A Science and Innovation Audit for the D2N2 Local Enterprise Partnership area

Derby
Derbyshire
Nottingham
Nottinghamshire

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SQW

Contents

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1. Introduction

Context and purpose

1.1 Science and Innovation Audits (SIAs) were launched by the UK Government in 2015. They were intended to enable local consortia to analyse their strengths in science and innovation, and identify specific areas of existing or emerging excellence, which can be built on to drive long-term productivity gains and enable the local areas to realise their full economic growth potential.

1.2 The Midlands Engine SIA was one of the 'wave one' SIAs and was completed in autumn 2016.[i] It focused on a broad spatial footprint spanning 11 Local Enterprise Partnership (LEP) areas across the Midlands. The Midlands Engine SIA identified specific market opportunities around Next Generation Transport, Medical Technologies and Pharmaceuticals, Future Food Processing, and Energy and Low Carbon. These were supported by enabling competences of Advanced Manufacturing and Engineering, Digital Technologies and Data, and Systems Integration.

1.3 This SIA report for the Derby, Derbyshire, Nottingham and Nottinghamshire (D2N2) LEP area complements the Midlands Engine SIA by providing a more spatially fine-grained and in-depth analysis. With Place as one of the foundations of the Industrial Strategy, this report is designed to help partners identify the world-class science and innovation assets and activity in the D2N2 LEP area. With Brexit negotiations continuing, further commitments to science, technology and innovation investment announced in the Autumn Budget 2017 and the recent publication of the Industrial Strategy White Paper and Made Smarter (the Industrial Digitalisation review), this SIA report is particularly timely.

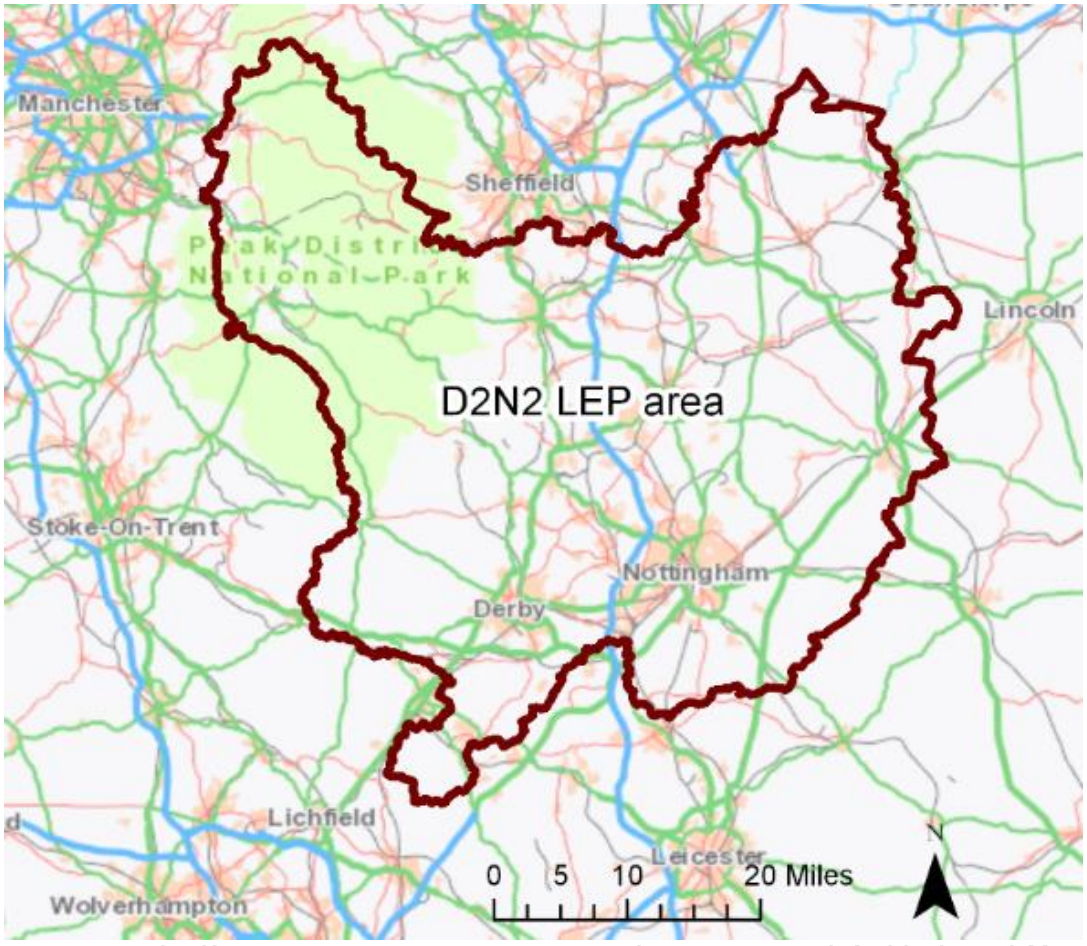
1.4 It is anticipated that the D2N2 SIA will be used to shape and inform both local and national investment priorities. It will also help to 'make the case' for further public and private investment to drive long-term productivity improvement, identify where there is scope for developing more pervasive open innovation and collaborative R&D cultures, and set out those specific opportunities for building a more resilient and interconnected innovation ecosystem.

Introducing the area

1.5 The D2N2 LEP area covers a diverse geography, from the major urban centres of Nottingham and Derby in the south, to the rural Peak District in the north west. In total, almost 2.2m people live within the LEP boundary, over 3% of the UK total. This combination of urban areas and easily accessible rural landscapes supports the area's impressive and distinctive quality of life offer.

1.6 Situated in the heart of the country, the D2N2 area enjoys good national and international transport linkages. The nationally significant M1 runs through the centre of our area and is crucial to transporting people and goods within and beyond the D2N2 boundaries. The arrival of HS2 will further strengthen these national linkages, whilst international connectivity is provided by the adjacent East Midlands Airport and Doncaster Sheffield Airport.

Figure 1-1: Map of the D2N2 SIA geography



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1.7 The D2N2 area boasts a well developed innovation ecosystem, underpinned by an internationally competitive business base and higher education offer. These are explored in more detail later in this SIA report with headlines including:

- One of the largest LEP economies outside the South East
- Three universities whose research and business support have international reach
- Three science parks and over ten innovation centres/incubators, all home to numerous innovative and technology-rich SMEs
- A mix of world class advanced manufacturing firms in Derby including Rolls-Royce, Bombardier and Toyota
- A growing life sciences cluster in Nottingham anchored by Boots and BioCity
- An emerging digital tech cluster in and around Nottingham's Creative Quarter.

Developing the SIA

1.8 The SIA draws on an extensive evidence base, and has benefited from considerable testing and validation with partners and stakeholders across the area, including the Innovation Working Group of the D2N2 LEP.

1.9 The SIA process has been shaped by two core strands of complementary evidence:

- **Data collation and analysis**: drawing on publicly available data on science and innovation from national sources (e.g. the Research Excellence Framework, Research Councils and Innovate UK), analysis of the Business Register and Employment Survey (using the latest available data), and information provided by local partners. We have also analysed data on scientific research quality and collaborations from Sci Val.[ii]

- **Stakeholder engagement**: a workshop with the D2N2 Innovation Group and bilateral consultations with other key actors in the local innovation ecosystem were undertaken between August and November 2017. In total, around 40 stakeholders directly contributed to the development of the SIA. This helped to secure feedback on the underpinning evidence base and inform the identification of key strengths and growth opportunities for the future.

1.10 The qualitative and quantitative evidence has informed the development of a bespoke '*D2N2 Science and Innovation Framework*', which has been approved by the D2N2 LEP Board and is used as the basis for the SIA report. The Framework is described more fully in Section 3 of this report, with the subsequent Sections providing the underpinning evidence base on the Innovation Ecosystem, Enabling Competences, and Market Strengths. A series of case study cameos are presented throughout the report, showcasing some of D2N2's impressive science and innovation excellence in action.

1.11 Initially, Section 2 provides an overview of the scale, breadth, and nature of the economic and research landscape within which the knowledge exchange, commercialisation and wider science and innovation activity occurs across the D2N2 area.

2. Overview of the D2N2 economic and research landscape

Summary

- D2N2 has a large and growing economy. Manufacturing remains a distinctive feature of our economy, with broader science and technology employment at similar level to the UK average. However, we suffer from a productivity gap, in part because of relatively low levels of innovation among our businesses.
- The research landscape in our area is dominated by the University of Nottingham, which is complemented by the more applied University of Derby and Nottingham Trent University. The University of Nottingham and Rolls-Royce are both major recipients of public R&D funding.

The economy

D2N2 is one of the largest economies outside the South East of England

2.1 The D2N2 LEP geography is one of the largest in England, covering 17 city, borough and district council areas. The area contains 72k business units, almost 1m jobs, and generates a Gross Value Added (GVA) of over £44bn annually. In GVA terms we are the ninth most significant LEP area economy in England and the fourth most significant outside the greater South East.[iii]

2.2 We are also a growing economy. Employment has grown by 8% and GVA by 37% since the turn of the millennium. This GVA growth rate is particularly impressive as it is higher than the UK growth rate of 30% over the same period.

2.3 There are 960k jobs in our area, of which the largest proportion are in 'Wholesale and retail trade; repair of motor vehicles and motorcycles' (17%). 'Human health and social work activities' is the second largest sector (14%) but, in common with 'Wholesale and retail' is not specialised in employment terms.

With major concentrations of manufacturing and healthcare activity

2.4 Reflecting our industrial heritage, the 126k jobs in our 'Manufacturing' sector are still a highly distinctive feature of our economy. With a location quotient[iv] of 1.7, manufacturing employment is almost twice as concentrated here as the GB average. The 'Electricity, gas, steam and air conditioning supply' sector is also notable for its concentration, if not the scale of employment.

Table 2-1: D2N2 jobs and Location Quotient (LQ) vs. UK (2016), % change 2010-2015[v]

	Jobs	% of total	LQ	2010-2015 % change
Wholesale and retail trade; repair of motor vehicles and motorcycles	160,000	17%	1.1	8%
Human health and social work activities	134,000	14%	1.1	4%

Manufacturing	126,000	13%	1.7	2%
Administrative and support service activities	98,000	10%	1.2	54%
Education	84,000	9%	1	9%
Accommodation and food service activities	72,000	8%	1	-5%
Professional, scientific and technical activities	59,000	6%	0.7	6%
Construction	51,000	5%	1.1	-7%
Public administration and defence; compulsory social security	40,000	4%	1	-26%
Transportation and storage	39,000	4%	0.9	6%
Information and communication	25,000	3%	0.6	-8%
Arts, entertainment and recreation	20,000	2%	0.8	-27%
Other service activities	16,000	2%	0.8	-6%
Real estate activities	12,000	1%	0.7	-25%
Financial and insurance activities	10,000	1%	0.3	-7%
Electricity, gas, steam and air conditioning supply	7,000	1%	1.8	133%
Water supply; sewerage, waste management and remediation activities	6,000	1%	1	-17%
Mining and quarrying	1,500	0%	0.9	-25%
Agriculture, forestry and fishing	1,000	0%	0.1	0%
Total	**960,000**	**-**	**-**	**4%**

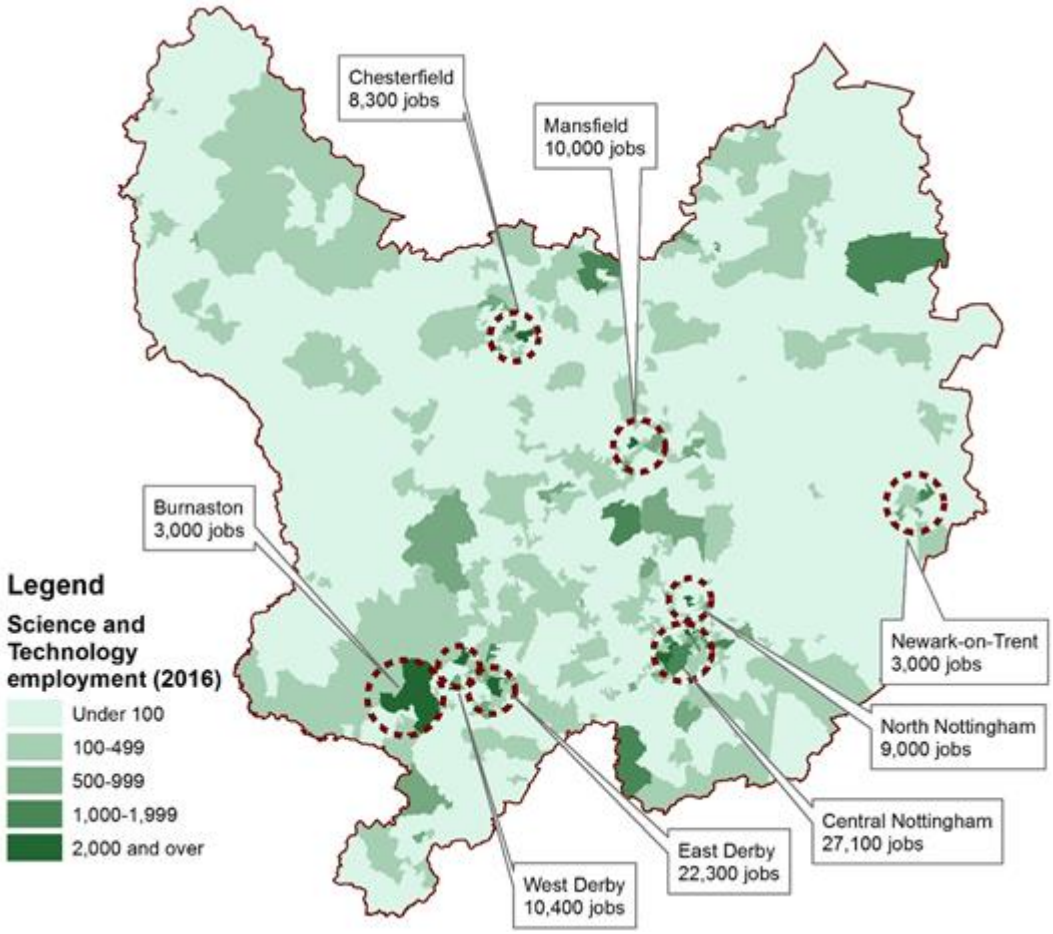
Source: SQW analysis of open access Business Register and Employment Survey

And significant Science and Technology activity

2.5 The Office for National Statistics has developed a formal definition of 'Science and Technology' sectors. Whilst noting that SIC code based definitions are imperfect - given that businesses work increasingly across industrial classifications and that technologies are converging rapidly - the ONS definition still provides a useful indicator of the scale of employment focused on science and technology related activity.

2.6 The data indicate an employment of around 188k in 'science and technology' sectors across our area in 2016; a major part of our economy. This represents one in five jobs, which is very similar to the Great Britain average. However, growth in D2N2 has been markedly slower than elsewhere, with a 3% uplift recorded over the 2010-2015 period compared to 10% nationally. Science and technology employment is found across our geography as shown in Figure 2-1. A number of 'hot spots' can be identified, including: Derby, with key employers Rolls Royce and Bombardier; Nottingham, with Boots, BioCity and MediCity; and Toyota at Burnaston.

