Identifying potential growth centres across Great Britain

CATAPULT
Connected Places

The Connected Places Catapult is the UK Government-backed centre of excellence for innovation in the built environment and mobility. A trusted, expert broker, we operate at the intersection between public and private sectors, and between local, regional and national decision making. Leveraging our deep understating of all corners of this complex ecosystem, we convene the disparate market actors and translate between them, helping innovators to navigate the complexity of doing business in this market and helping places to unlock the economic and environmental benefits on offer from innovation.

Centre for Cities is an independent, non-partisan think tank. We are the only think tank dedicated to helping the UK's largest cities and towns improve their economic performance and the opportunities they offer to people. Our track record of original research built up over the last 15 years means we have an unrivalled depth of understanding of urban economics and the UK's economic geography.

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Foreword

It is now widely recognised that economic productivity is unevenly distributed across the UK and that something needs to be done to 'level up' the cities and towns outside the south east of England. What is less clear is where and how public investment should be focussed in order to deliver the desired improvements in regional productivity and prosperity.

At the Connected Places Catapult, we have experience supporting future-facing place leaders to seed and stimulate innovation economies in the UK and globally. From steering elements of the Belfast City Region Deal to supporting the creation of Smart Dubai, we have partnered with places to unlock economic and environmental benefits through the adoption of new technologies and innovative approaches.

Building on that experience, we have commissioned new analysis looking at how proposed investments and attention might best be directed to realise the Government's levelling up ambitions – and how places themselves can rise to the opportunity. This first report, delivered in collaboration with the Centre for Cities, looks particularly at the characteristics that define the UK's top performing

innovation economies. It also looks at places outside of this group which have the strongest potential to join London, Oxford and Cambridge as engines of Britain's future economy.

I trust you will find this contribution to the debate useful.

Nicola Yates OBE, Chief Executive – Connected Places Catapult

1 Introduction

Levelling up and the prospect of an increase in R&D and infrastructure investment leads to the question of where to invest as not all places have the same need, or the same potential to transform investments into outcomes.

There are different opinions on how to target and distribute R&D funding – in the past, this has been done by focussing on specific areas (London, Oxford, Cambridge) but if we are to level up the entire economy of Great Britain[1], a stronger geographic spread is crucial. This would involve a shift away from "innovation at excellence" towards "innovation everywhere". On the other hand, not all places in Great Britain are able to absorb new funding in R&D – only those places which have a critical size and baseline research and innovation capacities will be able to achieve a levelling up effect, at least in terms of innovation.

This piece explores the potential of different places across Great Britain to absorb future R&D funding and related activities. The report will also identify where to concentrate investment and energy to deliver a levelling up effect for the whole economy. Similar work has been undertaken by the Brookings Institution and the Information Technology & Innovation Foundation to identify new growth centres across the United States.[2]

We start by looking at what factors affect innovation and how these play out in the most successful places in the country to arrive at "innovation models" in section two. In the third section, this understanding is applied to identify places in which new R&D investment has the greatest potential for impact

[1] Data for Northern Ireland are not available.

[2] https://www.brookings.edu/wp-content/uploads/2019/12/Full-Report-Growth-Centers_PDF_BrookingsMetro-BassCenter-ITIF.pdf

2 How to define the potential of a place?

In previous years, public sector R&D spending was largely focussed on the champions of the South East: 41 per cent of all public R&D spending takes place in just three sub-regions of the UK: Oxford and its environs, Cambridge and its sub-region, and inner West London.[3] One reason for this focus is the outstanding research excellence and the already existent research and innovation capacities in these places: these cities concentrate high-qualified international researchers, modern facilities and laboratories and host highly innovative firms whose capacities can easily transform new funding into innovative output. While the focus on these places has been successful in strengthening them and safeguarding their national and global leadership, other cities across the country have often not benefited from these R&D investments.

However, apart from the three innovation leaders in the South, there are other places across Great Britain which also have the potential to increase their innovative activity even if they have played a comparably smaller role in R&D and innovation activities in the past. While a detailed analysis of the innovation activities is beyond the scope of this initial analysis, the potential of each place to develop into a growth centre can be estimated by combining a number of different indicators.

Table 1 sets out the performance of Great Britain's 62 cities and largest towns on six different indicators. These indicators combine a range of measures across the various factors associated with innovation. Together, they capture a city's relative strength across: the basic economic conditions, the R&D innovation capacities and the ability to transform innovative activities into outputs (elaborated in the info box). For simplification, the values for each indicator have been categorized into "very strong", "strong", "weak" or "very weak".

[3] http://www.softmachines.org/wordpress/wp-content/uploads/2019/05/ResurgenceRegionsRALJv22_5_19.pdf

Table 1 The potential to become a growth centre for GB's cities and largest towns

Data for Northern Ireland are not available.

