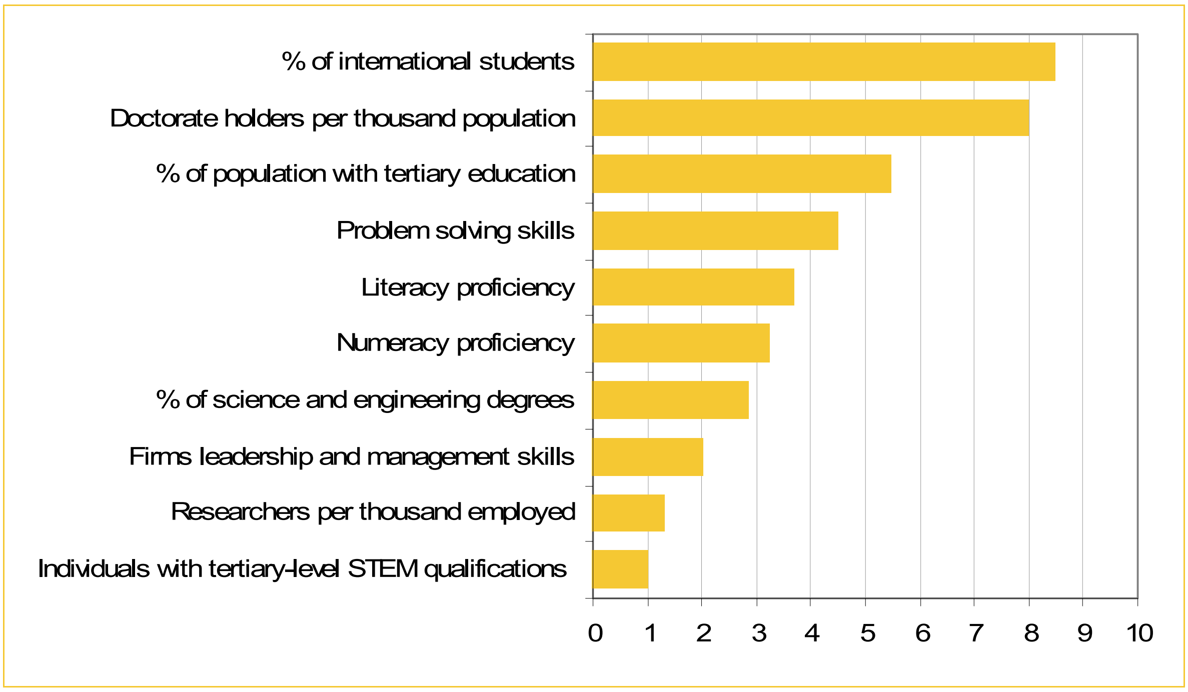
Talent indicators

The analysis of talent indicators shows that UK performance is mixed and, overall, raises concerns about the UK's ability to make the most of its science and innovation strengths.

The UK's main strengths include ability to attract international students, a large number of doctorate holders and a rapidly growing population with tertiary education. This suggests good availability of human capital at the high end of the educational spectrum.

At the same time, lower scores for numeracy, literacy and problem solving show gaps in basic and problem-solving skills. The UK also lags behind other countries in terms of tertiary-level STEM qualifications among the active population and firms' leadership and management capabilities.

Talent indicators – UK scores (1-10)[7]



Source: *BIS analysis*

Overall, no country performs well on all measures. Japan and Finland appear to receive the highest scores but both of them also have their areas of weakness. For example, both countries attract relatively low number of foreign students suggesting limited access to international talent.

[7] The data on numeracy, literacy and problem solving skills refer to England and Northern Ireland only

Data availability

Our assessment of talent relies largely on measures of skills and educational attainment. Owing to the lack of comparable data, it is not always possible to adequately assess the quality of education (e.g. there might be some differences in the quality of doctorate programmes). Also, our indicators do not capture less formalised learning such as on-the-job-training, which is also a vital source of human capital development.

In some instances, the lack of data makes it difficult to draw firm conclusions. For example, a high number of foreign students in the UK can be seen as a strength but to have a full-picture, it would be important to know how many of them stay in the UK after graduating and how this compares with other countries. For instance, low retention rates will limit benefits to the domestic science and innovation system.

Furthermore, data on the stock of the active population with tertiary-level STEM qualifications were only available for the EU countries, which significantly limits the scope of our comparison. To our knowledge, internationally comparable data on STEM-related jobs do not exist.

Finally, given the lack of comparable data, the indicators do not capture some of the more qualitative and subjective issues which were mentioned during our meetings with experts and feature on the systems map. For example, it was not possible to find reliable data on the number of "curious" and "persistent" academics.

T1: Literacy proficiency among adults (mean score)

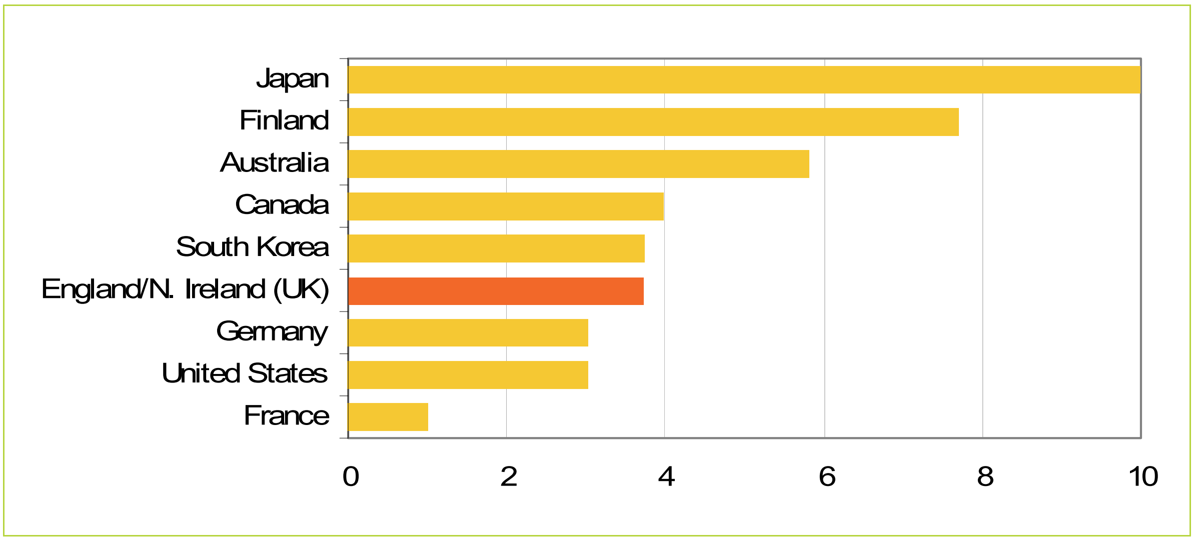
Definition: The Survey of Adult Skills (PIAAC) assesses the proficiency of adults from age 16 onwards in literacy. Mean scores for each country are reported.

Rationale: Successful innovation processes not only require human capital that works at the high end of educational attainment but also, more generally, a well-educated population. This can be measured, in broad terms, by using indicators of numeracy, literacy and problem solving abilities among working age adults.

Source: OECD Skills Outlook 2013, First Results from the Survey of Adult Skills

England/Northern Ireland (UK) is ranked in the middle across the countries studied, ahead of its major European competitors. The more detailed data show England/ Northern Ireland (UK) is among the three highest-performing countries in literacy when comparing 55-65 year-olds; but among the bottom three countries when comparing literacy proficiency among 16-24 year olds.

Relative country scores



Underlying data table

Country	Rank	Score	Mean score in literacy
Japan	1	10.0	296
Finland	2	7.7	288
Australia	3	5.8	280
Canada	4	4.0	273
South Korea	5	3.8	273
England/N. Ireland (UK)	6	3.7	272
Germany	7	3.0	270
United States	8	3.0	270
France	9	1.0	262

T2: Numeracy proficiency among adults (mean score)

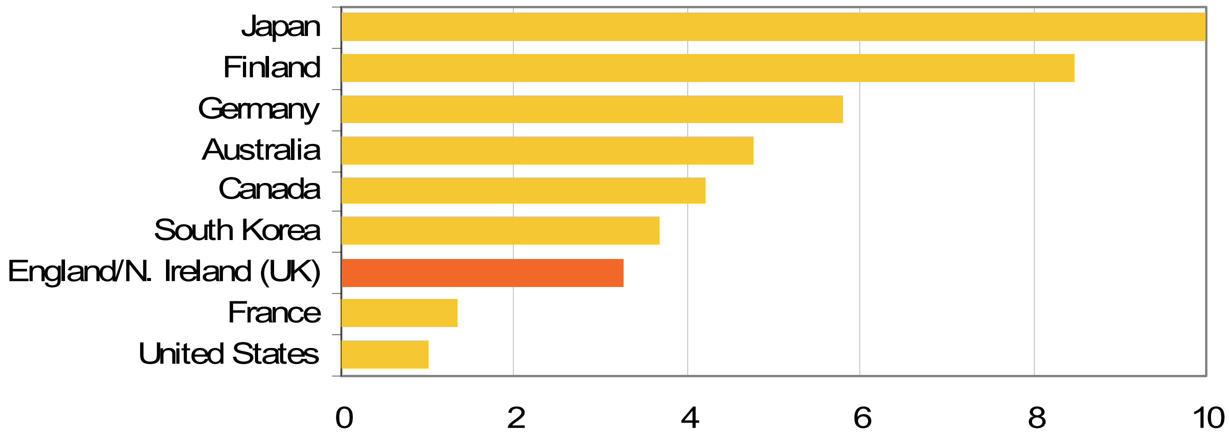
Definition: The Survey of Adult Skills (PIAAC) assesses the proficiency of adults from age 16 onwards in numeracy. Mean scores for each country are reported

Rationale: Successful innovation processes not only require human capital that works at the high end of educational attainment but also, more generally, a well-educated population. This can be measured, in broad terms, by using indicators of numeracy, literacy and problem solving abilities among working age adults.

Source: OECD Skills Outlook 2013, First Results from the Survey of Adult Skills

England/Northern Ireland (UK) is ranked among the bottom three countries, which suggests bigger gaps with the top performing countries (albeit differences with the countries in the middle of the ranking are relatively small). Japan and Finland achieve the highest scores, both in terms of numeracy and literacy.

Relative country scores



Underlying data table

Country	Rank	Score	Mean score in numeracy
Japan	1	10.0	288
Finland	2	8.5	282
Germany	3	5.8	272
Australia	4	4.8	268
Canada	5	4.2	265
South Korea	6	3.7	263
England/N. Ireland (UK)	7	3.3	262
France	8	1.3	254
United States	9	1.0	253

T3: Proficiency in problem solving in technology-rich environments among adults

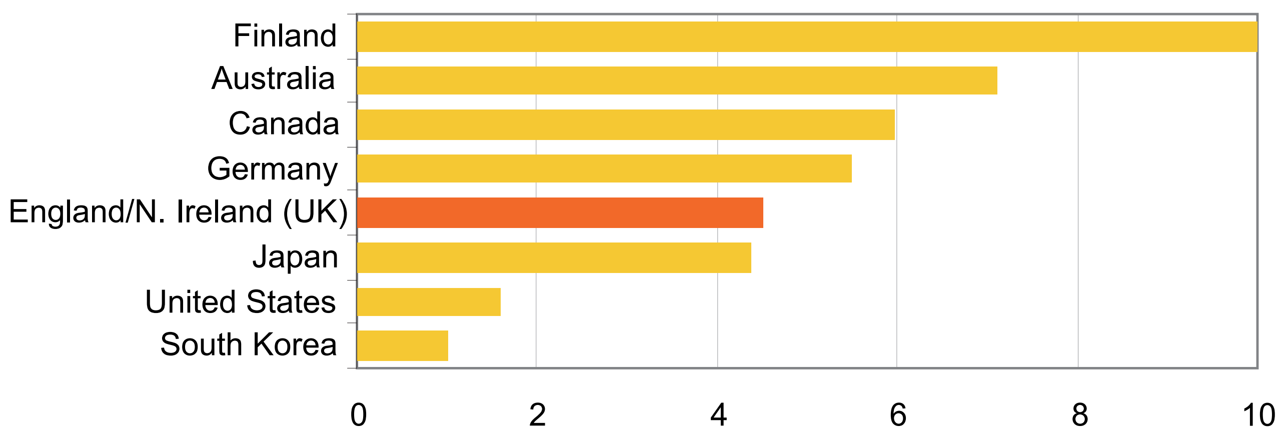
Definition: The percentage of 16-65 year olds achieving Level 2 or Level 3. Problem solving in technology rich environments is defined as the ability to use digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks.

Rationale: Successful innovation processes not only require human capital that works at the high end of educational attainment but also, more generally, a well-educated population. This can be measured, in broad terms, by using indicators of numeracy, literacy and problem solving abilities among working age adults.

Source: OECD Skills Outlook 2013, First Results from the Survey of Adult Skills

The results suggest that the majority of adults in England and Northern Ireland lack good problem solving skills, with a considerable proportion of the population having no or very limited ICT skills. Compared to other countries, adults in England and Northern Ireland appear to perform similarly to Japan and Germany, but below Finland and Australia.

Relative Country Score



Underlying data table

Country	Rank	Score	Adults scoring Level 2 or Level 3
Finland	1	10.0	41.6
Australia	2	7.1	38.0
Canada	3	6.0	36.6
Germany	4	5.5	36.0
England/N. Ireland (UK)	5	4.5	34.8
Japan	6	4.4	34.6
United States	7	1.6	31.1
South Korea	8	1.0	30.4

T4: Percentage of population that has attained tertiary education

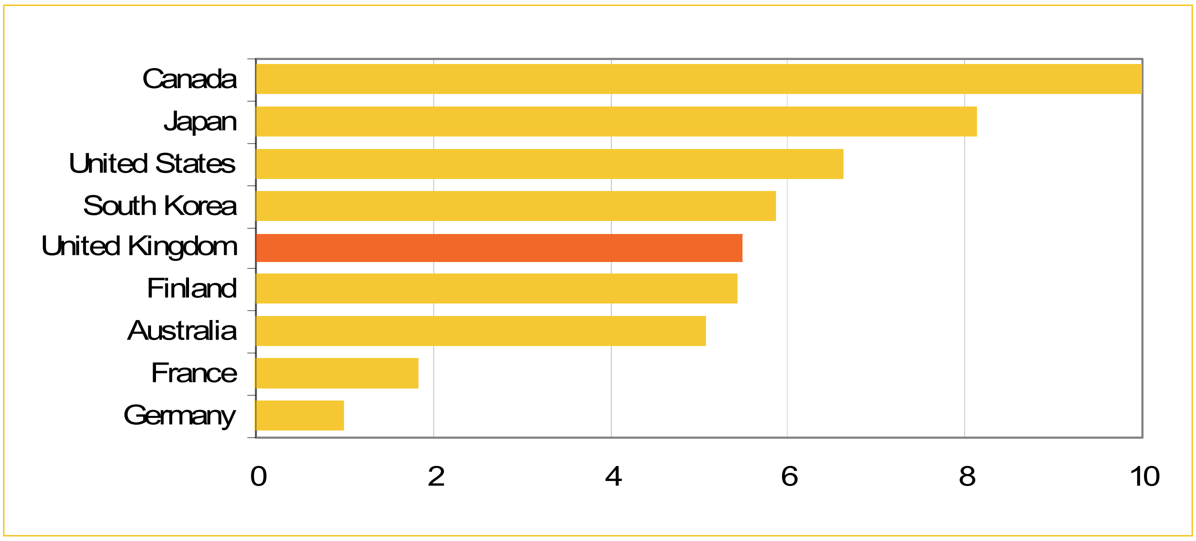
Definition: The population that has attained tertiary education, as a percentage of 25-64 year olds

Rationale: Highly-skilled labour is a key input to the innovation process in terms of generating, absorbing, and applying new knowledge. Tertiary education is the most commonly used proxy for highly qualified human capital.

Source: OECD (2013) Education at a Glance 2013

The UK is ranked in the middle across the countries studied, ahead of its major European competitors. Canada and Japan have the highest proportion of the population with tertiary education. Comparisons over time suggest that the UK achieved one of the highest growth rates in tertiary education graduates between 2000 and 2010.

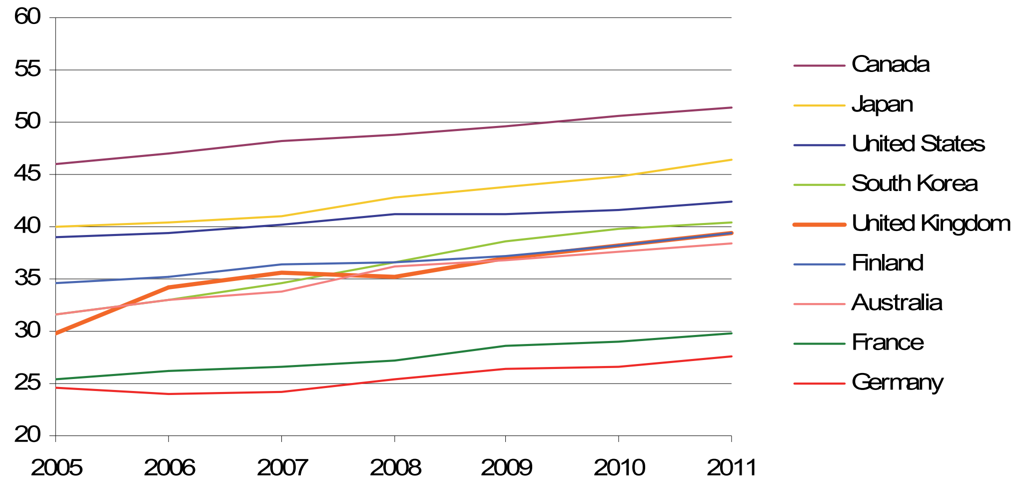
Relative country scores



Underlying data table

Country	Rank	Score	Percentage of 25-64 year olds with tertiary education (2011)	Total population with tertiary education
Canada	1	10.0	51.3	17,700,421
Japan	2	8.1	46.4	59,298,736
United States	3	6.6	42.4	132,263,964
South Korea	4	5.9	40.4	20,115,142
United Kingdom	5	5.5	39.4	24,942,160
Finland	6	5.5	39.3	2,118,572
Australia	7	5.1	38.3	8,559,484
France	8	1.8	29.8	18,824,734
Germany	9	1.0	27.6	22,545,338

Time series



T5: Percentage of students earning first university degrees in science and engineering

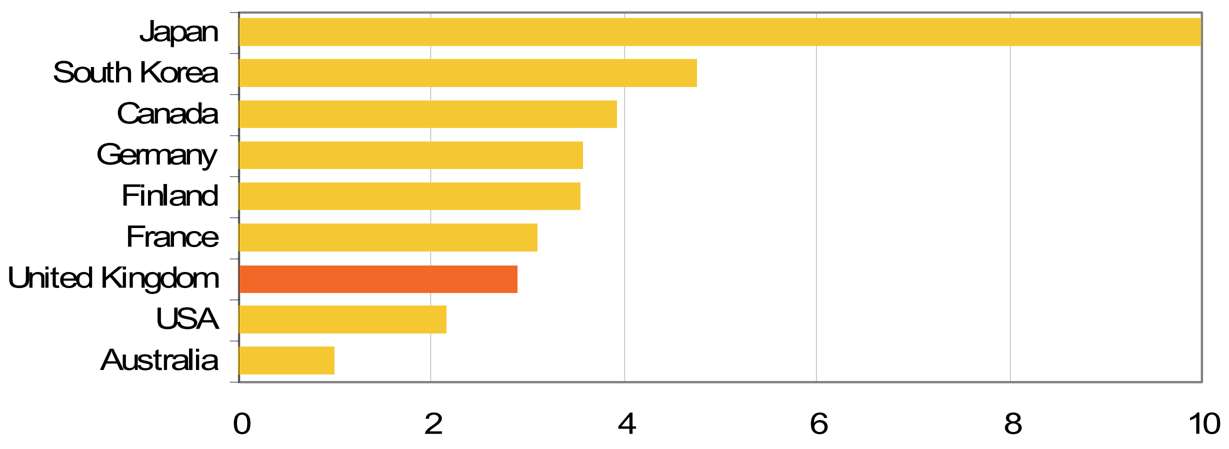
Definition: Percentage of total first university degrees in science and engineering (flow); including physical, biological and agriculture sciences, mathematic and computer science, social and behavioural sciences and engineering.

Rationale: The evidence shows that high levels of science andengineering qualifications have a positive impact on innovation. Traditionally, these have been associated with the number of graduates obtaining first degrees in science and engineering.

Source: IMD (2013) World Competitiveness Yearbook

Degrees in science and engineering are most popular in Japan and South Korea. UK students are less likely to study science and engineering, although the proportion of graduates leaving university with science and engineering degrees has been relatively stable since 2001, while decreasing for many countries included in the sample.

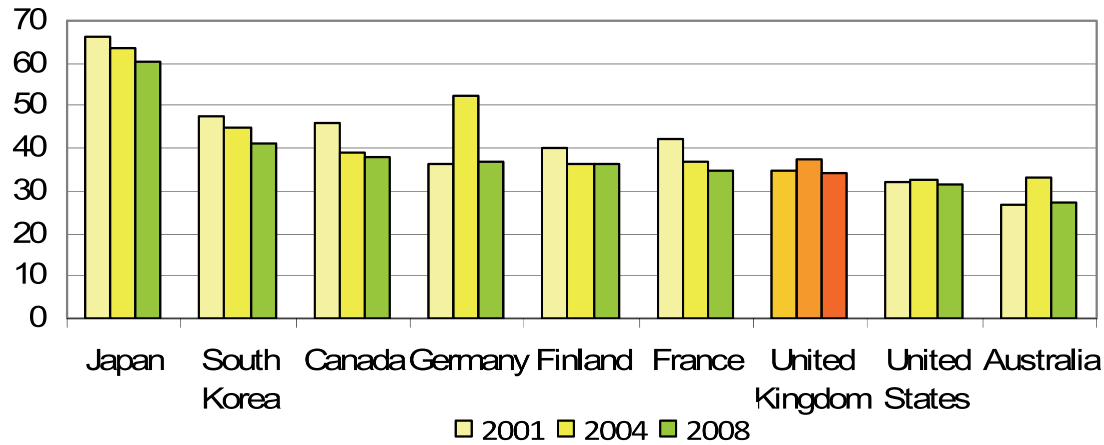
Relative country scores



Underlying data table

Country	Rank	Score	Percentage of total first university degrees in science and engineering
Japan	1	10.0	61
South Korea	2	4.8	41
Canada	3	3.9	38
Germany	4	3.6	37
Finland	5	3.6	37
France	6	3.1	35
United Kingdom	7	2.9	34
United States	8	2.2	31
Australia	9	1.0	27

Time series



T6: International students as a percentage of total tertiary enrolment rate

Definition: The number of students from abroad studying in a given country, expressed as a percentage of total tertiary enrolment in that country.

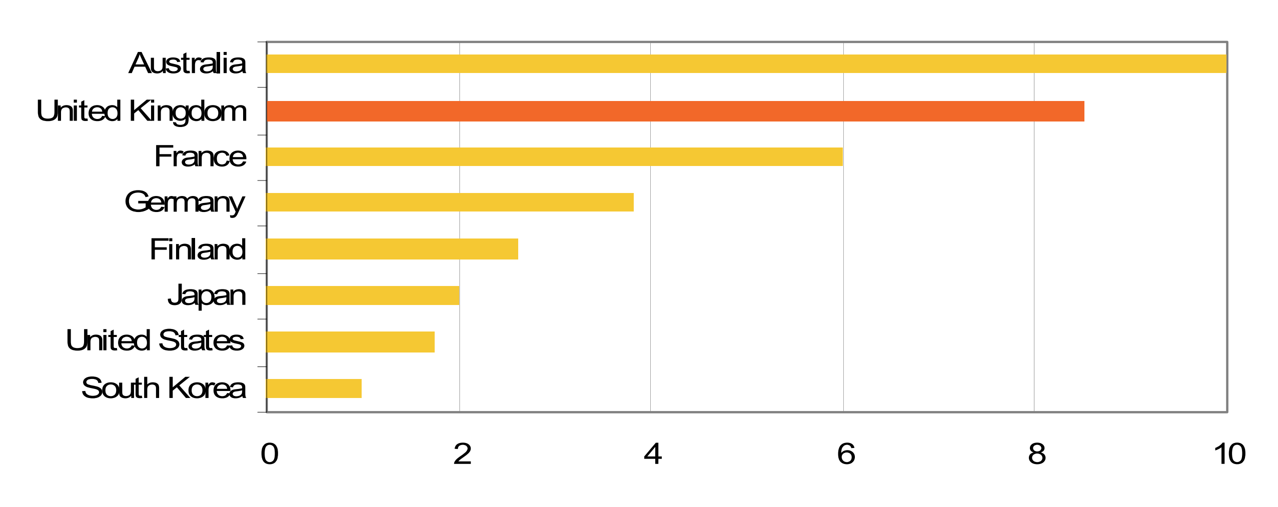
Rationale: Students moving abroad to study are an important source of knowledge flows between countries. The ability to attract skilled individuals is also a good indication of the quality of the tertiary education system.

Source: UNESCO database

The UK is the second preferred destination among international students after the US. Students from abroad account for almost 17% of the student population in the UK, which is considerably higher than for the majority of countries included in the sample. The UK performance has been consistent over time. Finland and South Korea attract the lowest number of international students.

The ability to attract a large number of international students suggests strong performance of the UK higher education system compared with our competitors. It also increases the talent pool available to UK employers and enhances the ability of UK universities to conduct research. However, many benefits to the UK will depend on the ability to retain foreign skilled graduates. Large outflows of skilled individuals who graduated in the UK may lead to some skills shortages.