Figure 2-1: Science and technology employment across the D2N2 area (2016)



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Rolls-Royce in D2N2

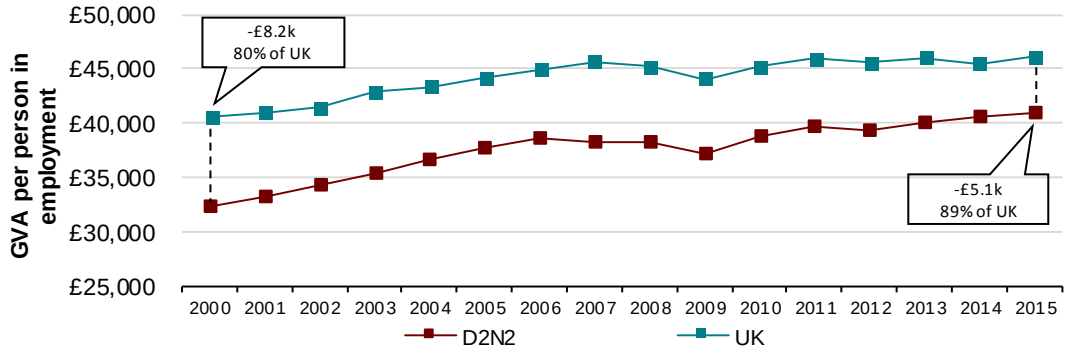
Worldwide engineering firm Rolls-Royce is headquartered in Derby. It employs over 14,000 people across three sites in D2N2: Derby, Derby Raynesway and Hucknall. Across the East Midlands region as a whole, Rolls-Royce accounts for c£3.8 billion of GDP, some 3.9 per cent of the region's economy, and supports c41,000 direct and indirect jobs.[vi]

Derby hosts the largest concentration of Rolls-Royce employees in the UK, with one in 11 workers directly employed by the company. The main site concentrates on civil aerospace and submarines, as well as the Rolls-Royce Academy, which recruits over 200 apprentices annually. The Derby Raynesway site employs 2,400 people to manufacture nuclear reactor cores and propulsion components, making it one of the largest nuclear skills bases in the UK. Finally, 800 workers focus on manufacturing components for gas turbines in defence and civil aerospace at Rolls-Royce's Hucknall site.

D2N2's productivity challenge

2.7 Despite the strengths identified above, our productivity performance is well below the national level. This is not a recent development. Figure 2-2 shows that D2N2's GVA contribution per person in employment has been consistently lower than the UK average since at least 2000. Encrouaginly though, the productivity gap is narrowing; closing from 80% to 89% by the end of 2015. Tackling this long-term productivity challenge has been a dominant feature of our SIA thinking.

Figure 2-2: Productivity over the period 2009-2015 (£)



Source: SQW analysis of CE data

2.8 Looking at the differences *between* firms in our area and those elsewhere, previous research undertaken by the University of Nottingham has identified two major causes of our productivity gap:

- **Low allocative efficiency** – we have *relatively* unproductive large firms, but relatively productive small firms
- **Low productivity of the average firm** – this results from too many 'below average, but not very weak' firms and too few 'above average, but not exceptional' firms'[vii].

2.9 This research did not explicitly address the causes of productivity differences *within* firms. However, previous research in other areas, for example SQW's work on the Independent Economic Review of the Northern Powerhouse, has found that skill levels are an important factor in explaining the UK's productivity gap. The information provided on this in Section 4 suggests that D2N2 does face a challenge on skills and that our skills system must adapt if we are to boost our long-term productivity.

2.10 The University of Nottingham research suggested some high-level actions that the D2N2 LEP and wider stakeholders could take to address this key issue. These included targeting support at firms just below the average productivity level, supporting small *productive* firms and not just small firms, as well as supporting firms to increase investment in new capital, close the export gap and improve management practices. Additional research emphasises the role that 'workplace innovation' can play in closing the productivity gap.[viii]

2.11 In addition to these actions, the scope for science and innovation excellence to increase productivity is clear. The SIA process is a crucial first step to identify how we can leverage our world-class science and innovation assets to drive increased cluster development within our higher value sectors and ensure that our supply chains are able to compete effectively on an international stage.

The innovation imperative

2.12 In an increasingly competitive global marketplace, having many of our companies engaged in innovation and R&D activity will help to support our economy. The introduction of innovations – whether in products, processes or services – boosts the productivity of an area. As the Industrial Strategy White Paper notes: "unless we improve productivity while holding on to high employment, we cannot raise living standards and quality of life for all our citizens."[ix]

2.13 However, despite the presence of several highly innovative multinational businesses, our area faces a major innovation challenge. Previous research has suggested that our firms perform relatively poorly in terms of both innovation behaviour and especially innovation outcomes compared to firms from other LEP areas. This is shown in the table below, with categories where our firms ranked in the bottom 10 LEP areas highlighted in red.

Table 2-2: Innovation performance of D2N2 firms

		% of D2N2 firms	D2N2 rank (out of 39 LEP areas)
Organisational and marketing innovation	Introduction of new business practices	29	17
	New methods work organisation	16	37
	Marketing innovation	16	28
R&D, design and collaboration	Undertaking R&D	22	13
	Design investment for innovation	10	32
	Collaboration	25	23
Innovation outcomes and sales	Product or service innovation	18	32
	New to market innovation (product or service)	5	39
	Process innovation	14	29
	Sales of innovative products/services (mean)	21% of sales	38

Source: Benchmarking Local Innovation, ERC & EEN, 2017. Based on 417 firms, margin of error c.4%

2.14 The specific factors contributing to this are analysed in detail in Section 4, but in headline terms, our skills base and limited access to finance are likely to be key to this underperformance.

The research landscape

2.15 The research base in the D2N2 area is dominated by the internationally significant University of Nottingham, which is ranked in the Top 100 in the world by one of the major university rankings.[x] This research intensive institution, which recently announced a £200m investment in six beacons of excellence, is complemented by the more applied University of Derby and Nottingham Trent University, which is the Sunday Times Modern University of the year for 2018. Alongside these three HEIs, major innovative multinational private sector firms are also based in our area, as are the British Geological Survey and Health and Safety Laboratory. At present, however, there are no major RTOs or Catapult Centres within the D2N2 area.

2.16 The following sub-section provides a high-level summary of the higher education research landscape across all research areas, and summarises other key knowledge assets. Two case study cameos – on HEIs as direct drivers of economic activity and indirect drivers through spin-outs – are also included. More detail on individual assets relevant to the SIA Framework is presented in the subsequent sections of this SIA report.

The University of Nottingham's economic impact

Universities are important as drivers of the economy in their own right, and not just as part of the knowledge base and skills system. The University of Nottingham delivers a substantial economic impact in the D2N2 area, generating £469m of GVA annually. It is the sixth largest employer in Nottinghamshire, with one in every 24 jobs in Nottingham relying in some part on the University.

Further economic effects are created through the University's direct expenditure on goods, services and wages. Over 650 suppliers are supported through £32.9m of annual expenditure, whilst the University's Ingenuity Network service has provided 1,800 SMEs with innovation support since its inception in 2008.[xi] The universities of Derby and Nottingham Trent generate similar types of beneficial impacts for the D2N2 economy.

Key statistics

2.17 Table 2-3 below uses several measures to reflect the importance of the three HEIs to our economy, and the wider national and international research landscape.

2.18 The Research Excellence Framework (REF) 2014 is an important, if somewhat dated, source of information on the scale and relative quality of academic research. Out of 36 units of assessment – equivalent to broadly defined subject areas – at least 10% of the research submitted by the University of Nottingham was rated as world leading in 30 of these areas, illustrating an impressive breadth of excellence. This is emphasised by Nottingham's overall research power ranking, which is 13th in the UK. Complementing this, Nottingham Trent University had 10 units of assessment where at least 10% of the submitted research was assessed as world leading.

2.19 Data from the Higher Education Business Community Interaction survey (HEBCI) suggest that in 2015/16, the three institutions' combined income from collaborative research (involving public funding) was over £50m, equivalent to 4% of the UK total. Nottingham received the majority of this funding.

2.20 Over 76,000 students were enrolled across the three HEIs in 2015/16, some 3% of the UK total. This includes some of the largest universities in the country, with both Nottingham institutions ranked in the national Top 20 for enrolment. This flow of well-educated people entering the workforce is important in driving our prosperity. Our graduate retention rates vary by institution, with noticeably larger percentages of Nottingham Trent and Derby graduates working in the D2N2 area six months after graduation than is the case for their peers from the University of Nottingham. Boosting the volume of high quality graduate opportunities in our area will help to increase these retention rates.

Table 2-3: Breadth and depth of research excellence, and perspectives on scale

	Nottingham Trent University	University of Derby	University of Nottingham
REF: Units of assessment with at least 10% of outputs rated world leading (2014)	10	2	30
REF: Overall GPA ranking (2014)	71	129	31
REF: Overall research power ranking (2014)[xii]	93	114	13
FTE students (and % international) 2015/16	27,920 (13%)	16,300 (8%)	32,125 (23%)
Graduate retention in D2N2 (2015/16)	34%	47%	12%
Collaborative research income (2015/16)	£2m	£1.4m	£48m
Contract research income (2015/16)	£2.7m	£0.5m	£31m
Times Higher Education World University Ranking – Globally (and UK) (2018)	601-800 (=67)	801-1000 (=90)	=147 (=21)
Complete University Guide – overall UK ranking (2018)	52	97	18

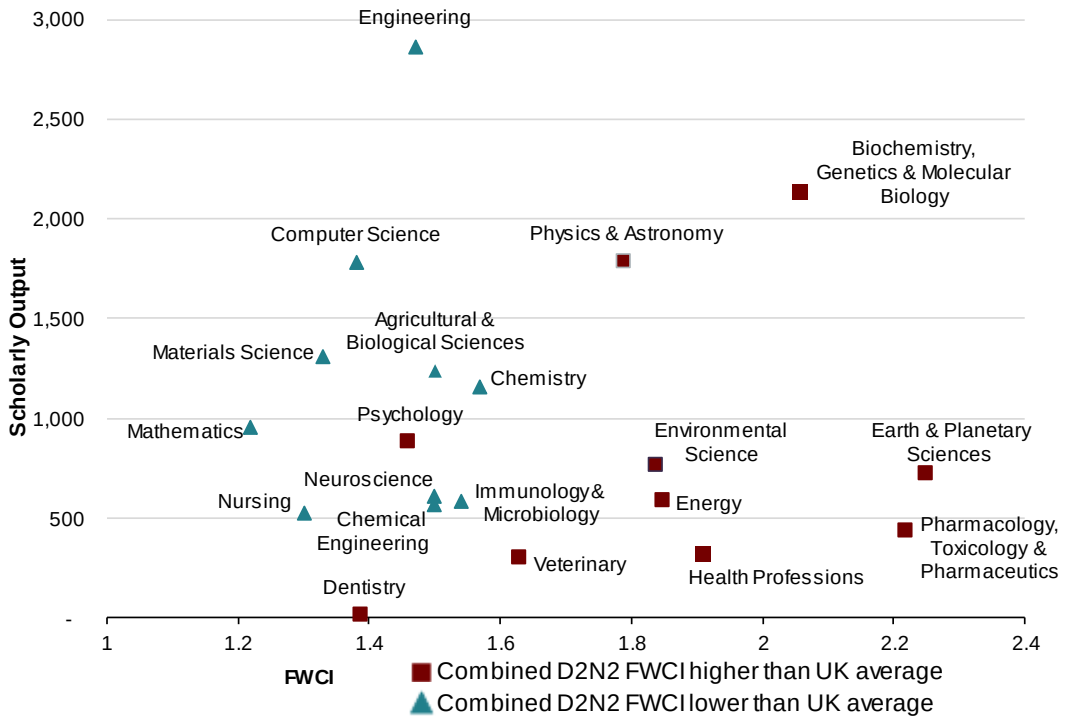
Source: SQW analysis of REF, HESA, HEBCI, Times Higher Education and Complete University Guide

Internationally significant research strengths

2.21 To provide a further perspective on national and international research excellence, we have used Elsevier's SciVal database. Figure 2-3 combines two metrics: Field Weighted Citation Impact (FWCI), used as a proxy for the quality of research; and Scholarly Output, used as a proxy for the quantity of research output.

2.22 Twenty different subject areas are shown, but medicine is excluded as there were over 5k publications in this area; some 2k more than in the next highest subject area. Combining quality and quantity perspectives shows that research in Biochemistry, Genetics and Molecular Biology, and Physics and Astronomy is particularly strong (represented by red squares on the upper right hand side of the graph). Other areas where there is clear research excellence in terms of quality include: Earth and Planetary Sciences; Pharmacology, Toxicology and Pharmaceuticals; Medicine; Health Professions; Energy; and Dentistry. Section 6 discusses the specific centres of excellence within our HEIs that contribute to this.

Figure 2-3: Field Weighted Citation Index for the combined D2N2 HEIs in relevant subject areas[xiii]



Source: SQW analysis of SciVal data

2.23 It is important to note that these data are an *average* of the HEIs and mask disparities between them. Nottingham for example, tends to have a higher FWCI than Derby and Nottingham Trent. In addition, different subject areas have different norms in terms of research output; what may be considered a relatively low scholarly output in one area may be a high output for another. Nevertheless, these data do provide a useful indication of the aggregate strengths of our HEIs.

Spin-out success: Quotient Sciences

Quotient was founded as a spin-out from the University of Nottingham in 2000. Since its inception, the company has rapidly expanded, most recently acquiring Co-formulate and Pharmaterials (a Reading based CXO), to form Quotient Sciences. The company now supports over 700 jobs across six operating sites in the UK and the USA.

Since 2004, Quotient has pioneered Translational Pharmaceutics, an approach which integrates drug formulation development, drug manufacturing and clinical pharmacology services. This approach provides opportunities for Quotient to accelerate the delivery of products to patients, whilst reducing development timelines and costs.[xiv]

Research funding

2.24 Data from Gateway to Research indicate that our universities hold 'active' research funding from the UK Research Councils of over £310m, some 3% of the UK total. The majority (almost £309m) is concentrated at Nottingham, which is ranked 8th in the UK in terms of 'active' research funding.[xv]

2.25 In terms of broad area of focus, the funding data indicate that the D2N2 HEIs 'punch above their weight' in attracting significant amounts of biotechnology and engineering research funding. Additional sources of research funding, including Horizon 2020, are discussed in Section 4.

Table 2-4: Active research council funding for D2N2 HEIs

Research Council	Active funding (£m)	Proportion of UK
Arts and Humanities	6.9	2.6%
Biotechnology and Biological Sciences	72.7	5.7%
Engineering and Physical Sciences	174.8	3.7%
Economic and Social	17.7	1.9%
Medical	27.5	1.9%
Natural Environment	3.9	0.4%
Science and Technology Facilities	6.1	1.0%

Source: SQW analysis of Gateway to Research data

Wider research assets

2.26 Although D2N2 has many science and innovation strengths, our area does lack a Catapult Centre or similar high profile RTO. Nevertheless, our university research is complemented by the **British Geological Survey** (BGS), which has its headquarters in Keyworth, Nottinghamshire. The BGS provides authoritative geoscientific data and information to both the government and the public. An internal review by the Natural Environment Research Council, the parent body of the BGS, concluded that the impact of BGS research was outstanding.[xvi]

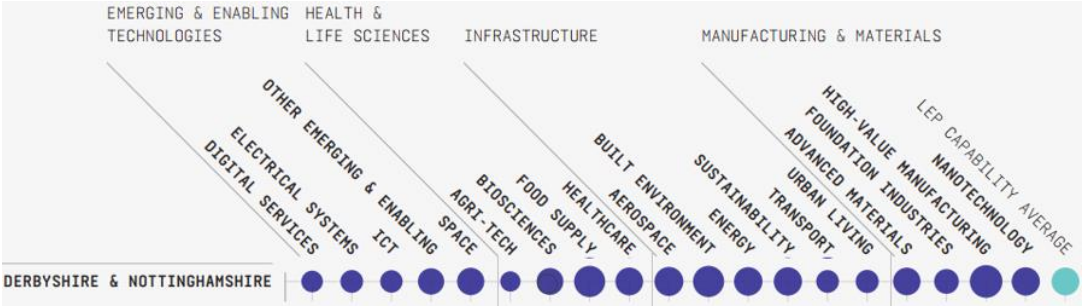
2.27 The **Health and Safety Laboratory** is a leading provider of workplace health and safety research, training and consultancy. It employs over 350 scientific, medical and technical specialists in Buxton. Part of the Health and Safety Executive, it offers a mix of free advice, alongside paid-for training and bespoke research for businesses aspiring to the highest standards of workplace health and safety.