		Patents strength	Trademarks strength	University innovation strength	Business innovation strength	Skills and spillover strength	Infrastructure strength	City size (PUA)	Region
	London	Strong	Very strong	Strong	Very strong	Very strong	Very strong	10,151,260	South East
	Slough	Strong	Very strong	Very weak	Strong	Very strong	Strong	149,112	South East
	Aldershot	Strong	Weak	Very weak	Strong	Strong	Very strong	184,016	South East
	Reading	Strong	Weak	Weak	Very strong	Very strong	Very strong	331,182	South East
	Derby	Very strong	Very weak	Strong	Strong	Strong	Very strong	257,174	East Midlands
Top 10%	Cambridge	Very strong	Very weak	Very strong	Very strong	Very strong	Very strong	125,758	East
	Milton Keynes	Weak	Very strong	Very weak	Strong	Strong	Very strong	268,607	South East
	Aberdeen	Very Weak	Weak	Weak	Strong	Weak	Weak	227,560	Scotland
	Crawley	Strong	Very weak	Very weak	Strong	Very strong	Very strong	112,448	South East
	Oxford	Very strong	Very strong	Very strong	Strong	Vey strong	Very strong	154,327	South East
	Edinburgh	Very weak	Very strong	Very strong	Strong	Strong	Weak	518,500	Scotland
Top 20%	Luton	Very weak	Very weak	Very strong	Strong	Very Strong	Very strong	214,109	East
	Southampton	Very weak	Weak	Very strong	Very strong	Strong	Strong	384,615	South East
	Swindon	Very weak	Very weak	Very weak	Weak	Strong	Strong	221,996	South West
	Bristol	Strong	Strong	Strong	Strong	Strong	Strong	746,049	South West
	Glasgow	Very weak	Strong	Strong	Weak	Strong	Strong	1,007,700	Scotland
	Birmingham	Very weak	Weak	Weak	Weak	Very strong	Strong	2,549,673	West Midlands
	Leeds	Very weak	Strong	Strong	Weak	Strong	Very strong	789,194	Yorkshire
Top 30%	Manchester	Very weak	Strong	Strong	Strong	Very strong	Weak	2,486,481	North West
	Blackpool	Very weak	Weak	Very weak	Weak	Very weak	Very weak	219,075	North West
	Portsmouth	Weak	Very weak	Weak	Strong	Strong	Strong	542,568	South East
	Coventry	Very strong	Strong	Strong	Weak	Strong	Weak	366,785	West Midlands
	Hull	Very weak	Weak	Weak	Very weak	Strong	Very weak	260,645	Yorkshire
	Northampton	Very weak	Weak	Weak	Strong	Strong	Strong	225,146	East Midlands
	York	Strong	Weak	Strong	Weak	Weak	Weak	209,893	Yorkshire
	Cardiff	Strong	Strong	Very strong	Weak	Strong	Strong	364,248	Wales
	Bournemouth	Very weak	Strong	Weak	Weak	Weak	Weak	395,800	South West
	Liverpool	Very weak	Weak	Strong	Very strong	Strong	Weak	644,385	North West
	Warrington	Very weak	Strong	Very weak	Weak	Strong	Weak	209,547	North West
	Exeter	Weak	Weak	Strong	Weak	Strong	Strong	130,428	South West
50%	Basildon	Weak	Weak	Very weak	Strong	Weak	Weak	185,862	East
	Brighton	Weak	Strong	Weak	Very strong	Strong	Very strong	354,264	South East
	Blackburn	Very weak	Very strong	Very weak	Weak	Very weak	Weak	148,942	North West
	Newcastle	Very weak	Very weak	Strong	Weak	Strong	Weak	858,954	North East
	Newport	Very weak	Very weak	Very weak	Strong	Very weak	Strong	246,351	Wales
	Wakefield	Very weak	Very weak	Very weak	Very weak	Very weak	Very weak	345,038	Yorkshire
	Gloucester	Strong	Strong	Very weak	Weak	Strong	Weak	129,285	South West
	Dundee	Very weak	Very weak	Strong	Weak	Weak	Very strong	148,750	Scotland
	Sunderland	Very weak	Very weak	Weak	Weak	Weak	Very weak	277,417	North East
	Peterborough	Strong	Strong	Very weak	Strong	Very weak	Very strong	201,041	East
	Chatham	Very weak	Very weak	Very weak	Weak	Weak	Weak	277,855	South East
	Ipswich	Very weak	Very weak	Weak	Weak	Strong	Very strong	137,532	East
	Sheffield	Weak	Very weak	Strong	Weak	Weak	Weak	847,177	Yorkshire
	Telford	Very weak	Very weak	Weak	Weak	Very weak	Very strong	177,799	West Midlands
	Worthing	Very weak	Weak	Very weak	Weak	Strong	Strong	110,025	South East
	Middlesbrough	Weak	Very weak	Weak	Weak	Weak	Very weak	474,476	North East
	Nottingham	Weak	Weak	Strong	Very weak	Strong	Weak	667,617	East Midlands
	Bradford	Very weak	Weak	Weak	Weak	Weak	Weak	537,173	Yorkshire
	Plymouth	Very weak	Very weak	Strong	Weak	Strong	Very weak	263,100	South West
	Doncaster	Weak	Very weak	Very weak	Weak	Very weak	Weak	310,542	Yorkshire
	Birkenhead	Very weak	Weak	Very weak	Very weak	Weak	Very weak	323,235	North West
	Barnsley	Very weak	Very weak	Very weak	Weak	Very weak	Very weak	245,199	Yorkshire
	Preston	Weak	Weak	Very Strong	Very weak	Weak	Very weak	369,166	North West
	Leicester	Weak	Strong	Weak	Weak	Strong	Weak	512,695	East Midlands
	Mansfield	Very weak	Very weak	Very weak	Weak	Very weak	Very weak	235,992	East Midlands
	Norwich	Weak	Very weak	Strong	Very weak	Very weak	Very weak	270,601	East
	Stoke	Weak	Very weak	Strong	Very weak	Weak	Strong	385,323	West Midlands
	Swansea	Weak	Very weak	Strong	Strong	Very weak	Very weak	389,372	Wales
	Wigan	Very weak	Very weak	Very weak	Very weak	Weak	Very weak	326,088	North West
	Burnley	Very weak	Very weak	Very weak	Strong	Very weak	Very weak	179,932	North West
	Huddersfield	Very weak	Strong	Weak	Weak	Very weak	Very weak	438,727	Yorkshire
	Southend	Very weak	Very weak	Very weak	Weak	Weak	Weak	359,514	East

INFO BOX: METHODOLOGY – HOW TO DEFINE THE POTENTIAL TO BECOME A GROWTH CENTRE?