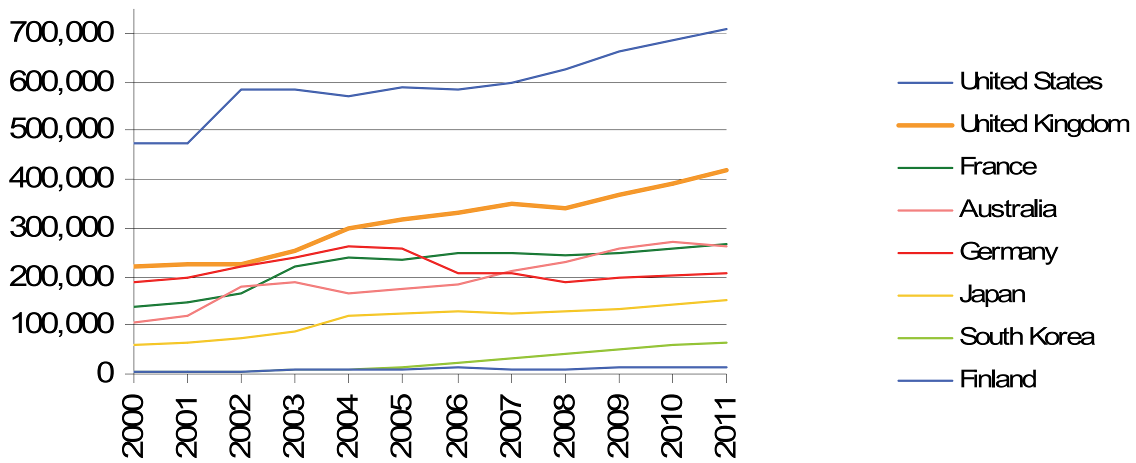
Relative country scores



Underlying data table

Country	Rank	Score	Percentage of foreign students	Number of students from abroad
Australia	1	10.0	19.8	262,597
United Kingdom	2	8.5	16.8	419,946
France	3	6.0	11.9	268,212
Germany	4	3.8	7.5	207,771
Finland	5	2.6	5.1	15,707
Japan	6	2.0	3.9	151,461
United States	7	1.8	3.4	709,565
South Korea	8	1.0	1.9	62,675

Time series



T7: Doctorate holders per thousand population

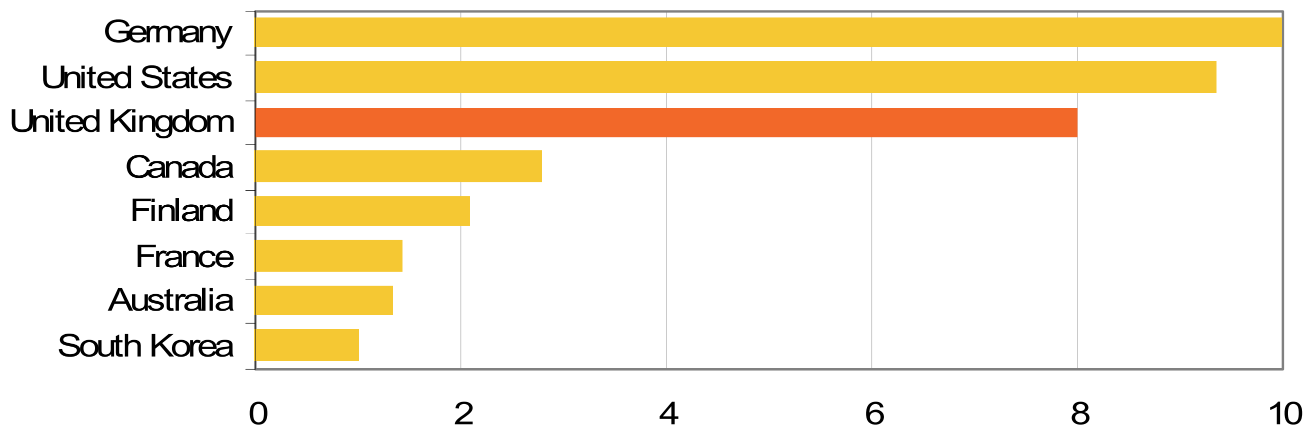
Definition: Doctorate holders in the working age population, per thousand population aged 25-64, 2009

Rationale: Highly-skilled individuals with advanced research degrees are an essential element of modern science and innovation systems. They are not only the most qualified in terms of their educational attainment but also are specifically trained to conduct research.

Source: OECD (2013) Science, Technology and Industry Scoreboard

The UK has one of the highest numbers of doctorate holders per thousand population aged 24-65. The lowest numbers are reported for South Korea, Australia and France.

Relative country scores



Underlying data table

Country	Rank	Score	Doctorate holders per thousand population aged 25-64
Germany	1	10.0	14.0
United States	2	9.4	13.5
United Kingdom	3	8.0	12.4
Canada	4	2.8	8.2
Finland	5	2.1	7.6
France	6	1.4	7.1
Australia	7	1.4	7.0
South Korea	8	1.0	6.7

T8: Researchers per thousand employed

Definition: Researchers are defined as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems and are directly involved in the management of projects (measured on a full-time equivalent basis).

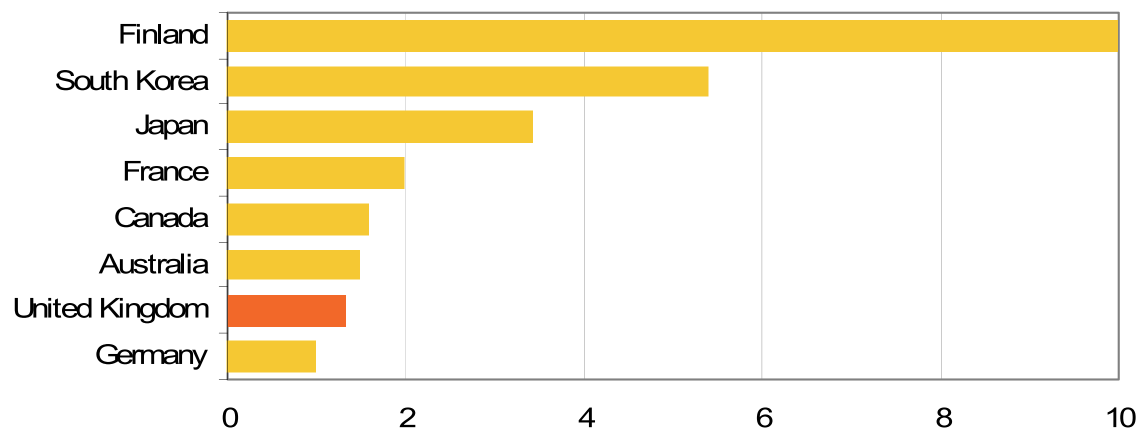
Rationale: Measuring the volume of human capital resources devoted to research in a country is another consideration when assessing talent. This can be proxied by looking at the number of researchers across all professions engaged in the creation and conception of new knowledge and products.

Source: OECD (2013) Science, Technology and Industry Scoreboard

Researchers in the UK account for a relatively low proportion of the labour force, although differences between countries in the bottom of the ranking are very small. Finland, with almost double the number of researchers per 100,000 employed, is a clear leader. Overall, employment of researchers has risen over the last decade in all countries. Data for the US are only available up to 2007, so it was excluded from the ranking.

A relatively low number of researchers in the UK is surprising given high graduation rates at doctorate level. This may suggest that a considerable proportion of doctorate holders take up non-research jobs or pursue research careers in other countries.

Relative country scores



Underlying data table

Country	Rank	Score	Researchers per thousand employed	Total researchers
Finland	1	10.0	15.93	40,003
South Korea	2	5.4	11.92	288,901
Japan	3	3.4	10.20	656,651
France	4	2.0	8.95	239,613
Canada	5	1.6	8.60	149,060
Australia	6	1.5	8.50	92,649
United Kingdom	7	1.3	8.36	262,303
Germany	8	1.0	8.08	327,953

T9: Individuals with tertiary-level STEM qualifications as percentage of total employment (excludes medical and biological sciences)

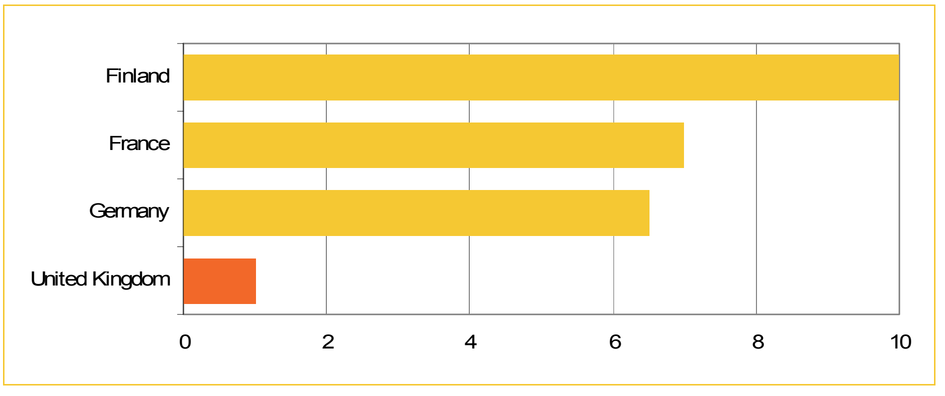
Definition: Human resources in science and technology in terms of STEM education: individuals who have successfully completed a university level education in the field of science, mathematics and computing, engineering, manufacturing and construction (as percentage of total employment)

Rationale: The evidence shows that employees with high-level STEM skills are important for various aspects of the innovation process. For example, STEM skills are necessary to carry-out high level research and improve firms' absorptive capacity.

Source: Eurostat database

The data are available for EU countries only, which significantly limits the scope for the cross-country comparison. Overall, STEM graduates in the UK account for the lowest share of the active population among comparator EU economies. However, it is important to bear in mind that the indicator does not include medical subjects and biological sciences, which are often classified as STEM and where the number of UK graduates is relatively high.

Relative country scores



Underlying data table

	Rank	Score	Percentage of active population	persons in thousand
Finland	1	10.0	14.4%	358
France	2	7.0	12.5%	3,218
Germany	3	6.5	12.2%	4,876
United Kingdom	4	1.0	8.6%	2,532

T10: Firms' leadership and management capabilities

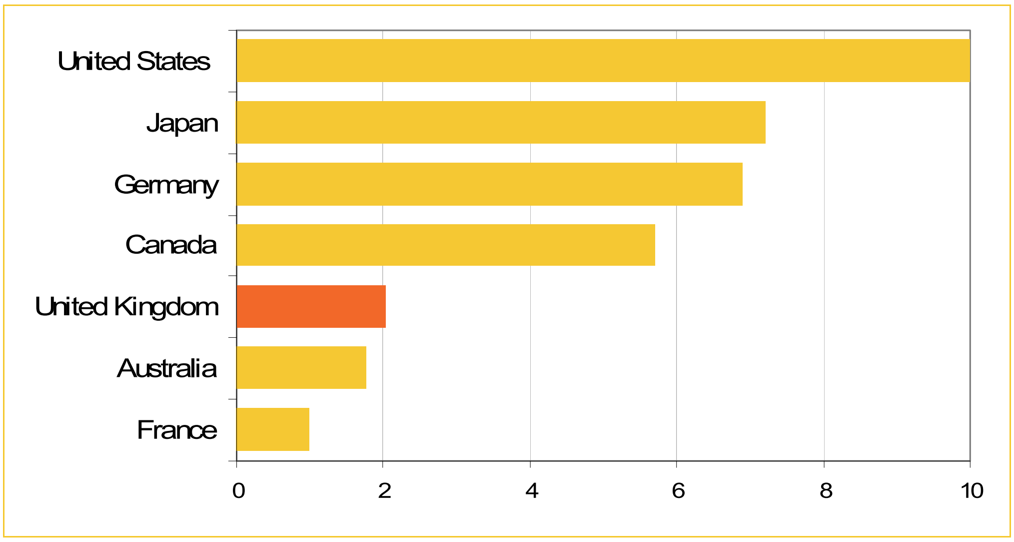
Definition: The average management score (over 18 questions) across all firms in each country. The results are based on 8,261 management interviews between 2006 and 2010.

Rationale: Management and leadership are important drivers of the ambition and successful implementation of business strategies, including R&D and innovation strategy. Evidence shows a clear link between management skills and productivity. Business building skills are also seen as a key bottleneck in many countries in moving from small-scale application of science and innovation into scale-up and exports.

Source: Centre for Economic Performance at London School of Economics

The data indicate that UK companies have some deficiencies in management quality compared to the top-performing countries, although differences in average scores are relatively small. The detailed results show that skills are an area where the UK has a relatively poor record.

Relative country scores



Underlying data table

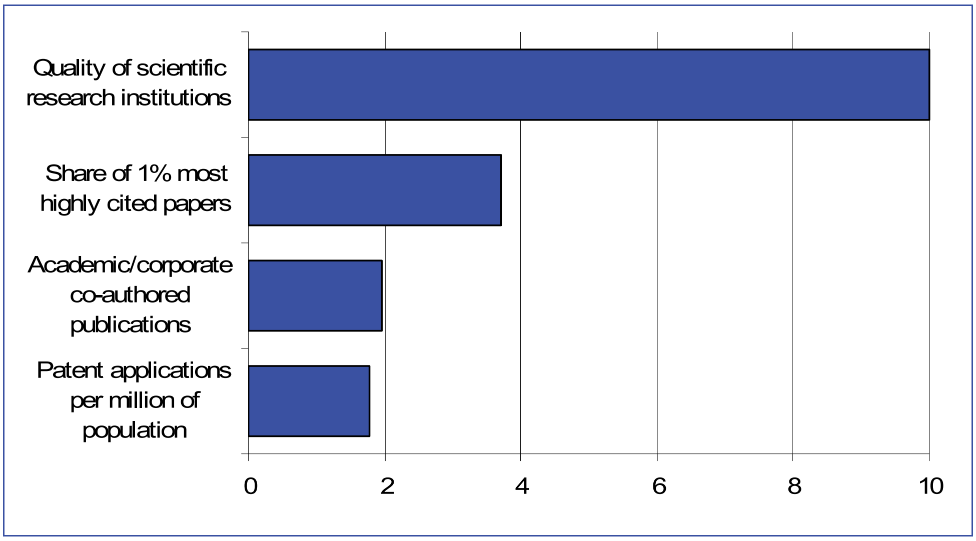
Country	Rank	Score	Management score
United States	1	10.0	3.3
Japan	2	7.2	3.2
Germany	3	6.9	3.2
Canada	4	5.7	3.2
United Kingdom	5	2.0	3.0
Australia	6	1.8	3.0
France	7	1.0	3.0

Knowledge assets indicators

While the summary chart below might suggest otherwise, on balance the UK can be judged to perform relatively strongly on knowledge assets. The UK's score for the share of the 1% most highly cited papers is skewed by the USA's dominance on this measure; despite its low score, the UK has the second highest share of the 1% most highly cited papers. Further, the quality of the UK's research base is a particular strength of its science and innovation system, as reflected by the score for 'quality of scientific research institutions'.

The UK scores relatively poorly on academic/corporate co-authored publications, a measure of the amount of formal knowledge codification taking place based on collaboration between researchers and businesses. While this might suggest an area for improvement, this is an imperfect measure of productive collaboration between academia and businesses, and strong conclusions should not be drawn from this indicator. The UK also has a low score for patent applications per million of population, though, as discussed below, this might not be a cause for concern for the UK.

Knowledge assets indicators – UK scores (1-10)



Source: *BIS analysis*

Data availability

Measures of scientific excellence are reasonably strong and available across all comparator countries, e.g. the share of the top 1% most highly cited papers. However, the UK scores poorly on academic/corporate co-authored publications. While this is an imperfect proxy, it might suggest that collaboration between the UK's research base and businesses is not as effective as in other comparator countries – more robust data on the extent to which the research base and businesses are effectively linked-up would help to improve the analysis of this issue.

It is debateable the extent to which the UK's poor score on patent applications is a cause for concern. While patents are one way of appropriating the profits from scientific breakthroughs and innovation, it is not the only way. Other studies, perhaps in part due to the fact that better indicators are not available, have tended to put a large weight on measures of patent performance. However, this might over-emphasise the importance of patenting in ensuring a successful science and innovation system. The UK's weak performance on this measure might be explained, at least in part, by its industrial structure, due to the UK having strengths in some industries that are less likely to patent.

K1: Share of 1% most highly cited papers

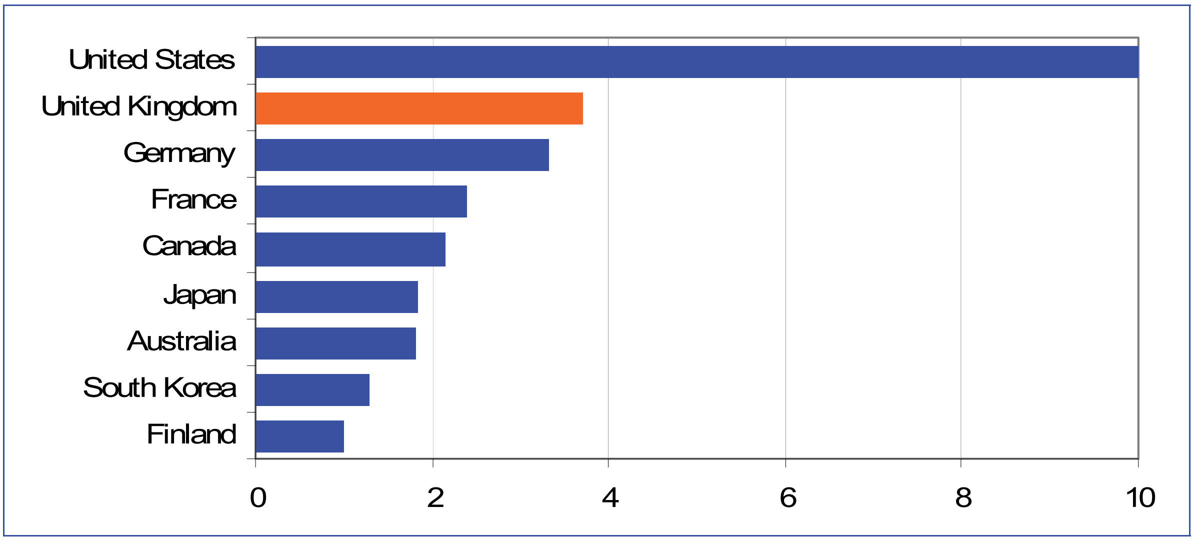
Definition: A country's share of the top 1% most highly cited papers in the world.

Rationale: The number of citations of an article is a proxy for its quality and the significance of the work. Focussing on the share of the top 1% most highly cited papers gives a perspective on the quality of the research produced by a country.

Source: Scopus (2013)

The US dominates in terms of its share of the most highly cited papers. This is partly due to the quality of its research and institutions but also reflects its size. The UK has the second largest share of most highly cited papers and this share has been on a slight upward trend over the last decade.

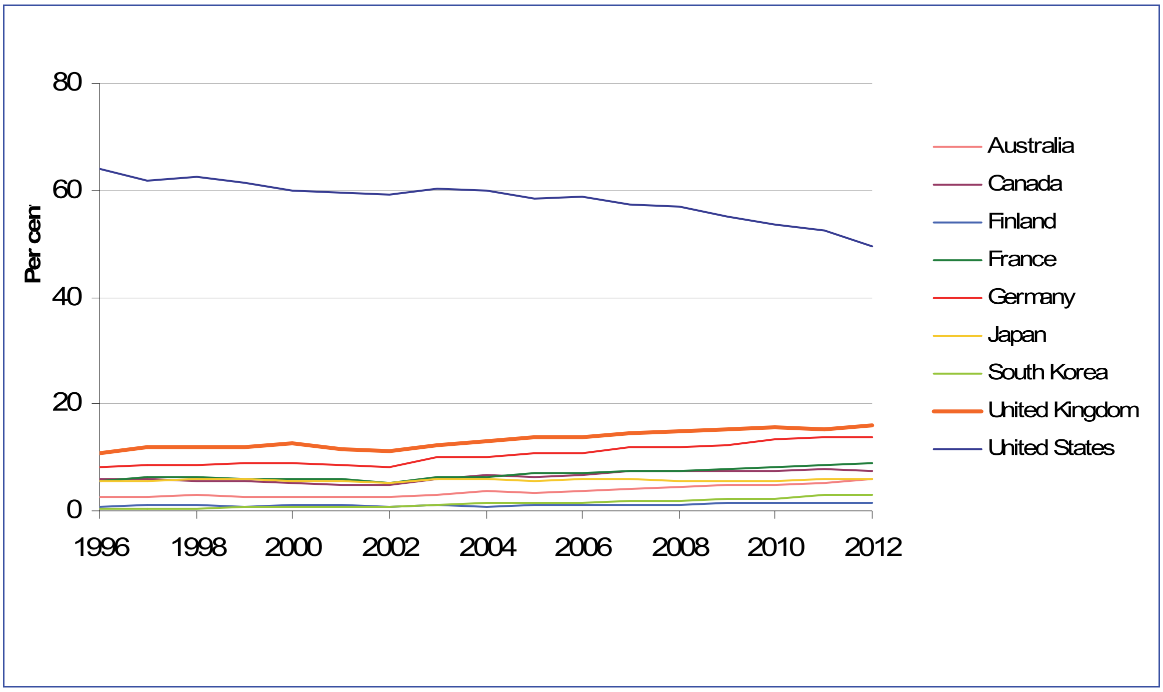
Relative country scores



Underlying data table

2012	Rank	Score	Value (Per cent)
United States	1	10.0	49.4
United Kingdom	2	3.7	15.9
Germany	3	3.3	13.9
France	4	2.4	8.9
Canada	5	2.1	7.5
Japan	6	1.9	6.0
Australia	7	1.8	5.8
South Korea	8	1.3	3.0
Finland	9	1.0	1.4

Time series



K2: Patent application per million of population

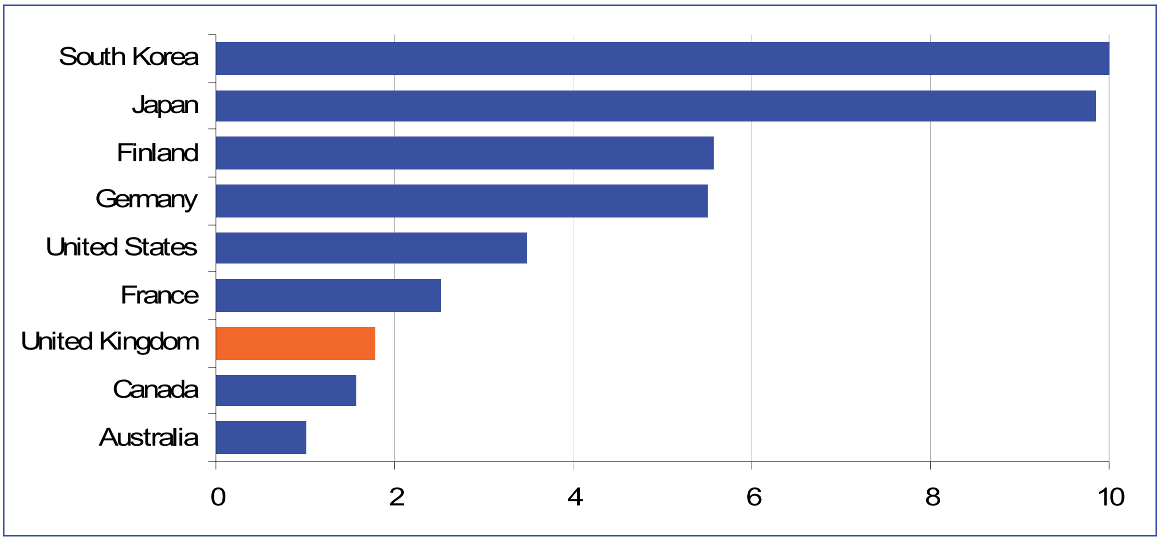
Definition: This measures the number of patent application per million of population. Counts are based on the patent filing date.

Rationale: The number of patent applications gives an indication of how active researchers and businesses are regarding attempting to protect their intellectual property. Patents could be considered to be a proxy for the amount of commercially valuable innovations that are produced by a country. However, there are a number of caveats. First, a high number of patent applications does not tell us how many of those applications were successful. Second, there are a number of ways of commercialising knowledge and patenting is just one of them. A low score on patents might reflect a country's comparative advantage in sectors that are not suited to patenting.

Source: WIPO statistics database (2013)

Korea and Japan are the leading nations in terms of patent applications per million of population. The UK score poorly on this measure, ranking seventh out of the nine countries considered here. However, it is important to note two caveats relating to these patent data. First, a high number of patent applications does not necessarily result in a high number of granted patents (presuming that granted patents are a proxy for commercialisation of knowledge). Second, there are a number of ways of commercialising knowledge. Patenting might not always be the best method, and certainly isn't the only solution. The UK's poor performance on this measure might, in part, be explained by industrial structure: certain industries are more likely to patent than others.

Relative country scores



Underlying data table

2011	Rank	Score	Value (Patent applications per million population)
South Korea	1	10.0	3,771.4
Japan	2	9.8	3,716.6
Finland	3	5.6	2,171.0
Germany	4	5.5	2,146.1
United States	5	3.5	1,413.5
France	6	2.5	1,061.0
United Kingdom	7	1.8	801.9
Canada	8	1.6	724.0
Australia	9	1.0	516.5

K3: Academic/corporate co-authored publications

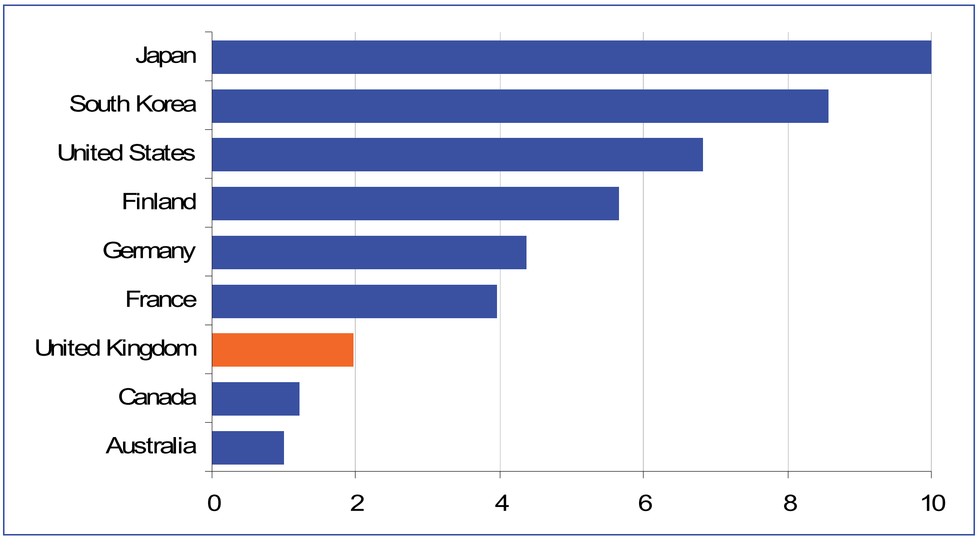
Definition: This measures publications co-authored between academics registered in universities with researches registered as working in the corporate sector.

Rationale: This variable gives an indication of the amount of collaboration between research institutions and businesses. A high score does not necessarily mean that this collaboration results in high quality research. However, the extent to which a research base and businesses are appropriately linked is considered to be an important facet of a successful science and innovation system. While not ideal, this indicator attempts to proxy for the successful collaboration and linkage between research and business. In general, evidence suggests that collaboration enhances the translation of knowledge into applications.

Source: Scopus (2013)

The UK performs relatively poorly on this measure against the comparator countries, with only 0.8 per cent of its publications being a result of academic/corporate collaboration. Japan, South Korea and the US are the leading nations for this indicator.