Our resulting broadly based innovation strengths

2.28 The graphic below shows the Smart Specialisation Hub's mapping assessment of D2N2's innovation capability, with larger circles denoting higher levels of innovation capability. In

comparison to other LEP areas, D2N2 is a strong all-rounder with no weak areas identified in the research. We have at least medium capability in all areas, with a high capability in high value manufacturing, food supply and the built environment.

Figure 2-4: D2N2's innovation capability



Source: SQW adapted from Smart Specialisation Hub (2017) Mapping England's Innovation Activity

3. The D2N2 SIA framework

Developing the framework

3.1 The starting point for the D2N2 SIA was the framework developed for the original Midlands Engine (ME) SIA. This was informed by D2N2's science and innovation strengths, but mainly reflected broader strengths evident across the whole of the Midlands. As explained in the introduction, the D2N2 SIA has been designed to act as a more detailed and bespoke analysis of this.

3.2 Following the SQW methodology used successfully in the West Midlands Combined Authority SIA, the initial work on the D2N2 SIA focussed on testing the applicability of the ME framework to the D2N2 LEP area. This analysis combined a data and document review with feedback from members of the LEP Innovation Group, alongside additional consultation evidence. It was agreed that the structure of the original ME framework remained relevant for the D2N2 SIA framework. In addition, the enabling competencies and market priorities identified in the Midlands Engine SIA remain relevant for the D2N2 LEP area at a headline level. However, reflecting D2N2's distinctive asset base and supporting capabilities, the specific areas of focus within each of these areas are different to those presented in the Midlands Engine SIA.

Framework components

3.3 The D2N2 SIA Framework at Figure 3-1 incorporates the key factors which must be in place for D2N2 to achieve its full science and innovation potential. It includes three components:

- The underpinning **innovation ecosystem**. This includes physical assets and infrastructure (including incubation facilities, science parks and superfast broadband connectivity), growth finance and specialist business support, people and skills, policy and regulation, as well as innovation networks and knowledge exchange programmes. These elements are explored in Section 4.
- The **three enabling competencies** which represent increasingly pervasive areas of expertise across D2N2. They support innovative business activity across multiple technology areas and are discussed in Section 5.
- **Four market priorities,** based on the unique combination of university research, major private sector businesses, SME supply chains and early stage clusters, and the underpinning innovation ecosystem and enabling competencies. These are explained in Section 6.

Figure 3-1: The D2N2 SIA Framework

Source: D2N2 and SQW

3.4 It is important that the Framework is forward looking and takes account of emerging market and technology trends. In addition to specific drivers of change within each of the Enabling Competencies and Market Priorities, global megatrends will impact significantly on all of our businesses. Five are highlighted here:

- **Industrial digitalisation** or Industry 4.0 is becoming increasingly important across all manufacturing sub-sectors. More generally, D2N2 must ensure that *all* of its firms (including those in non-digital sectors) and communities are able to prosper in the digital world. This is discussed in more detail in Section 5[xvii]
- **Climate change** will impact bring two categories of impact. The first directly caused by climate change (e.g. the impact of changing temperatures and rainfall patterns on crop production) and the second related to efforts to mitigate this (e.g. reducing CO2 emissions in energy generation and use)[xviii]
- **A growing worldwide population** will mean increased demand for energy and food. The accompanying increases in urbanisation will provide opportunities for transport that relies on high density to function efficiently e.g. rail, bus and metro systems[xix]

- **An increasingly elderly population** will drive a shift away from remedial care/treatments to predictive/preventative and more personalised care. In addition, transport must become more accessible, impacting on design and influencing the 'mobility as a service' trend[xx]

- Coupled with emissions reduction targets, **resource scarcity** is promoting a shift towards renewable sources of energy for transport, homes and industry. The emerging threat of water scarcity will also impact greatly on food production[xxi]

3.5 Although published after the Framework was agreed, the Industrial Strategy White Paper[xxii] also picks up on similar themes, identifying four so-called 'Grand Challenges'. As Table 3-1 shows, these align well with the Enabling Competencies and Market Priorities identified in our SIA Framework.

Table 3-1: Grand Challenge areas

Put the UK at the forefront of the **artificial intelligence** and data revolution (Digital Technologies and Data)	Maximise the advantages for UK industry of the global shift to **clean growth** (Energy and Low Carbon)
Become a world leader in shaping the future of **mobility** (Next Generation Transport)	Harness the power of innovation to help meet the needs of an **ageing society** (Life Sciences and Healthcare)

Source: SQW analysis of the Industrial Strategy White Paper

4. The D2N2 innovation ecosystem

Summary

- Businesses benefit from our central location and well-developed transport network. Our mix of science parks and innovation centres, along with superfast broadband connectivity, provide our businesses with the necessary physical assets for growth
- Business employment and spending on R&D is rising across the East Midlands. This is reflected in our area by almost 300 organisations receiving £134m in funding from Innovate UK since April 2010. Encouragingly, this is proportionately higher than our population of firms would suggest. However, this is dominated by the University of Nottingham and Rolls-Royce
- We face a stubborn challenge on skills, but there are opportunities if schools focus on raising attainment, colleges focus on building technical routes that aid the flow of skilled people into businesses, and universities continue to focus on higher level skills co-created with our regional employers and supply chains. Our skills system must become more specialised and responsive to the rapidly changing demands of D2N2's business base
- Our organisations play active roles in networks which range from the local to the international, and include both industrial and academic partners. For example, 69% of publications resulting from HEI-HEI collaborations are with partners from outside the UK
- Strong national and local policies recognise the importance of innovation. From the Industrial Strategy to our innovation plan 'Time to Innovate' - they focus on increasing levels of innovation activity to drive productivity gains and generate economic growth.

Physical assets and infrastructure

4.1 Our central location and transport connections mean that many logistics businesses are based in our area, particularly at Markham Vale. The M1 is a key arterial route not just for D2N2, but the whole country. It runs through the heart of our area providing the main North-South link, and is supported by a network of A-roads. International links are provided by the adjacent East Midlands Airport and Doncaster Sheffield Airport.

Physical assets

Science parks, incubators and innovation centres

4.2 There are seven United Kingdom Science Park Association (UKSPA) member sites in our geography. Some of these are focussed on particular sectors (e.g. BioCity and MediCity in Nottingham, and manufacturing at the iHub on the University of Derby Science Park), others are more general, but include specific features (e.g. workshops at Mansfield i-Centre, Newark Beacon and Worksop Turbine). Other facilities have a broader focus on science and technology across all sectors and disciplines as shown in Table 4-1. For example, UNIP combines accommodation for technology based businesses with research assets from diverse sectors such as the Aerospace Technology Centre, GSK Zero Carbon Chemistry Lab, and the Horizon Digital Economy Research Institute.

4.3 Figure 4-1 illustrates that our centres of innovative activity are spread across the D2N2 geography, providing an attractive offer for both indigenous start-ups, expanding SMEs and in-movers. The concentration of assets in and around Derby and Nottingham is particularly

important as this allows spin-outs from major firms and graduate start-ups to stay in the same area, and retain access to academics and associated innovation networks and support systems.

Table 4-1: Key science parks and innovation centres in D2N2

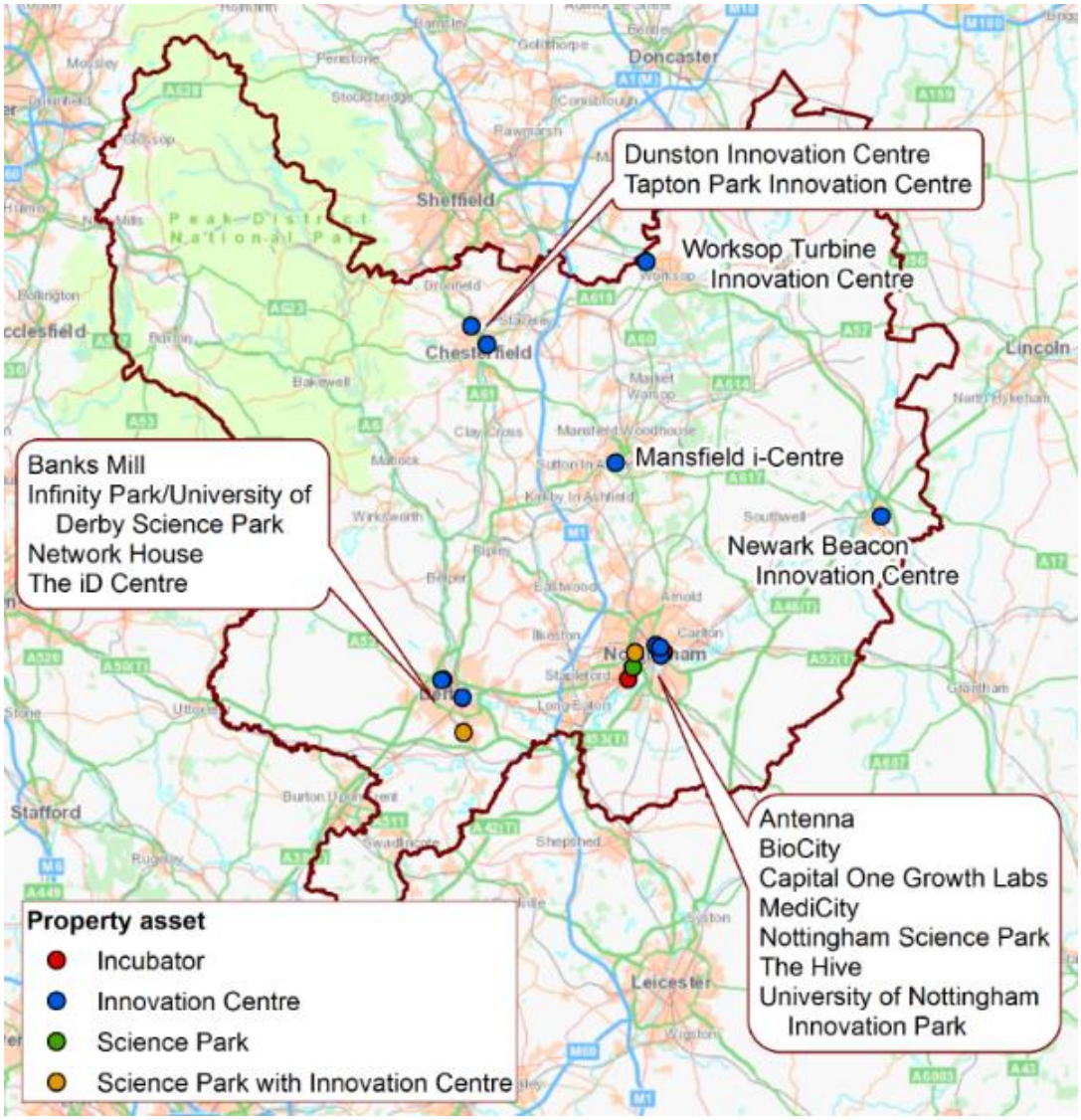
Name	Sectoral focus	Scale
Science parks		
Infinity Park/University of Derby Science Park	Manufacturing	100 acre site, including iHub innovation centre - 45k sq ft
Nottingham Science Park	All sectors	261k
University of Nottingham Innovation Park (UNIP)	Loose focus on manufacturing, aerospace and space, energy, digital. Only UoN students/alumni can join the Ingenuity Lab	c.45k sq ft across 3 buildings, including 40 hot desks in the Ingenuity Lab
Innovation centres/incubators		
Antenna	Creative Industries: Games, animation and design, PR, film companies	c.6k sq ft office and meeting room space
Banks Mill	Creative and digital	38 studios, plus gallery
BioCity	Bioscience, Pharmaceutical, Medical technology, Life Sciences, Healthcare	173k sq ft of office and lab space
Capital One Growth Labs	Fintech	Five start-ups in each cohort
Dunston Innovation Centre	All sectors	-
Mansfield i-Centre	All sectors	-
MediCity	Healthcare, Wellness, Beauty, Medical technology, Life Sciences, Digital applications for health and wellness	62k sq ft of office and lab space
Network House	ICT/New Media	11 offices
Newark Beacon Innovation Centre	All sectors	-
Tapton Park Innovation Centre	All sectors	-
The Hive	Primarily for students and graduates of NTU	c.3,300 sq ft, including 6 offices
The iD Centre	Rail, engineering, aerospace and technology businesses.	27 offices
Worksop Turbine Innovation Centre	All sectors	-

Source: SQW analysis

4.4 Encouragingly, the number and quality of these facilities in our area continues to grow. For example, Nottingham Science Park has secured funding to develop a new 35k sq ft building, whilst Nottingham Trent University is considering ambitious plans to develop an Enterprise and Innovation Centre in the city. The Medical Technologies Innovation Facility proposed by Nottingham Trent is detailed at paragraph 6.28. Finally, consultees reported that discussions are ongoing between our three HEIs over an innovation focussed development at the Toton HS2 station site, possibly incorporating an Innovation Centre.

4.5 Incubators provide flexible property and value-added business support services to new start-up firms. In addition to being an UKSPA member, BioCity is our longest running and most successful incubator. Founded in 2003 by the two Nottingham universities and the East Midlands Development Agency, BioCity now operates MediCity (see box below) on the Boots site, as well as running centres in Glasgow and Alderley Park, Cheshire. There are currently around 800 people on site at BioCity, spread across around 70 tenant companies.

Figure 4-1: Property assets in D2N2



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Enterprise zones

4.6 Enterprise Zones are designated areas which offer specific benefits to businesses located there. Under the **Nottingham and Derby Enterprise Zone** umbrella, our area has a number of specific enterprise zones:

- Alliance Boots site in Beeston, which hosts the MediCity medtech incubator
- Beeston Business Park, which includes both office and industrial units, and focuses on technology and IT firms
- Nottingham Science Park, an UKSPA member located opposite the University of Nottingham. The Science Park has ambitious expansion plans for the future
- Infinity Park in Derby, a 250-acre commercial and technology park. This aims to create a focus for the further development of advanced manufacturing and related services.

4.7 University Enterprise Zones are specific geographical areas that aim to increase interaction between universities and businesses. One of four pilots chosen by a competitive process, the focus of the **Nottingham University Enterprise Zone** is on the University of Nottingham Innovation Park, and more specifically the recently opened Ingenuity Centre (formerly known as the Technology Entrepreneurship Centre). This focuses on a range of technologies (manufacturing, aerospace and space, energy, digital) and offers business support and mentoring for students and alumni.[xxiii]

Boots Enterprise Zone and MediCity

Boots has been operating in Nottingham since 1849. Building on its longstanding presence in the city, the company has established the Boots Enterprise Zone on around 35 hectares of the main Boots HQ site. The long term project aims to create a centre of health, wellbeing and beauty comprising of a world class life sciences campus, residential and commercial space, and its own company HQ. The site already accommodates the Boots Support Office, Data Centres, R&D, Manufacturing, Pharmaceutical Wholesale and Logistics functions.

Planning consent has been granted for up to 81,000 sq m of commercial space, providing opportunities for local and regional businesses. Up to 675 homes will also be built, encompassing a mix of low and high-density residences

In addition, the site houses MediCity – a joint venture between Boots and BioCity. Med-tech firms benefit from BioCity's business support and Boots' expertise in the global healthcare sector. Consultees reported that there are over 20 tenants, employing over 200 people in total at MediCity.[xxiv]

The proposed Medical Technologies Innovation Facility - a multi-partner dual site medical devices research and development facility – with one facility at the Enterprise Zone is detailed at paragraph 6.28.