Great Britain's largest 62 cities and towns have firstly been ranked according to their economic success – indicated by workplace wages. This gives a broad picture of the overall health of the economy which is important for the absorption of R&D investments. To fully depict innovation and R&D capacities, further characteristics of a city that can be linked to innovation & R&D have been added. These are partly based on the indicators used by the Brookings Institution to identify growth centres across the US.

The categories can be broadly classified into three groups:

1. Basic conditions

To build up a functioning innovation system and innovative capacity, places must fulfil certain preconditions. Places without these baseline factors for innovation should first focus on eliminating barriers in these fields before heavily investing in innovation. These categories include:

- Skills and knowledge indicators such as a highly-skilled workforce and a level of job density which allows for knowledge spill overs
- Physical infrastructure indicators such as enough office space and accessibility by (public) transport

2. A working innovation system with sufficient R&D and innovation capacities

Further R&D investments won't have the same effect everywhere in the country. A positive effect is strongly influenced by the already existing innovative capacities resulting from innovating stakeholders, institutions as well as existing R&D intensity. This can be broken down to include indicators such as:

- Business innovation indicators such as innovative firms or elevated business dynamics
- University innovation indicators such as research intense universities and spin-offs from universities

3. The ability to transform innovative activities into outputs

Patents and trademarks are both the output of an innovation process but can be linked to different types of innovations. While patents are used to protect processes, products and designs, often stemming from manufacturing, trademarks are used to protect words, symbols or logos. Trademarks are consequently an indicator for incremental and non-technological innovation[4] such as marketing or service innovation. Considered indicators:

- Patent indicators such as the number of patents per 10k population
- Trademark indicators such as their concentration in specific sectors

Based on these indicators and categories, six indices have been built and sorted by workplace wages to give a more comprehensive picture of the innovative potential of cities and large towns across Great Britain. An overview on all indicators can be found in Appendix A. For simplification, the values for each index have been categorized into four categories ("very strong", "strong", "weak", "very weak") according to their broad performance.

[4] https://conference.druid.dk/acc_papers/nv9r3f3sl6p5e0431rj6sxfblv4g.pdf

3 What can we learn from the data?

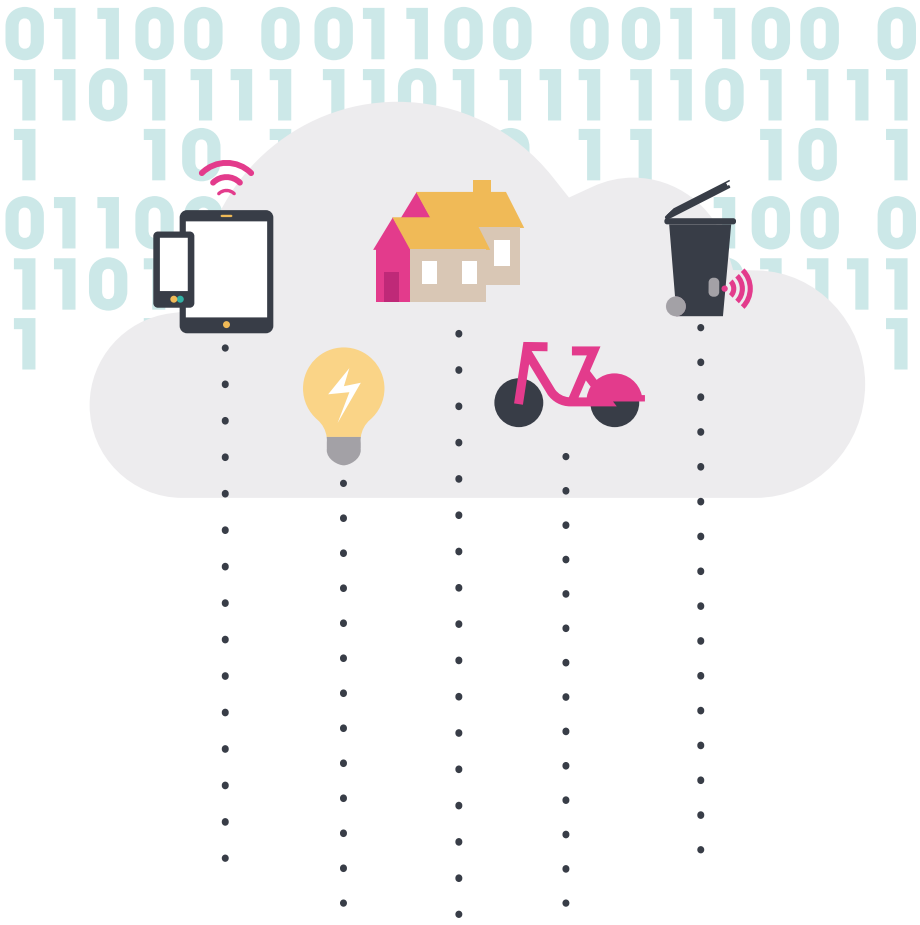
3.1 Trends and patterns across all 62 cities and large towns

(I) The most successful places with the healthiest economies often score higher on a number of indicators, while cities at the bottom perform poorly on many. This points to a systematic relationship between the different indicators, which is important when thinking about the integrity of an innovation system as a precondition for economic success.