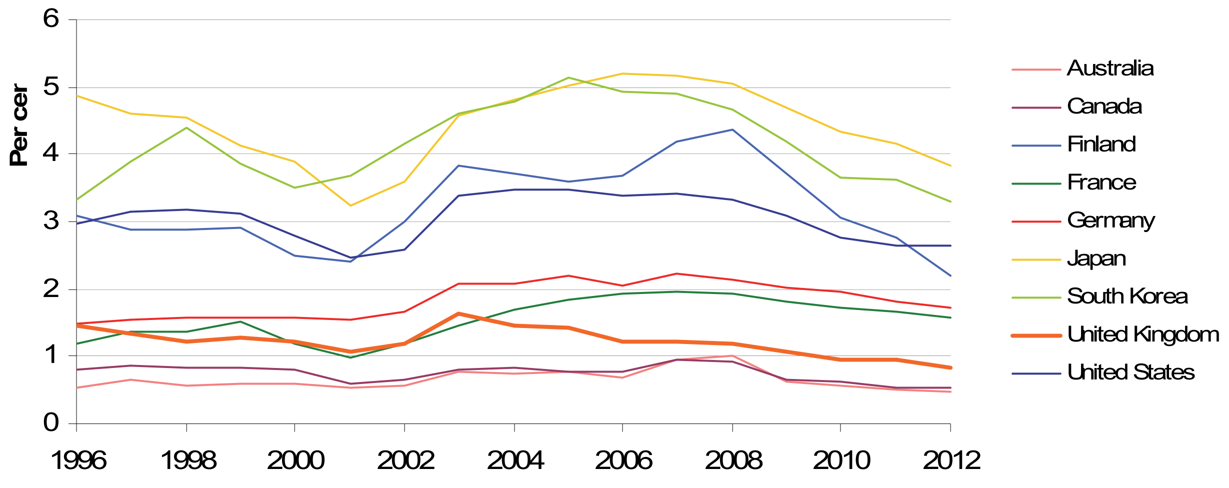
Relative country scores



Underlying data table

2012	Rank	Score	Value (Per cent)
Japan	1	10.0	3.8
South Korea	2	8.6	3.3
United States	3	6.8	2.6
Finland	4	5.7	2.2
Germany	5	4.4	1.7
France	6	4.0	1.6
United Kingdom	7	2.0	0.8
Canada	8	1.2	0.5
Australia	9	1.0	0.5

Time series



K4: Quality of scientific research institutions

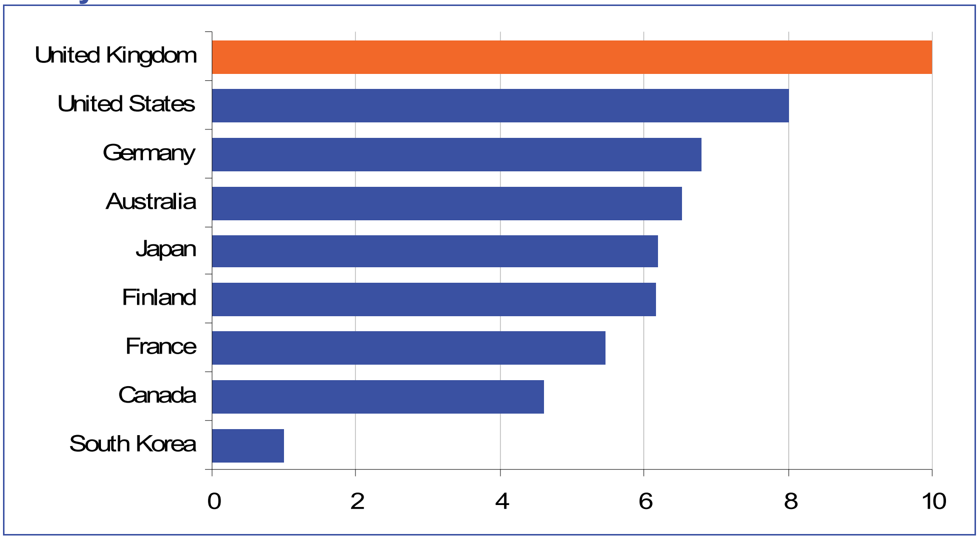
Definition: Survey question: In your country, how would you assess the quality of scientific research institutions? [1 = extremely poor—among the worst in the world; 7 = extremely good—among the best in the world]

Rationale: This indicator is based on a questionnaire asking how respondents would assess the quality of scientific research institutions in their country. This might be based on the quality of the facilities available to them, but also the quality of its outputs.

Source: World Economic Forum – 12.02

The UK is the highest ranked country according to the quality of its research institutions. The UK has many prestigious universities and is generally attractive to foreign researchers and students. The US and Germany also score well on this measure.

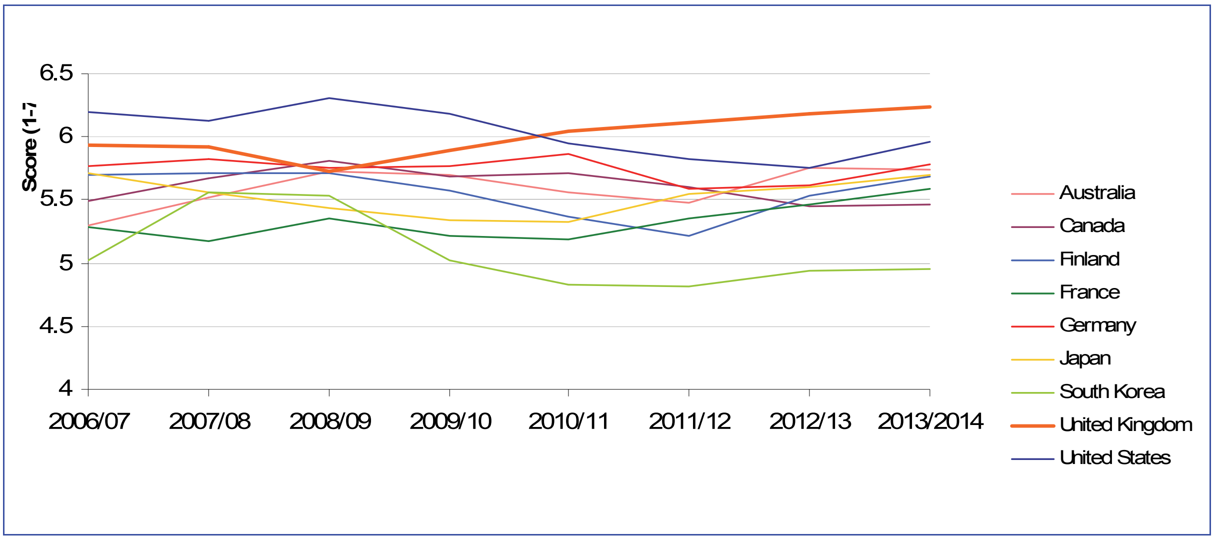
Relative country scores



Underlying data table

2013/14	Rank	Score	Value (1-7)
United Kingdom	1	10.0	6.2
United States	2	8.0	6.0
Germany	3	6.8	5.8
Australia	4	6.5	5.7
Japan	5	6.2	5.7
Finland	6	6.2	5.7
France	7	5.5	5.6
Canada	8	4.6	5.5
South Korea	9	1.0	4.9

Time series

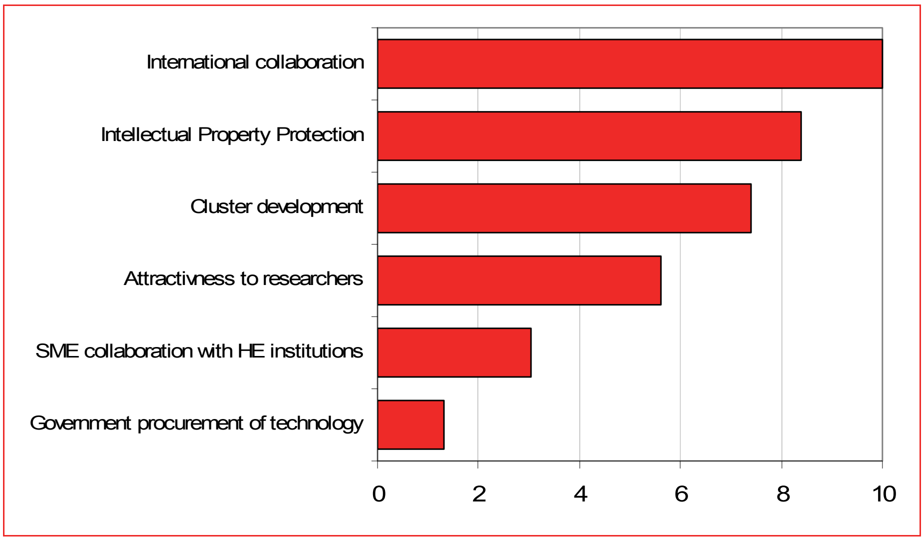


Structures and incentives indicators

The UK generally performs well. We are rated particularly highly for the strength of intellectual property protection and the development of economic clusters. Furthermore, the UK is seen as a fairly attractive location for scientists and researchers.

UK innovation active firms are also more likely to collaborate with international and national partners than their counterparts in other countries. A more detailed analysis, however, suggest that the extent of collaboration varies considerably by firm size and collaborating partner, with UK SMEs less likely to collaborate with higher education and research institutions compared to SMEs in some other countries included in the study.

Structures and incentives indicators – UK score (1-10)



Source: BIS analysis

As for the main weaknesses, the UK ranks poorly in terms of the impact of government procurement on stimulating innovation, although no country included in the study performed strongly in this area.[8]

Overall, the US appears to provide the most attractive structures and incentives for innovation. However, this does not take into account the assessment of collaboration indicators, for which US data are not available.

Data availability

Structures and incentives indicators consist of a mix of quantitative and qualitative indicators. Using both types of data has clear advantages. It allows capturing not only the quantitative outcomes but also perceptions, which can be equally important. For example, how businesses view the quality of the intellectual property framework in a given country

[8] The US, which is the best performing economy among comparator countries, received 4.3 points on the scale 1 to 7.

will, to some extent, influence their decision to engage in the innovation process in this country.

As for data gaps, the existing data allow for only a limited assessment of the potential impact of government procurement on innovation and how it differs across countries. Similarly, it is difficult to capture and compare, in an objective and comprehensive manner, the attractiveness of research careers and incentives for highly skilled individuals to take up science and innovation jobs.

Finally, not all data are available for all countries, limiting the scope for cross-country comparisons.

S1: Attractiveness to researchers and scientists

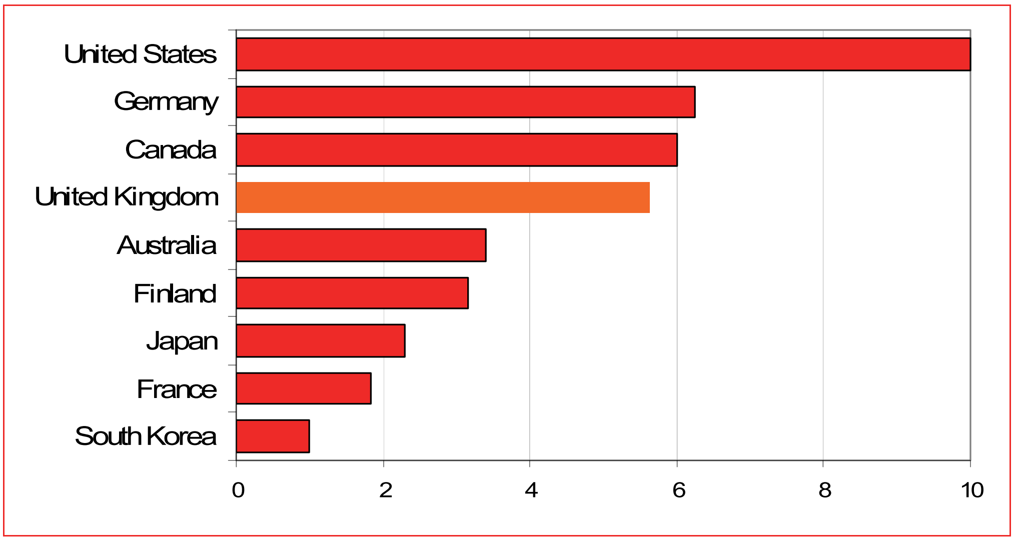
Definition: Business opinion survey: Researchers and scientists are attracted to your country (based on an index from 0 to 10)

Rationale: Researcher migration is becoming an increasingly important feature of modern innovation systems; and as such, ability to attract scientists is key in ensuring the supply of highly-qualified researchers. As attractiveness could be influenced by a number of factors (the quality of research institutions, career prospects and the overall standard of living) comparing countries is not straightforward. As the proxy for these factors we use a measure of assessing business perceptions of countries' attractiveness to researchers and scientists.

Source: IMD World Competitiveness Yearbook

The US is seen as the most attractive location for researchers and scientist and has maintained this position over the last few years. The UK performs in line with Germany and Canada and ahead of other countries included in the sample.

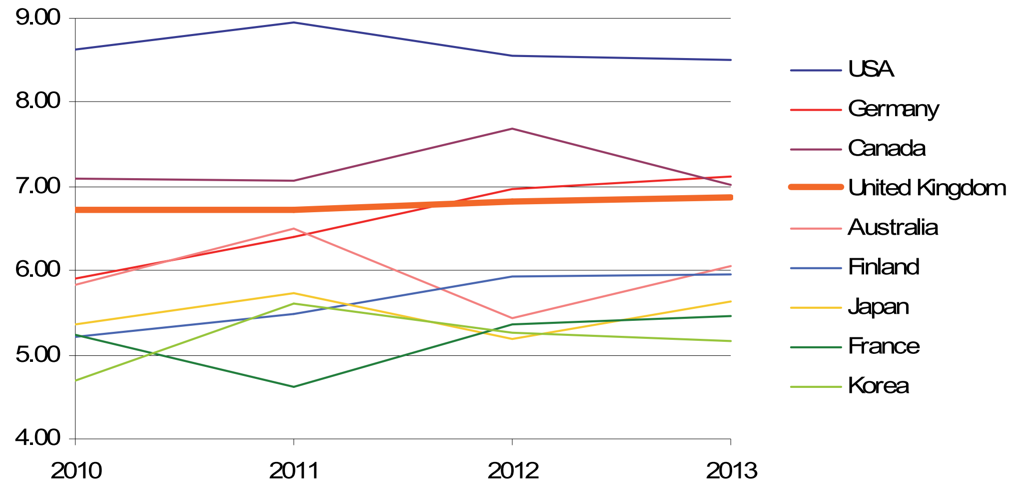
Relative country scores



Underlying data table

Country	Rank	Score	Survey results
United States	1	10.0	8.51
Germany	2	6.2	7.11
Canada	3	6.0	7.02
United Kingdom	4	5.6	6.88
Australia	5	3.4	6.05
Finland	6	3.2	5.96
Japan	7	2.3	5.63
France	8	1.8	5.46
South Korea	9	1.0	5.15

Time series



S2: Intellectual property protection

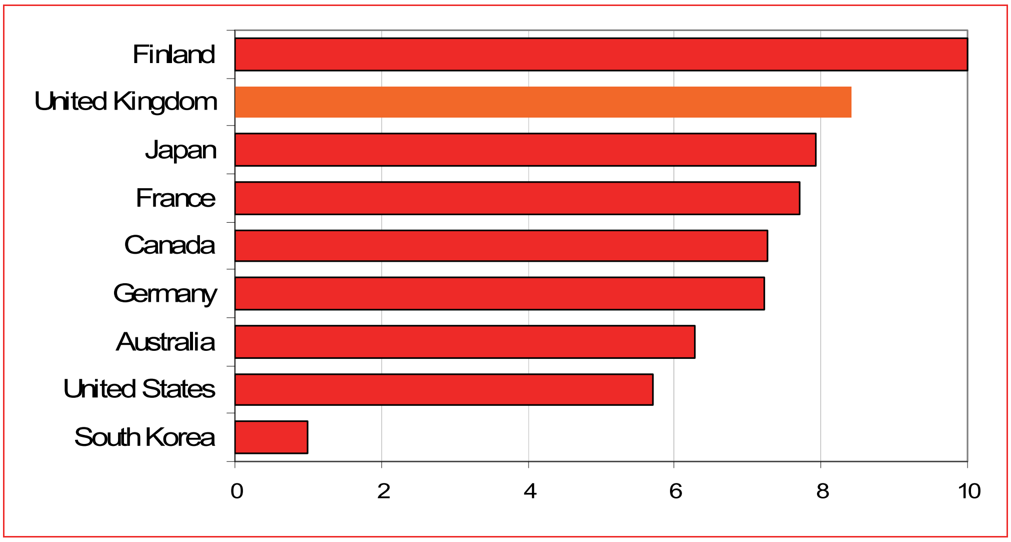
Definition: Business opinion survey: In your country, how strong is the protection of intellectual property, including anti-counterfeiting measures? [1 = extremely weak; 7 = extremely strong] | 2012–13 weighted average

Rationale: Having a well-functioning intellectual property (IP) rights framework supports innovative activity and diffusion of new knowledge. Effective IP protection is particularly important for firms investing in generating new technology when the returns to technological investment are very long term, involve high risks and are easy to copy. Our assessment of IP regimes is based on business opinion surveys.

Source: WEF Global Competitiveness Report 2013-14

The UK is seen as having one of the best intellectual property regimes among the comparator economies, second to Finland only. South Korea appears to perform substantially worse than other countries included in the study, with the gap increasing over time.

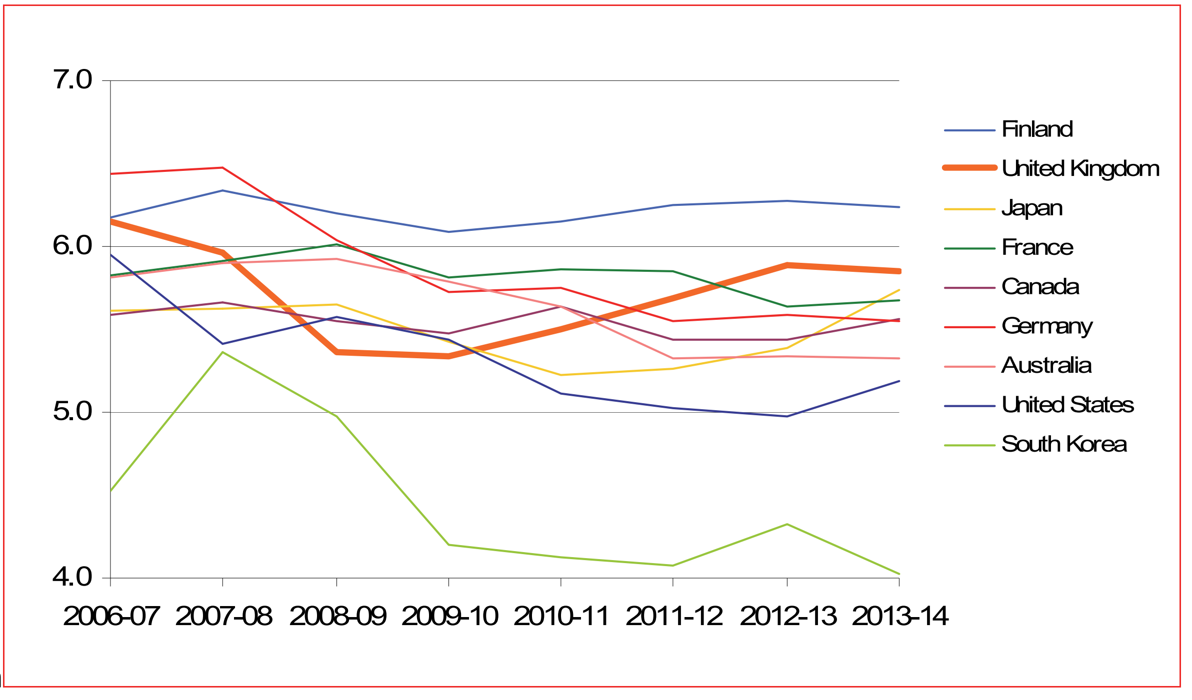
Relative country scores



Underlying data table

Country	Rank	Score	Survey results
Finland	1	10.0	6.2
United Kingdom	2	8.4	5.8
Japan	3	7.9	5.7
France	4	7.7	5.7
Canada	5	7.3	5.6
Germany	6	7.2	5.6
Australia	7	6.3	5.3
United States	8	5.7	5.2
South Korea	9	1.0	4.0

Time series



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S3: Cluster development

Definition: Business opinion survey: In your country, how widespread are well-developed and deep clusters (geographic concentrations of firms, suppliers, producers of related products and services, and specialized institutions in a particular field)? [1 = nonexistent; 7 = widespread in many fields] | 2012–13 weighted average

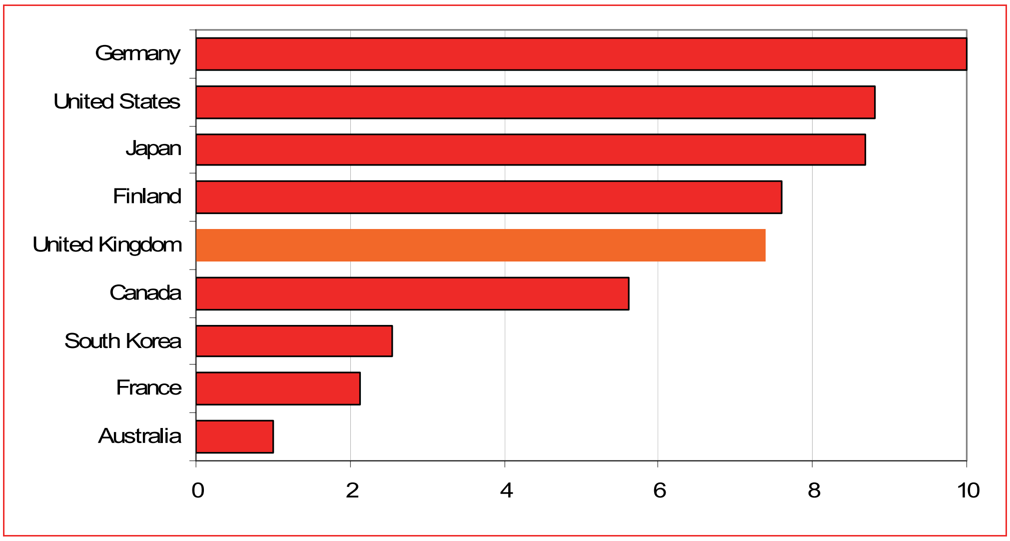
Rationale: A breadth of evidence suggests that there are strong productivity advantages to economic clusters. In the context of innovation systems, successful clusters allow companies (especially SMEs) to collaborate with research institutions, suppliers, customers and competitors located in the same geographical area, and thus lead to increased synergies between different innovation actors.

To compare the state of cluster development between countries, the report uses qualitative data capturing executive opinion surveys.

Source: WEF Global Competitiveness Report 2013-14

The UK is ranked in the middle across the comparator economies. Differences between countries included in the study are relatively small.

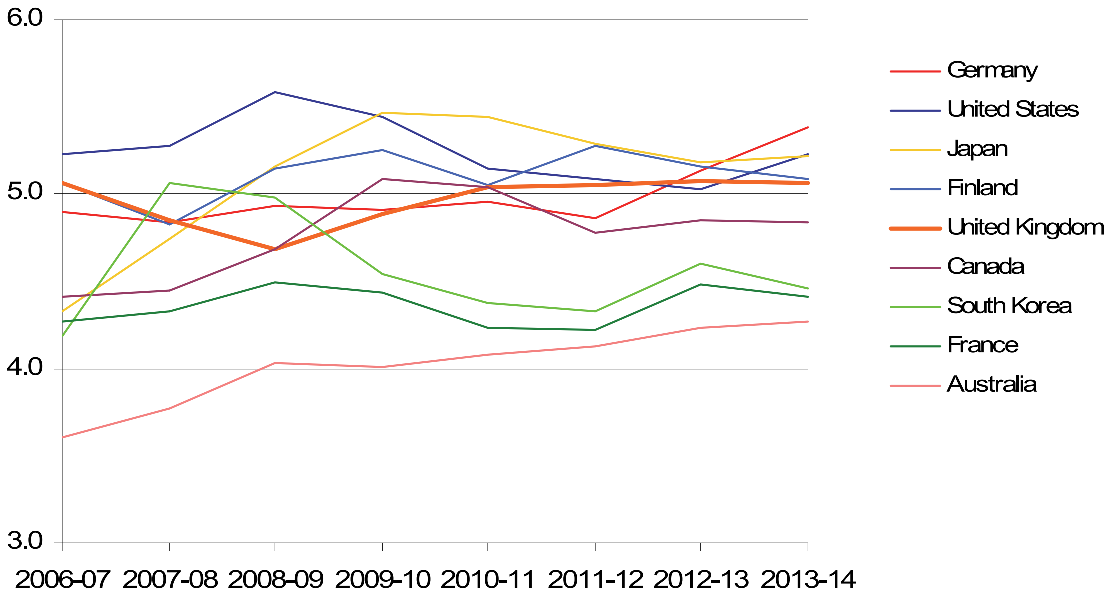
Relative country scores



Underlying data table

Country	Rank	Score	Survey results
Germany	1	10.0	5.4
United States	2	8.8	5.2
Japan	3	8.7	5.2
Finland	4	7.6	5.1
United Kingdom	5	7.4	5.1
Canada	6	5.6	4.8
South Korea	7	2.5	4.5
France	8	2.1	4.4
Australia	9	1.0	4.3

Time series



S4: Government procurement of advanced technology products

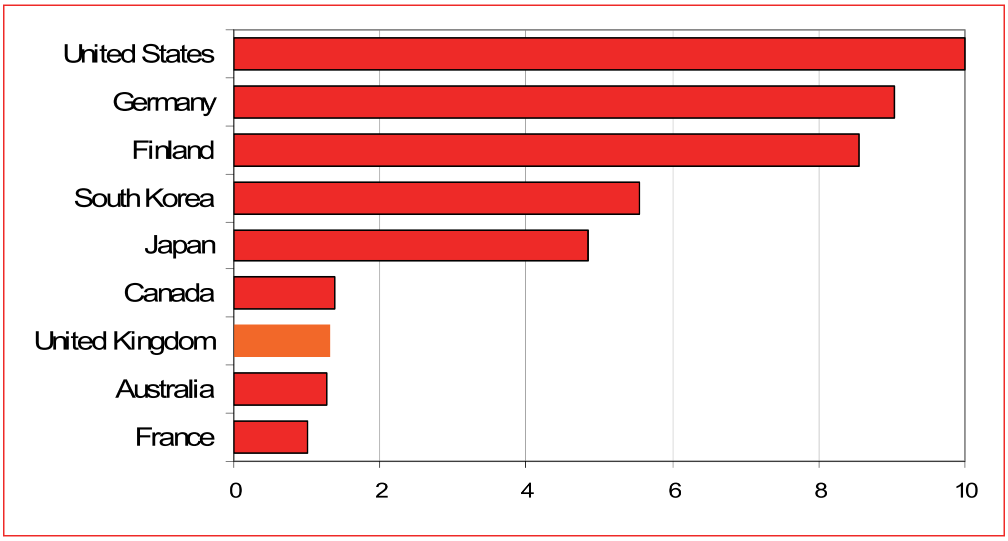
Definition: Survey Question: In your country, to what extent do government purchasing decisions foster innovation? [1 = not at all; 7 = to a great extent] | 2012–13 weighted average

Rationale: Government procurement has the potential to drive innovation by demanding new products or technologies. However, measuring to what degree governments stimulate innovation and advanced technologies is difficult. In the absence of quantitative indicators, the report uses the data assessing business views on the impact of government procurement on innovations in different countries.