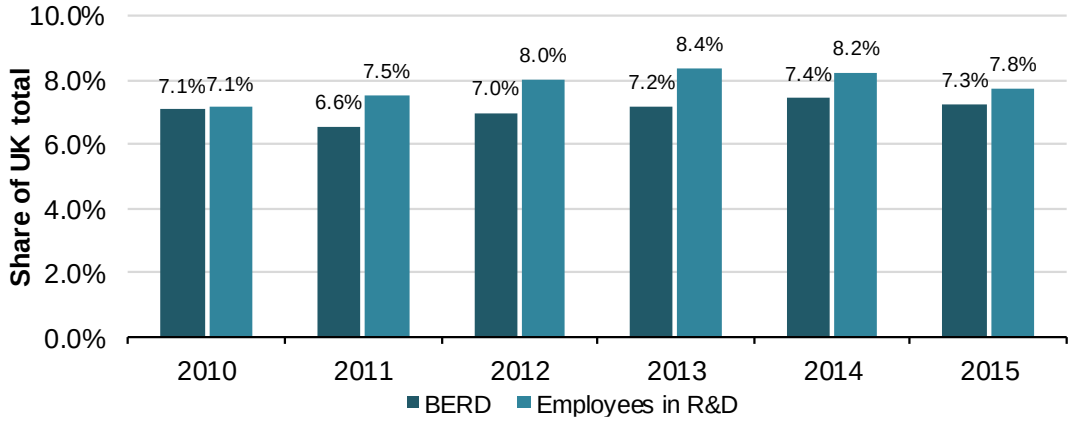
Broadband connectivity

4.8 Fast and reliable broadband is becoming increasingly important for businesses in all sectors of the economy. The proportion of premises with superfast broadband – defined as download speeds of 30mbps+ – ranges from 99.5% for Mansfield to 77.7% for the Derbyshire Dales as of November 2017. In general, broadband speeds correlate with the population density of districts, with more rural areas generally having lower levels of superfast broadband than urban areas. In total, 15 of our districts have 90% of their premises with superfast broadband, and eight districts have 95% connectivity.

Funding and support

4.9 Business investment in R&D (BERD) data are only available at a regional level i.e. the East Midlands region, the majority of which is outside of the spatial focus of this SIA. These data are therefore only indicative of firms in our area. They show that in 2015, businesses across the East Midlands spent £1.5bn on R&D, and employed 16k FTEs in R&D related activities. Encouragingly, East Midlands spending on R&D increased by 33% and R&D employees increased by 45% between 2010 and 2015, although the proportion of the national figures this represents was relatively stable.

Figure 4-2: Business enterprise research and development



Source: SQW analysis of BERD

HEI collaboration on business support through the Enabling Innovation programme

A collaborative programme involving all three of our HEIs, Enabling Innovation aims to provide support to over 2,000 SMEs by early 2019. Its overarching objective is to stimulate interest and investment in research and innovation by SMEs. This relates to developing innovation capacity and capability, commercialising cutting-edge R&D, and supporting product and process innovation within business, ultimately leading to business growth.

By involving all three of our HEIs, Enabling Innovation is taking a new collaborative approach to supporting local SMEs. Efforts to promote their different areas of expertise and business support offers through a 'single front door' could provide a useful template for future D2N2 innovation support.

Individual projects under the overall Enabling Innovation programme focus on: Graduate talent, covering business-led student projects and enterprise creation; technologies and R&D, including accessing enabling technologies and specialist facilities; and Management and Leadership, delivering business development workshops and an extensive events programme.

Local funding sources

4.10 The £40m **Foresight Nottingham Fund** is a private equity regional growth fund that makes investments of between £100k and £2m in SMEs based in Nottingham and Nottinghamshire. Its first round, partly backed by the British Business Bank, is due to be open until August 2018. However, consultees questioned the effectiveness of the fund in supporting science and technology-focused activity given its broad funding remit.

4.11 The £20m **Derby Enterprise Growth Fund** and £2.6m **D2 Enterprise Growth Fund** offer financial support to businesses based in Derby and the travel to work area, and the whole of Derbyshire respectively. Grants of £20k and above are available for local businesses, especially for projects around supply chain innovation or enterprise expansion. The **N2 Business Growth Fund** performs a similar service for Nottinghamshire businesses, whilst FEAST offers grants of up to £80k for food and drink manufactures.

4.12 Despite these funds, consultees were of the opinion that our area suffers because of the regional imbalance of the supply of growth finance across the UK. They felt that if the supply of finance was better, more innovative businesses would be started and existing businesses would find it easier to grow and develop in our area.

4.13 Data from the British Venture Capital Association (BVCA) support this perception of an undersupply of finance. These data indicate that 23 companies across the whole of the East Midlands received a total private equity and venture capital (VC) investment of £294m in 2016. Whilst significant in absolute terms, it accounts for just 4% of all investment in 2016.

4.14 The disparity with London and the South East is reinforced by BVCA figures for investment on a per business basis. In 2016, 0.11 companies per 1,000 local units secured VC investment in the East Midlands, well behind the 0.32 receiving investment in the South East and London. In fact, the East Midlands was the lowest ranked UK region on this measure. On a sectoral level, data from BioCity reveal that from 2012 to 2016, life science start-ups in the East Midlands received less than 1% of the total investment in UK life science start-ups.[xxv]

4.15 As part of efforts to eliminate the regional imbalance, the **Midlands Engine Investment Fund** (MEIF) launched £120m of SME debt finance in August 2017. The whole MEIF is worth £250m and will also include equity funding options.[xxvi] It will be crucial that our innovative firms make good use of this opportunity, particularly the debt finance which is most likely to be appropriate to pre-revenue science-based firms, and ensure that they are 'investment ready'.

4.16 The Industrial Strategy announced further sources of funding which may be of interest to our businesses and academics. This includes the £725m Industrial Strategy Challenge Fund, the expanded £31bn National Productivity Investment Fund and a £2.5bn Investment Fund to be managed by the British Business Bank. Again, businesses across all sectors must capitalise on these opportunities if our area is to achieve its productivity potential.

Innovate UK

4.17 Almost 300 D2N2 organisations were involved in nearly 600 Innovate UK funded projects in 687 instances (some projects involved multiple D2N2 organisations) over the period of April 2010 to March 2017, with D2N2 organisations receiving £134.2m of funding, representing 3.4% of the UK total. The majority of funding, 67%, was received by academic organisations, followed by large companies, 14%, and micro companies, 10%.

4.18 The recipients were dominated by two major science and innovation actors in our area: The University of Nottingham received £86.6m (65% of D2N2 total) from almost 160 projects; Rolls-Royce received £14.8m (14%) from 20 projects.[xxvii] The remaining 290 recipients each received 1.3% or less of the total funding to D2N2 organisations.

Horizon 2020

4.19 Horizon 2020 is the EU's flagship science and innovation funding programme and runs from 2014 to 2020. Beneficiaries located in our area have directly received €18.6m in funding across 33 projects from Horizon 2020 to date. D2N2 beneficiaries have also been involved in a further 100 projects, either as lead or partner, which have received total funding of €490.7m. Unfortunately, the publicly available data do not record the proportion of this funding that was received by D2N2 partners. Therefore, Table 4-2 only shows organisations who have been involved in projects with a total value of more than €5m.

4.20 In common with the Innovate UK funding picture, the University of Nottingham was involved in more Horizon 2020 funded projects than any other D2N2 organisation. It participated in 94 projects that received total funding of €381.4m, of which €13m is known to have been received by the university as the sole beneficiary. An unknown percentage of the remaining c. €368m will also have been received by the university.

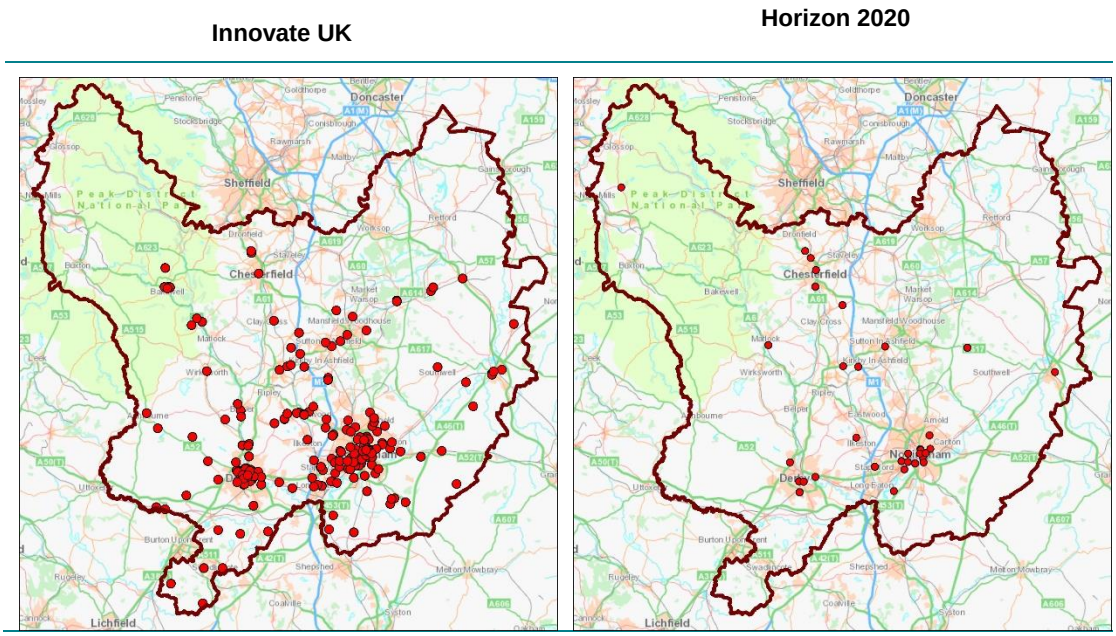
Table 4-2: Number of Horizon 2020 projects and level of funding by recipient organisation[xxviii]

	Industry/type	No. of projects	Funding received directly	Total value of projects
University of Nottingham	HEI	94	€13.0m	€381.4m
Nottingham Trent University	HEI	6	-	€48.1m
Rolls-Royce Power Engineering	Adv. manufacturing	3	-	€40.6m
Nottingham City Council	Local authority	2	-	€27.8m
INFOHUB Ltd	Digital	1	-	€23.8m
SASIE Ltd	Energy	1	-	€23.8m
Nottingham Energy Partnership	Energy	1	-	€23.8m
Netcomposites Ltd	Adv. manufacturing	3	-	€22.5m
Embedded Rail Technology Ltd	Adv. manufacturing	1	-	€18.0m
Meadows Ozone Energy Services Ltd	Energy	1	-	€15.4m
Promethean Particles Ltd	Chemical engineering	2	-	€13.5m
Upperton Ltd	Life sciences	1	-	€8.4m
Altek Europe Ltd	Adv. manufacturing	2	€2.5m	€8.1m
Far-UK Ltd	Adv. manufacturing	1	-	€8.0m
Resources Computing International Ltd	Digital	2	-	€7.0m
Interkonsult Ltd	Scientific research	1	-	€5.1m
Miles-Bramwell Executive Services Ltd	Professional services	1	-	€4.9m

Source: SQW analysis of Horizon 2020 data

4.21 Figure 4-3 compares the locations of beneficiaries of Innovate UK and Horizon 2020 funding. For both funds, beneficiaries are predominantly concentrated around Nottingham and Derby, followed by other urban areas. Innovate UK funding is more widely distributed, but this may be expected given the larger number of beneficiaries.

Figure 4-3: Locations of Innovate UK and Horizon 2020 beneficiaries



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People and skills

4.22 The link between innovation and skills development will become increasingly important in improving our prosperity. Investment in capital assets will only generate maximum impact when there is a suitable supply of skilled labour to interact with them. Therefore, to generate inclusive growth we must ensure that interventions take an integrated approach to innovation and skills challenges. This includes making appropriate use of employer based learning and developing employer led courses in specific sectors/technologies. Promoting more broadly applicable management and leadership skills are also essential if our smaller businesses are to take the opportunity to scale up.

4.23 Universities in the D2N2 area offer **exceptional opportunities for study** at undergraduate and postgraduate level. All three universities offer a wide range of subjects and the University of Nottingham in particular attracts many students from international territories (see **Table 4-3**). With over **60,000 undergraduates and 16,000 postgraduates,** there are many talented young people and mature learners available in our labour market.

4.24 PhD students studying in some disciplines also benefit from being part of **Research Council Doctoral Training Partnerships** where universities arrange specialist training and support for their students across the HE network. The University of Nottingham participates in 14 such partnerships, with the Nottingham Trent University being part of one. These include eight that are funded by the Engineering & Physical Sciences Research Council that focus on research in areas such as Additive Manufacturing and 3D Printing, Carbon Capture and Storage, and Cleaner Fossil Energy, and personal Data[xxix].

Table 4-3: Higher Education Student numbers in D2N2 (2016/17)

	Undergraduate			Postgraduate		
	UK	EU + Int	Total UG	UK	EU + Int	Total PG

University of Derby	12,495	875	13,375	2,580	345	2,925
University of Nottingham	19,860	4,070	23,935	5,015	3,170	8,185
Nottingham Trent University	21,085	1,760	22,840	3,260	1,820	5,080
D2N2 total	**53,440**	**6705**	**60,150**	**10,855**	**5,335**	**16,190**

Source: HESA 2017

4.25 Our HEIs also work with a wide range of employers to establish **Degree Apprenticeships**[xxx]. Derby currently offer six routes focusing on engineering, data science, construction and management; whilst Nottingham Trent University currently offers five in construction, food, electronics and management. The University of Nottingham also plan to develop their provision further meaning that there will be increasing opportunities for leading businesses to engage with universities to ensure that students develop the skills they will need for the future workforce.

Skills challenges

4.26 Several **skills challenges** could impact on our ability to maximise our substantial portfolio of science and innovation assets.

4.27 **Student migration** remains an important issue. According to a Centre for Cities report, the city of Nottingham is the largest contributor to London's graduate population[xxxi]. In the 2013-2015 period, 88% of Nottingham's student population came from somewhere other than Nottingham but only 21 per cent of its graduates remained in Nottingham to work (compared to 31% retention in Sheffield, for example).

4.28 **Our young people are also less likely to study at higher education** than average. HEFCE analysis shows that 34% of our Middle Super Output Areas (MSOAs) are in the lowest quintile for HE attendance by age. Moreover, some of our Local Authorities rank very poorly nationally: Mansfield has the 3rd highest proportion of MSOAs in the lowest quintile, with Bolsover 4th and Ashfield 9th. To combat this, the D2N2 LEP has worked with employers to develop an employability framework which is being implemented in schools, and they have also actively engaged with the Careers and Enterprise Company to help raise aspirations.

4.29 We have some exceptional schools but there is a **primary and secondary quality deficit in education**. The broader East Midlands region is currently the joint lowest performing Ofsted region in terms of inspection outcomes, whilst Derby and Nottingham were among the 10 lowest ranking local authority areas nationally for GCSE examinations in 2015[xxxii]. However, this has created a new energy and impetus for change - Derby is now one of the first of the DfE's Opportunity Areas to redress this issue.