(II) In successful places, business innovation plays a very important role: All places in the top 20 per cent score either strong or very strong for all indicators describing business innovation. In the bottom 50 per cent, only 22 per cent of the cities score either strong or very strong on this indicator.

(III) Despite many of the cities in the top 20 per cent having very strong university innovation, the relationship with economic success is not as clear cut. Some places in the top 20 per cent perform very well even without strong universities or research facilities, such as Crawley. The opposite is also true, with some places not performing well even with the presence of a high-quality university: as the home of the University of Central Lancashire, Preston does very well with regards to university innovation but scores poorly when it comes to other innovation indicators.

(IV) On the whole, it is the places with the strongest innovation systems and healthiest economies that have the best outcomes in terms of patents. Patents as innovation outputs are much more concentrated in the top 10 per cent cities than trademarks are. In contrast, cities in the third decile are weak when it comes to patents but strong in trademarks. Most of these places are amongst the largest cities in Great Britain.



3.2 Typology of the most successful cities

Successful places are not successful for the same reasons. While the least successful places often score poorly on a similar set of indicators, the more successful places differ in the indicators that they perform strongly in; they have different 'success profiles'. Looking at the top 30 per cent of cities, seven types of success-profiles can be identified, as summarized in Table 2. It is important to note that these types are categorized based on the extracted indicators only and that no in-depth review of the places and their innovation system has been undertaken. These categories are:

(I) **Super cities**, who have it all: They perform highly on all indicators across business and university innovation and create proportionate output when it comes to patents. These places identified in our work are also the places which received a significant share of R&D funding in recent years.

(II) **All-rounder cities**, which are strong for indicators in both university and business innovation as well as having a complete innovation system. They score slightly less well than the super cities across the indicators.

(III) **University-led innovators**, which are cities that score well on innovation outputs and have strong university-related innovation activities. Business innovation activities are weak.

(IV) **Business innovation-led innovators**, which are cities which have very strong innovation output when it comes to patents and also score highly with

regards to business innovation meaning that they have large shares of Science and Technology workers or start-ups. They don't tend to have a lot of trademarking activity though.

(V) Commercialisers, which are places with sufficient preconditions to innovate but this is captured mainly through trademarks rather than patents. One reason for this may be that they have less complex innovation systems or engage more in non-technological innovations.

(VI) Applied innovators, which have on the necessary preconditions such as skills and density, but are actually (very) weak on patents and trademark output. One reason may be that they apply innovations from elsewhere rather than innovating themselves.

(VII) Cities with a disjointed innovation system, which rank highly for workplace wages but are missing several other crucial components of innovation. Birmingham and Swindon, for instance, score very poorly on all output and innovation capacity indicators despite doing well regarding the basic indicators such as skills and infrastructure.

Table 2 Different success profiles of the best performing cities and large towns

Category	Characteristics	Examples
Super cities	(Very) Strong on a range of indicators.[5]	Cambridge, London, Oxford
All-rounder	Strong performance regarding business and university innovation but not as strong as the super cities when it comes to output.	Bristol, Derby, Edinburgh, Manchester
Business innovation-led innovators	(Very) Strong innovation output (mainly patents), Strong business, weaker or very weak university innovation (or no university at all)	Slough, Reading, Crawley, Aldershot
University-led innovators	Strong innovation activities by universities.	Cardiff, Coventry[6]
Applied innovators	(Very) weak innovation output despite doing well in the rest of the indicators.	Luton, Southampton
Commercialzers	Cities in the top 30 per cent with appropriate basic requirements. Most of them are strong in the commercialisation of ideas but have less complex innovation systems.	Leeds, Glasgow, Milton Keynes
Disjointed innovation system	Cities scoring highly for basic indicators but lacking crucial innovative capacity.	Aberdeen, Swindon, Birmingham

[5] Cambridge appears weak when it comes to trademarks but as it scores "Very strong" in all other categories, it has been still classified as All-rounder.

[6] Neither city is part of the top 30 percent.

4 Which places are best placed to benefit from further R&D investments?

Innovation-focussed policy interventions can aim for different things and address different types of places depending on what the primary objective of the intervention is. For instance, there can be interventions aiming to increase the overall innovative capacity of a place or more specifically target businesses or universities, depending on their particular strengths and weaknesses shown above.

To help guide which cities are best placed to benefit from further R&D spend, there are two things to consider. The first is a set of criteria based on economic profile and existing R&D spend, and the second, given discussions about the need to broaden out R&D spend, is regional geography.

A. Economic profile criteria

(1) Decent scale

To have a certain impact on the overall economy, investment should focus on places with a decent size to facilitate agglomeration economies. As one of the selection criteria, we focus on places which have a population of more than 200,000.

(2) Functioning economy

In general, places at the top have a healthier economy and possess the pre-conditions to transform new investments into long-lasting benefits for the city. Places at the bottom often lack the crucial fundamental ingredients such as a sufficiently skilled workforce or physical infrastructure. Before starting large R&D interventions, these places need to improve their core fundamentals. Given this, only the cities in the top half of Table 1 are considered.

(3) Exclusion of high performers

The "super cities" already are recipients of large R&D spend and so are excluded.

(4) Sufficient innovative capacity

Scoring strong or very strong on at least four indicators.