Source: WEF Global Competitiveness Report 2013-14

Overall, government purchasing decisions in all countries included in the study are seen to have a limited impact on stimulating innovation. The UK performs relatively poorly, ranked among the bottom three countries, the gap with many comparator countries appears to be relatively small.

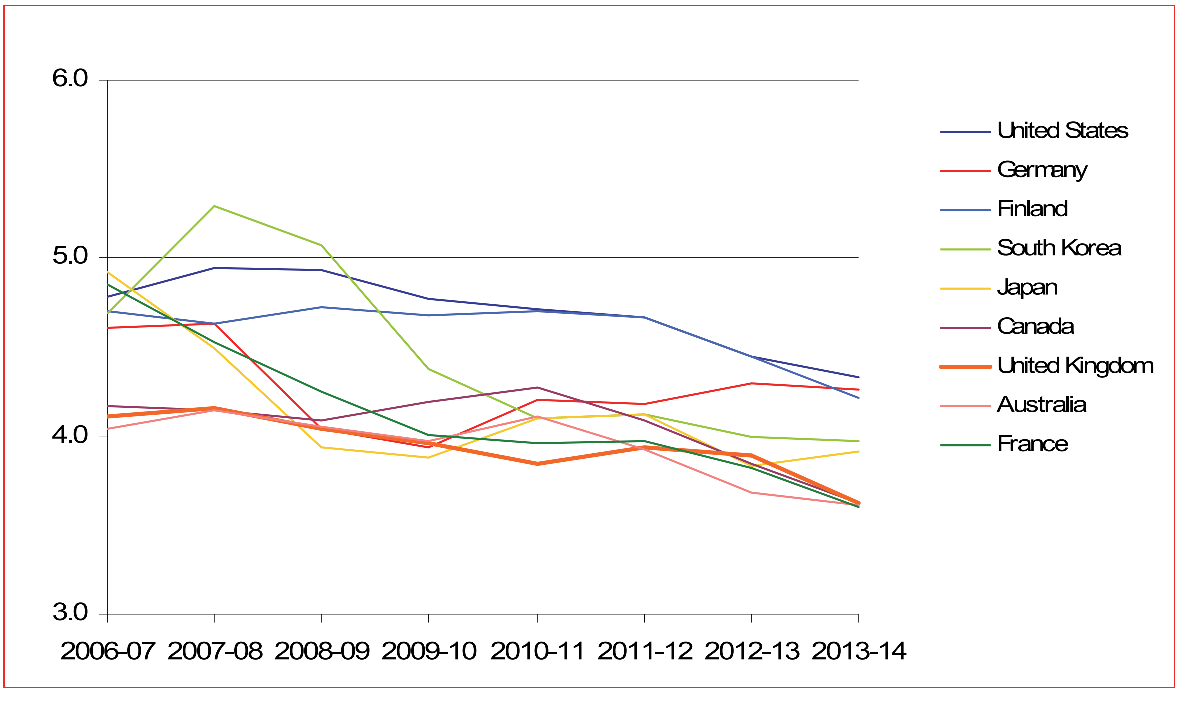
Relative country scores



Underlying data table

Country	Rank	Score	Survey results
United States	1	10.0	4.3
Germany	2	9.0	4.3
Finland	3	8.6	4.2
South Korea	4	5.5	4.0
Japan	5	4.8	3.9
Canada	6	1.4	3.6
United Kingdom	7	1.3	3.6
Australia	8	1.3	3.6
France	9	1.0	3.6

Time series



S5: SME collaboration with Higher Education institutions

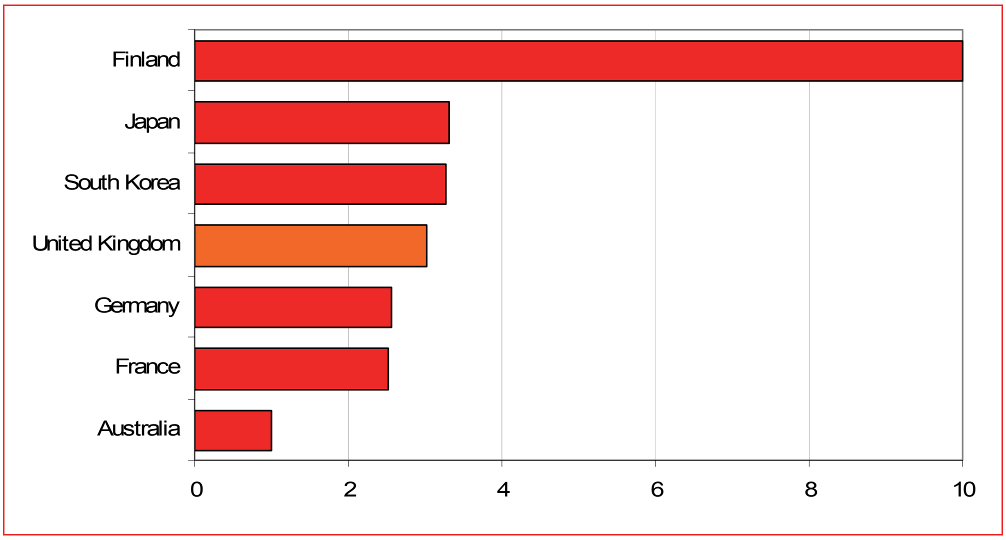
Definition: Small and medium sized firms collaborating on innovation with higher education or public research institutions using the percentage of product or process innovative firms in that size category. Collaboration involves "active participation in joint innovation projects with other organisations" but excludes pure contracting out of innovation-related work.

Rationale: Given the sophistication and complexity of various fields of science and knowledge, collaboration with higher education or public research institutions could be an important source of knowledge transfer. We measure this using the proportion of innovative SMEs that collaborate with higher education or public research institutions. This reflects the existence of some sort of collaboration, but not the type, frequency or intensity of innovation collaborations

Source: OECD (2013) Science, Technology and Industry Scoreboard

The extent of collaboration varies a lot across the countries included in the sample. Finland has the highest proportion of SMEs collaborating with higher education/public research institutions, substantially ahead of all other comparator economies. The UK is ranked in the middle.

Relative country scores



Underlying data table

Country	Rank	Score	Survey results
Finland	1	10.0	60.7
Japan	2	3.3	18.7
South Korea	3	3.3	18.3
United Kingdom	4	3.0	16.8
Germany	5	2.6	13.9
France	6	2.5	13.7
Australia	7	1.0	4.1

S6: International collaboration on innovation by firms

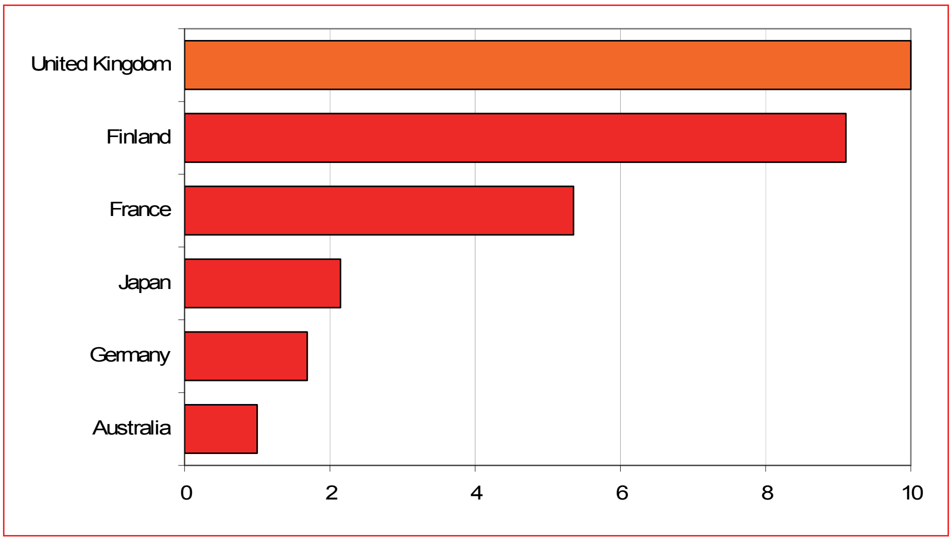
Definition: International collaboration by firms who are product and/or innovative active (2008-2010). International collaboration refers to active cross-border participation even if both parties do not benefit commercially.

Rationale: International collaboration can play an important role in the innovation process by allowing firms to gain access to bigger pools of knowledge and resources. In addition collaboration allows firms to share risks and costs.

Source: Eurostat database

International collaboration rates vary widely across countries. UK firms are most likely to collaborate internationally, followed by Finland. All other comparator countries, for which data are available, have significantly lower collaboration rates.

Relative country scores



Underlying data table

Country	Rank	Score	Percentage of innovative firms, which collaborate
United Kingdom	1	10.0	31.1
Finland	2	9.1	28.7
France	3	5.4	18.2
Japan	4	2.2	9.3
Germany	5	1.7	8.0
Australia	6	1.0	6.1

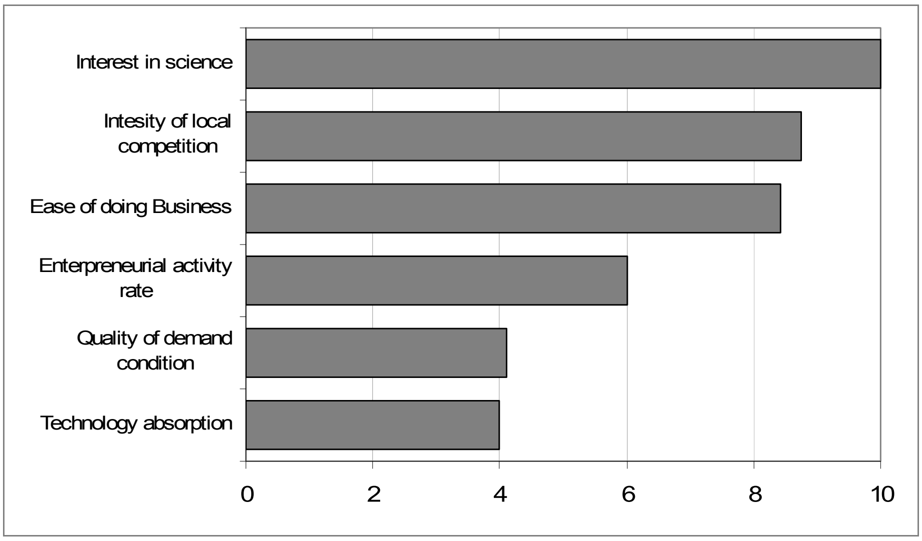
Broader environment indicators

The analysis of indicators related to the broader environment shows that the UK performs well compared to other countries included in the study. The UK's particular strengths include a good degree of competition in the economy and an effective regulatory environment.

The role of consumers in driving innovation appears to be more mixed. On the one hand, UK consumers seem to be more interested in new technological innovations than their counterparts in other European countries. On the other hand, the UK is seen as having a less satisfactory degree of consumer orientation and buyer sophistication.

The main perceived weakness relates to the ability of UK firms to adapt to new technologies.

Broader environment indicators –UK score (1-10)



Source: BIS analysis

Looking at other countries, the US broader environment seems to be most supportive of innovation, while France performs particularly poorly in this element of the Six-Part-Framework.

Data availability

The assessment of the broader environment is mostly based on survey data. This means that it describes perceptions rather than actual performance. The exceptions are the measure of ease of doing business and the entrepreneurial activity rate, which reflect actual performance.

The lack of comparable data does not allow for a comprehensive comparison across all countries within this study. Current data limitations also constrain our understanding of the nature of firms' absorptive capacity. This is an area where more quantitative indicators would be very useful in better assessing cross-country performance.

It is also important to note that we excluded some indicators, which are key elements of broader environment but less helpful in identifying differences between countries included in the study. For example, all comparator economies have stable political and institutional environments, and therefore, including this measure would add only a limited value to our understanding of UK's relative strengths and weaknesses.

E1: Ease of doing business

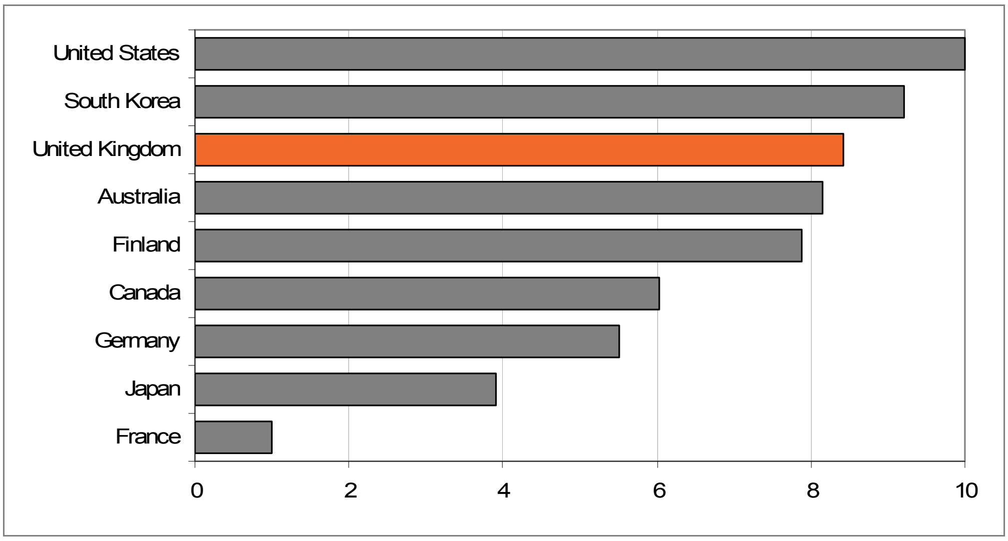
Definition: Economies are ranked on their ease of doing business, from 1 – 189. A high ranking on the Ease of Doing Business Index means the regulatory environment is more conducive to the starting and operation of a local firm. This index averages the country's percentile rankings on ten topics, made up of a variety of indicators, giving equal weight to each topic. The rankings for all economies are benchmarked to June 2013.

Rationale: R&D decisions and innovative activities are influenced by the regulatory and policy environment. Well-functioning legal and administrative frameworks facilitate business creation and healthy competition. This, in turn, supports the creation and application of new knowledge. We measure the quality of business environment using the Ease of Doing Business ranking produced by the World Bank.

Source: World Bank Doing Business Report 2014

The UK is ranked third for the overall ease of doing business, below the US and South Korea, but above its major European competitors. The more detailed analysis shows that UK strengths include investor protection, resolving insolvency and the ease of getting credit.

Relative country scores



Underlying data table

Country	Rank	Score	Doing Business rank
United States	1	10.0	4
South Korea	2	9.2	7
United Kingdom	3	8.4	10
Australia	4	8.1	11
Finland	5	7.9	12
Canada	6	6.0	19
Germany	7	5.5	21
Japan	8	3.9	27
France	9	1.0	38

E2: Total early-stage entrepreneurial activity (TEA)

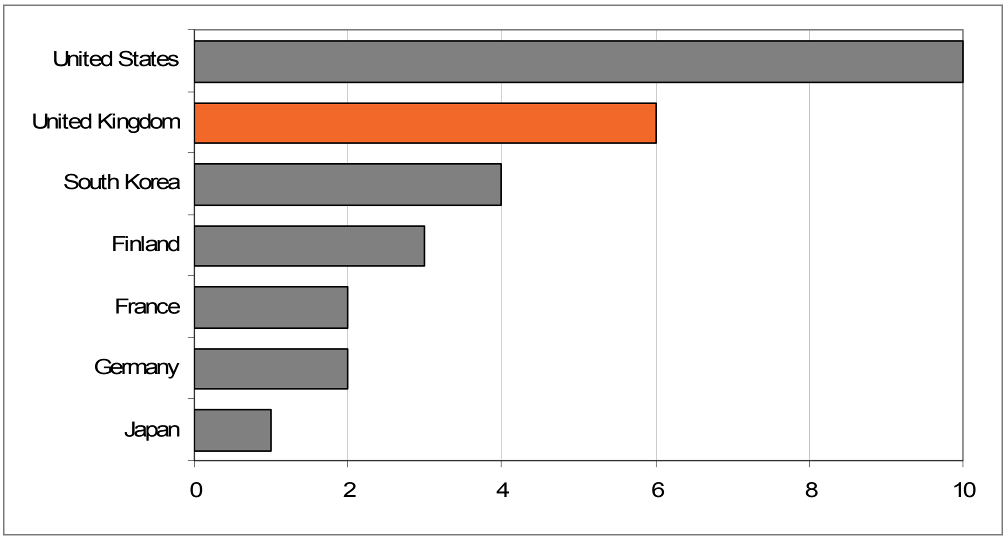
Definition: The total entrepreneurial activity (TEA) rate consists of the percentage of individuals aged 18 – 64 years in an economy who are in the process of starting or are already running new businesses. The TEA rate therefore includes both nascent and new entrepreneurs.

Rationale: The entry and growth of new firms ais important to the innovation process. High levels of churn help speed up the process of reallocation of resources and reflect competitive and innovative pressures in a market.

Source: Global Entrepreneurship Monitor 2012 Report

Comparable data on early entrepreneurial activity across countries are limited. The existing evidence suggests that the UK has a relatively high rate of new businesses as compared to other countries included in the study, with only the US raising higher.

Relative country scores



Underlying data table

Country	Rank	Score	TEA (%)
United States	1	10.0	13
United Kingdom	2	6.0	9
South Korea	3	4.0	7
Finland	4	3.0	6
Germany	5	2.0	5
France	6	2.0	5
Japan	7	1.0	4

E3: Intensity of local competition

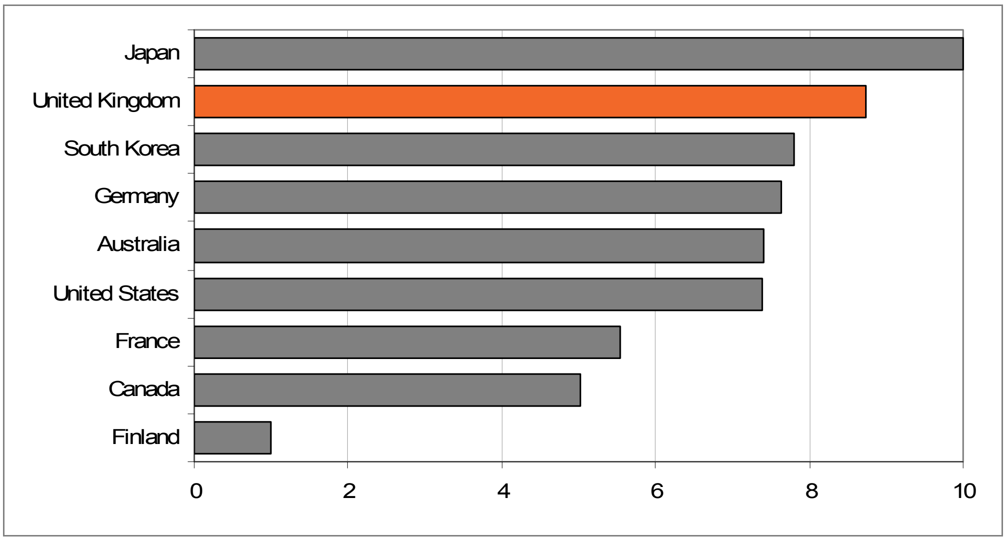
Definition: Survey Question in your country, how intense is competition in the local markets? [1 = not intense at all; 7 = extremely intense] 2012–13 weighted average

Rationale: Higher levels of competition tend to increase the incentive to innovate, which will help firms gain a competitive advantage on their competitors. As a proxy for the degree of competition, we use the data on business perceptions on intensity of competition in local markets.

Source: WEF Global Competitiveness Report 2013-14

Intensity of competition as reported by the WEF does not vary a lot between countries included in the study, with the exception of Finland that performs relatively poorly on this measure. Intensity of competition in the UK is rated highly, second only to Japan.

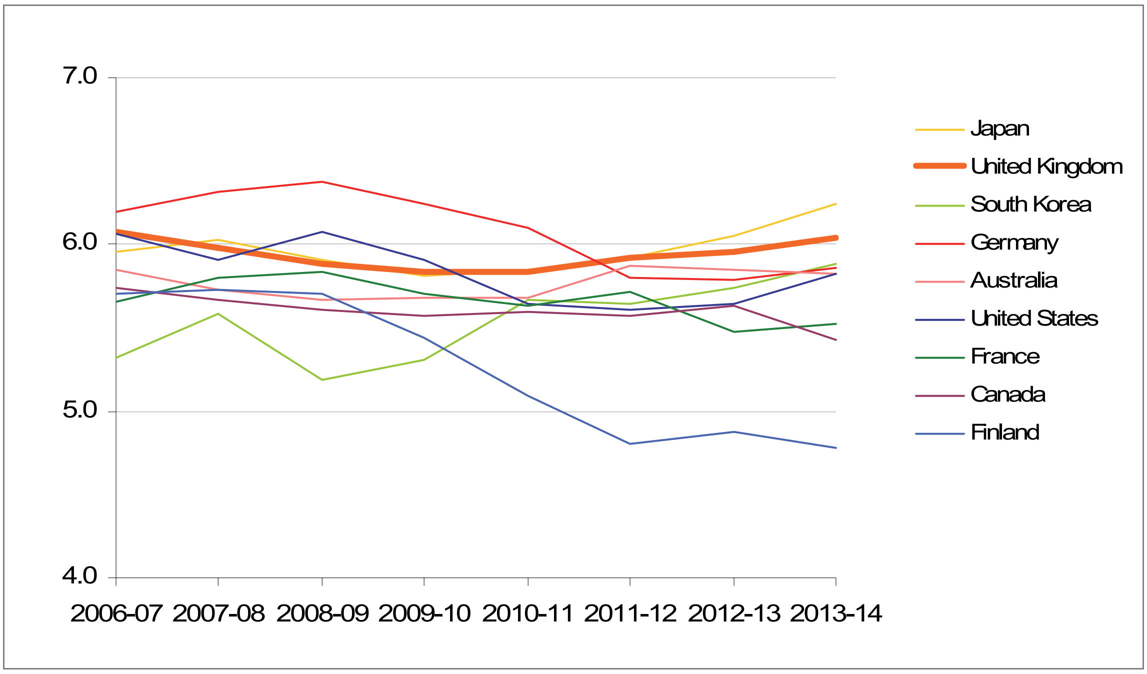
Relative country scores



Underlying data table

Country	Rank	Score	Survey Results (1-7)
Japan	1	10.0	6.2
United Kingdom	2	8.7	6.0
South Korea	3	7.8	5.9
Germany	4	7.6	5.9
Australia	5	7.4	5.8
United States	6	7.4	5.8
France	7	5.5	5.5
Canada	8	5.0	5.4
Finland	9	1.0	4.8

Time series



E4: Firm-level technology absorption (2013-2014)

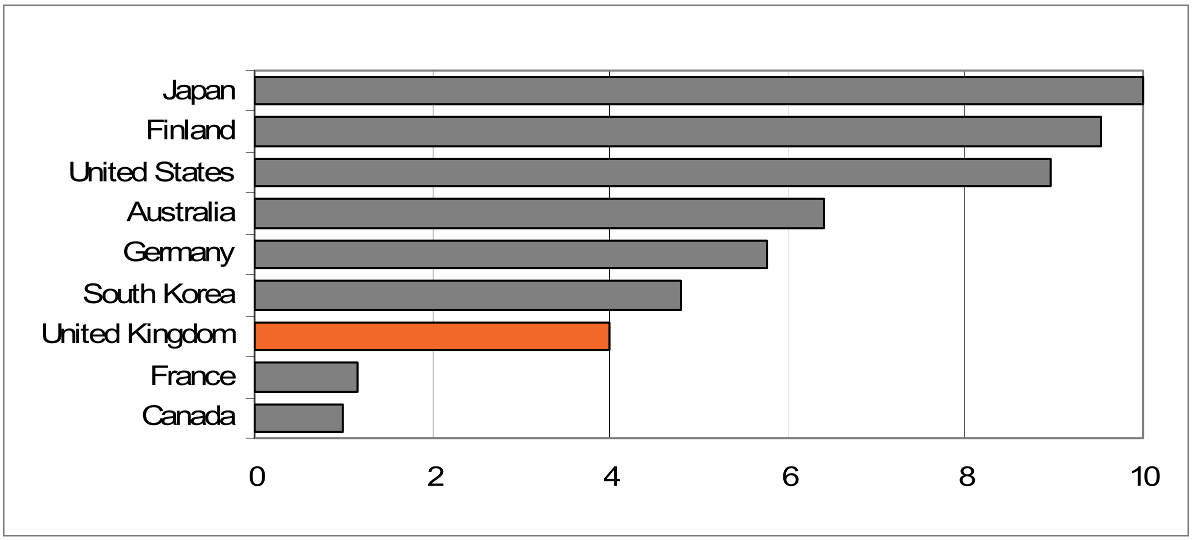
Definition: Business opinion survey: in your country, to what extent do businesses adopt new technology? [1 = not at all; 7 = adopt extensively] 2012–13 weighted average

Rationale: The absorptive capacity of firms is an important determinant of the speed and quality of technology diffusion. Given the lack of quantitative indicators, the report relies on business executives' assessment of firm-level absorptive capacity in their own countries.

Source: WEF Global Competitiveness Report 2013-2014

The WEF survey indicates that UK firms are seen as having relatively poor absorptive capacity compared to other countries included in the study. The ranking has been fairly stable over the last few years, with Japanese, US and Finish companies ranked the highest.