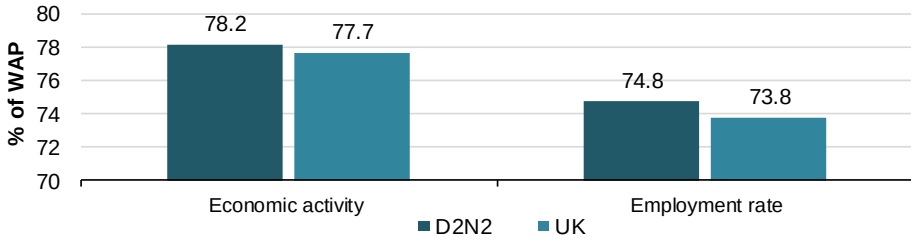
4.30 As the recent Industry Strategy and Industrial Digitalisation Review state, there is a **need for a pipeline of STEM skilled people**. However, Sir Adrian Smith's[xxxiii] review of post-16 mathematics highlighted that Derby had the joint third lowest progression rate (60%) for students who achieved A/A* at age 16 and progressed to study Level 3 maths (A level equivalent). The figures for Derbyshire (73%) Nottingham (66%) Nottinghamshire (71%) are also lower than the 80% progression achieved by local authorities in London and the South East.[xxxiv] This means that our young people are less likely to be equipped with the necessary

skills to capitalise fully on local science and innovation opportunities. FE Colleges and Independent Training Providers have been working with the Education Training Foundation to address this.

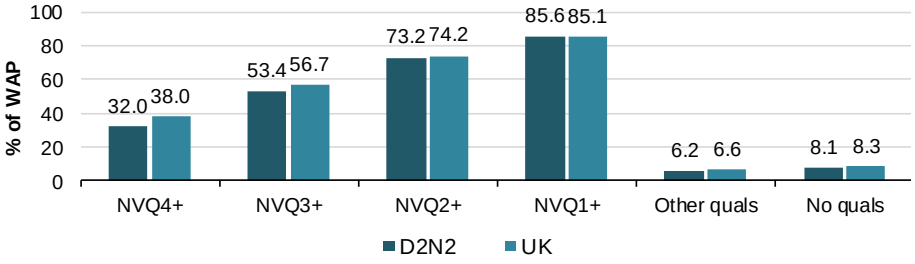
As a consequence of these skills challenges, our high levels of workforce participation occur in disproportionally low skill roles, which can build a **skills trap,** see **Table 4-4**. This is particularly acute for those in lower skilled or low paid employment who face difficulties finding the time or money to upskill or re-skill.

Table 4-4: People and skills in D2N2 (2016)

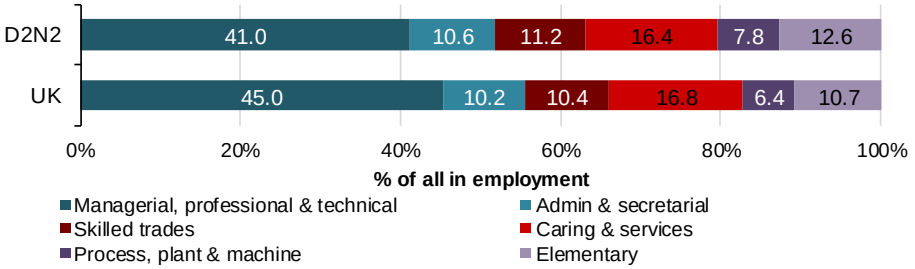
A higher proportion of our population are economically active than UK average



But we have too few people at the highest skill levels…



… and too few working in the highest occupational categories



Source: SQW analysis of APS data

4.31 This generates **skills mismatches**. Our businesses had almost 24,000 more technical vacancies than there were FE course completions in D2N2 in 2015/16[xxxv]. This suggests that there are major opportunities for us if schools focus on raising attainment, colleges focus on building technical routes that aid the flow of people with the right skills into business, and universities continue to focus on higher level skills and innovation that are co-created with our regional employers and supply chains. In short, without developing a stronger supply of higher level skills, it will be impossible for D2N2 to tackle its long-term productivity and innovation challenges.

Networks and knowledge exchange

4.32 The effective sharing and dissemination of knowledge between sectors and technology areas, institutions, firms and people is the cornerstone of any successful innovation ecosystem. Whilst some informal, relationship based networks operate at local levels, a range of more formal networks and partnerships operating within and beyond our area can be identified.

Table 4-5 provides some examples to illustrate how institutions are working extensively with partners to drive commercialisation and tackle key innovation challenges.

Table 4-5: Networks and knowledge exchange

Predominantly within D2N2/East Midlands	Broader spatial focus
East Midlands Academic Health Science Network brings together the NHS, universities, industry, third sector, patients and social care	**Midlands Aerospace Alliance** supports and represents the aerospace industry across the Midlands
East Midlands Chamber is the second largest chamber of commerce in the country and has a membership of more than 4,000 businesses	**Midlands Connect** brings together local authorities and LEPs from across the Midlands to improve connectivity across the region
Medilink East Midlands provides specialised business support to health technology companies through personal consultations, site visits, business meetings and events.	**Midlands Engine** aims to improve the economy of the Midlands and deliver an enhanced quality of life for citizens and communities. Midlands Connect is a theme within this
Rail Forum East Midlands, formerly known as the Derby and Derbyshire Rail Forum (DDRF), represents over 150 businesses across the East Midlands, employing over 25,000 people	**Made in the Midlands**, a privately-run peer group for MD's and CEO's of Manufacturing and Engineering firms in the Midlands
The Food and Drink Forum is a membership based not-for-profit organisation which runs the Food and Drink iNet network	

Source: SQW analysis

4.33 Many of the networks identified above include both universities, businesses and RTOs as members. In addition to these, our universities are also widely involved in a number of HEI specific networks and groups at regional, national and international levels. Regional groups include:

- **Midlands Innovation**, a collaboration of six research intensive universities including Nottingham, aims to drive cutting-edge research, innovation and skills development, and build global hubs of research and innovation excellence.
- **Midlands Enterprise Universities**, a partnership of seven universities, including Derby and Nottingham Trent, with the ambition to drive productivity and growth through skills, innovation and enterprise.
- Nottingham is one of four partners of the AHRC-funded **Midlands3Cities** (M3C) Doctoral Training Partnership, alongside institutions in Birmingham and Leicester. M3C provides research expertise for the professional and personal development of the next generation of arts and humanities doctoral researchers.

4.34 Our universities are also engaged in associations across the spectrum of UK higher education. For example, Nottingham is a member of the **Russell Group**, whilst Nottingham Trent is part of the 18 member **University Alliance**. On an international level, the University of Nottingham is a member of the European Consortium of Innovative Universities and Universitas 21.

Evidencing collaboration

4.35 Demonstrating collaboration and knowledge exchange through data is challenging. However, the Higher Education Business Community Interaction Survey (HEBCI) does provide useful

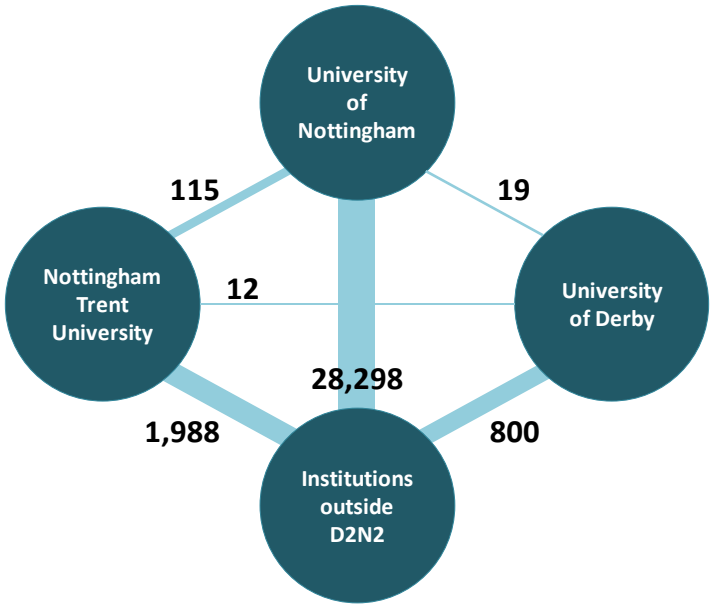
information. The data included in Table 2-3 above reveal that our HEIs generated £52m in collaborative research income in 2015/16, equivalent to 4% of the UK total. Our HEIs also punched above their weight in accounting for £34m, or 2.8%, of contract research income in the same year. The University of Nottingham is the major contributor in both categories.

Academic collaborations with local HEIs and partners across the world

4.36 SciVal data on university-university and university-industry collaborations provides another good source of evidence on the scale of collaboration across our area.

4.37 The level of collaboration between the D2N2 universities can be gauged through the number of co-authored publications, as shown in Figure 4-4 below. The University of Nottingham and Nottingham Trent collaborated the most during the 2014-2016 period, with minimal collaboration resulting in published outputs occurring between the D2N2 universities otherwise.

Figure 4-4: Number of university-university co-authored publications (2014-2016)



Source: SQW analysis of SciVal data

Collaboration between the Universities of Derby and Nottingham

The objective of the iTrend (Intelligent Technologies for Renal Dialysis) project is to improve patient outcomes during kidney dialysis by controlling patient blood pressure in real-time during treatment, and constant monitoring during inter-Dialysis phases. iTrend promotes low cost, non-invasive technologies.

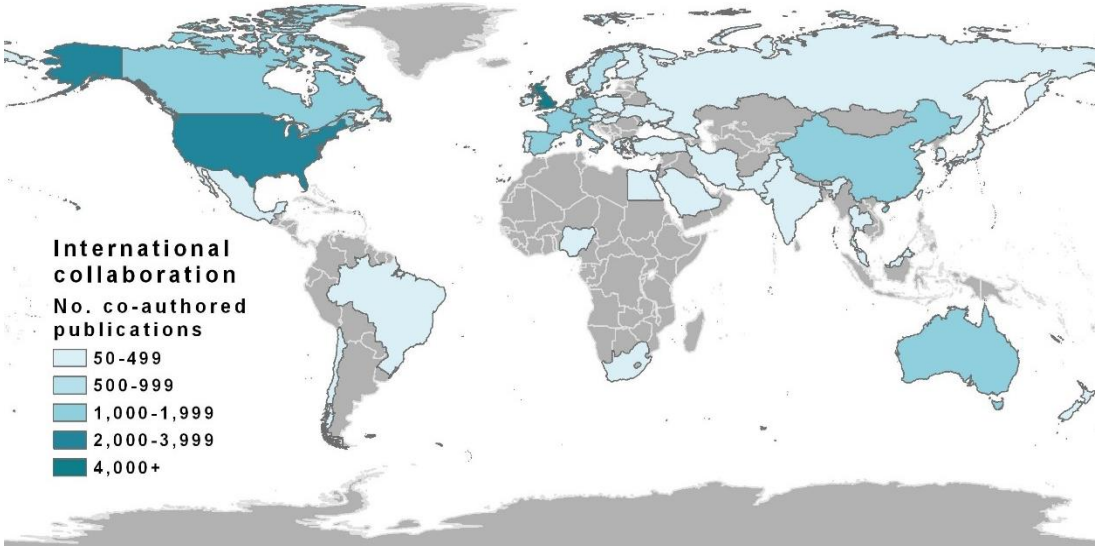
iTrend is funded by the MStart Trust and is a three year collaboration between the universities of Derby and Nottingham, and Derby Royal Hospital. In parallel with sensor and real-time modelling and control development at the University of Derby, the University of Nottingham is conducting a patient study at Derby Royal Hospital's Renal Unit.[xxxvi]

4.38 Considering collaboration with academic institutions outside of D2N2, the University of Nottingham co-authored far more publications than the other D2N2 HEIs; over 90% of the total. As a world class research intensive institution with campuses in China and Malaysia, this is perhaps not surprising.

4.39 Of the over 31k publications that were co-authored with c.2,350 non-D2N2 based institutions over the 2014-16 period, 19% were with Russell Group universities. Thirteen of the top 15 UK HEI collaborators (those with at least 240 co-authored publications) are Russell Group members, with the remaining two (Leicester and Loughborough) important local collaborators.

4.40 Of the same 31k publications, 69% were with institutions outside of the UK. Figure 4-5 presents the number of D2N2 co-authored publications by country, for those countries with at least 50 co-authored publications. This shows that our HEIs have a global reach, collaborating with countries as far afield as Japan and Chile. In general, our HEIs tend to collaborate more frequently with more developed nations, particularly those in Western Europe and North America. The countries collaborated with the most are the USA (3,899), France (1,550), Germany (1,452) and China (1,420).

Figure 4-5: Number of co-authored publications by country (2014-2016)



Source: Produced by SQW 2017. Licence 100030994. Contains SciVal data

Industrial collaborations with major corporates

4.41 SciVal data can also be used to show the three D2N2 universities' corporate collaborations. During the 2014-2016 period, there were over 600 co-authored publications that involved 164 different companies in total. Again, the majority of these collaborations involved the University of Nottingham, accounting for 95% of the co-authored publications.

4.42 Table 4-6 shows the corporate partners that publications have been co-authored with most frequently. The list is dominated by life science companies, but also includes a number of advanced manufacturing, digital, fast moving consumer goods and agri-tech firms. Collaborating with such major corporates as these illustrates the high regard in which world leading companies hold our HEIs.

Table 4-6: Top industrial collaborators by number of co-authored publications (2014-16)

	Industry	NTU	UoD	UoN	D2N2 total
GlaxoSmithKline	Life science	-	3	39	42
AstraZeneca	Life science	-	-	39	39
Unilever	Consumer goods	-	-	19	19

	Industry	NTU	UoD	UoN	D2N2 total
Pfizer	Life science	1	-	18	19
ADAS	Environmental consultancy	-	-	18	18
Microsoft USA	Digital	-	-	18	18
AstraZeneca Sweden	Life science	-	-	18	18
Jaguar Land Rover	Advanced manufacturing	-	-	14	14
Novartis	Life science	-	-	13	13
Rolls-Royce	Advanced manufacturing	-	1	10	11
Hamad Medical Corporation	Life science	-	-	11	11
Merck	Life science	-	-	10	10
Waltham Centre for Pet Nutrition	Scientific research	6	-	3	9
Fera Science Ltd.	Agri-tech	1	-	8	9
Genentech Incorporated	Life science	-	-	9	9

Source: SQW analysis of SciVal data

Policy and regulation

4.43 A supportive policy and regulatory framework is key to 'oiling the wheels' for innovation activity. Created in 2016, the National Productivity Investment Fund (NPIF) is a key government policy in this area. The **Autumn Budget 2017** reinforced this by extending the NPIF to 2022-23 and increasing its size to £31bn, some £7bn of which is dedicated to R&D and £0.75bn to digital communications. Further support for innovation was provided by increasing the R&D expenditure credit - which gives Corporation Tax relief – to 12%.[xxxvii]

4.44 The Budget made clear the importance of the recently published **Industrial Strategy White Paper** which announced further support for science and innovation. Of particular importance given our SIA Framework are the sector deals for four areas with a strong presence in D2N2: life sciences and healthcare, construction (Energy and Low Carbon), artificial intelligence (Digital Technologies and Data / Advanced Manufacturing and Engineering) and the automotive sector (Next Generation Transport). The four identified Grand Challenges also resonate strongly with our Framework, see Table 3-1. The overall ambition and specific areas of focus identified in both lists also resonate strongly with the call for the UK to become a global leader in industrial digitalisation by 2030 set out in **Made Smarter Review 2017**. This proposes a series of actions to tackle challenges around adoption, innovation and leadership in industrial digitalisation to drive productivity and prosperity; see Section 5.

4.45 Our local approach in D2N2 also places science and innovation at the heart of the economic growth agenda. For example, innovation is one of five strategic priorities detailed in our Strategic Economic Plan. This is reinforced by our strategic plan for innovation, **Time to Innovate**[xxxviii]. This aims to enhance innovation levels amongst D2N2 companies, particularly high growth SMEs, through three activity strands: providing flexible and tailored business support; investing in physical and communications infrastructure; and exploiting the knowledge base by building on local specialisms and encouraging collaboration. In total, and with considerable ESIF support, it is estimated that £74.4m will be invested in innovation by 2020 in our area.