B. Geography selection criteria

(1) Regional innovation hubs[7]

To systematically strengthen different parts of Great Britain, spending could be focussed on the leading cities and large towns of each region if they comply with the general selection criteria to create regional innovation hubs. The data in Table 1 suggests that these would be:

- East Midlands: Derby
- South West: Bristol
- Scotland: Glasgow
- West Midlands: Coventry
- North West: Manchester
- North East: Newcastle
- Wales: Cardiff
- Yorkshire: Leeds

(2) Regional alliances

Some places which have been identified as those with higher potential are located close to each other or close to places which were not selected as potential growth centres but have a certain strength to be built on (size, patenting etc). Facilitating a strategic alliance between these places may lead to an uplift in the place with the more disadvantaged preconditions by making use of its specific strength. Such an approach would need more research to understand the innovation and diffusion links between these places.

- Reading-Aldershot (South East)
- Coventry-Birmingham (West Midlands)
- Derby-Nottingham (East Midlands)
- Bournemouth-Southampton (South)
- Liverpool-Birkenhead (North West)

[7] As the South East and East do already have regional innovation hubs, cities from these regions are excluded.

(3) Largest cities

Recent research from the Centre for Cities[8] on output gaps stemming from the underperformance of some cities across the UK revealed that it is very often the largest cities which are underperforming. This leads to a significant loss of GDP in absolute terms and suggests that any interventions should focus on those places where we can see the largest effects – for GDP and people at the national level. Addressing this through innovation spending and other areas will be important if the Government is to achieve its levelling up' agenda.

Cities to focus on would be:

- Glasgow
- Manchester
- Bristol
- Liverpool

C. Types of intervention

Much of the discussion on the geography of R&D tends to focus on the distribution of university innovation spending. Given this, it's interesting to note that the top tier cities' fortunes are driven less by their university strength and the strength of the physical infrastructure in the place, and more by the strength of business in the place. This suggests that the proposed solutions to 'level up' the second-tier cities through R&D cannot focus only on investment in universities and infrastructure – it will need to encourage and facilitate greater private innovation.

Research is light on the best way to do this. The What Works Centre for Local Economic Growth investigated how local economic growth can be encouraged by R&D grants and tax credits and the effects these have on different recipients.[9] By conducting an evidence review of 63 evaluations, the Centre identified positive effects of R&D grants, especially for SMEs and product innovations. Also, R&D programmes emphasising collaboration seem to perform better than just supporting single private firms. But more research and evaluation is required to understand the effectiveness of interventions in this area.

Research should also look to better understand the interactions between public and private sector innovation. Lessons from the Sheffield Advanced Manufacturing Research Centre show how a national innovation asset in a place doesn't necessarily mean that that place captures the value from the knowledge created in it. The nature of ideas is such that, more often than not, new processes and technologies created in one location are often 'implemented' and create productivity gains well outside the local area. Careful consideration needs to be given to how innovation can be harnessed to benefit the local area. Interventions seeking to 'level up' places should consequently understand the mechanisms through which innovation in an area translates into improved local economic performance.

Addressing skills challenges will also be vital to underpin any innovation interventions. Looking across all cities shows that the success of a city, as defined by workplace wages, is strongly related to the skill level of the workforce. Any interventions designed to improve the performance of a place must address skills challenges.

[8] https://www.centreforcities.org/reader/why-big-cities-are-crucial-to-levelling-up/big-cities-are-crucial-to-levelling-up

[9] https://whatworksgrowth.org/policy-reviews/innovation/evidence-review

Appendix

A. Selected indicators

Factors	Measures	Explanation	Year	Source	Weight within the factor
Basic conditions					
Skills and spillovers strength	Density of jobs (Workers per hectare)	The job density in the city is measured by jobs per hectare. Especially for innovative high-skilled exporting businesses, the ability to exchange ideas and information is crucial. They locate in places with many knowledge spill overs which is proxied by workers per hectare.	2011	Census	25%
Skills and spillovers strength	Number of workers with NVQ4+ qualification living in city plus hinterland	The absolute number of workers with a qualification at NVQ4 or above in the city and its hinterland indicates the immediate availability of high-skilled workers. A larger labour market means that workers and firms can match each other's requirements better and specialise in more productive forms of work.	2011	Census	75%
Infrastructure strength	Travel time to London (Minutes)	London is the largest market in the UK and hosts a large number of exporting firms and highly skilled workers. Proximity to London is an indicator of the size of the markets that businesses can access.	2013	Department for Transport Statistics	14.3%
Infrastructure strength	Intra-urban accessibility score	Urban connectivity (connectivity within places) is calculated using the average of travel times between each point in the place and its centre, weighted by demand (population or employment) at each point. This is normalised by the measure for these journeys at 50km/hr. A score of 1 = an average speed of 50km/hr for the journey from point to point.	2016	National Infrastructure Commission	14.3%
Infrastructure strength	Inter-urban accessibility score	Inter-urban connectivity (connectivity between places) is calculated in the same way as (intra-)urban connectivity, except it measures distances/travel times between the centre of a place and the centre of other places.	2016	National Infrastructure Commission	14.3%
Infrastructure strength	Premises receiving reliable 4G signal (%)	This is a measure for how well connected a place is digitally. The indicator tells us what shares of premises in a given city are able to receive 4G signal indoors, from all operators. Good digital connectivity is expected to aid productivity as it helps people and businesses share greater volumes of information, quickly and easily. It is worth noting that this is not a measure of how much information is actually shared but rather what the technology is able to facilitate.	2018	OfCom Connected Nations report	14.3%
Infrastructure strength	Premises that receive Superfast Broadband (%)	This is a measure for how well connected a place is digitally. The indicator tells us what share of premises in a given city is able to access superfast broadband (greater than 30 Megabytes per second). Good digital connectivity is expected to aid productivity as it helps people and businesses share greater volumes of information quickly and easily. It is worth noting that this is not a measure of how much this ability is taken up but rather what the infrastructure is able to facilitate.	2018	OfCom Connected Nations report	14.3%
Infrastructure strength	High quality office space as a share of office space in the city centre (%)	This measure uses Energy Performance Certificates (EPCs) to proxy office quality. Using the Non-Domestic Energy Performance Register, the number of offices that are high quality in city centres can be estimated by looking at all of those with EPCs A, B and C. These are the most energy-efficient buildings in the B1 building class and are presumably the newest and therefore highest quality office space. The strongest city centre economies tend to have higher quality offices on average than the weakest city centres.	2018	Non-Domestic Energy Performance Register	14.3%
Infrastructure strength	Office space as a share of all space in the city (%)	The Valuation Office Agency is part of HMRC tasked with valuing properties for the purpose of Council Tax and for non-domestic rates. The respective database for non-domestic rates has been used to calculate the proportion of floor space in each city that has been designated for office use. The rationale is that the cities that are best at providing this space are likely to be the choice of location for innovating firms.	2018	Valuation office agency	14.3%
Innovative capacity					
Business innovation strength	Private employment in Science and Technology (%)	This measure is the share of private-sector employees in a city, engaged in STEM and related activities. It indicates the extent to which a city's resources are dedicated to technical activities. A limitation is that those employed could be engaged in research or supporting activities, and this may vary by place. As it stands, the available data does not allow us to distinguish between the two.	2018	ONS	25%
Business innovation strength	Venture capital offices per 10,000 population	This measure is the number of venture capital offices in a city, adjusted for city size. Venture capital firms specialise investing in companies that either have the potential for or have demonstrated high growth. Their presence, therefore, indicates that there is substantive innovative, commercially viable activity happening in a city. A limitation of this measure is that it relies on a well-functioning VC market, free of information blind spots and biases.	2020	Tech Nation	25%