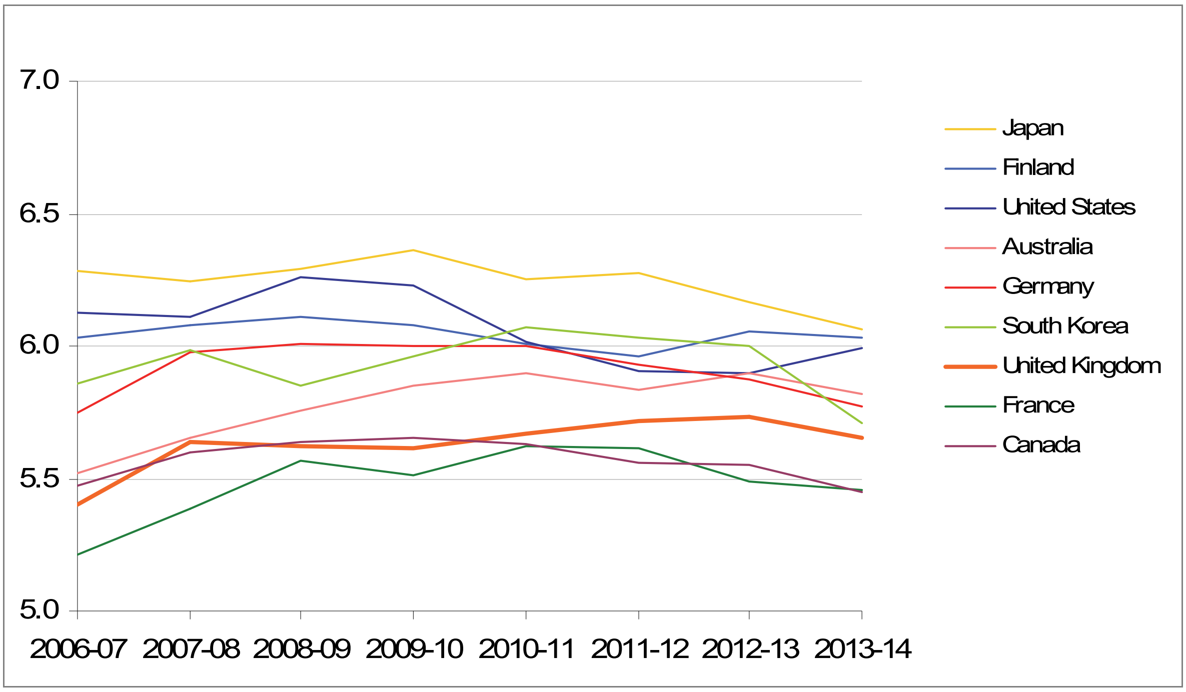
Relative country scores



Underlying data table

Country	Rank	Score	Value
Japan	1	10.0	6.1
Finland	2	9.5	6.0
United States	3	9.0	6.0
Australia	4	6.4	5.8
Germany	5	5.8	5.8
South Korea	6	4.8	5.7
United Kingdom	7	4.0	5.7
France	8	1.2	5.5
Canada	9	1.0	5.4

Time series



E5: Quality of demand conditions

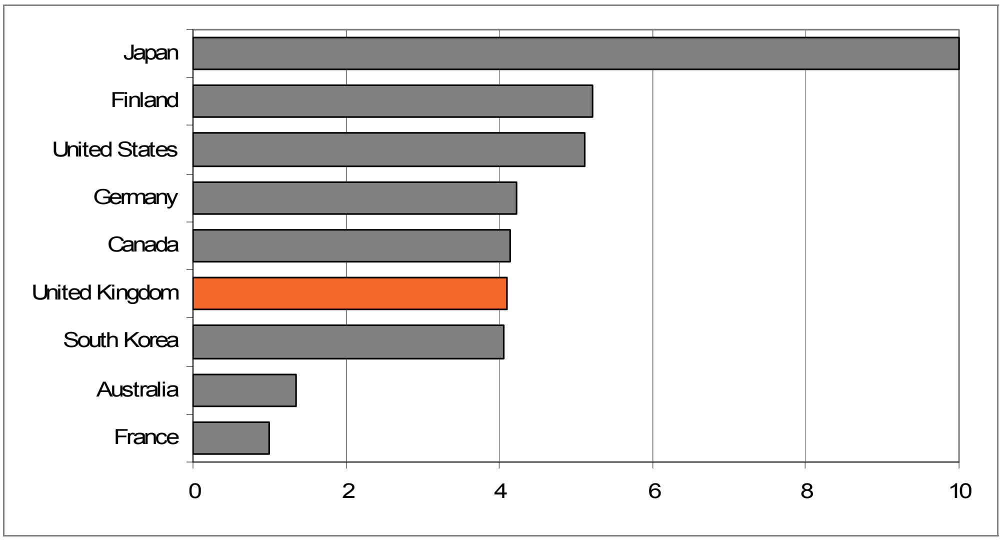
Definition: The assessment of quality of demand conditions is based on two indicators: degree of consumer orientation (In your country, how well do companies treat customers? [1 = indifferent to customer satisfaction; 7 = highly responsive to customers and seek customer retention] 2012–13 weighted average) and buyer sophistication (In your country, how do buyers make purchasing decisions? [1 = based solely on the lowest price; 7 = based on a sophisticated analysis of performance attributes] 2012–13 weighted average)

Rationale: Innovation also depends on demand conditions such as customer orientation and buyer sophistication. More demanding customers force companies to provide better products and services, hence creating stronger incentives to innovate. This indicator is also based on a business opinion survey.

Source: WEF Global Competitiveness Report 2013-14

Quality of demand conditions deteriorated for all countries included in the sample between 2006 and 2008, but have remained fairly stable since. Japan is reported to have the most supportive demand conditions. The UK is ranked in the middle.

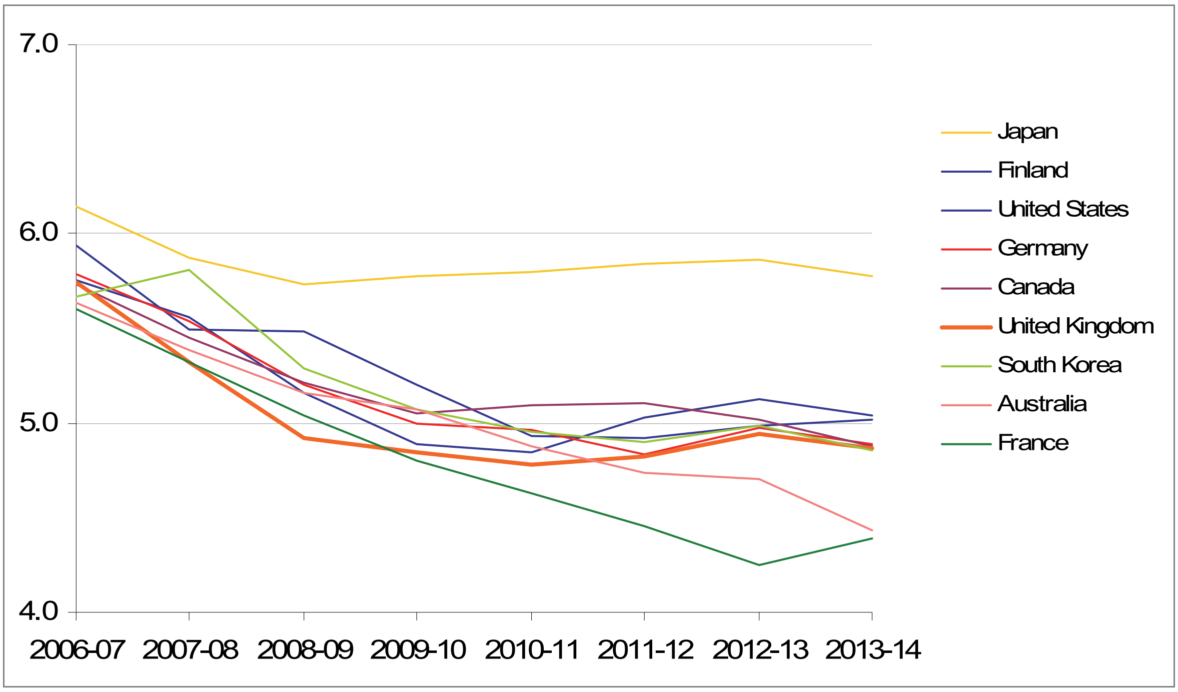
Relative country scores



Underlying data table

Country	Rank	Score	WEF Results
Japan	1	10.0	5.8
Finland	2	5.2	5.0
United States	3	5.1	5.0
Germany	4	4.2	4.9
Canada	5	4.1	4.9
United Kingdom	6	4.1	4.9
South Korea	7	4.1	4.9
Australia	8	1.3	4.4
France	9	1.0	4.4

Time series



E6: Interest in science and technology

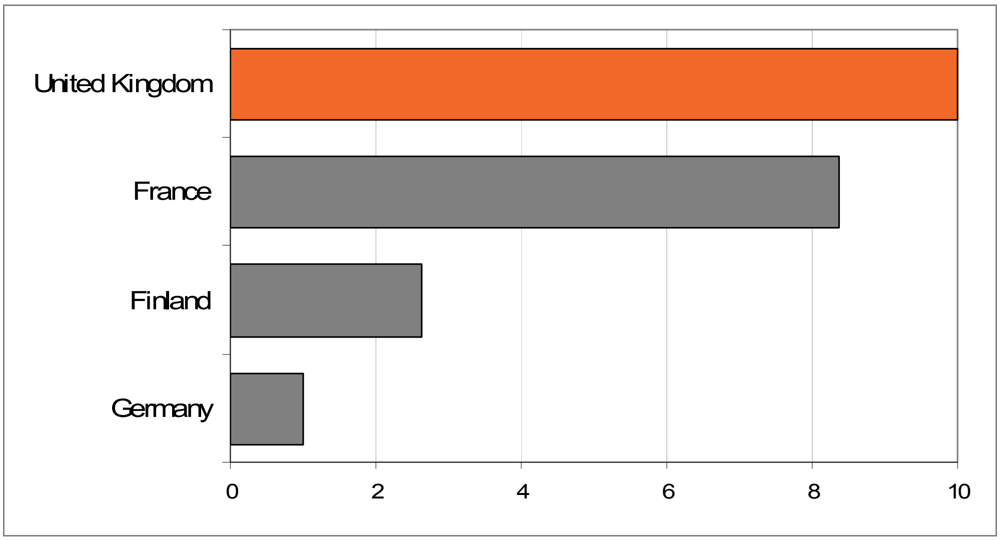
Definition: Percentage of respondents who declared they are very interested in new scientific discoveries in technological developments.

Rationale: Interest in science and technology is a measure of attitudes to new technologies. Consumers who are interested in scientific discoveries are likely to demand more technologically advanced products, and therefore create more incentives for firms to innovate.

Source: European Commission, Special Barometer 340, Science and Technology Report (2010)

The data are available for EU countries only, which significantly limits the scope for the cross-country comparison. The UK population appears to be most interested in scientific discoveries and technology among comparator EU countries. This suggests positive attitudes towards technological innovations.

Relative country scores



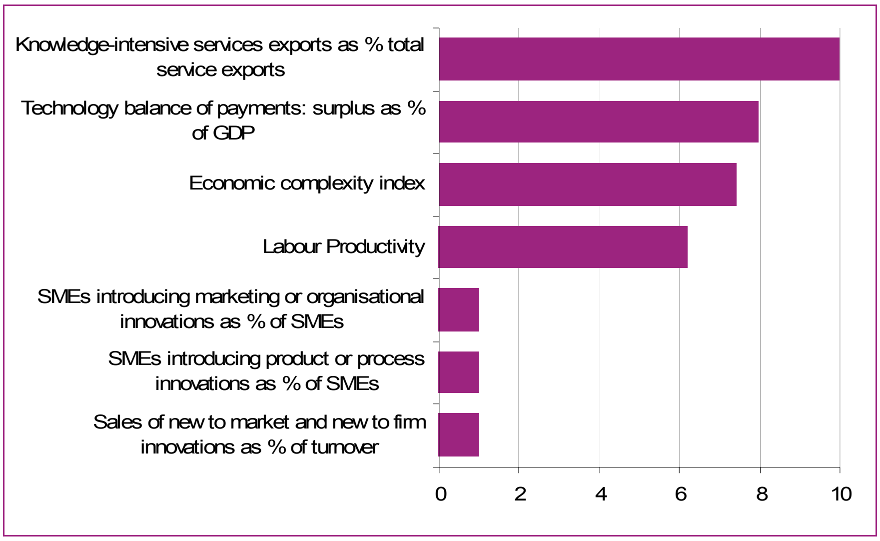
Underlying data table

Country	Rank	Score	Value
United Kingdom	1	10.0	43%
France	2	8.4	41%
Finland	3	2.6	34%
Germany	4	1.0	32%

Innovation outputs indicators

Overall, the UK has a mixed performance on innovation output indicators. The UK scores poorly on sales and introduction of product and process innovations, as well as marketing or organisational innovations, although this is compared with a limited number of comparator countries. The UK's labour productivity, as measured by GDP per hour worked, is high relative to the rest of the world. However, compared with our main competitors identified in this report, the UK's productivity is at the lower end of the scale. The UK scores well on exporting and importing of technology and also on knowledge intensive exports.

Output indicators – UK scores (1-10)



Source: BIS analysis

Data availability

There is a lack of robust output indicators, making it difficult to assess the effectiveness of investment in science and innovation and also the true strength of a science and innovation system. This is particularly true for the assessment of innovation performance.

O1: Labour productivity

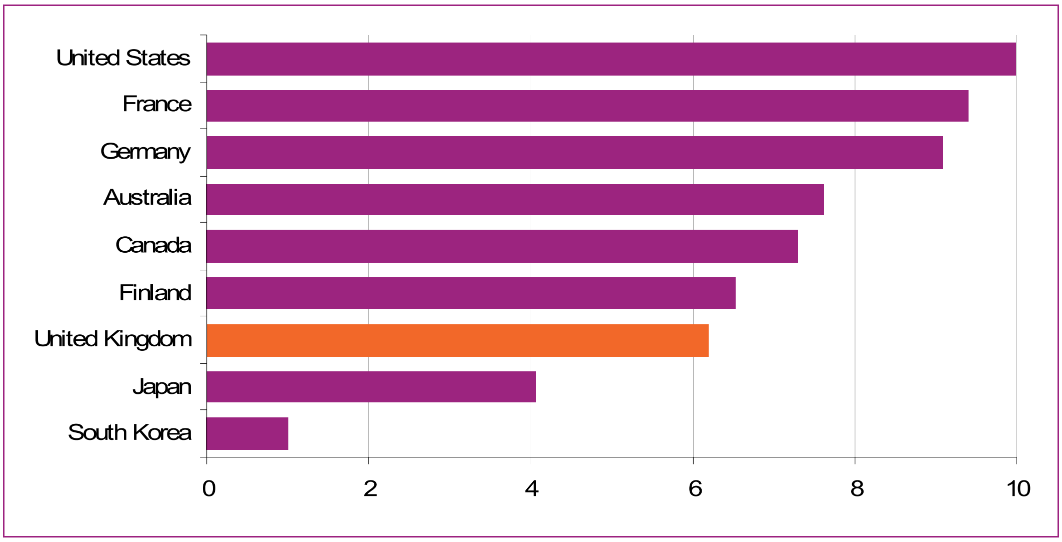
Definition: GDP per hour worked, current US dollars PPP

Rationale: GDP per hour worked gives an indication of the level of productivity in a country. We have used a metric on the actual level rather than focusing on growth rates, which can be volatile from year to year.

Source: OECD, Labour Productivity levels

In the long run, productivity growth is a result of technological progress. The UK scores relatively poorly on this measure. The US has the highest level of GDP per hour worked.

Relative country scores



Underlying data table

Country	Rank	Score	Value (GDP per hour worked, current US dollars)
United States	1	10.0	61.6
France	2	9.4	59.5
Germany	3	9.1	58.3
Australia	4	7.6	53.0
Canada	5	7.3	51.8
Finland	6	6.5	49.0
United Kingdom	7	6.2	47.8
Japan	8	4.1	40.1
South Korea	9	1.0	28.9

O2: Sales of new to market and new to firm innovations as percentage of turnover

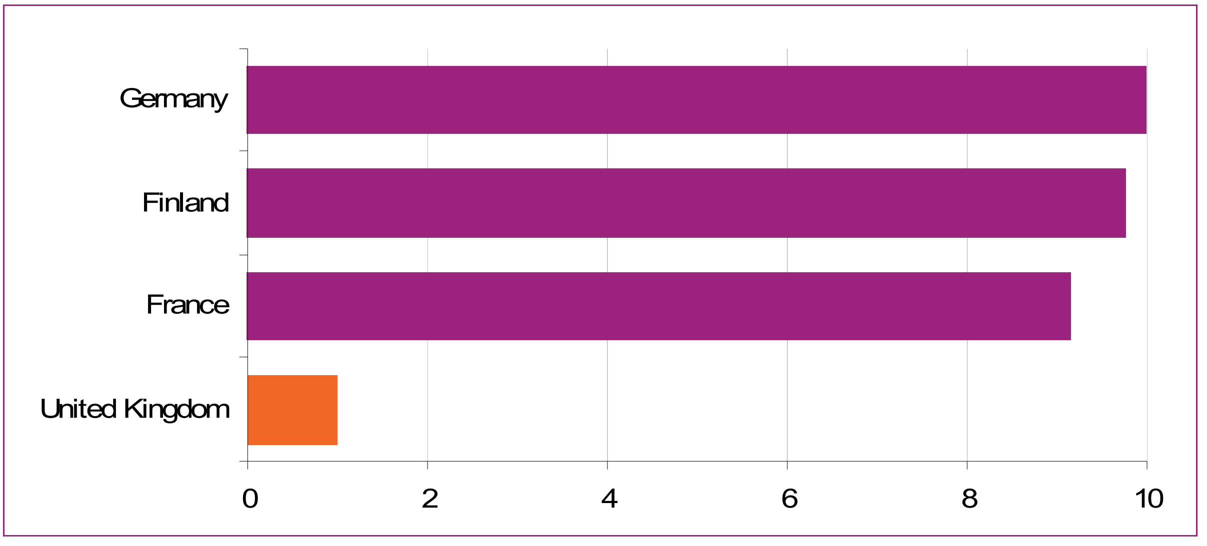
Definition: This measures what percentage of firms' turnover was from new-to-market and new to firm innovations

Rationale: This gives an indication of the amount of product and process innovations that firms have implemented or utilised. A high percentage of turnover suggests a presence of highly innovative firms that also turn those innovations into commercial successes.

Source: Innovation Union Scoreboard (3.2.4)

Data were only available for four of the key comparator countries. The UK performs poorly on this measure. Sales of new-to-market and new-to-firm innovations as a percentage of turnover is around twice as high in France, Germany and Finland than in the UK.

Relative country scores



Underlying data table

2010 (UK=2008)	Rank	Score	Value (percentage of turnover)
Germany	1	10.0	15.5
Finland	2	9.8	15.3
France	3	9.2	14.7
United Kingdom	4	1.0	7.3

O3: Economic complexity index

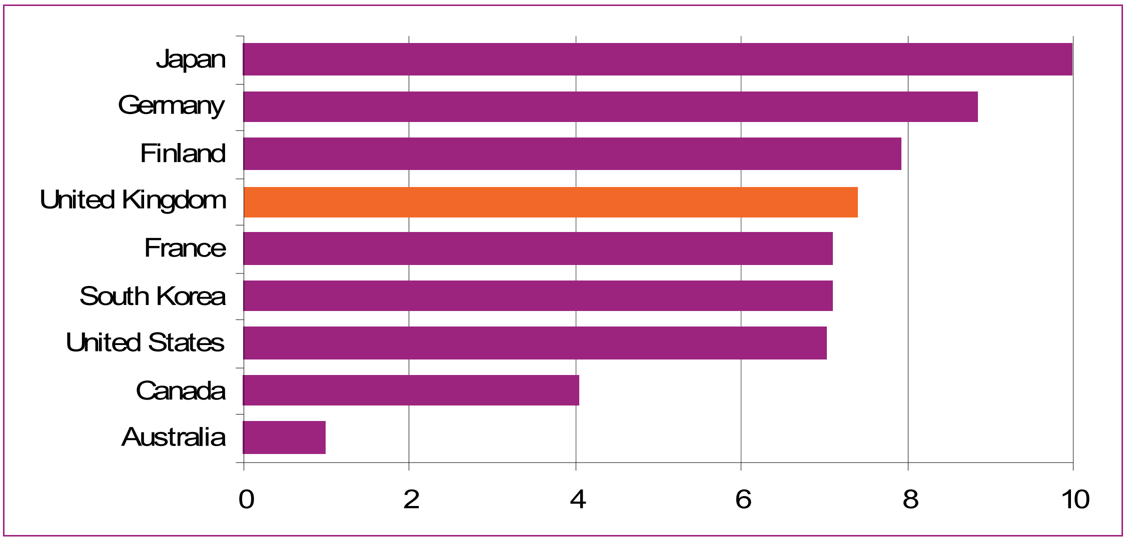
Definition: Countries are scored based on the amount of productive knowledge that is implied in their export structures

Rationale: A good score suggests that the country contains strong productive knowledge and that it manufactures and exports a large number of sophisticated goods.

Source: The atlas of economic complexity - mapping paths to prosperity. Hausmann, Hildago et al

The UK performs reasonably well on this measure. A good score on this measure suggests that the country contains strong productive knowledge and that it manufactures and exports a large number of sophisticated goods. It is perhaps unsurprising to see Japan, Germany and Finland are the leading countries according to this indicator – they are typically associated with being strong exporters of technologically advanced products. The UK is slightly ahead of France, South Korea and the US according to this indicator.

Relative country scores



Underlying data table

2008	Rank	Score	Value (Index)
Japan	1	10.0	2.3
Germany	2	8.9	2.0
Finland	3	7.9	1.7
United Kingdom	4	7.4	1.6
France	5	7.1	1.5
South Korea	6	7.1	1.5
United States	7	7.0	1.4
Canada	8	4.0	0.6
Australia	9	1.0	-0.3

O4: Knowledge-intensive services exports as a percentage total service exports

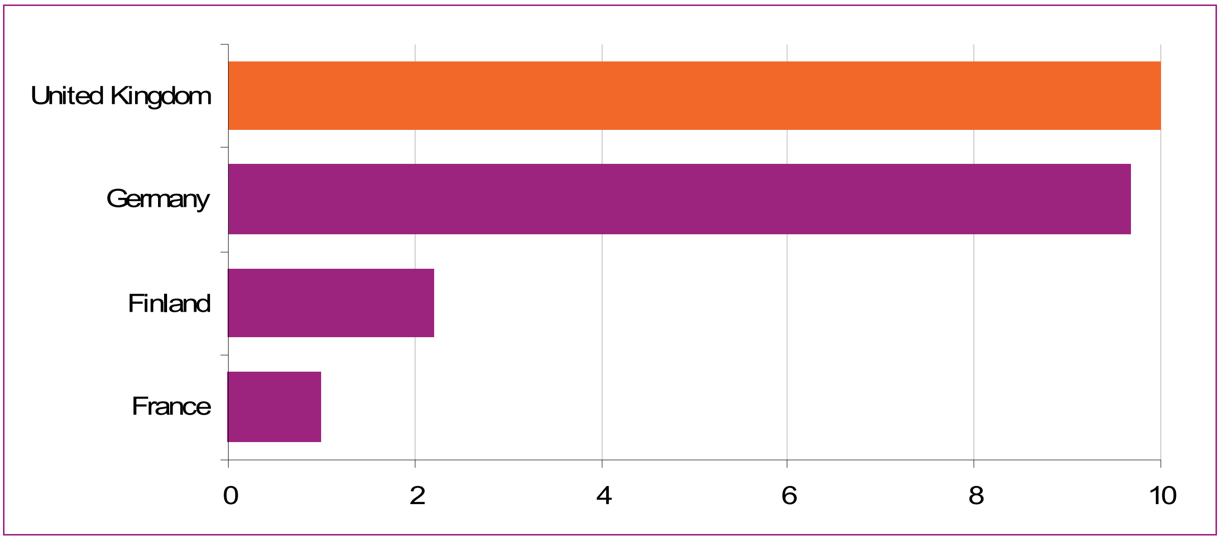
Definition: Knowledge-intensive services exports as percentage of total service exports

Rationale: For advanced economies, knowledge-intensive services are one of the areas in which they are likely to have a comparative advantage over less advanced economies. Strength on this indicator would suggest that the country produces knowledge-intensive services that are demanded from abroad.

Source: Innovation Union Scoreboard (3.2.3)

The UK performs well on this measure, suggesting that it is good in producing knowledge-intensive services for which there is a demand from abroad. Germany has only a slightly lower share (56.7% compared with 57.6% for the UK), but Finland and France are some way behind.

Relative country scores



Underlying data table

2010	Rank	Score	Value (% of total service exports)
United Kingdom	1	10.0	57.6
Germany	2	9.7	56.7
Finland	3	2.2	35.9
France	4	1.0	32.6

O5: Technology balance of payments: surplus as percentage of GDP (Gross Domestic Product)

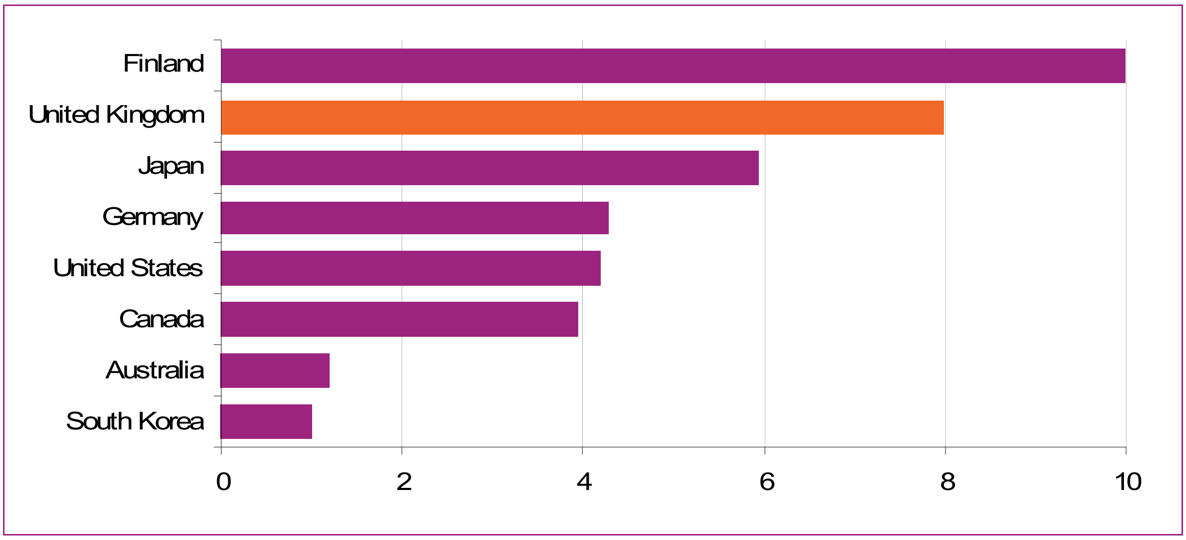
Definition: Technology receipts minus technology payments, as a percentage of GDP

Rationale: This indicator measures international transfers of technology, including licenses, patents, research and knowledge. The receipts represent payments for production-ready technologies. If a country exports more technology than it imports, it will have a technology balance of payments surplus. This might suggest that the country produces technologies that are demanded abroad, suggesting a competitive science and innovation system and a resulting trade surplus. However, as the OECD points out, a technology balance of payments deficit does not necessarily equate to low competitiveness. A deficit might be a result of a country being effective at absorbing foreign technologies, as well as being able to export its own technologies.

Source: OECD MSTI and National Accounts data

This indicator tells us whether a country exports more technology than it imports. The UK performs well on this measure, second only to Finland (who overtook the UK recently). Australia and South Korea have a technology balance of payments deficit.