5. Three Enabling Competencies

Summary

- Manufacturing is changing to incorporate a much broader value chain and improved production techniques. With major industrial players and rapidly growing SMEs across the different manufacturing sub-sectors, our area is at the forefront of Advanced Manufacturing and Engineering. This capability is supported by research excellence that spans our universities.
- As digital technologies and data become increasingly pervasive across all sectors of the economy, the way industries operate is changing. This includes the increasing adoption of digital techniques, the derivation of value from analysis of 'big data', and the emergence of the internet of things. Our strengths in Digital Technologies and Data include a developing cluster in Nottingham focussed on computer games, financial data management and analysis, and e-health, with growing activity in satellite applications. In addition, the ability of our leading advanced manufacturing firms to embrace and exploit the exciting opportunities associated with industrial digitisation will be key as they seek to enhance their international competitiveness.
- Systems Integration involves research into the development of products, processes, and services and their subsequent implementation to enable 'whole systems' approaches to a wide range of economic and social activities. Our capability in this area is particularly evident in relation to energy, but is also relevant to smart cities and many of our major manufacturers and engineering firms. This competency is also underpinned by a significant consultancy and technical testing and analysis business base.

5.1 The three Enabling Competencies are an integral part of our D2N2 SIA framework. They are not specific sectors or industries, but instead cut across sectors and act as shared capabilities. They therefore reflect common areas of research expertise, technical specialism and broader thought leadership in our HEIs and business base, which underpin the international competitiveness of our Market Priorities.

5.2 The three Enabling Competencies are also mutually reinforcing. For example, and as discussed below, the rise in Industry 4.0 has been enabled by linked advances in digital technologies. Likewise, the expansion of the manufacturing value chain can be seen as manufacturers adopt more of a whole systems view of the world. Finally, big data analysis and computer simulation are important in using whole systems approaches to tackle complex problems and society's 'grand challenges'.

5.3 The importance of the Enabling Competencies is not unique to D2N2, and indeed was acknowledged in the Midlands Engine SIA. However, the specific strengths of each of the three and they exact way that they interlock is. As explained below, the evidence and feedback from stakeholders indicates that we have real strengths in 'Advanced Manufacturing and Engineering', 'Digital Technology and Data', and 'Systems Integration' – all three, including the synergies and linkages between them, must be harnessed and built upon as we seek to accelerate our productivity growth over the coming years.

EC1: Advanced Manufacturing and Engineering

5.4 Manufacturing is changing, both in terms of production and the broader value chain. Taking the production element first, the emergence of Industry 4.0 and its associated technologies

and techniques – cyber physical systems, big data analytics, the Internet of Things and cloud computing (often summarised as industrial digitalisation) – will lead to the rise of 'smart factories' and a major shift in how products across multiple sectors and technology areas are produced. Capitalising on industrial digitalisation has recently been identified as a major opportunity for UK firms to "make things smarter, better and faster."[xxxix] With businesses and researchers in D2N2 offering important capabilities in this space (see below and the following section on Digital Technologies and Data), we are very well placed to make significant contributions to achieving the three goals of the recent industrial digitalisation review in the UK: leveraging technological leadership; promoting more rapid adoption; and driving further innovation in this area.

5.5 More broadly, the manufacturing value chain is also expanding to incorporate a much wider set of activities than previously. R&D, product design and development, supplier management, and after sales services are all increasingly seen as opportunities to generate value, including through the 'servitisation' of manufacturing.

5.6 Set against this evolving context, and as noted in Section 2, manufacturing and engineering remain an important part of our economy. Some 126k people are employed across the full spectrum of the manufacturing sector in our area. Their employers range from SMEs to multinational firms and they operate across a broad spectrum of manufacturing sub-sectors. Organisations in our area are therefore not just reacting to the trends discussed above, they are helping to shape and drive them. For this reason, Advanced Manufacturing and Engineering is our first enabling competency.

5.7 Large multinational manufacturers in areas as diverse as transport and food operate in our area; Toyota's largest UK site is in D2N2, whilst Nestle has largescale facilities at the very northern and southern edges of our area. Textiles manufacturing has historically been important to our area and continues to be with Speedo's HQ and R&D centre located in Nottingham, alongside Paul Smith, Quantum Clothing, and technical and medical textiles firm Capatex.

Toyota's investment in advanced manufacturing

Toyota's manufacturing plant in Burnaston, which covers c580 acres, is to receive an investment of more than £240m, including up to £21.3m from the UK Government. The investment will enable the production of new vehicles using the Toyota New Global Architecture platform, which will boost competitiveness and encourage UK supply chain efficiencies. Government investment will be focused on training, R&D and the enhancement of environmental performance across the plant.

The Burnaston plant, located seven miles from Derby City Centre, is one of two Toyota manufacturing plants in the UK (the other is an engine production facility at Deeside, North Wales). It has the capacity to produce more than 180,000 vehicles per annum. The larger of the two sites, Burnaston specialises in vehicle manufacturing and supports over 2,400 employees.[xl] Around 85% of the cars produced at the Burnaston site are exported to markets across Europe and South Africa.

According to the Toyota UK website, the first car, a Carina E, left the Burnaston production line on 16 December 1992. The Avensis replaced the Carina E in 1997 and in 2008, the third generation Avensis was launched. In 1998 a second model, the Corolla, was introduced and in 2001 the new generation Corolla was launched. In 2007, production of Auris, the new Toyota hatchback, started replacing Corolla. Production of the Auris Hybrid, the first full mass-produced hybrid in Europe, began in 2010. In 2013, the Auris Touring Sport was introduced. The processes at Burnaston include stamping, welding, painting, plastic mouldings and assembly and at Deeside machining, assembly and aluminium casting.

5.8 In addition to these major corporates, recent research has identified that three of our fastest growing scale-ups are manufacturers[xli]:

- Tioga - Offers contract manufacturing services for advanced electronic products to a range of sectors from healthcare to telecommunications
- Lasershape - Provides laser and waterjet cutting for a wide range of materials
- Swiftool Precision Engineering - Manufactures a range of components, turnkey projects and kits.

5.9 Our strengths are by no means confined to industry alone. For example, REF 2014 data shows that the University of Nottingham had the third most powerful research in 'General Engineering' in the UK. Specific centres of excellence in our area include Nottingham's Precision Manufacturing Centre, Derby's Institute for Innovation in Sustainable Engineering, and Nottingham Trent's Advanced Design and Manufacturing Engineering Centre. The University of Nottingham also hosts the 20 partner Network Plus: Industrial Systems in the Digital Age project, and will formally open its new Advanced Manufacturing Building in early 2018 to house research and teaching activity.

5.10 The research and scientific excellence this gives rise to is emphasised by the well-known names of our most common industrial collaborators as shown in Table 5-1. Indeed, work by the Smart Specialisation hub identified a high innovation capability in High Value Manufacturing, see Figure 2-3.

Table 5-1: Advanced manufacturing and engineering corporate collaborators (2014-16)

Transport	Cross-sector and engineering
Jaguar Land Rover	General Electric
Rolls-Royce	Arup
Alstom	Siemens
Airbus Group	
BMW Group	
Ford Motor	

Source: SQW analysis of SciVal

5.11 Importantly, the Derby Manufacturing University Technical College will help to train the next generation. Support from lead industrial partners Rolls-Royce, Toyota, and Bombardier will ensure that they are fully equipped to tackle the challenges and opportunities that Industry 4.0 and associated trends will represent for our businesses. The UTC specialises in engineering education and training, with a specific focus on advanced manufacturing, product design, materials science, advanced composites and sustainability in engineering.

EC2: Digital Technologies and Data

5.12 As digital technologies and data become increasingly pervasive across all sectors of the D2N2 economy, the way industries operate is changing rapidly. This includes the increasing adoption of digital techniques from computer based filling systems through to industrial digitalisation, the derivation of value from analysis of 'big data', and the emergence (and proliferation) of the Internet of Things. Our enabling competency in this area reflects these trends and the emergence of a dynamic digital tech cluster in Nottingham.

5.13 Employment in digital related industries is notoriously difficult to capture in data. Nevertheless, using Tech City's definition of digital technology employment, there are 23k jobs in this area across D2N2. Many of these are in Nottingham where Tech City identified a digital cluster.[xlii] Four specific areas of activity are highlighted below.

Table 5-2: Digital technologies and data in Nottingham

Computer games sector	Ukie has identified 28 firms in Nottingham and a further 10 in Derby, with significant players including Sumo.[xliii]
Financial data management and analysis	Experian is one of the world's most prominent data gathering and analysis businesses and has its HQ in Nottingham. TDX Group, a data and technology company that develops technology platforms for debt collection management is also based in Nottingham as is Capital One.
Life sciences and e-health	BioCity hosts a number of firms reliant on the development of advanced digital applications to drug discovery and medical devices. Smaller digital businesses within the life sciences sector include the online health guides producer Dr Foster and the public health app developers, North 51. Consultees also identified strengths in telehealth and biometrics.
Satellite applications	Consultees identified growing activity in the satellite applications field. For example, the University of Nottingham hosts the Space TEC Programme, a 2 year incubation project based at UNIP, which is part-funded by the UK Space Agency.[xliv]

Source: SQW

5.14 These applied industrial strengths are backed by complementary research at our HEIs. The University of Nottingham's Horizon Digital Economy Research Institute and Nottingham Trent's Computational Intelligence and Applications Research Group and Creative and Virtual Technologies Research Lab help the combined FWCI of our HEIs in the 'Computer science' subject area to 1.4, well above the international average and only slightly below the UK average of 1.5. Moreover, Nottingham was ranked ninth nationally in research power in Computer Science and Informatics by the REF 2014. As noted at paragraph 5.2 above, our Advanced Manufacturing research assets connected to industrial digitisation are also important in the context of Digital Technologies.

5.15 Our HEIs also provide valuable training in this area. For example, Nottingham Trent University offers an MSc in Data Analytics for Business, which follows a curriculum co-designed with employers, whilst the University of Derby has an MSc course in Big Data Analytics.

5.16 Again, our HEIs are collaborating with internationally significant players in this area: there have been 18 collaborations with Microsoft and Nottingham, as well as three with IBM. In addition, all three of our HEIs have collaborated with cyber security experts QinetiQ, and both Nottingham HEIs have worked with Cambridge based ARM.

5.17 In addition to the sectors highlighted in Table 5-2, our strengths in this enabling competence are also applied in areas as diverse as heritage. Nottingham Trent University is using digital technologies for 3D modelling, animation and scanning as part of its research theme on Global Heritage.

5.18 Despite these well-evidenced strengths, the feedback from consultees suggests that the potential linkages between EC 1 (advanced manufacturing and engineering) and EC 2 (digital technologies and data) have thus far, not been fully leveraged by D2N2 firms and wider stakeholders. Given the obvious complementarities and synergies, on the face of it, this would

appear to be an important strategic opportunity for driving further growth and building resilience across the D2N2 economy. Additionally, it would also strengthen economic ties and supply chain/R&D collaborations between Derby and Nottingham.

Digital at the heart of Nottingham's Creative Quarter

Nottingham's Creative Quarter (CQ) includes the historic Lace Market, Hockley, Sneinton Market and Pennyfoot Street areas. It is also home to BioCity.

Innovative firms based in the CQ operate across the digital, life sciences and low carbon sectors. The co-location with independent retailers, bars and restaurants, small creative companies and artists helps to attract and retain enterprising firms and young workers.

For digital firms, the CQ has workspace and business support at Antenna, digital media training at Confetti and is already home to growing businesses such as animation and video production firm Bottletop.[xlv]

EC3: Systems Integration

5.19 Systems integration involves research into the development of products, processes, and services and their subsequent implementation to enable 'whole systems' approaches to a wide range of economic and social activities. It also includes how these products, processes and services can be better designed, managed and operated, including through the intelligent use of data to inform decision making.

5.20 Whole systems thinking and integration is particularly prominent in our area in relation to energy. The 'energy trilemma' – how to ensure the sustainability, affordability and security of energy supplies – can only be solved by adopting a 'whole systems' rethink in how energy is generated, stored, supplied, managed and consumed. As Section 6 discusses in more detail, energy demonstrators in Nottingham are providing real life insights into this.

5.21 Drawing on the Internet of Things and digital technologies, Smart Cities are another area where whole systems thinking is critically important. Nottingham City Council is a member of the Smart Cities Partnership and its Citycard functions as an integrated smartcard which can be used for public transport, cycles, libraries, leisure and retail discounts. Through the EU funded REMOURBAN project, Nottingham aims to take advantage of the crossover between energy, mobility and ICT to develop a new method for developing smart cities. Nottingham City Council, Nottingham Energy Partnership and Nottingham Trent University are involved in this international collaboration. Going forward the Derby and Nottingham Metropolitan Strategy is based on a smart cities model and includes the use of technology, innovation and infrastructure to deliver economic, social and environmental benefits.[xlvi]

5.22 As well as these broader themes, whole systems thinking can also be applied to more specific areas of focus and these are demonstrated by our major private sector firms. SNC-Lavalin, with its UK HQ in Derby, has expertise in integrating rolling stock and infrastructure though rail control systems. Systems integration is also evident in integrated manufacturing systems to ensure efficient and high quality product design, development and production. This is particularly important to major companies such as Rolls-Royce and supported by the Manufacturing Systems Integration Laboratory at Nottingham University, which focuses on manufacturing processes, automation control and the use of sophisticated robotics. We also have a wider consultancy and technical testing and analysis business base.

5.23 As systems integration is inherently cross-cutting and multi-faceted, involving thinking across rather than within individual disciplines, it is difficult to capture within published data on research excellence.

6. Four Market Priorities

Summary

Following a detailed review of the evidence base, we have identified four market priorities for the D2N2 SIA Framework:

- Next Generation Transport - Major industrial strengths and research excellence are evident in our aerospace, automotive and rail sectors. Our business base covers the full spectrum from R&D through to production and after sales service
- Life Sciences and Healthcare – A broad base of strengths with a clear spatial opportunity around Nottingham's expanding cluster. Our strengths include biotech and pharma, alongside med tech and wellbeing
- Future Food Processing - The food and drink market is becoming increasingly competitive and globalised so our companies must continue to innovate and introduce new products and processes to survive. Specific sub-sectors where this innovation is occurring include: chocolate and confectionary, coffee, brewing, and baking
- Energy and Low Carbon - Our excellence in academic research, important employers, and the application of innovative low carbon technology (whether in low carbon construction, district heating or demonstrator projects) form the basis of our strength

6.1 The D2N2 SIA has identified four evidence-based Market Priorities. Whilst they vary in their scale and maturity, they are all areas where we have distinctive strengths and genuine competitive advantage derived from our science and innovation base.

6.2 It should be noted that these four areas are *not* the only ones which are important for our economy. Instead, they represent significant opportunities to unlock productivity gains and exploit fully the excellence of our science and innovation assets. This is particularly important in the context of the overarching market and technology drivers of change identified in Section 3 and those highlighted in the individual Market Priority sections below.

MP1: Next Generation Transport

Introduction and scope

6.3 The D2N2 area is recognised as being home to a critical mass of globally competitive businesses, and high-technology SMEs, operating within and across a range of transport-related industries. Major industrial strengths and research excellence are evident in the aerospace, automotive and rail sectors. In aerospace and rail particularly, our business base covers the full spectrum from R&D through to production and after sales service, putting us at the forefront of 'Next Generation Transport'. More specifically:

- Our broadly based strengths in **rail** cover all aspects of rolling stock – design, manufacturing, safety assurance, maintenance, information systems – alongside rail consultancies with franchising, manufacturing, and infrastructure expertise. Growing areas of strength include the application of digital technology and advanced materials such as composites
- Alongside the HQ of internationally significant firm Rolls-Royce, our supporting **aerospace** strengths lie mainly, but not exclusively, in machining and fabrication. We

host firms with expertise in fabricating parts to exacting specifications, which requires advanced capabilities in machining 'exotic' materials.