Factors	Measures	Explanation	Year	Source	Weight within the factor
Business innovation strength	Business births per 10,000 population	The number of new businesses started in that city, per 10,000 people every year. This is used as an indicator for the dynamism of businesses and entrepreneurs. It is a key indicator of the health of a city economy.	2018	ONS	25%
Business innovation strength	Business churn	The business churn rate is the difference between start-ups and business closures as a percentage of total business stock. Similar to business births per 10k population it indicates dynamism of businesses and entrepreneurs but also indicates its overall effect on the business stock.	2018	ONS	25%
University innovation strength	Number of STEM academic staff per 10,000 population	This measure is a proxy of university research intensity in a place. It uses data from HESA to estimate the number of people in a place that are dedicated to technical research within a university, using the number of academic staff employed in STEM and related departments. The resultant number has been adjusted for city size.	2014 – 2018	HESA, ONS	33%
University innovation strength	Average rating of university STEM submissions to the REF	This measure is a proxy for the quality of university research in a place. The Research Excellence Framework assesses the quality of research produced by each university, in each subject on a scale of 0 to 4. This data has been used to calculate the average quality of the research produced by all universities in a city, for STEM and related subjects.	2014 – 2018	REF, HESA	33%
University innovation strength	University affiliated spin-offs/ start-ups per 10,000 population	This measure is the number of spin-offs and start-ups affiliated to the universities in the city, adjusted for city size. Looking at the number of start-ups and spin-offs generated allows us to understand how application-orientated and commercially-orientated (since the companies develop concrete products and services) the innovative activity happening within these universities is.	2014 – 2018	HESA, ONS	33%
Innovation output					
Innovation output – Trademark strength	Trademarks per 10,000 population	The trademark applications made in a city per 10,000 population is used as a proxy to measure commercial innovation. Registering a trademark is recommended practice for businesses to protect their own brand or their product branding. As such, the level of trademarks registered in a place is informative on the extent to which ideas/products are being commercialised. However, it does not capture innovation within firms i.e. improved business practices.	2017	Intellectual Property Office	75%
Innovation output – Trademark strength	Trademarks concentration, by field	The concentration measure is calculated by splitting trademarks registered in a place by the sector that they have been applied through. It indicates whether the trademarks are being filed in a few specific areas or whether they are created across a range of industries. A lower concentration number indicates an innovative economy with a range of capabilities while a higher concentration number means that the innovative output is delivered through a limited number of strongholds.	2017	Intellectual Property Office	25%
Innovation output – Patent strength	Patents per 10,000 population	The patent applications made in a city per 10,000 population are used as a proxy to measure innovation. While R&D activities just give information on the intensity of research undertaken, patents give information on the innovative output. Patents are limited to specific types of innovation such as products, processes or design. Non-technological innovations cannot be captured with this indicator. A limitation of this dataset is that patents are also only classified based on where there are registered, which may not always be where the research is carried out.	2017 – 2018	European Patent Office, Intellectual Property Office	75%
Innovation output – Patent strength	Patents concentration, by field	The concentration measure is calculated by splitting patents registered in a place by the sector that they have been applied through. It indicates whether the patents are being filed in a few specific areas or whether they are created across a range of industries. A lower concentration number indicates an innovative economy with a range of capabilities while a higher concentration number means that the innovative output is delivered through a limited number of strongholds.	2017 – 2018	European Patent Office, Intellectual Property Office	25%