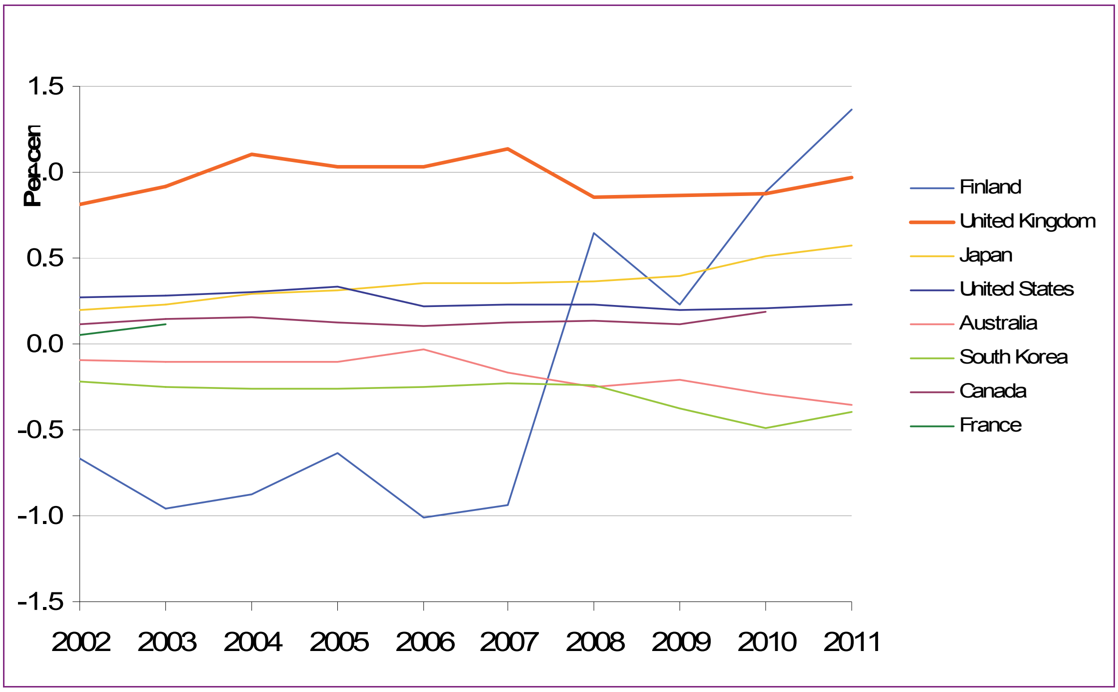
Relative country scores



Underlying data table

2011	Rank	Score	Value (Surplus as a percentage of GDP)
Finland	1	10.0	1.4
United Kingdom	2	8.0	1.0
Japan	3	5.9	0.6
Germany	4	4.3	0.2
United States	5	4.2	0.2
Canada	6	4.0	0.2
Australia	7	1.2	-0.4
South Korea	8	1.0	-0.4

Time series



O6: SMEs introducing product or process innovations as percentage of SMEs (Small and Medium-Sized Enterprises)

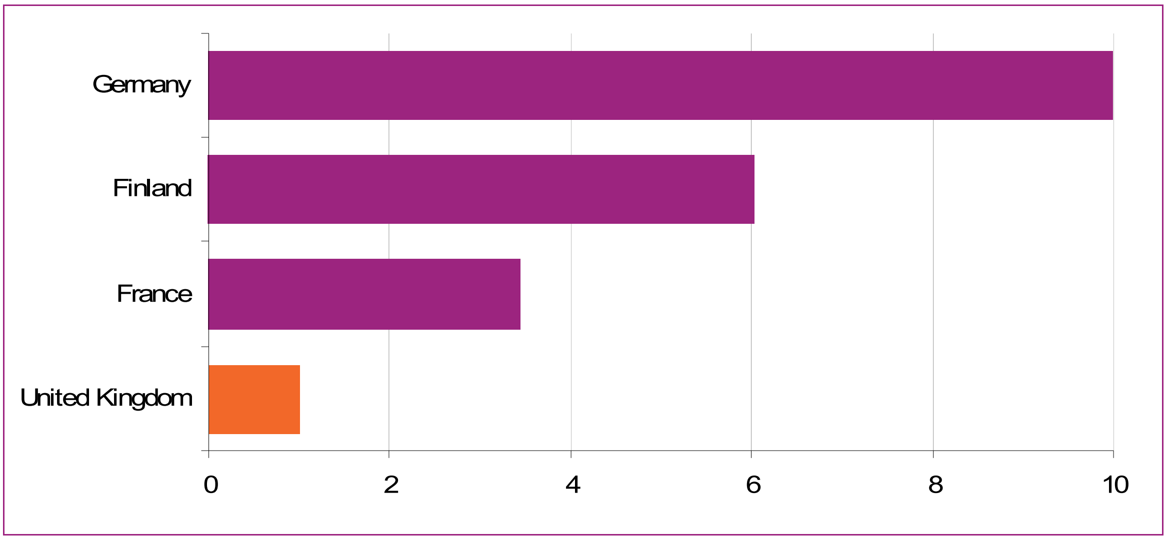
Definition: The percentage of SMEs that introduced a product or process innovation.

Rationale: This attempts to assess how successful small and medium sized enterprises are at implementing and making use of innovations

Source: Innovation Union Scoreboard (3.1.1)

Consistent with indicator O2, SMEs in the UK also appear to be less likely to introduce new product or process innovations than in France, Germany and Finland.

Relative country scores



Underlying data table

2010	Rank	Score	Value (Surplus as a percentage of GDP)
Germany	1	10.0	63.2
Finland	2	6.0	44.8
France	3	3.5	32.7
United Kingdom	4	1.0	21.3

O7: SMEs introducing marketing or organisational innovations as percentage of SMEs (Small and Medium-Sized Enterprises)

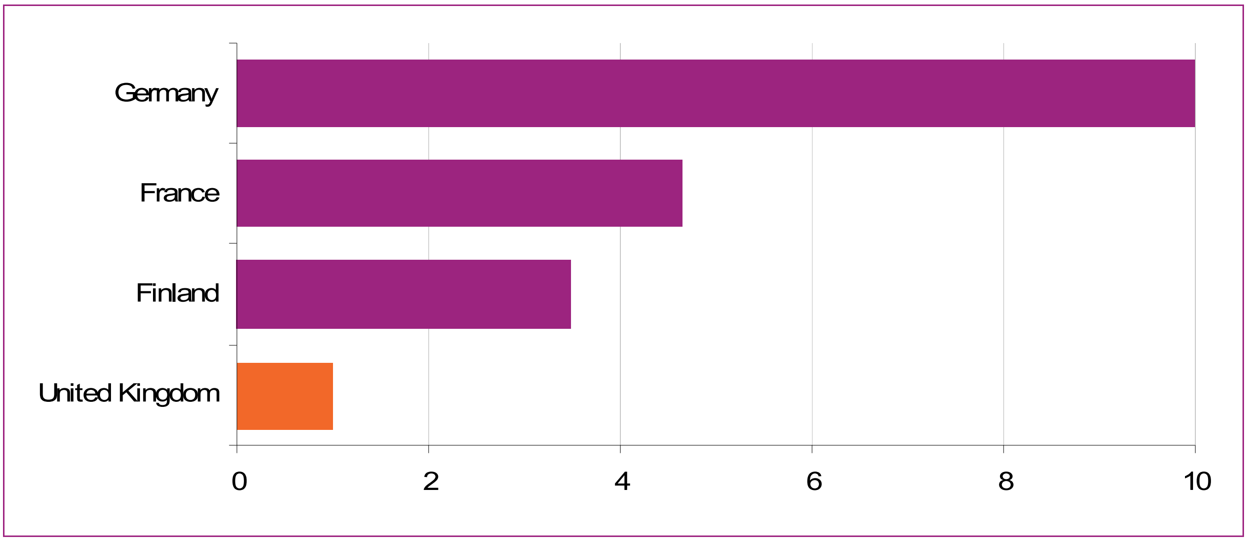
Definition: The percentage of SMEs that introduced marketing or organisational innovation.

Rationale: This variable gives an indication of innovations that might be classed as 'intangible innovations'.

Source: Innovation Union Scoreboard (3.1.2)

UK SMEs also appear to be less likely to introduce marketing or organisational innovations than Germany, France and Finland. This is perhaps surprising given the UK's relatively high investment in intangible assets.

Relative country scores



Underlying data table

2010	Rank	Score	Value (Surplus as a %of GDP)
Germany	1	10.0	60.5
France	2	4.7	42.8
Finland	3	3.5	38.9
United Kingdom	4	1.0	30.6

Annex D: The importance of money to the science and innovation system

Research and innovation investments provide good returns and support growth

20. Investment in research and innovation is fundamental to increased productivity and wellbeing. Returns on research and development are high, with a social rate of return typically estimated to be in the range of 20-50 per cent – meaning that a one-off investment of £1 generates a return of £0.50 a year in perpetuity.[9] Returns can, however, be significantly higher than this range. For example, US and Australian studies have suggested exceptional returns, typically between three and eight-fold, for biomedical research.[10] On UK collaborative projects between business and academia, the net cumulative gross value added is estimated at £0.96 per annum for every £1 spent,[11] even though this figure does not fully capture all spill-over benefits, which are hard to measure but can be significant. Private sector R&D expenditure has a positive impact on firms' innovative capacity and more broadly on their competitiveness, productivity, profit, export capacity and success.[12]

21. Academic studies on the impacts of both public and private sector R&D expenditure also find a positive link between R&D investment and economic growth.[13] While there are nuances, the data suggest that this link holds across a range of countries, implying that, even for relatively inefficient research and innovation systems, R&D investment drives economic growth. The studies also show that different types of public sector investment have different impacts on growth, with the highest growth impact arising from public funding of business R&D.[14]

A well-functioning science and innovation system relies on inter-dependent public and private input

22. In all developed economies, the science and innovation system relies on both public and private funding, with government financed GERD accounting for some 30% of total R&D expenditure on average in the OECD. The interconnectedness of the system means that assessments tend to look at the total value of activity as well as the separate amounts funded by the public and private sectors, and this is the approach we follow below. It is

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[9] Salter and Martin (2001)
[10] Hughes and Martin (2012), p. 46
[11] These benefits are measured in 2010 prices and are assumed to persist for 6 years. This return should not be directly compared with the 20-50% rate of return referred to above due to the different methods used.
[12] Department for Business, Innovation and Skills (Dec 2013)
[13] Guellec et al (2001)
[14] Guellec et al (2001). The research indicates that the next best impacts arise from research performed by higher education institutions, then from public sector research institutions, and finally from R&D on defence. This should, however, not be interpreted as a policy prescription as each country's optimal mix will depend on its current portfolio and the complementarity of new opportunities with its entire science and innovation system.

also possible to sub-divide the money according to the actors that perform it and to examine the complex flows of funding. A summary is set out in Table 2.

Table 2: Composition of UK expenditure on R&D 2011*

		Sector carrying out the work						
		Government	**Research Councils**	**Higher Education**	**Business Enterprise**	**Private Non-Profit**	**Total**	**Abroad**
Sector Providing the funding	**Government**	977	86	406	1,601	68	3,138	531
	Research Councils	47	819	1,979	11	86	2,942	188
	Higher Education Funding Council	-	-	2,257	-	-	2,257	-
	Higher Education	2	11	290	-	14	317	-
	Business Enterprise	203	26	284	11,957	85	12,556	2,003
	Private Non-Profit	3	47	987	104	165	1,306	-
	Abroad	77	51	923	3,734	79	4,864	-
	Total	1,308	1,040	7,127	17,408	496	27,380	-

Note: ** Figures are quoted in £millions*
Source: *ONS (2013)*

23. Private sector funding of R&D is clearly important as it represents by far the biggest share of the total. Private funding can include basic research but tends to be more in the applied and innovation territory as these tend to offer the quickest and most apparent return – and it is of course the activity of private sector firms that is most directly related to the capture of economic value. It is no surprise that the most successful countries in this space tend to have high levels of private sector R&D.[15]

24. Public funding is also needed, especially where the private sector holds back. There are three main reasons why the private sector can be unwilling to invest (or at least invest alone) at sufficient scale:

- there is a large degree of uncertainty about which research activities will deliver new commercially-valuable knowledge, products or services, particularly at the earliest stages of basic research;

[15] See Figure 5 (duplication of Figure 7 in the main report)

- research is a long-term endeavour which may be reprioritised relative to activities that bring short-term rewards; and
- most critically, there are often spill-over benefits from investment in basic science, research and other innovation activities that the investing firm cannot fully retain.

25. All of these are particularly true in the case of basic science. It is this type of research which tends to yield transformative new insights that fuel the innovation system, though these often take many years to be fully commercialised. In most countries, public funding is therefore weighted towards areas where the returns are too distant or appropriable to be commercially viable or where there is a societal challenge to be solved, either pressing (such as defence and health) or longer-term (such as resource scarcity). It also includes a certain amount of investment in infrastructure.

26. Private and public funding are, however, complementary rather than substitutes for each other.[16] Public sector investment is crucial to a country's absorptive capacity which allows it to turn scientific knowledge into innovations that deliver societal and economic benefits. Box A illustrates the ways in which strong public investment in science can build capacity, enable international collaboration and attract talent thus enabling virtuous circles of increasing private sector R&D and innovation investment, competitiveness, investment and added value.

BOX A: What does public sector R&D buy? A potential virtuous circle

In simple terms, public sector R&D expenditure covers the cost of researchers and infrastructure in publicly funded research organisations. The research undertaken could be seen to produce the following "goods":

- codified knowledge in the form of published papers and citations; and
- tacit knowledge in the form of expertise embedded in the researchers

If the quality of these "goods" is globally recognised as high, they in turn "buy":

- involvement in international collaboration, including the benefits of networks and relationships with other leading researchers; and
- ability to attract the best talent, which in turn will further enhance the quality of research and expertise

A world-class science base that is created in this way, in turn, has the potential to attract:

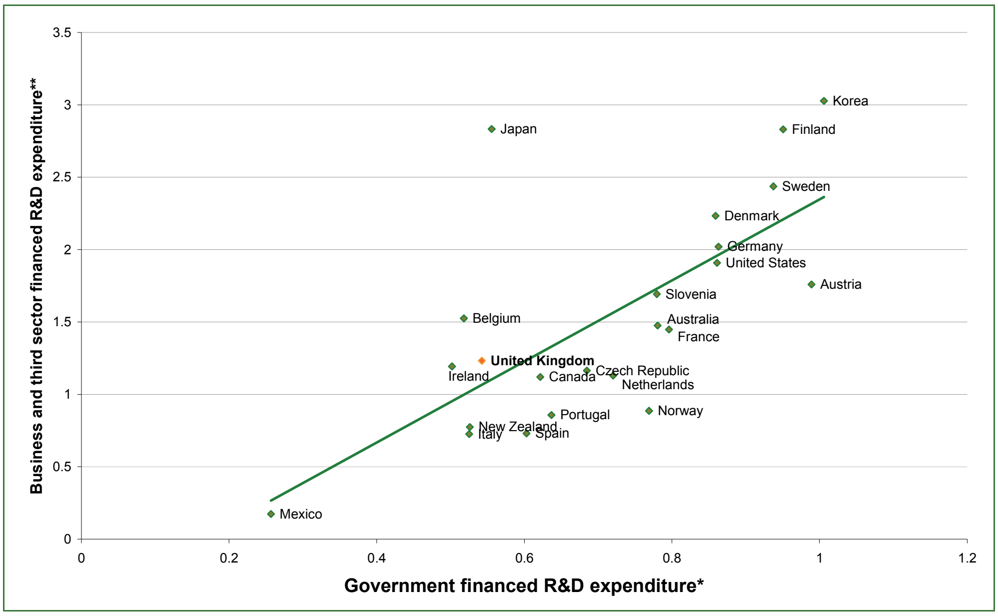
- foreign direct investment (FDI) in business funded R&D (e.g., in the form of research centres), and sometimes FDI in manufacturing capability; and
- foreign and domestic business R&D and innovation investment to exploit the knowledge and absorptive capacity of the country.

Not only does this dynamic enable a country to make the most of its own science and innovation investment, it also enhances its capacity to benefit from the investment in other countries. Public investment can therefore lead to a virtuous cycle of performance.

[16] Hughes and Martin (2012) review three studies suggesting there is complementarity. Scott (1984) also found this. He controlled for company and industry, and found that company-financed R&D intensity is greater in lines of business (detailed industry categories) where government-financed R&D is greater, hence pointing to complementarity. Falk (2004) found that "expenditures on R&D performed by universities are significantly positively related to the business enterprise sector expenditures on R&D indicating that public sector R&D and private R&D are complements". He found "a dollar increase in R&D performed by universities leads to an additional industry R&D of about $ 0.6 in the short run and $ 3.0 in the long-run." He also found complementarity between public-funded spending on business performed R&D and the R&D spending by businesses themselves.

27. While the causal links between public and private sector R&D investment are complex and path-dependent, the pattern of expenditure in the leading countries shows a marked correlation, as Figure 3 indicates. There are also several studies suggesting a demonstrable effect of public expenditure leveraging in private expenditure.[17]

Figure 3: Government and private sector financed R&D as % of GDP in 2011



Note: *Government financed R&D expenditure based on OECD statistics, **Total expenditure on R&D (GERD, Gross Expenditure on R&D) minus government financed GERD.
Source: OECD; BIS analysis

28. The UK's recent experience supports this. There was a significant increase in public expenditure on science and innovation from 2004 onwards, much of which was expressly intended to stimulate additional private sector investment.[18] Private sector investment did increase, as Figure 4 shows. In one of the constituent initiatives, for example, £220m awarded through the UK Research Partnership Investment Fund leveraged £615m from business and charities plus additional contributions from universities' own reserves.[19]

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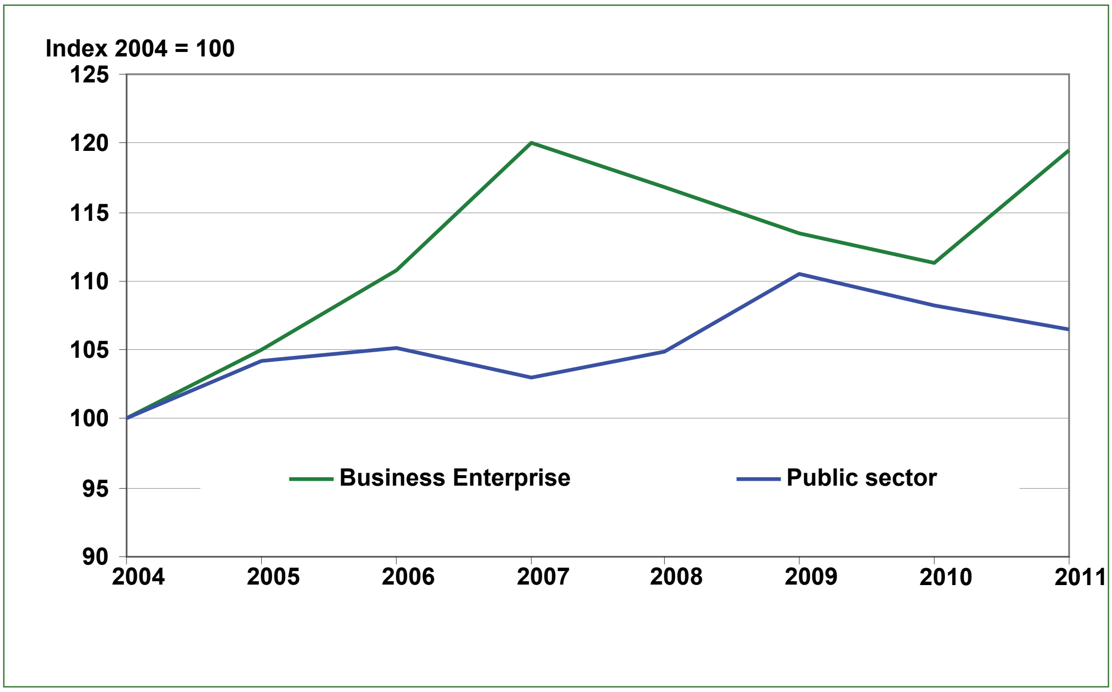
[17] Scott (1984); Mazzucato (2013)
[18] HM Treasury (July 2004)
[19] Department for Business, Innovation and Skills (June 2013)

Figure 4: UK R&D funded by public and business sectors 2004 to 2011



Source: *ONS; BIS calculations based on GERD*

Higher levels of spending are linked to superior outcomes, with little evidence of diminishing returns

29. It follows from the preceding section that success requires both public and private sector investment to be healthy: the private sector because it funds and carries out most of the R&D and is most closely connected with capturing value; and the public sector because it generates knowledge assets and absorptive capacity and because it also appears to leverage additional private sector funding.

30. As noted above, academic studies find a positive link between R&D investment and economic growth. Most of these find that that the link holds regardless of scale[20] − i.e., that there is not an obvious pattern of diminishing returns. The one academic paper[21] that suggests that there might be a point of optimum expenditure, beyond which the relative returns taper off, also acknowledges that the UK is still substantively below this level.[22] There is no evidence that the key comparator countries that spend more on R&D than the UK get poor returns on this investment. Indeed, most perceive significant positive value in continued investment and are aiming to increase their expenditure further.

31. There are many reasons why the overall levels – the critical mass, as it were – of spend matter. Most importantly, the positive dynamics and feedback loops described in Box A above and the systems map in Annex A suggest that science and innovation

[20] Guellec et al (2001)
[21] Coccia (2009)
[22] Coccia estimates the optimal R&D expenditure for labour productivity growth to be around the 2.3-2.6% of GDP range, which compares to a UK level of 1.8% of GDP in 2011.

systems may be subject to increasing, not diminishing, returns to scale. This hypothesis is consistent with the strong evidence on the effectiveness and efficiency of clusters.[23]

32. In addition, experts have stressed to us that some forms of R&D simply have to be carried out on a reasonably large scale. The cost of research equipment in some fields can be so high as to make it viable only for a large group of researchers engaged in a sustained programme. Examples include areas such as gene sequencing and aerospace. The same argument applies at a larger scale to international collaborations such as the European Space Agency and the Large Hadron Collider. Germany has set up a number of Helmholtz Institutions to provide large infrastructure that both the public and private sector can utilise, but which neither could afford to build and operate in their own rights.

33. There is also the fact that some fields are simply expensive to be involved in. In an interesting recent paper, Richard Jones stresses that long-term, substantial and targeted investment is particularly needed to secure technological progress in the realms of materials and biology, attempting to address challenges such as those relating to energy generation, improving aircraft and tackling diseases of old-age. He contrasts this with the low barriers to entry in the world of application (app) development.[24]

While higher efficiency may allow for lower investment at the margin, relying on UK's research productivity is not sufficient

34. Despite the findings quoted above, the efficiency with which expenditure is turned into outputs and outcomes clearly matters. It is sometimes argued that, given the UK's high research productivity, we can maintain global leadership in science and innovation despite a lower level of investment. As Box B in Chapter 4 shows, the UK does indeed achieve a very high quality and quantity of outputs for its investment in science.

35. There are, however, three reasons why relying on this alone is not sufficient. Firstly, focusing on measurable outputs, such as articles and citations, ignores the crucial role that R&D investment plays in building the country's absorptive capacity and hence its ability to turn knowledge into economic and societal benefits.[25] Secondly, international collaboration has been shown to be hugely beneficial for science and innovation performance[26] – but requires a meaningful level of sustained investment.

36. Thirdly, despite its strong research productivity, the UK's overall innovation performance is mixed (see Chapter 3); and its private sector R&D expenditure low (see Chapter 4). This, considered together with the evidence outlined above about the high returns to public sector R&D and its ability to attract private sector investment, implies that the UK's investment level is sub-optimal.

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[23] Sena (2013)
[24] Jones (2013)
[25] Griffith et al (2004)
[26] Elsevier (2013)

Annex E: Summary data on comparator countries' expenditure on science and innovation

37. This annex provides a summary of the data on key comparator countries' expenditure on research and development (R&D) and innovation. Much of this data has been referred to in Chapter 4 and in Annex C, but the tables below pull it together for ease of comparison.

38. Spending is often presented as a share of GDP in order to account for economy size. We have presented data below on this basis. However, we also believe that it is important to consider the scale of funding in each country. This matters because it is likely to be the case that the level of spending is one factor that determines the success of a science and innovation system. A large economy, such as the US, with the scale of their spending, is likely to be able to achieve outcomes that smaller nations could not. For this reason, we have also presented data below in absolute terms where relevant.

Country economic and population data

39. The latest year for which OECD R&D data (our main source of spending in science and innovation) is 2011. Table 3 uses 2011 data so that it is on the same basis even though more recent data on GDP, population and government expenditure is available. The GDP data is presented as US dollars in current prices based on Purchasing Power Parity (PPP). This means that the GDP data does not take into account inflation and adjusts for different exchange rates so that each dollar effectively buys the same amount of goods in each country.

Table 3: Size and composition of comparator countries' economies

	GDP	Population	General govt total expenditure as % of GDP	Private sector expenditure as % of GDP
	US $ billions, current PPPs	million	Per cent of GDP	Per cent of GDP
	2011	2011	2011	2011
	OECD	OECD	IMF	IMF residual
Australia	987	22.6	36.2	63.8
Canada	1,395	34.5	41.6	58.4
Finland	201	5.4	54.8	45.2
France	2,312	63.3	56.0	44.0
Germany	3,249	81.8	45.3	54.7
Japan	4,325	127.8	40.7	59.3
South Korea	1,483	49.8	21.4	78.6
United Kingdom	2,264	61.8	45.3	54.7
United States	15,534	311.6	41.4	58.6

Source: *OECD; IMF and BIS calculations*

40. The US is the largest economy in the world. The UK's GDP is similar to France, while Finland is the smallest economy out of the comparator group.

41. General government expenditure in the UK was 45.3% in 2011. The US (41.4%) is slightly lower, and Finland (54.8%) and France (56.0%) have a relatively high share of government expenditure as a share of total expenditure. South Korea at 21.4% appears to be an outlier. Private sector expenditure as a share of GDP is taken as the residual. It should be noted that each country might classify spending differently and this might account for some differences in the figures above. However, overall the UK's relative share of public and private expenditure appears to be broadly in line with most of the comparator countries.

Expenditure on research & development

Table 4: R&D expenditure (per cent of GDP)

	Government financed GERD*	Private and third sector GERD**	Total GERD
	Per cent of GDP	*Per cent of GDP*	*Per cent of GDP*
	2011***	2011	2011****
	OECD	OECD	OECD
Australia	0.8%	1.4%	2.2%
Canada	0.7%	1.1%	1.7%
Finland	0.9%	2.8%	3.8%
France	0.8%	1.4%	2.2%
Germany	0.8%	2.0%	2.9%
Japan	0.6%	2.8%	3.4%
South Korea	1.0%	3.0%	4.0%
United Kingdom	0.6%	1.2%	1.8%
United States	0.9%	1.8%	2.8%

Note ** GERD = Gross Expenditure on Research and Development. ** Private and third sector GERD is calculated as the residual of total GERD minus Government financed GERD. *** Data for Australia = 2008; Canada = 2010; France = 2010; and Germany =2010. **** Data for Australia = 2010*
Source: *OECD*

42. Total spending on R&D (right hand column Table 4) was relatively low in the UK (1.8%) compared with its comparator countries. USA (2.8%) and Germany (2.9%) spent more on R&D as a percentage of GDP, while Finland (3.8%) and South Korea (4.0%) were the leaders on this measure. Of the comparator countries, only Canada had a lower value (1.7%) than the UK in 2011.