- Our **automotive** innovation strengths are driven primarily by Toyota's large manufacturing plant at Burnaston, Derbyshire. Although much of Toyota's c.£2bn product R&D spend takes place in Japan, the Burnaston operations have been responsible for driving continuous *process* innovation, helping to maintain the international competitiveness of the plant.

- Emerging **cross-cutting areas** such as composites through the work of the University of Nottingham alongside EPM Composites Ltd (high end composite structures manufacturing) and Far-UK (high end composite structures development)

Scale and concentration of activity

6.4 The number, location quotient and growth of jobs and businesses in sectors relevant to Next Generation Transport are shown in Table 6-1 below. Jobs in these sectors are twice as concentrated in our area as Great Britain overall. However, the number of jobs in D2N2 grew more slowly than the UK average between 2010-2015; a rate of 5% compared to 13% for GB as a whole.

6.5 Notably, D2N2 has an absolutely high number of jobs and a relatively higher concentration of jobs compared to GB, in the aerospace, automotive and rail sectors as explained below.

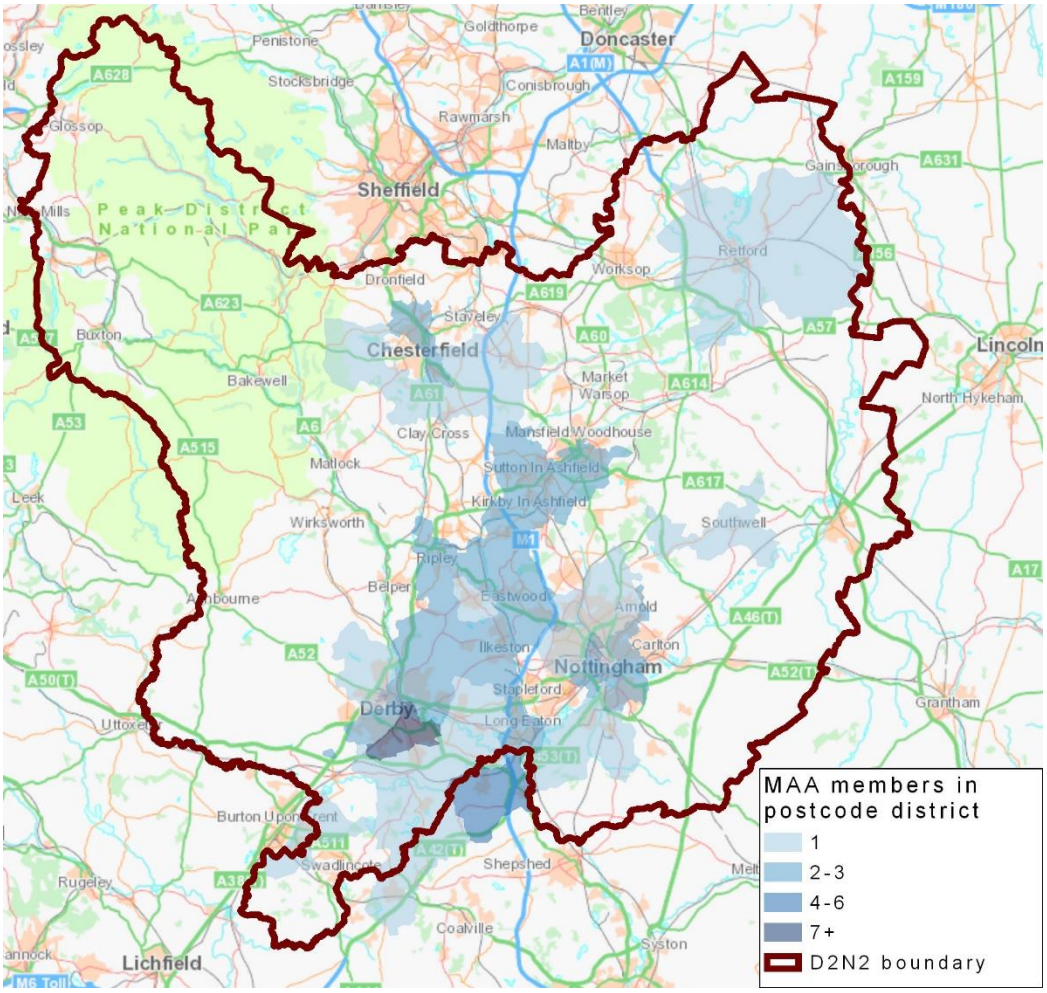
Table 6-1: Count, location quotient (vs. GB) and 2010-2015 % growth – jobs and businesses

	Jobs			Local Units		
	Count (2016)	LQ	% '10-'15	Count (2017)	LQ	% '10-'17
29: Manufacture of motor vehicles, trailers and semi-trailers	4,000	0.8	-10%	140	1.4	-4%
30: Manufacture of other transport equipment (inc. aerospace and rail)	18,000	4.2	15%	100	1.4	13%
3315: Repair and maintenance of ships and boats	10	0.0	67%	5	0.3	0%
3316: Repair and maintenance of aircraft and spacecraft	250	0.4	-38%	45	0.8	67%
3317: Repair and maintenance of transport equipment n.e.c.	700	1.7	100%	150	3.8	420%
Next Generation Transport	**23,000**	**2.1**	**5%**	**435**	**1.5**	**44%**

Source: SQW analysis of BRES and UK Business Counts - Local Units, Nomis

6.6 In total, there are approximately 16,000 jobs in our area in the '**Manufacture of air and spacecraft and related machinery**.' The vast majority of these are in Derby where Rolls-Royce has its HQ (see cameo box in Section 2). Assystem, Barnes Aerospace, Daher Aerospace and Pattonair are also based in close proximity. However, as Table 6-1 shows, the over 75 members of the Midlands Aerospace Alliance in our area are spread across the geography, including Glenair in Mansfield, Icon Aerospace Technology in Retford, and Midland Aerospace in Sutton-in-Ashfield.

Figure 6-1: Map of D2N2 based MAA members



Source: Produced by SQW 2017. Licence 100030994 Contains OS data © Crown copyright [and database right] [2017]. Contains data from Midlands Aerospace Alliance and OpenDoorLogistics

6.7 With 1,750 jobs, employment in '**Manufacture of railway locomotives and rolling stock**' is on a smaller scale than our aerospace industry, but is arguably even more nationally significant. These jobs, almost exclusively in Derby, represent 29% of all jobs in the sector in GB, giving our area an LQ of 9.2. This may underestimate true levels of employment as consultees reported that there are c.100 rail firms in our area. In addition to multinationals Bombardier and SNC-Lavalin, this includes countless supply chain companies providing design services, rolling stock consultancy, manufacturing, IT systems and rolling stock assurance.

Bombardier: designing and building trains in D2N2

Bombardier's 88-acre site in Derby is home to the design and production centre of the AVENTRA train. AVENTRA comprises a variety of innovations, including flat-pack assembly for more cost-effective transportation, automated train inspection using the Bombardier AVIS system, and live occupancy updates for customers.

AVENTRA was initially contracted for use on Crossrail, and its success attracted subsequent orders from four other rail franchises, including West Midlands Rail. Bombardier are therefore expanding production of AVENTRA, which will result in the employment 900 additional staff in Derby by 2018. Some 20% of Bombardier's suppliers are local and Bombardier supports its supply chain to apply for specialist funding in order to increase productivity.

6.8 Finally, and reflecting the presence of Toyota's major manufacturing facility at Burnaston, there is also a slightly higher concentration of workers in the '**Manufacture of motor vehicles**' relative to GB, with 3,000 workers giving an LQ of 1.2. Our automotive sector also includes innovative firms such as Romax (gearbox development), SDC (seating solutions development), Great British Sports Cars (low-weight vehicle development) and Ferodo (brakes). Although not strictly automotive, the JCB Power Systems manufacturing facility at Foston is an important linked asset here.

6.9 Illustrating the importance of Toyota to the wider supply chain, it has 260 parts and materials suppliers based in the UK and Europe, with a further 800 suppliers providing supplies and site services to their two UK plants.[xlvii] Discussions with Toyota reveal that there are a handful of major suppliers (including for wheels, tyres and seats) located within a ten mile radius of the Burnaston plant – all working on a 'just-in-time' basis.

6.10 Whilst the data makes these sectors appear distinct, feedback from local partners indicates that there is considerable overlap between supply chains. For example, approximately 80% of the Midlands Aerospace Alliance members who are 'make to print' – i.e. those who manufacture components designed elsewhere - supply into two or more sectors. Moreover, members of the Rail Forum East Midlands also supply into our aerospace and automotive sectors. This suggests the presence of a highly interconnected supply chain.

Supporting assets and research base

6.11 Our strengths in Next Generation Transport are underpinned by an asset and research base which includes facilities with a relatively narrow focus as well as those with broader applicability. For example, the University of Nottingham hosts several centres with direct relevance to all elements of Next Generation Transport: its Additive Manufacturing Centre; the EPSRC Future Composites Manufacturing Hub; the Rolls-Royce University Technology Centre in Manufacturing Technology; the Nottingham Geospatial Institute and its Global Navigation Satellite Systems R&D and testing facility GRACE; the Sino-UK Geospatial Engineering Centre and the Sino-UK Academy of Intelligent Mobility; and the Power Electronics Spoke of the Advanced Propulsion Centre. In addition, the Future Factory Research and Consultancy Centre at Nottingham Trent supports businesses to work with the university on collaborative projects around smart design, manufacturing and innovative technologies. Future developments include the University of Nottingham's planned Power Electronics and Machines Research and Innovation Centre which will link to its Propulsion Futures research beacon.

6.12 Assets with more specific areas of research include Network Rail's Rail Innovation and Development Centre at Tuxford and the Institute for Aerospace Technology at The University of Nottingham. In addition, the University of Nottingham is part of the Infrastructure Innovation Centre of the UK Rail Research Innovation Network.

6.13 Our assets also allow us to train the next generation of engineers. Derby hosts the Rolls-Royce Academy, which recruits over 200 apprentices each year, as well as the Rolls-Royce Learning and Development Centre. In addition, Derby College has a Rail Employment and Skills Academy which was co-developed with the Rail Forum East Midlands and has a curriculum which is shaped by industry. Finally, Burnaston hosts Toyota's European – Global Production

Training Centre which trains up to 1,000 employees per year from Toyota's European operations in production and maintenance.

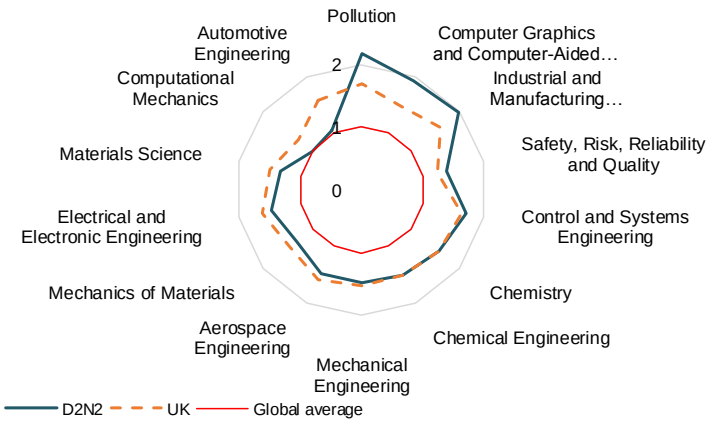
6.14 Demonstrating the international significance of our research base, the University of Nottingham is a Core Partner in Clean Sky 2, a major EU aerospace R&D programme.[xlviii] Further evidence on our strengths in Next Generation Transport is provided in Table 6-2.

Table 6-2: Further evidence on D2N2's strengths in relation to Next Generation Transport

Sci Val data

D2N2 is around the national average in the broad subject areas of Chemistry and Chemical Engineering, but below for Materials Science.

However, looking at detailed disciplines, D2N2 performs above the national average in Pollution, Computer Graphics and Computer-Aided Design, Industrial and Manufacturing Engineering (for which D2N2 is responsible for 7% of all scholarly outputs in the UK) and Control and Systems Engineering, and is around the national average for Mechanical Engineering and Aerospace Engineering.



Corporate collaboration (number of co-authored publications)

- Jaguar Land Rover – 14
- Rolls Royce - 11
- Alstom – 8
- General Electric – 7
- Airbus Group – 6
- BMW Group – 4
- Ford Motor – 4
- Arup Group – 3
- Transport Research Laboratory (TRL) – 2

Research Excellence Framework (REF)

UK ranking by research power

- General Engineering: Nottingham (3)
- Physics: Nottingham (8)
- Chemistry: Nottingham (10)

UK ranking by quality

- Physics: Nottingham (3)

Witty Review

Institutions ranked in the top 20 in the UK for their field weighted citation impact:

- **Aerospace**: Nottingham (2),
- **Automotive**: Nottingham (15)

Research Council Funding

	% UK funding 2010-15	Value of funding (£m)
• Engineering and physical sciences (EPSRC)	• 3%	• 179

Innovate UK Funding

- £10m of grants offered over 2010/11-16/17 in the Transport budget area
  - ➢ 4.2% of UK total in the budget area
- £1.5m of grants offered over 2010/11-16/17 in the High value manufacturing budget area
  - ➢ 1.3% of UK total in the budget area
- £14m of grants offered over 2010/11-16/17 in the Manufacturing and materials sector area
  - ➢ 1.7% of UK total in the sector area

Source: SQW analysis of SciVal, REF, Gateway for Research, Innovate UK data and Witty Review

Moving forward

6.15 As Table 6-3 identifies, the transport market is expected to continue to grow over the coming years. Consultation evidence identified the following specific areas of focus for our firms and researchers:

- **'Digital railway'** (including data analysis and modelling, and linking to mobility as a service), future rolling stock, and high speed train design, manufacture and maintenance
- **Composites**, low emission fuels and additive manufacturing will be especially important for aerospace, but also relevant to our other sectors as firms seek to source materials that are "stronger and lighter"
- **Electrification**, building on research at the University of Nottingham, Rolls-Royce's publicly announced ambitions to develop hybrid-electric propulsion for aircraft, and interest from JCB [xlix]
- **Better connecting SMEs** with the research base (both in terms of academia and OEMS or Tier 1 firms) to allow them to maximise the benefits offered by new technology and to accelerate the commercialisation of new products or processes as part of a more open and collaborative innovation system
- **Sustaining the pipeline of skilled** labour and helping to diversify the workforce. A key challenge for the D2N2 area will be to attract and retain enough digitally skilled workers within manufacturing related sub-sectors.

6.16 The review of market and technology trends presented in Table 6-3 highlights additional areas, such as autonomous vehicles, which will also be very significant as we seek to maintain our international competitiveness.