B. Indicator table (Ranking)

			Patent strength	Trademark strength	University innovation strength			Business innovation strength				Skills and spillovers strength		Infrastructure strength						
City	Region	Workplace wages	Patents per 10,000 population	Trademarks per 10,000 population	Number of STEM academic staff per 10,000 population	Average rating of university STEM submissions to the REF	University affiliated spin-offs/ start-ups per 10,000 population	Private employment in Science and Technology (%)	Business births per 10,000 population	Business churn	Venture capital offices per 10,000 population	Number of workers with NVQ4+ qualification living in city plus hinterland	Density of jobs (Workers per hectare)	Office space as a share of all space in the city (%)	High quality office space as a share of office space in the city centre (%)	Inter-urban accessibility score	Intra-urban accessibility score	Travel time to London (Minute)	Premises receiving reliable 4G signal (%)	Premises that receive Superfast Broadband (%)
London	South East	1	18	1	28	10	14	18	1	12	2	1	5	1	1	56	56	55	2	43
Slough	South East	2	14	4	41	40	39	17	9	11	10	18	2	13	37	52	41	54	33	10
Aldershot	South East	3	6	19	41	40	39	5	20	47	30	11	33	5	26	24	4	50	54	32
Reading	South East	4	16	13	23	19	37	3	10	23	5	5	30	4	8	21	24	48	25	54
Derby	East Midlands	5	4	41	29	39	7	1	39	21	15	42	9	29	44	14	6	28	13	4
Cambridge	East	6	1	14	1	2	13	2	27	58	1	40	3	3	51	9	46	44	5	11
Milton Keynes	South East	7	21	5	41	40	39	33	4	10	22	8	41	22	2	6	1	45	56	46
Aberdeen	Scotland	8	5	26	10	26	35	8	22	48	7	43	26	N/A	N/A	48	23	N/A	6	60
Crawley	South East	9	8	35	41	40	39	6	30	37	8	12	6	7	13	46	3	47	34	3
Oxford	South East	10	3	3	2	1	4	4	45	41	3	37	1	2	36	11	26	46	8	8
Edinburgh	Scotland	11	7	6	5	6	8	24	14	18	4	10	21	N/A	N/A	53	53	N/A	9	18
Luton	East	12	60	30	37	34	1	16	7	7	49	4	4	14	40	20	17	52	1	2
Southampton	South East	13	28	38	8	8	3	26	6	2	20	31	19	26	25	N/A	N/A	38	18	38
Swindon	South West	14	26	53	41	40	39	15	31	39	9	13	42	19	14	1	31	39	43	61
Bristol	South West	15	10	16	13	5	28	10	24	31	12	6	40	11	17	36	52	30	15	42
Glasgow	Scotland	16	55	17	14	14	30	28	40	50	17	7	35	N/A	N/A	28	21	N/A	22	30
Birmingham	West Midlands	17	49	27	30	23	31	38	13	22	36	3	16	39	22	8	49	31	20	20
Leeds	Yorkshire	18	40	22	17	15	21	21	19	59	13	15	32	10	5	5	11	13	23	47
Manchester	North West	19	47	8	26	18	24	40	3	43	16	2	24	23	6	27	55	16	14	29
Blackpool	North West	20	43	31	41	40	39	19	36	26	60	57	45	27	47	37	45	4	39	39
Portsmouth	South East	21	24	36	31	28	32	11	28	13	44	9	27	33	43	N/A	N/A	41	38	17
Coventry	West Midlands	22	2	20	6	4	6	13	38	30	29	28	11	30	56	16	16	36	50	49
Hull	Yorkshire	23	52	42	24	25	27	41	60	32	51	55	13	46	20	12	20	7	3	62
Northampton	East Midlands	24	31	40	35	38	20	59	5	8	28	25	10	42	42	4	28	43	40	12
Cardiff	Wales	25	15	23	7	3	5	45	41	53	6	27	15	6	9	51	42	N/A	29	19
York	Yorkshire	25	13	25	9	12	26	51	46	34	19	41	51	12	7	23	37	10	41	55
Bournemouth	South West	27	20	10	33	35	36	34	16	19	41	19	47	25	50	15	48	33	36	35
Liverpool	North West	28	50	34	11	24	17	35	8	1	21	24	18	21	18	47	54	15	7	23
Warrington	North West	29	45	12	41	40	39	27	25	61	11	23	34	20	21	41	22	19	59	31
Exeter	South West	30	19	24	3	11	19	31	42	58	14	52	7	8	33	39	40	21	12	41
Basildon	East	31	23	9	41	40	39	14	12	14	46	49	31	48	49	34	15	53	30	56
Brighton	South East	32	35	7	19	21	33	30	2	3	33	33	20	9	4	32	43	42	44	6
Blackburn	North West	33	38	2	41	40	39	55	35	38	56	60	44	49	38	43	39	9	4	22
Newcastle	North East	34	17	44	20	17	23	22	49	35	25	14	25	18	41	35	18	1	17	28
Newport	Wales	35	36	55	41	40	39	44	21	6	40	44	55	43	16	25	8	N/A	28	40
Wakefield	Yorkshire	36	59	45	41	40	39	62	55	52	48	58	46	53	23	N/A	N/A	18	27	59
Gloucester	South West	37	9	18	41	40	39	37	48	33	34	46	12	16	27	10	14	32	60	53
Dundee	Scotland	38	32	51	4	22	34	25	58	24	23	56	22	N/A	N/A	31	9	N/A	11	5
Sunderland	North East	39	56	58	38	37	15	7	62	55	32	54	28	36	55	49	34	2	24	34
Peterborough	East	40	12	21	41	40	39	36	11	9	59	47	54	34	19	2	13	35	19	25
Chatham	South East	41	33	56	41	40	39	49	29	28	61	22	53	47	52	44	44	51	32	36
Ipswich	East	42	51	49	40	40	39	61	33	16	27	59	8	17	11	18	12	37	31	14
Sheffield	Yorkshire	43	48	47	15	7	22	29	53	49	24	20	39	37	15	38	32	23	42	57
Telford	West Midlands	44	30	50	36	31	39	12	50	42	38	38	56	50	12	3	2	26	52	24
Worthing	South East	45	37	33	41	40	39	23	34	27	26	61	14	15	35	N/A	N/A	40	51	1
Middlesbrough	North East	46	44	57	34	32	29	32	54	40	45	32	52	41	57	13	25	3	37	37
Nottingham	East Midlands	47	22	28	12	16	12	39	43	60	31	16	29	31	24	30	51	27	35	13
Bradford	Yorkshire	48	46	37	39	20	38	43	47	20	43	36	37	40	28	N/A	N/A	6	21	33
Plymouth	South West	49	25	46	18	29	16	9	61	25	55	34	17	28	58	45	50	8	10	15
Doncaster	Yorkshire	50	57	59	41	40	39	53	18	29	37	48	61	58	32	17	7	22	55	52
Birkenhead	North West	51	11	39	41	40	39	46	52	44	52	29	50	45	54	54	10	12	45	44
Barnsley	Yorkshire	52	53	61	41	40	39	58	51	15	54	62	59	56	30	33	29	20	46	48
Preston	North West	53	27	32	27	33	2	54	32	57	42	17	48	32	45	19	30	11	53	45
Leicester	East Midlands	54	29	11	22	27	25	56	15	54	35	26	23	35	39	22	47	34	26	16
Mansfield	East Midlands	55	54	62	41	40	39	42	56	17	39	51	43	51	46	42	35	25	48	9
Norwich	East	56	39	29	16	9	10	57	44	62	18	50	60	24	31	26	33	29	61	58
Stoke	West Midlands	57	42	52	25	30	9	48	59	46	50	30	38	52	3	7	27	24	57	21
Swansea	Wales	58	34	54	21	13	11	52	26	4	47	39	62	38	29	29	38	N/A	58	27
Wigan	North West	59	62	60	41	40	39	60	57	36	62	35	36	57	53	50	19	17	62	7
Burnley	North West	60	61	48	41	40	39	20	23	5	58	53	58	55	48	40	5	5	47	26
Huddersfield	Yorkshire	61	41	15	32	36	18	47	37	45	53	45	49	54	34	N/A	N/A	14	16	50
Southend	East	62	58	43	41	40	39	50	17	51	57	21	57	44	10	55	36	49	49	51