43. This total spending on R&D has been broken down (left hand columns of Table 4) into ‘government financed GERD’ and ‘private and third sector GERD’ (the residual of total GERD minus government financed GERD). The UK (0.6%), Japan (0.6%) and Canada (0.7%) had the lowest share of government financed GERD as a percentage of GDP. South Korea (1.0%), Finland (0.9%) and USA (0.9%) had the highest values of the group in 2011.

44. The UK has the second lowest private and third sector expenditure on GERD as a % of GDP (1.2%) of the comparator group, with Finland (2.8%), Japan (2.8%) and South Korea (3.0%) the leading countries according to this measure.

Table 5: R&D expenditure (levels)

	Government financed GERD *US $ billion current PPP** **2011** **OECD**	Private and third sector GERD *US $ billion current PPP* **2011** **OECD**	GERD *US $ billion current PPP* **2011** **OECD**
Australia	7.7	14.0	21.7
Canada	9.3	15.0	24.3
Finland	1.9	5.7	7.6
France	19.2	32.7	51.9
Germany	27.6	66.1	93.7
Japan	24.0	122.5	146.5
South Korea	14.9	44.9	59.8
United Kingdom	13.0	27.2	40.2
United States	143.7	286.6	430.2

Note: *PPP = Purchasing Power Parity*
Source: *OECD*

45. As illustrated in Table 5 in 2011, the US spent almost as much on GERD as the rest of the comparator countries put together. The UK ($40.2 billion PPP) spends less on R&D than France ($51.9 billion PPP), despite it being a similar sized economy.

46. In terms of how GERD is broken down, government financed GERD is relatively low in the UK ($13.0 billion). Only Australia, Canada and Finland spend less than the UK. The UK also lags behind its main rivals according to the level of private and third sector spending on GERD.

Broader measures of expenditure on science and innovation

47. The above provides a good measure of spending on R&D. However, R&D spending only tells part of the story. Despite there being some overlap between the two, not all innovation spending - which is a broader concept than R&D – will be included in the R&D figures above. For example, some innovation spending, for example on training, software development or branding/marketing is not classed as R&D.

48. While it is important to consider other types of spending to attempt to get a more complete picture, it is important to note that data on innovation investment is not as clearly

established or as well defined as R&D, partly due to the nature of the investment. This makes it difficult to compare innovation expenditure across countries.

49. One proxy for total innovation expenditure is experimental development R&D. The Frascati Manual[27] defines experimental development as "systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units."

Table 6: Experimental Development R&D (Total)

	Per cent of GDP	*US $ billion current PPP*
	2010	**2010**
	OECD	**OECD**
Australia	0.8%	7.9
Canada	-	-
Finland	-	-
France	0.7%	16.4
Germany	-	-
Japan	2.0%	87.3
South Korea	2.3%	32.9
United Kingdom	0.9%	19.9
United States	-	-

Source: *OECD*

50. Data is only available for some countries. As Table 6 shows The UK (0.9%) has a lower percentage than Japan (2.0%) and South Korea (2.3%), though this is a higher percentage than France (0.7%) and Australia (0.8%).

51. A proxy for public sector spending on innovation is Industrial, Production and Technology (IPT) investment, a sub-set of GBAORD (Government Budget Appropriations & Outlays on R&D). This provides an estimate of the amount that government spends on innovation, both in terms of its own expenditure on innovation activities and its funding of other public sector institutions, the private sector and third sector.

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[27] OECD (Dec. 2002)

Table 7: Industrial production and technology (GBAORD)

	Per cent of GDP 2010 (using 2010 GDP) OECD	US $ billion current PPP 2010 OECD
Australia	0.06%	0.6
Canada	0.06%	0.8
Finland	0.26%	0.5
France	0.02%	0.3
Germany	0.13%	4.1
Japan	0.05%	2.3
South Korea	0.30%	4.3
United Kingdom	0.01%	0.2
United States	0.01%	1.1

Source: *OECD*

52. GBAORD comes from a survey of central government departments, so only reflects part of the public sector's funding in this area. Due to the fact that IPT is a sub-set of the headline GBAORD figures it also relies on those filling in the survey to correctly include investments in IPT. Further, accurate comparisons across countries rely on each country classifying expenditure on the same basis. Although this applies to all data sources, it is particularly relevant to IPT due to the level of disaggregation.

53. Table 7 highlights that South Korea (0.3%) and Finland (0.26%) have the highest share of spending on IPT as a percentage of GDP. The UK (0.01%) and the US (0.01%) have the lowest share. While the level of spending in the UK suggested by IPT data might be broadly of the right order of magnitude, the low percentage and absolute spending seen in the US according to this measure is not credible; public sector support for innovation in the US is likely to be much greater than these figures suggest. This leads us to believe that this proxy for innovation spending is imperfect. However, apart from the US, other countries are ordered roughly as expected, even if the order of magnitude is not exactly correct.

54. A broader definition of innovation might include investment in non-R&D intangible assets, such as staff training, software development and branding and marketing. The UK performs well according to a measure of intangible investment. While this may indicate that the above sources only tell part of the story, it is important to consider that the measurement of intangible investment is inherently difficult and much less developed than

other types of investment, e.g. R&D. Further not all intangible spend is necessarily innovation related and there is further discussion on investment on intangibles in Annex F.

Table 8: Investment in non-R&D intangible assets

	Software	Other intellectual property products	Brand equity, firm-specific human capital, organisational capital	Total investment in intangible assets
	Per cent of GDP	*Per cent of GDP*	*Per cent of GDP*	*Per cent of GDP*
	2010	**2010**	**2010**	**2010**
Australia	-	-	-	-
Canada	-	-	-	-
Finland	1.3	1.1	2.9	5.3
France	1.6	1.5	3.8	6.8
Germany	0.8	1.1	3.0	4.8
Japan	-	-	-	-
South Korea	-	-	-	-
United Kingdom	1.8	1.4	4.8	8.1
United States	1.7	2.0	5.4	9.2

Note: ** This excludes expenditure on R&D.*
Source: *Corrado et al (2012)*

55. Data is only available for certain countries. As shown in Table 8 the US (9.2%) had the highest share of investment in non-R&D intangible assets as a percentage of GDP. The UK had the second highest share at 8.1%. This data suggests that ‘traditional’ metrics of investment, such as GERD, only tell part of the story and that when non-R&D intangible investment is taken into account the UK performs more favourably

56. The above coverage shows that robust data on innovation spending for all comparator countries is not available. The proxy variables that are available only provide, at best, a partial indication of spending on innovation. And data coverage across comparator countries is relatively poor. A more robust accurate and consistent indication of investment in innovation across countries, both public and private, could significantly help our understanding of the science and innovation system.

57. As part of this project we have attempted to gather comparable data on public sector expenditure on innovation, focusing on direct support for innovation (such as grants), rather than indirect support (such as tax credits). Table 7 below shows the annual budget for the UK's innovation agency (the Technology Strategy Board) and similar organisations in Finland (TEKES) and Germany (Fraunhofer Institutes).

Table 9: Comparison of innovation bodies in the UK, Germany and Finland

Country	Innovation body	Budget 2013, £m*	Budget as % of GDP
UK	Technology Strategy Board	440	0.03
Germany	Fraunhofer Institutes	1600	0.07
Finland	TEKES	490	0.29

Note: *Average exchange rate for 2013 used €1=0.86 GBP*
Source: *Innovation bodies' websites; Eurostat [for GBP and exchange rates]*

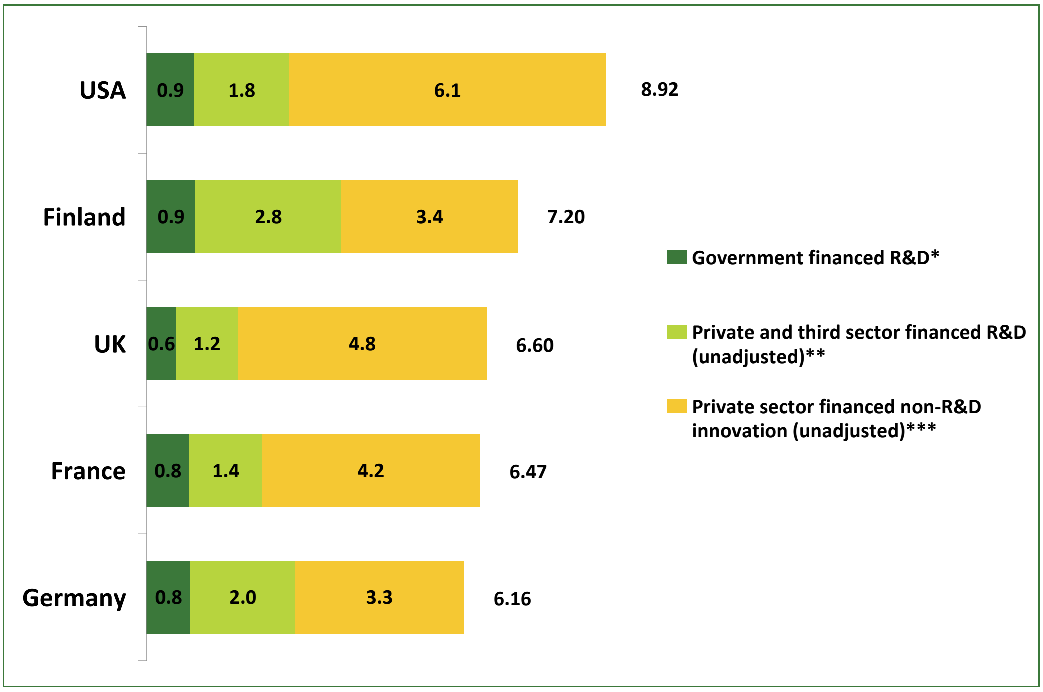
19. Table 9 suggests that the UK provides less public sector support for innovation in terms of total expenditure than Germany and Finland. The total budget of the German Fraunhofer Institutes is around 4 times larger than the UK's TSB. Finland's TEKES has roughly the same budget as the TSB despite Finland's economy being roughly one-tenth the size of the UK's economy.

Annex F: Methodological note on total R&D and innovation spend estimation

58. As discussed in Chapter 4, it is important to consider investment in intangible assets alongside R&D expenditure for three main reasons: first, it is a proxy for innovation investment and hence important in its own right; second, it is possible that BERD is under-recorded in service sectors; and third, an assessment of investment in intangibles might also indicate more broadly an environment that is able to absorb new ideas and use them.

59. This methodological note explains the calculations behind Figure 7 in the main report showing total R&D and innovation spend as a % of GDP, reproduced here, Figure 5, for reference:

Figure 5: Rough estimate of total R&D and innovation spend as % of GDP in 2011[28]



Source: *Corrado et al (2012); OEC; BIS analysis*

60. The first two sections for each country (the dark and light green sections) are calculated from OECD 2011 R&D statistics.

61. The dark green bar is "government financed R&D". While this is unlikely to include *all* public sector expenditure on innovation, at least some is included (given the nature of the questionnaire and that the definition of R&D and innovation involves some overlap).

[28] The details of the methodology used to derive estimates for the components of total R&D and innovation expenditure are provided at Annex F

62. The light green bar is calculated as the residual of total R&D expenditure (GERD) minus "government financed GERD". This is labelled "private and third sector financed R&D".

63. At this point, the sum of the first two sections of the bar adds up to GERD as a % of GDP. However, for the reasons explained above, in order to get a fuller picture of expenditure on science and innovation, we have attempted to measure expenditure on non-R&D innovation by using private sector intangible investment data. The rest of this annex explains the calculation of the yellow bar in the figure above.

64. The intangibles data are accessed at the following website: www.intan-invest.net. The latest year for which data are available is 2010 (data for Japan, South Korea, Canada and Australia are not available). Below, this dataset is referred to as "OECD data". A second data set[29], available only for the UK, was also used and is referred to as "NESTA data".

65. It is likely that some of the investment in intangibles is 'non-innovation' (e.g. expenditure on software maintenance, health and safety training etc.). In order to account for this, three adjustments were made to the OECD data:

- NESTA data (which already attempts to focus on purely innovation related intangibles) and OECD data (which includes all intangibles investment and therefore non-innovation intangibles) were compared for the UK according to each category of spending on intangibles. (2009 data were used because this is the latest year for which NESTA data are available). The difference between the NESTA data and OECD data for each category provides an indication of the adjustment that is needed to "remove" non-innovation expenditure from the international OECD data on intangible investment. It is assumed that the same adjustment for the UK data applies to the comparator countries, given that data is not available on the same basis for other countries. The magnitudes of these adjustments are shown in Table 10 below.
- A further adjustment was made to the data based on understanding of business practices, investment decisions and cost structures relating to each of the different categories of intangibles investment. While this adjustment is fairly subjective, it was decided that this was necessary to make the data more comparable and relevant for the purposes of the figure above. The magnitudes of these second sets of adjustments are shown in Table 11 below.
    i. In order to avoid double counting with the R&D figures (dark and light green bars), any intangible investment in R&D was excluded from the innovation related intangibles investment (yellow bars).

66. The resulting figures for an estimate of innovation-related intangibles (called "Private sector financed non-R&D innovation") were then expressed as a percentage of 2010 GDP (taken from www.intan-invest.net) and added to the R&D figures to produce the totals chart.

[29] From Goodridge et al (July 2012)

Table 10: First set of adjustments made on the basis of differences between the NESTA and OECD data for the UK in 2009

Category	% reduction applied to original OECD figure
Software	-12
R&D	0
Design	0
Entertainment, literary and artistic originals and mineral explorations	0
New financial products	-35
Advertising	0
Market research	-50
Training	0
Organisational capital	-46

Source: *Goodridge et al; Corrado et al*

Table 11: Second set of adjustments based on a judgement on what proportion of remaining expenditure (after the first adjustment) is innovation related

Category	% of adjusted* figure included in final estimate
Software	-12
R&D	0
Design	0
Entertainment, literary and artistic originals and mineral explorations	0
New financial products	-35
Advertising	0
Market research	-50
Training	0
Organisational capital	-46

Note: *Adjusted figure refers to the figures remaining after the 1st adjustment*
Source: *Goodridge et al; Corrado et al*

Annex G: Comparator country case studies

67. This Annex provides further information on the methodology behind the choice of comparator countries, the process of data collection and an overview of findings for each country.

Comparator countries were chosen based on existing evidence

68. Given the report timescales it was necessary to select a short-list of comparator countries. These were chosen following an initial trawl of available indicators from the OECD Science, Technology and Industry Scoreboard, INSEAD Global innovation Index and World Economic Forum Competitiveness Rankings. This was used to identify a short-list of countries that offered meaningful comparison to the UK, based on their overall performance in science and innovation:

- Australia
- Canada
- Finland
- France
- Germany
- Japan
- South Korea
- United States

69. Research was also carried out into a number of other countries. We have not included a detailed documentation of these, but this analysis assisted us in our thinking. These additional countries are:

- China
- Czech Republic
- Denmark
- Italy
- Netherlands
- New Zealand
- Poland
- Qatar
- Sweden
- Switzerland

70. A number of countries have not been included that may have been expected including:

- China has not been included as its scale and systems are so different from the UK, with interventions at state level being critically important. While China is becoming an increasingly important economy within the global science and innovation system, it is still emerging, and is therefore a less relevant point of comparison than other countries. Data for China on some key indicators is also not available, which makes comparisons between the UK and China difficult;

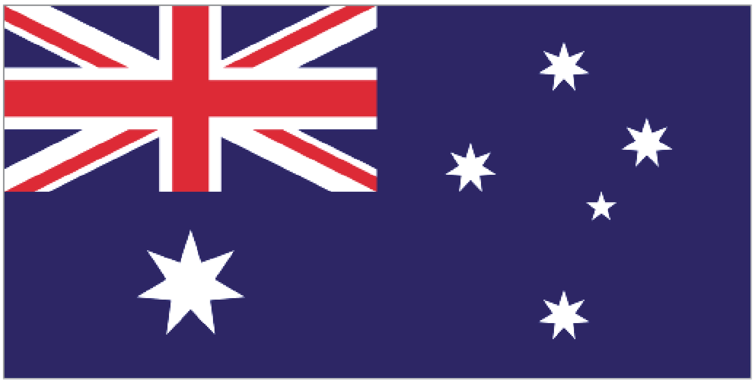
- Israel has not been included because it has been judged to be a special case. The scale of their R&D investment (4.2% of GDP) is at a level that is not realistically achievable for the UK in the medium term, and there are fewer general lessons from Israel's science and innovation system that can be used to inform the UK's system; and
- Singapore and Switzerland are other high performing countries which have not been considered. Again, we consider Singapore and Switzerland to be special cases, with limited general lessons to be drawn from in depth comparisons with the UK.

71. Information has been collected in a number of ways, including:

- quantitative evidence as discussed in Annex B, C and D;
- literature reviews (See Annex I);
- interviews with HMG's Science and Innovation Network in the relevant countries; and
- visits to a number of countries and interviews with key government officials and business groups.

72. The quantitative analysis of indicators is provided in Annex C and D. The rest of this chapter sets out the qualitative data collected from countries.

Australia



Many similarities exist between the Australian and UK science and innovation systems. However, Australia has higher levels of public and private R&D investment and a stronger focus on applied research and has a less conducive innovation environment than the UK (scoring below on the OECD ease of entrepreneurship Index). Whilst Australia has historic links to the West, it is increasingly focusing attention on the emerging Asian power-houses.[30]

Science and innovation environment

Responsibility for science sits with the newly created Department of Industry, with public funding for research distributed primarily via two bodies:

- Australian Research Council (ARC)
- National Health and Medical Research Council (NHMRC)

The Commonwealth Scientific and Industrial Organisation (CSIRO) (which is a significant force with 6500 staff) are unique to the Australian structure and are widely recognised internationally.

Key strengths	Key issues and weaknesses
• Overall research productivity, where performance is at or above international standards and high standards of scientific research (across most disciplines) • High levels of connectivity with the global research community • Good levels of scientific education • High proportion of the world international students	• Concerns around commercialisation of research from universities and low levels of research collaboration with industry • Weak in enabling and agricultural sciences • High levels of reliance on foreign students

[30] Australian Government (May 2012)

Emerging policy trends

- Focus on enhancing levels of international collaboration (Australia has no Science and Innovation network equivalent) particularly with Asia- recent announcement of new Colombo plan (funding undergraduate exchanges) and encouragement of foreign languages at high school.
- Improving links between academia and industry (Australia is behind the UK here, with cultural concerns in universities that this will affect their citation rates). The last government instituted precinct programme which has recently stalled – but CSIRO report success in initial tranche with businesses co-locating with universities.
- Concerns that the high reliance of many universities on revenue from international students is unsustainable, with some getting between 20-40% of their annual incomes from fees;.
- The government is being called on to produce a strategy to focus direction of travel on priority areas.
- Food security – a key concern for Australia and focussing policy makers on need to increase strength in agricultural sciences.

Perceptions of the UK	Points of interest for the UK
• Australia sees the UK as the old world with only historical links- it sees Asia as the way forward	• Lessons to be learned from widely recognised CSIRO model • Impact of reductions in basic research funding vs applied research over last 20 years • The future impact of recent significant reductions in HE spend (inc masters) in favour of school level investment • Impact of 2011 tax breaks for companies investing in R&D in Australia

Canada

Science and innovation in Canada are politically driven with funding targeted at high priority areas. Despite a strong research base Canada lags behind other OECD nations in the area of innovation. The most recent federal budget announced significant cuts in the science and innovation budget (10%) on a par with those experienced in the mid-1990s. Recent report by the Council of Canadian Academies describes Canada as enjoying an excellent international reputation for science, with a science and innovation sector that is healthy and growing in terms of both output and impact.[31]

Science and innovation environment

Canada's science and innovation policy is based on the 2007 report Mobilising Science and Technology to Canada's Advantage. It aims to foster Canada's competitiveness through the role of the private sector in innovation, research excellence, strategic R&D and knowledge-based workers.

Overall policy is formulated by the Prime Minister and Cabinet with the Science, Technology and Innovation Council acting as an advisory body.

Policy is implemented by Industry Canada and the Department of Finance with the science based departments and agencies. Canadian provinces have a high degree of autonomy and develop and fund R&D policies for their own regions.

Key strengths	Key issues and weaknesses
• Strong research base • Tax credit system in R&D is the largest in the world (can also be used by foreign companies)	• Funding unstable and politically driven – flat funding over recent years has meant a cut in real terms • Overall view that Canada could be better at commercialising research findings • Lack of academic postings with high demand for each Post • Small start up and spin off market (due to risk aversion)

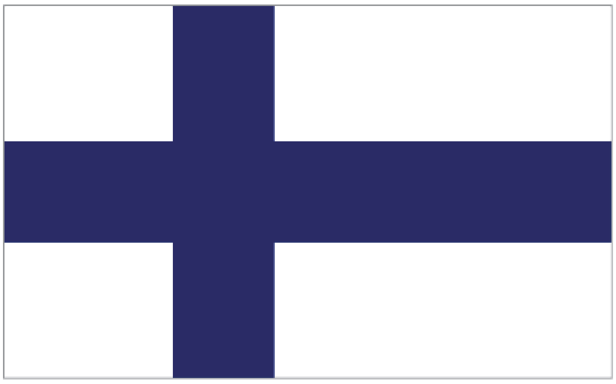
[31] Council of Canadian Academics (2012)

Emerging policy trends

- Government leaning towards the need for an increased focus of applied over basic research – driven by its desire to increase research economic value.
- Push to attract international talent to improve the mix of people at national level.
- Canadian Government has been taking steps to increase industrial R&D: doubling the amount of money that goes to the Industrial Research and Assistance Program (IRAP), restructuring the National Research Council to put more emphasis on business-oriented research, increased investment for 'incubator' organisations and setting up national centres of excellence (similar to catapults)
- Technology priority areas are environmental sciences, natural resources and energy, heath and life sciences and ICT

Perceptions of UK	Points of interest for the UK
• Strong historic connections, shared language, similar political and health systems and comparable demographics have helped to foster excellent science & Innovation relationships • Canada has followed the development of the UK's Innovation Strategy very closely	• Ongoing impacts of 1990s cuts in government funding and impact of insecurity of funding • Lessons from Canada's drive to increase industrial R&D – successes and failures

`Finland



Finland continues to rank in science and innovation, with one of the highest levels of investment in R&D (GERD) in the world at 3.8% of GDP. Finland continues to be committed to R&D and innovation as a driver for economic growth, and has traditionally focused on the high-tech communications sector, with Finnish company Nokia being central. However, has raised issues in recent years as Nokia declines and remodels. Finland has a highly educated population with free higher education that is accessible to all based on competitive selection. Universities of Applied Sciences provide training in vocational and technical skills.

Science and Innovation Structure

Funding for science and innovation is administered by a number of organisations such as:

- The Academy of Finland finances high quality scientific research with a focus on basic research
- Tekes supports innovation. It concentrates on provided funding from applied research through concept development and commercialisation. It is increasing its emphasis on service firms, non-technical innovation and SMEs and away from industrial and technological R&D.
- Sitra is responsible for financing technical research and development, and covers multiple technical research, educational and venture capital activities

Finland has strategic centres for Science, Technology and Innovation (SHOKs), which are cooperation platforms for innovative companies and research that look to engage in intensive and long term work to achieve shared goals (similar to Catapults).

Finnvera, is a specialist financing company owned by the State of Finland. It provides loans, guarantees, venture capital investments and export credit guarantees, and looks to strengthen the operation potential and competitiveness of Finnish enterprises. Finnerva operates within the goals laid down by the government, which include increasing the number of start-ups, promotion of enterprise growth, internationalisation and exports.

Finland has a large number of universities relative to its population, and recent changes to the law have increased their autonomy. The majority of students in Finnish Universities will study four year courses resulting in a master’s degree.

Key strengths	Key issues and weaknesses
• Finland is committed to sustaing a high level of public sector funding with the aim of reach 4% of GDP • Following Nokia redundancies, Finland has a high number of software developers, many of which are starting their own companies, or attracting foreign investment. • Finland has a free higher education system • Finland has good internal collaboration between academia and industry, helped by its relatively small size	• Finland has been heavily reliant on Nokia's success over the last few decades and its reductions have hit the research community hard • Finland does not have any world class universities, which makes it difficult to attract international talent and students

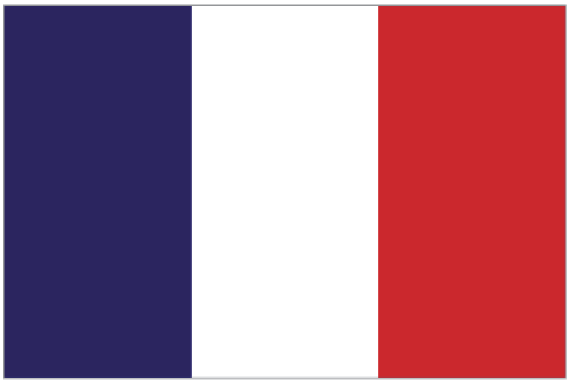
Emerging policy trends

- Tekes are looking at providing support services along side funding in order to assist companies and researchers in commercialising. Aspects of funding offers are being ring-fenced for commercialisation research.

- Finland does not currently attract large numbers of international researchers or students, but is looking at how to increase these numbers- and pushing for a world leading university. Recently three universities have been combined to form a single Aalto University, with the hope of attracting international researchers.

Perceptions of the UK	Learning points for the UK
• The UK is the top destination for Finnish students studying abroad • Finland is generally impressed with the UK's strategic approach to science and innovation	• Finland continues to spend on R&D and innovation, as they see this as key for growth • Finland is providing support services alongside finance to ensure success

France



France is one of the world’s top five economies and has several knowledge intensive sectors. In 2011, France spent 2.25% of GDP on R&D, with 1.32% from business. Although France ranks fifth in the world in terms of cited scientific publications, it scores less well on innovation, ranking twentieth in the latest Global Innovation Index. According to the OECD, France now has the most business –friendly tax treatment of R&D amongst its members (equiv. EUR4.5 billion in R&D tax credits in 2010).

Science and Innovation Structure

The French S&I system is complex and multi-layered, with strategy and prioritisation largely being set by Government. A new Strategic Research Council, reporting directly to the PM, was set up in January 2014 to take charge of defining the research strategy and priorities.

Public research takes place in universities and research agency labs. France is home to the world's largest multidisciplinary research agency, CNRS, and other reputed public research agencies such as INSERM (biomedical), CEA (energy) and INRA (agronomy). The Research Alliances, which gather representatives from all research agencies into virtual thematic institutes, are responsible for prioritisation of research programming and strategic orientation. The National Funding Agency, ANR, manages and allocates project funding on a competitive basis.

The university landscape remains largely divided between the elite *Grandes Ecoles* and the public universities, including a number of strong research universities. Recent reforms have allowed universities greater autonomy with their budgets, with an increased emphasis on public-private research partnerships.