C. Methodological notes

Innovation is difficult to codify conceptually – there are various types of innovation, various sources of innovation and the nature of innovation changes across sectors, by type of organisation and with technological progress. While this makes the study of innovation interesting, it also makes 'innovation' itself very hard to measure.

Since the purpose of the research is to understand how we can make places more innovative, we started by compiling a list of the various factors that could affect the level of innovation in a place, through a review of the academic and grey literature on the topic. These are as follows:

- Patent strength
- Trademarks strength
- University innovation strength
- Business innovation strength
- Skills and spillovers strength
- Infrastructure strength

Several measures were then collated (40 in total) across these factors that would allow us to quantify the relative standing of our cities against each other. The measures were picked out from a combination of sources: our existing database, government releases, other research organisations (e.g. HESA) and other third-party organisations (e.g. TechNation for data on VCs).

Whilst having a range of measures for each factor allows us to capture the various ways in which the factor could play out differently in a place, it does also make it less straightforward to identify which places are doing better and which worse. To adjust for this, the measures within each factor were combined to create a single indicator which could be used to compare the cities against each other.

When creating these indicators, two critical processes were carried out:

1. Calculating Z-Scores: Adding together the various measures can create some complications especially when the measures operate on different scales. E.g. when looking at the strength of university innovation, we considered both the number of STEM academic staff in a city's universities and the quality of the research output. Given that the first of these ranges between 0 and upwards, and the latter ranges between 0 and 4, taking an arithmetic average would significantly overweight the importance of the first factor over the second. To account for this, we calculated the Z-Scores for these variables and averaged those instead. The Z-Score tells us how 'far' the underlying value strays from the mean, the formula for calculation is as follows:

Z-Score = (Observation- Population Mean)/ Population Standard Deviation

2. Checking for correlations: It is advised when building indicators to check for highly (positively or negatively) correlated measures. High correlations appear for one of two reasons: the factors that are being measured are intrinsically linked and often vary in relation to each other e.g. the level of skills in a place and the level of wages in a place or because the measures are quantifying the same thing in a slightly different way e.g. the number of people who went to university and the number of people who have a Bachelor's degree. Correlation of the latter type is effectively a duplication of the measures and can skew final indicators by overrepresenting some factors over another. Pairs of correlated measures were sense-checked individually and removed as appropriate to prevent this.

This process resulted in five final indicators, their constituents and their relative weightings are outlined in appendix A. For each resultant indicator, four sub-ranges were created, classifying the respective values into 'Very strong', 'Strong', 'Weak' and 'Very weak'. This was done individually for each indicator, using the Jenks Natural breaks method. The Jenks method allows us to create ranges where the observations within each range are close in value to each other and furthest from the other ranges. It is an improvement to using quartiles or deciles etc. in that it takes the underlying values and distribution into account in generating these ranges. In practical terms, this means that cities that perform very similarly to each other on a metric are assured to end up with the same classification.

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