Initiatives to promote technology transfer and innovation include the 71 thematic geographical clusters, which have received €6m since 2006 for projects that bring together research, academia and industry, and the Carnot Institutes, which receive extra funding on the basis of research contracts with Industry.

The eight Institutes for Technological Research, which are comparable to Catapult centres, select key strategic areas for industry and build on existing centres of excellence.

A new public investment bank, Bpifrance, provides a range of services in support of business innovation, including subsidies, loans and direct investment. In 2013, Bpifrance and the European Investment Fund (EIF) signed a guarantee agreement to support lending to SMEs under the Risk Sharing Instrument (RSI), a joint initiative of the European

Investment Bank Group and the European Commission. The new agreement allows Bpifrance Financement to provide EUR 200 million of loans to innovative companies, with the support of a 40% EIF guarantee with EU financial support under the Seventh Framework Programme for Research and Development (FP7). Bpifrance Financement has developed a specific product ("Prêt pour l'innovation" - PPI) for innovative SMEs and Small Mid-caps in France, offering reduced interest rates and collateral requirements thanks to the Risk Sharing Instrument.

Key strengths	Key issues and weaknesses
• Funding levels are stable • Good track record for managing large complex projects	• Weak collaboration ties between the public sector and industry • Relatively few top universities • Over complexity of support landscape

Emerging policy trends

- France sees investment in HE and Research as a key driver of innovation. In 2010, the Sarkozy government launched the €35bn Investments for the Future programme from the sale of government bonds, of which €21bn was allocated to HE and Research. Of this total, only around €6.5bn was spent upfront, the rest generating interest to help fund further spending over time. The objective is to invest in university and research facilities, new institutes aimed at promoting public/private sector research partnerships as well as university hospitals, biotech, aeronautics, nuclear and space over 2010-2020. Through the programme, the government also hopes to create 8-10 internationally competitive research and Higher Education clusters (including in Paris, Saclay, Bordeaux and Grenoble). The Hollande government has launched further waves of funding to promote further projects of excellence.

- In 2013, France passed a new Higher Education and Research law that looks to create a HE system that increases French universities' internationally standing, better prepares students for the world of work and simplifies the research system and how research projects are evaluated.

- Improving the economic impact of publicly funded research is a particular priority. In June 2012 a new national research framework, *France Europe 2020,* was launched which looks to create a new emphasis on transfer and innovation, building on the excellent research base as a way for technological development, competitiveness and economic growth. This programme is aligned with Horizon 2020 and will look to address societal, scientific and technological challenges as well as orientating public policy to support research.

- In April a new Innovation 2030 commission was launched. This looks to lead experts from various sectors to identify economic sectors and technologies in which France could become a world leader by 2030.

Perceptions of the UK	Learning points for the UK
• Good place to recruit from and to collaborate with • Has a good balance across sectors • English is a major advantage • Catapult centres are being looked at with interest	• Balance between generosity of tax credit system and tax system

Germany

Germany is the largest innovator in Europe with a strong focus on export and a reliable base of internationally competitive firms. Germany has high public spending on science and innovation with corresponding investment by the private sector. Germany is good at attracting international talent, particularly to its Max Planck Institutions and Fraunhofer Institutions that are well funded; however, retention is low outside of Max Planck Institutions. Germany is convinced of the need to carry out basic research and continues to fund it at a sustainable level. The general population is accepting of the need for spending on science and innovation in order to drive growth.

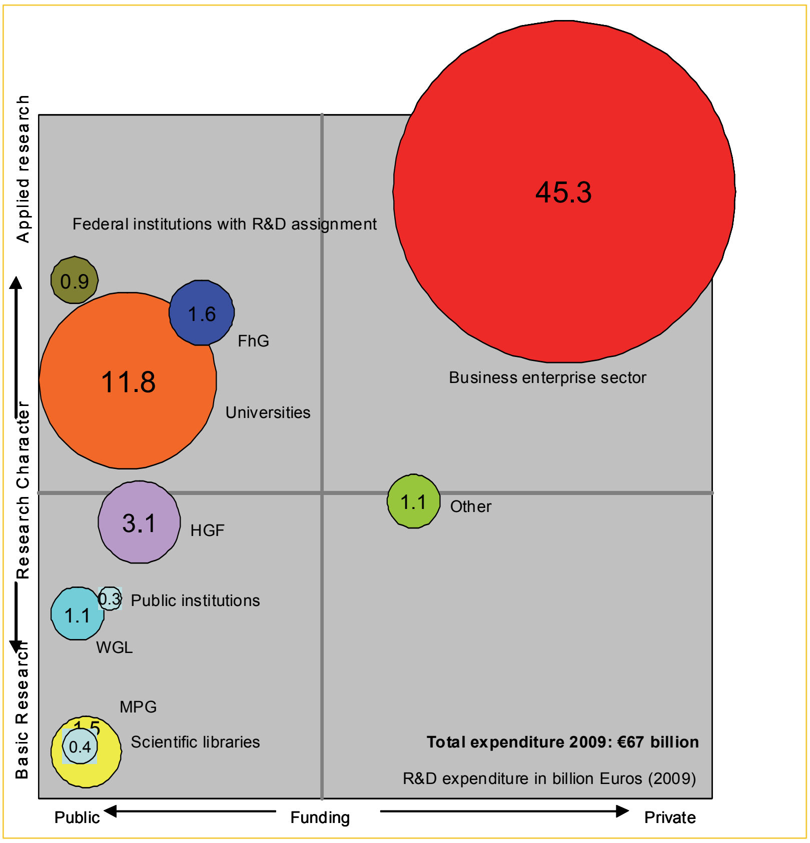
Science and innovation environment

In Germany both the Federal Government and states play an important role. The Federal Ministry of Education and Research directs public R&D activities towards particular areas of technology, and the Federal Ministry of Economics and Energy along side the KfW banking group (German government-owned development bank) oversee and fund innovation projects.

Germany has a number of distinct public organisations designed to support and promote science and innovation and these have large budgets. Whilst there is little overlap there is a lot of collaboration.

- The Max Planck Institute concentrates on basic research, and looks to attract leading researchers from Germany and internationally to undertake research. There is a clear focus on research fields that are particularly innovative or that are especially demanding in terms of funding or time requirements.
- The Helmholtz Association Institutes contribute to solving grand challenges and focus on complex systems which affect human life and the environment. Helmholtz receive around a third of its funding through contract work and run a number of large research infrastructures.
- The Leibniz Association is a union of non-university institutes from various branches of study who work in an interdisciplinary fashion connecting basic and applied science as well as forging cooperation with universities, industry and international organisations.
- The Fraunhofer institutes focus on different fields of applied research, whilst some funding is provided by the state around 70% is earned through contract work (government and industry). There are a number of overseas Fraunhofers in the USA, Asia and South America.

Figure 6: Relative spending on various components of the German Research landscape



Source: *Federal Ministry of Education and Research (2012)*

Germany's science and technology system is very different from the UK given the large number of public institutions. This reduces the role that universities play in basic and applied research and allows a greater focus on teaching, however there is strong collaboration between the various institutions. Universities are also funded at a local level which has contributed to Germany having few world-leading universities.

Career progression paths start at an early age, around 11-12, and determine a university or vocational study path, and around 37% of the population are engaged in science and technology work.

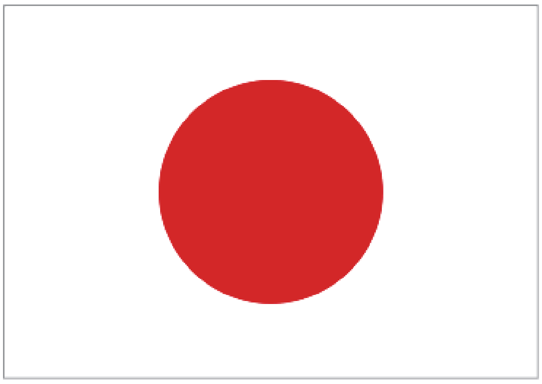
Key strengths	Key issues and weaknesses
• Strong international ties • High investment, with a strong understanding of the need of the general population • Large public infrastructure, available for both public sector and industry • Max Planck Institutes attract high numbers of international researchers • The Fraunhofer model is world renowned , and is Europe's largest application orientated research organisation	• Limited access to finance for start-ups and SME innovation projects • German universites are behind UK universities in attracting international talent, this is in part due to the role of other public institutions and a lack of world-leading universities

Emerging policy trends

- The High-Tech Strategy 2020 has identified five sectoral and global challenges (climate, nutrition/health, mobility/transport, security and communication), and aims to create lead markets and help drive innovation in key technology areas.
- Initiatives are underway to further increase collaboration between business and sciences including the Leading Edge Cluster Competition, Excellence Clusters, Research Campus and Research Binis.
- The Strategy for the Internationalisation of Science and Research looks to help German companies enter into partnerships with the worlds most innovative centres.
- Germany is looking to improve secondary schooling, increase tertiary attainment rates and addresses a lack of expertise in STEM subjects.

Perceptions of the UK	Points of interest for the UK
• Strong university research base at a few top institutions • Good venture capital and relatively good spin-off culture (but not comparable to US) • Less funding available than in Germany due to austerity • No long term vision – frequent changes (in contrast to German long term planning and also career paths)	• Germany is able to justify its science and innovation budgets by having a population that is aware of the benefits of science and innovation • Large public institutions are able to contract work in

Japan



Japan has high quality research at all levels and stands out for its consistently high levels of investment In R&D (11% world spend) and is the world 2 largest science and technology base. Japan's business sector is responsible for over ¾ of GERD and its top ten private companies spend more on R&D than the whole of the UK system. Japan tends to be problem focused in its R&D and innovation rather than idea focussed. Up until 2004 university-business collaboration was limited in Japan, however changes in legislation followed by other policy measures are now being taken to foster collaboration. Japan is characterised by a strong focus on in-house rather than university training to develop its skills base. Japan is now seeking to expand its international science and innovation links to foster innovation.

Science and innovation environment

State support for science and innovation research has traditionally been spread across a wide range of Ministries with varying levels of strategic direction with the Ministry of Education, Culture, Sports, Science and Technology (MEXT) typically receiving around two thirds of the overall budget. The Cabinet office through the Council of Science and Technology Policy (CSTP) has recently taken a greater leadership role and now has some budgetary responsibility. There are two main public sector funded research institutes: Japan Science and Technology Agency (JST) and the Japan Society for the Promotion of Science (JSPS). Japan has a strong network of national research institutions – with the majority set up to stimulate interaction between academia and industry.

Key strengths	Key issues and weaknesses
• Iterative innovation • High levels of private sector in-house R&D and protected public sector spend • High percentage of students take science subjects – with science emphasised at all levels of education • Strong performing universities compared to others in Asia-Pacific • Strong acceptance and knowledge of science in basic population • Identification of gaps in skills set and action taken • Stable funding regime	• Links between academia, industry and Government highly fragmented • 'Brain Drain' of Japanese researchers being drawn away • Hierarchical structures • Isolation and lack of international networks • Little scrutiny of the science spend as it is seen as a cornerstone for Japan • Less mobility of highly skilled people between private and public sectors • Inflexible funding systems (most of JSPS and JST funding resource has to be used within a fiscal year so less flexibility to continue multi-year projects) • Siloed Ministries mean public sector science and innovation spend not well coordinated

Emerging policy trends

- Challenging systems for innovation and research based around the 'big corporation' model – which is increasingly seen as isolating Japan from the wider global system and stemming innovation
- Increased focus on the need for international collaboration, with introductions of new funding streams in this area and targets for increased numbers of international researchers
- Ambitions to be the top innovation economy in 5 years
- Movement away from a sectoral to societal challenge approach to funding allocations e.g. the aging population
- Japan has one of the world's highest patent rates but has to look at how it ensures commercialisation of returns. Previously there has been little concern about IP leakage as research is kept in house with strong staff loyalty. With higher employee mobility Japan is considering how to deal with this.

Perceptions of the UK	Learning points for the UK
• The Japanese respect the UK's intellectual capacity and tradition, but do not generally associate the UK with high tech (although this is less the case when you go down to practitioner level) • UK strengths seen as excellent science base, stability, knowledge transfer through University-Business collaboration and as a hub for international networks. Absence of easily identifiable UK national research bodies poses a challenge for Japan. • The UK model of government scientific advice resonates with Japanese and they are considering its adoption • Strong profile of science community and a range of activities related to science for society and public engagement	• Japan's failed target driven approach to increasing its competitiveness in biotech is an example of potential pitfalls in incentivising behaviour • How Japan's research institutes operate and how successful they are in stimulating innovation • How Japan has successfully approached iterative innovation taking problem rather than idea focused approach (Toyota particularly strong example) • How Japan has integrated acceptance of science into the general population

South Korea

South Korea has made significant increases in its Science and Innovation funding over the last 10 years, and is now a world leader in terms of R&D intensity. It has a strong base of very large firms with a focus on information and communication technology, automobiles, construction and shipbuilding.

South Korea is seen as having an insular business environment which has lead to little internal or international collaboration. South Korea has a strong education system and continues to score highly on Pisa tests with a strong appreciation and acceptance of the need for science and innovation in the wider population. Whilst universities play a minor role in R&D and are historically seen as teaching institutions, South Korea has a strong infrastructure of Government funded national applied research institutions and laboratories. South Korea is heavily dependent on Business R&D which is generally undertaken by large conglomerates in house and focuses on problem solving research. The government is starting to realise the need for basic research for future growth and is quickly increasing funding for this area. Science and innovation are perceived as good career prospects, but there is still a focus on large companies over SMEs or academia.

Science and innovation environment

In South Korea science and innovation is overseen by the National Science and Technology Council (succeeding the National Science and Technology Commission) and the Presidential Advisory Council on Science and Technology (PACST). These councils are responsible for establishing the vision for national Science and Technology development and advise the President.

Innovation policy is mainly set by two ministries; the Ministry of Education, Science and Technology and the Ministry of Trade, Industry and Energy, however, as in the UK many other Ministries are involved to a lesser degree.

South Korea is very reliant on a number of large and competitive conglomerates which has led to a large gap between large and small companies, with many SMEs slotting in to conglomerate supply chains. This means that large conglomerates generally attract the top talent to the detriment of SMEs.

South Korea has a strong education system with a high level of STEM literacy, however the teaching methodology does not support the development of creativity. Work is ongoing to integrate arts and humanities into STEM subjects to try and increase creativity. Careers in science and innovation are seen as good prospects as long as it is in the private sector; academia is not highly regarded or paid.

Key strengths	Key issues and weaknesses
• South Korea has build up a strong high-tech manufacturing base in a short space of time • Good at adapting quickly and following new processes • Students perform consistently highly on global indexes of science, maths and literature • There is a national consensus on the importance of science and innovation	• Limited international collaboration, with limited inward flows of talent • Poor interaction between companies and academia and SMEs- R&D landscape dominated by the indigenous private sector • Spin offs are not occurring from Universities as limited research is taking place there • Lack of entrepreneurial skills in the general population • Lack of free-thinking at universities

Emerging policy trends

- Strong forward focus on improving quality of life and the creation of job opportunities as outlined in the 2013 third Science and Technology 5 year basic plan. It is hoped that by 2017 the contribution of R&D to new economic growth will reach 40%, there will be 640,000 new job opportunities and that Koreas science and innovation capability will increase in international standings. Five main areas of development with 30 priority technologies and 120 strategic technologies have been identified.

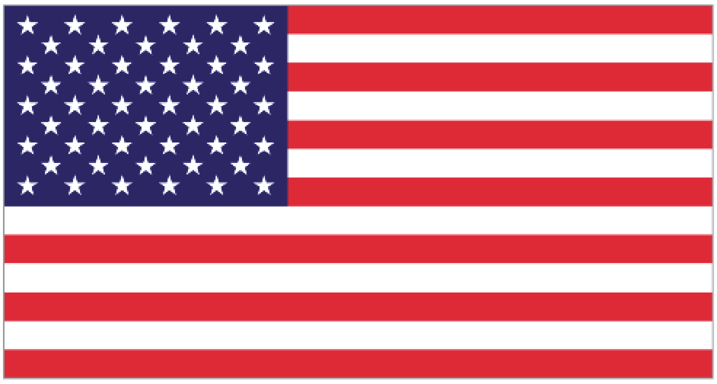
- A significant injection of capital has focussed concerns over the efficacy of the evaluation process and the need to avoid overlapping grants and improve investment efficiency,

- In order to plug emerging gaps in South Koreas skills offer, the government is creating specialist Science and innovation high-schools.

- Previously spin offs from universities have been unfavourable to the researcher as the universities control the IP, however, the Government are starting to realise this causes an issue and are looking at how to deal with this.

Perceptions of the UK	Points of interest for the UK
• South Korea is aware of the UK's strength in industrial R&D, however there is little awareness of the UK's continuing strength in engineering and manufacturing research excellence. • The education of science in UK schools is seen as a UK weakness in comparison with Korea, with 2013 OECD Pisa results an indication. • Despite appreciation for the UK's high research output, Korea perceives UK GERD as very low, with limited potential for financial support of bilateral research programmes. • UK is yet to be seen as a natural bilateral partner for Korean researchers, with the US and Japan as traditional collaborators due to historical researcher education trend.	• There is a need for balance in education to ensure creative thinking

United States



US is the global centre for science and innovation. It is responsible for around 34% of the world's total R&D spend; publishes over 60% of the world's highly cited publications; employs 25% of the world's researchers; is responsible for nearly 40% of OECD patented new technology; and is home to over half of the top 100 universities in the world. The UK-US scientific partnership is the world's strongest with nearly 30% of the UK's co-authored papers being with the US. President Obama has put science and technology at the heart of the agenda for his second term in office but with uncertain federal budgets, the Administration has prioritized certain science and technology areas. This situation resulted in a decrease of up to 5% in many budgets in FY2013, although most funding agencies have seen a small rebound for FY2014

Science and Innovation Structure

With the exception of National Institute of Health (NIH) and the National Science Foundation (NSF) all US funding comes from mission agencies. The Government takes a highly passive role in the innovation system.

Key strengths	Key issues and weaknesses
• A large and well functioning system with high levels of funding: the US has a workforce of around 6 million scientists and engineers and is estimated to spend $440 billion on R&D in 2013 • Strong sector or mission focus of all funders – provides clarity of funding and key partner for collaboration • Multi-agency Small Business Innovation Research Programme	• Relative instability of funding over recent years • Lack of scientific workforce at technician level leading to inefficient use of PhD resource • System very dependent on its size to function well and ensure balance across sectors and types of research

Emerging policy trends

- Ambition to have the highest proportion of college graduates in the world in 2020 – this is one of the least partisan issues in Congress.
- A general drift towards embedding business studies in STEM courses (this is as a result of the market rather than a policy shift per se) – driven by concern that America's best students are not entering STEM fields

- Within the innovation community there is a debate on whether the US government should play a more proactive role in innovation space and 'pick winners'

Perceptions of the UK	Learning points for the UK
• The UK is viewed as a partner of choice. In most sectors, the UK is viewed as part of a top tier globally. Common language and high-quality peer review are huge advantages. • Amongst think tanks and academics in innovation field the UK is viewed very highly. The Technology Strategy Board is seen as a prototype for something that should exist in the US to bring idea to market more quickly, the four year funding cycle is viewed with jealousy.	• Strong correlation between industry and public funding levels • The US institute led model and how this benefits the operation of their system

Additional country notes

Qatar:

- Qatar is an emerging science and innovation country with high levels of public investment, which is finding difficulties in leveraging private investment as they are as yet an unproven player but are looking to link contracts with research investment. Through the Qatar National Research Fund (QNRF) National Priorities Research Programme Qatar provides significant financial support for Qatar/international research partnerships that meet the requirements of the National Research Strategy.UK research groups are partnering in 69 projects worth up to $1 million over 3 years. There are a number of larger bilateral research investments including a Carbonates and Carbon Storage Research Centre, a Biobank, a Cardiovascular Reseach Centre, a Robotics Surgery Centre and a Stroke Register. Historically Qatar is linked to the UK as many of their scientists were educated in the UK. There has been a recent shift to the US, following a number of US satellite campuses opening in Qatar. Employment in science and innovation is not highly rated, however it is attracting an increasing level of female scientists. Qatar has in the past accused the UK of failing to engage in education and research collaboration, but this perception is changing.

Switzerland:

- Switzerland is a strong performer in science and innovation with strong international links and good export potentials. It values human capital highly given their lack of natural resources and universities are of a high standard. Mobility both domestically and internationally is seen as essential to develop skills and is actively encouraged. Switzerland's universities are also world renowned and attract international talent to study. Failure is discouraged in Switzerland; however, universities have well funded tech transfer offices which look to guide spin-offs through the valley of death.

Czech Republic:

- The Czech Republic is a country with strong scientific traditions, a young population of well qualified people and a strong commitment to increase science and innovation spending (1.89% of GERD in 2012). There is a relatively stable funding with science and innovation perceived as an ideal opportunity for national growth. The UK is seen as a role model and can be a good influencing factor in sharing the best practice. Czechs have invested over £3.7bn of EU Structural and Cohesion funds in 2007- 2013 into R&D and will continue to significantly invest in 2014-2020. Czechs still have to improve their business-university research collaborations and research evaluation strategy. Their newly build large research infrastructures are only starting to attract international talent.

Netherlands:

- Political changes within the country have resulted in cuts to the research budgets, with a withdrawal of money previously ear-marked for R&D. However, regional funding has been increased, with the independent promotion of regions internationally. The Government is keen to promote engineering skills and is engaging children at a primary school level. Previously scholarships were given in key STEM area, however following reviews it was concluded that individuals would have carried out these subjects without the bursary.

Italy:

- Italy has a strong historical representation for science and innovation, with a notable critical mass of internationally well reputed research institutions. It also remains a major player in many international large scale infrastructure projects. However, Italy is facing a brain drain of its highly qualified researchers; in part this is down to a capping of academics salaries and poor career progression, making it difficult to attract talent. The Government is aware that this is an issue and is looking to attract talent into the country, and Italians back as well as encourage STEM subjects at schooling level.

China:

- China has a large talent pool, however only around 10% of STEM graduates meet the standards required by international companies, and only 0.4% of graduates are from overseas, employment regulations also makes importing talent expensive. China is focusing on its seven Strategic Industries and innovation is seen as key to maintaining growth rates and solving national issues

Poland:

- Poland is looking to improve the quality of its higher education, research, academia and business interactions. To address the forthcoming demographic change, the government is trying to attract foreign students and be more open to mature students. In 2011, a multiannual Top 500 innovator programme was introduced, which looks to train 500 people in the commercialisation of research and will work as brokers to improve contact between academia and business. The Polish science and innovation landscape is dominated by large companies, mainly with foreign investment and many innovations from local SMEs are being exported. Some incentives have been put in place to rebalance funding and move toward greater private sector investment.

Denmark:

- Denmark has a high level of investment in R&D (3.1% of GDP), with an increasing focus on strategic and applied research, which has raised concerns in the research community that it has become too difficult to obtain funding for basic research. Denmark has relatively poor interaction between the various sectors but there is strong political will to improve this. Universities have previously been seen as available to a few, but with increasing numbers enrolling at universities there are concerns that this will affect the performance of those at the top, and there is a refocusing to strengthen the provision of non-university education to provide hands as well as brains.

New Zealand

- New Zealand is in the process of strengthening what has been historically weak research-industry ties, through Government funding leveraging industry funding. Historically institutions have been competitive in New Zealand, which has been encouraged by the funding model. New Zealand has managed to balance its flow of international talent with its domestic talent, with a realisation that it is unable to train for all areas.

Sweden:

- Sweden is ranked highly on innovation scoreboards. It comes first in the Commission's newest Innovation Indicator, and second worldwide in the Global Innovation Index 2013, with continued high investment in research (3.4% GDP - fourth in the world with the eventual aim of 4%). Sweden's private sector funding is dominated by a number of large firms, with the top 10 accounting for 55% of business R&D spend. Despite this strength, the future picture is less certain, with Sweden facing challenges, particularly in private R&D investment, and the perceived quality of Swedish research.

Annex H: Abbreviations

ARC	Australian Research Council
BERD	Business Enterprise Research and Development
CSIRO	Commonwealth Scientific and Industrial Organisation
CSTP	Council of Science and Technology Policy
ETHZ	Swiss Federal Institute of Technology in Zurich
EU	European Union
FE	Further Education
FTA	Free Trade Agreement
FDI	Foreign Direct Investment
FY	Financial Year
GBAORD	Government Budget Appropriations and Outlays on R&D
GDP	Gross Domestic Expenditure
GERD	Gross Domestic Expenditure on R&D
GFCF	Gross Fixed Capital Formation
GVA	Gross Value Added
HE	Higher Education
ICT	Information and Communications Technology
IP	Intellectual Property
IPT	Industrial Production and Technology
IRAP	Industrial Research and Assistance Program
JSPS	Japan Society for the Promotion of Science
JST	Japan Science and Technology Agency
MEXT	Ministry of Education, Culture, Sports, Science and Technology
NHMRC	National Health and Medical Research Council
NIH	National Institutes of Health
NSF	National Science Foundation
OECD	Organisation for Economic Co-operation and Development
OECD MSTI	OECD Main Science and Technology Indicators
OECD PISA	OECD Programme for International Student Assessment
IPT	Production and Technology Investment
PACST	Presidential Advisory Council on Science and Technology
PIAAC	Survey of Adult Skills
PPI	Prêt pour l'innovation
PPP	Purchasing Power Parity
QNRF	Qatar National Research Fund
R&D	Research and Development
RCA	Relative Comparative Advantage
S&I	Science and Innovation
SBRI	Strategic Business Research Initiative
SMEs	Small and Medium Enterprises
SHOKs	Finland's Strategic Centres for Science, Technology and Innovation
STEM	Science, Technology, Engineering and Mathematics
TEA	Total Entrepreneurial Activity
TEKES	Finnish Funding Agency for Innovation
TSB	Technology Strategy Board
UNESCO	United Nations Educational, Scientific and Cultural Organisation

WEF	World Economic Forum
WIPO	World Intellectual Property Organisation

Annex I: Acknowledgements

This report was produced by a joint team drawn from the Science and Innovation Evidence Project, Knowledge and Innovation Group, International Science team, Higher Education Student Funding team and Europe and International team at the Department for Business, Innovation and Skills (BIS). The project team would like to acknowledge the many contributions from colleagues within BIS, BIS partners and other Government Departments who came together for this report. A full list of individuals we would like to thank is provided below.

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Through the document a number of datasets have been used, which are referenced below:

- Eurostat (http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/)
- Global Entrepreneurship Monitor (http://www.gemconsortium.org/)
- IMD (http://www.imd.org/news/World-Competitiveness-2013.cfm)
- International Monetary Fund (http://www.imf.org/external/data.htm)
- OECD Statistics (http://stats.oecd.org/)
- Office for National Statistics (http://www.ons.gov.uk/)
- UNESCO (http://en.unesco.org/)
- World Intellectual Property Organization (http://www.wipo.int/ipstats/en/statistics/patents/)

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