Table 6-3: Next Generation Transport foresight

Next Generation Transport Trends	Scale of Market
• Increasing adoption of high speed rail across developed and developing markets is predicted; worldwide high-speed track length is forecast to have a compound annual growth rate of 4.5% to 2020.[l] • Use of lightweight materials is predicted to grow across all industries, particularly the automotive sector, creating a €300bn market for high-strength steel, aluminium, and carbon fibre by 2030.[li] • Connected and autonomous vehicles (CAVs) are currently being tested in the UK[lii] but fully autonomous vehicles are not expected to reach public streets and highways for 10 to 20 years.[liii] • The market for battery electric cars is growing. Of those currently driven in Europe, one in five were built in the UK. [liv]	• The global rail market is forecast to be worth £128bn by 2019.[lv] • Low emission vehicle exports were estimated to be worth £2.5 billion to the UK economy in 2015.[lvi] 80 per cent of UK produced vehicles are already exported across the world.[lvii] • The global volume of air traffic is expected to increase to 16bn passengers annually in 2050 (compared to 3.7bn passengers in 2016)[lviii] • Overall, the large civil airliner market is forecast to be worth $3.2tn by 2030.[lix] • The market for CAVs in the UK is estimated to be worth £28bn in 2035. Employment estimations for the manufacture and assembly of CAVs are 6,400 people in 2020, rising to 27,400 by 2035.[lx]

Source: SQW analysis

MP2: Life Sciences and Healthcare

Introduction and scope

6.17 The Industrial Strategy recognises the international competitiveness of the UK's life sciences sector. The Midlands Engine SIA also identified Medical Technologies and Pharmaceuticals as an important area of strength for the Midlands. Reflecting the presence of major employer Boots and its expertise in pharmacy, wellbeing and beauty, our strength in D2N2 extends beyond this.

6.18 We have a broad base of Life Science and Healthcare strengths with a clear spatial opportunity around Nottingham's expanding cluster, with links south to Charnwood. Our strengths include biotech and pharma, alongside med tech and wellbeing. For Human Health in particular, it is important to recognise our relationships with firms and researchers outside of the D2N2 area.

Scale and concentration of activity

6.19 Economic activity in the life sciences sector is notoriously difficult to capture with official SIC code based data for the reasons discussed in paragraph 2.5. Using this SIC code based data shows that D2N2 has a lower concentration of jobs in Life Sciences than GB overall – if we were to have a similar concentration to GB then this would be equivalent to an additional 2,500 jobs. The sector experienced a 25% fall in the number of jobs in D2N2 over 2010-2015, whereas there was no significant change at a pan GB level.

Table 6-4: Count, location quotient (vs. GB) and 2010-2015 % growth – jobs and businesses

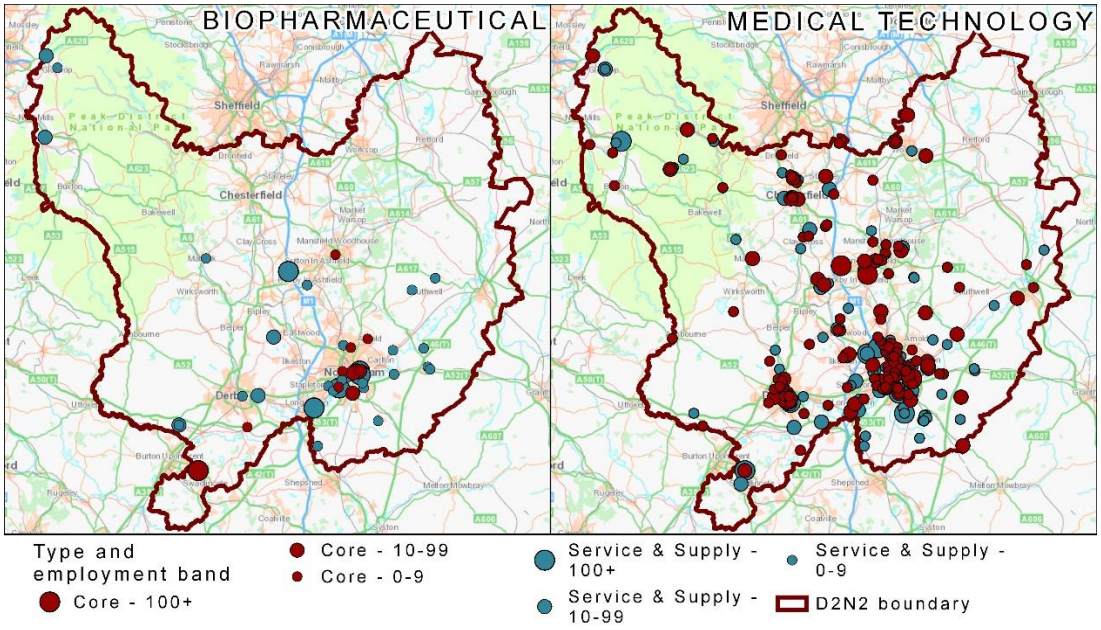
	Jobs			Local Units		
	Count (2016)	LQ	% '10-'15	Count (2017)	LQ	% '10-'17
21: Manufacture of basic pharmaceutical products and pharmaceutical preparations	1,500	1.3	-17%	25	1.3	33%
325: Manufacture of medical and dental instruments and supplies	1,000	0.9	-55%	80	1.3	0%
721: Research and experimental development on natural sciences and engineering	2,000	0.5	0%	130	0.8	23%
2660: Manufacture of irradiation, electromedical and electrotherapeutic equipment	0	0.0	-	0	0.0	-
46460: Wholesale of pharmaceutical goods	1,750	0.8	-22%	75	0.9	6%
47749: Retail sale of medical and orthopaedic goods (other than hearing aids) nec, in specialised stores	200	1.3	0%	50	1.5	10%
Life Sciences	**6,000**	**0.7**	**-25%**	**360**	**1.0**	**12%**

Source: SQW analysis of BRES and UK Business Counts - Local Units, Nomis

6.20 A more accurate picture of economic activity in this field can be gained from the Office for Life Sciences database. This shows that we have over 350 companies, equivalent to 6% of the UK total, and that 77% of these are Med Tech rather than Biopharmaceutical firms, against a UK average 64%. The locations of these businesses are shown in Figure 6-2, which identifies a

major concentration of activity in Nottingham. Additional sites of activity include Derby, for example medical device manufacturer Pennine Healthcare, and also along the M1 corridor, for example healthcare logistics specialists Alloga in Alfreton.

Figure 6-2: Life Science company locations by sector, type and employment



Source: Produced by SQW 2017. Licence 100030994 Contains OS data © Crown copyright [and database right] [2017]. Contains data from the Office for Life Sciences

6.21 Our strengths in **biotech** are demonstrated by the established success of BioCity. Over its first fourteen years of operation, companies based at BioCity had a 91% survival rate, well above national and sectoral averages. A particularly successful example is Sygnature Discovery, who have expanded to employ approximately 250 people and were the anchor tenant when BioCity opened its new building earlier in 2017. Along with many other tenants, Sygnature Discovery are a Contract Research Organisation (CRO). Changing business strategies in larger pharma and biotech firms – a move away from large in-house R&D teams and a greater emphasis on mergers and acquisitions- are boosting demand for CRO services, which benefits tenants in BioCity. XenoGesis were another firm highlighted for the rapid expansion of their CRO business.

6.22 **Pharmaceuticals** is another area where we have impressive capabilities. Our strengths here reflect a historic skills base as former AstraZeneca (AZ) employees from the Charnwood site which closed in 2011 are still active in our innovation ecosystem. CRO Aurelia Bioscience based at BioCity is a good example of this. Other pharma firms in our area include Juniper Pharma Services (formerly Molecular Profiles) in Nottingham and Concept Life Sciences (formerly Peakdale Molecular). Based in Chapel-en-le-Frith in the north east of our area, drug discovery firm Concept Life Sciences changed its name to reflect its status as part of a wider group which has operations at 11 sites across the UK. Our firms and skilled people also retain links to the Charnwood site, including Almac's pharmaceutical development and manufacturing facilities there. In addition, as Table 6-6 shows, our HEIs also collaborate on research projects with major pharma firms.

6.23 Major international firm **Boots acts as a key anchor institution** because of its R&D and manufacturing operations in the broader pharmacy, wellbeing and beauty area. As discussed

at paragraph 4.7, MediCity is a relatively new **medtech** incubator based on the Boots HQ campus in Nottingham. Thought by consultees to have the potential to become nationally significant, it was reported that there are already over 20 firms based at MediCity, with a combined employment of 200, after just three and a half years of operation. These firms span a broad range of activities including beauty and wellbeing, regenerative medicine, and remote sensing and assisted living. As at BioCity, tenants include academics from both Nottingham HEIs, as well as spin-outs from Boots and other large firms.

Supporting assets and research base

6.24 Innovation in life sciences requires the involvement of clinical actors to trial and adopt new techniques/technologies, in addition to the businesses and academics who develop them. Therefore, our NHS Trusts and the East Midlands Academic Health Science Network are important parts of the D2N2 innovation ecosystem.

6.25 Equally important are links to discoveries being made elsewhere. Having the European Association for Cancer Research - Europe's professional membership association for those working and studying in cancer research – based in Nottingham is therefore a key source of strength for our area.

6.26 Life Sciences and Healthcare is also a key focus for our HEIs. Precision Imaging is one of the University of Nottingham's research beacons, and two of Nottingham Trent University's five research themes are connected to this area: Health and Wellbeing, and Medical Technologies and Advanced Materials. In addition, two of the University of Derby's Colleges are active in this area: the College of Health and Social Care, and the College of Life and Natural Sciences.

6.27 More specifically, the quality of the University of Nottingham's research on "Allied Health Professions, Dentistry, Nursing and Pharmacy" was ranked in the top five in the country by the REF 2014. The university also hosts one of only two medical schools in the East Midlands. Nottingham has a long history in this area, including Peter Mansfield's work on MRI in the 1970s. This continues today at the Sir Peter Mansfield Imaging Centre, which is the focus of Nottingham's research beacon in Precision Imaging. Further key assets and research centres are summarised in the table below.

Table 6-5: Life Sciences and Healthcare Research Centres

Nottingham University Hospitals NHS Trust	• Centre for Healthcare Technology Assessment • NIHR Nottingham Biomedical Research Centre (with University of Nottingham) • Nottingham Health Science Biobank
Nottingham Trent University	• Medical Technologies Innovation Facility (see below) • Interdisciplinary Biomedical Research Facility • John Van Geest Cancer Research Centre
University of Derby	• Health and Social Care Research Centre
University of Nottingham	• Centre for Biomolecular Sciences • Centre for Healthcare Technologies • Institute of Mental Health (with Nottinghamshire Healthcare NHS Trust) • NIHR MindTech Healthcare Technology Co-operative (with Nottinghamshire Healthcare NHS Trust)

- Sir Peter Mansfield Imaging Centre

Source: SQW analysis

6.28 An important future asset for our area will be the **Defence and National Rehabilitation Centre** (DNRC), at Stanford Hall in Rushcliffe. In combination with the Nottingham Trauma Centre, this forms a key part of a Midlands wide strength in defence and trauma medicine. For example, the Royal Centre for Defence Medicine and the NIHR SRMRC are both based in Birmingham. This should provide a key route to market for our businesses in the future.

Nottingham Trent University: investing in Health and Wellbeing

The Medical Technologies Innovation Facility (MTIF) is Nottingham Trent University's planned dual site medical devices research and development facility. It aims to drive the invention, innovation and production of healthcare-related commercial products, whilst providing services to industry. The project will establish 1,600 sqm of R&D space to support product development and advanced materials technology, including smart textiles, medical devices and robotics.

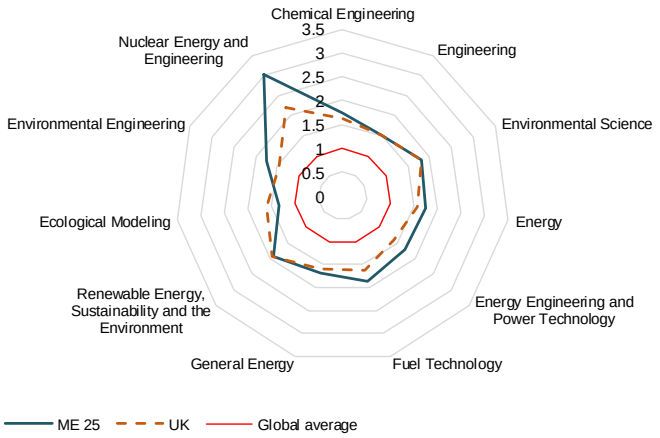
The Facility will be situated across two sites, with the potential to accommodate over 600 jobs in total. The first of the sites, at Nottingham Trent University's Clifton Campus, will focus on innovation and invention. These technologies will then be advanced at the second site, on the Boots Enterprise Zone, through to prototyping, pilot production, standardisation, quality assurance and validation.[lxi]

Table 6-6: Further evidence on D2N2's strengths in relation to life sciences and healthcare

Sci Val data

D2N2 strongly outperforms the national average in Pharmacology, Toxicology and Pharmaceutics, Health Professions, and Biochemistry, Genetics and Molecular Biology. In those areas D2N2 accounts for 3% of all scholarly outputs in the UK, which is the same as the proportion of all outputs that come from the area. It is also around the national average for Medicine and Nursing.

Looking at detailed disciplines, D2N2 performs above the national average in Biomedical Engineering.



Corporate collaboration (number of co-authored publications)

- AstraZeneca – 57
- GlaxoSmithKline – 42
- Unilever – 19
- Pfizer – 19
- Novartis – 19
- Hamad Medical Corporation – 11
- Merck – 10
- Waltham Centre for Pet Nutrition – 9
- Fera Science – 9
- Genentech Incorporated – 9
- Nordic Bioscience AS – 8
- Eli Lilly – 8
- MedImmune – 8
- deCODE Genetics – 6
- Johnson & Johnson – 6
- Boehringer Ingelheim GmbH – 6
- Biogen IDEC – 5
- Thermo Fisher Scientific – 5
- Amgen Incorporated – 5
- Siemens – 3

Research Excellence Framework (REF)

UK ranking by research power

- **Biological sciences**: Nottingham (8)
- **Chemistry**: Nottingham (10)
- **Psychology, Psychiatry and Neuroscience**: Nottingham (10)

UK ranking by quality

- **Allied Health Professions, Dentistry, Nursing and Pharmacy**: Nottingham (4)

Witty Review

Institutions ranked in the top 20 in the UK for their field weighted citation impact:

- **Life sciences**: Nottingham (19)
- **Life sciences - genetics and synthetic biology**: Nottingham (11)
- **Regenerative medicine**: Nottingham (19)

Research Council Funding

	% UK funding 2010-15	Value of funding (£m)
• Medical (MRC)	• 2%	• 40
• Biotechnology and Biological Sciences (BBSRC)	• 5%	• 89

Innovate UK Funding

- £0.8m of grants offered over 2010/11-16/17 in the Bioscience budget area
  - ➢ 2.3% of UK total in the budget area
- £5.6m of grants offered over 2010/11-16/17 in the Healthcare budget area
  - ➢ 2.4% of UK total in the budget area
- £10m of grants offered over 2010/11-16/17 in the Health and life sciences sector
  - ➢ 1.6% of UK total in the sector

Source: SQW analysis of SciVal, REF, Gateway for Research, Innovate UK data and Witty Review

Moving forward

6.29 In addition to the global megatrends presented in Section 3 - of which an ageing population is especially important in this context - specific trends relevant to Life Sciences and Healthcare are shown below. Other trends include the emergence of precision medicine, advances in medical imaging, the increased importance of health informatics and data analytics, and the changes to the business models of major pharma firms discussed at paragraph 6.21.

Table 6-7: Life sciences and Healthcare

Life Sciences and Healthcare Trends	Scale of Market
• Biotech products are slowly gaining a share of the market from conventional drugs, with biotech products comprising seven of the top ten drugs by global sales in 2015.[lxii] • The cost of selling new medicines is at its highest, as expense and complexities of drug development has increased. One reason for this is the focus on more challenging disease areas (e.g. cancer).[lxiii] • R&D expenditure will increasingly be focused on improving already approved devices rather than developing new products because of heightened regulatory scrutiny.[lxiv] However, this trend may be reversing; the number of first-time device approvals awarded by the US FDA increased by 43% from 2013 to 2014 – and this rate continued into 2015.[lxv] • Wearable medical technology is becoming increasingly popular, driven by consumer desire to monitor all aspects of their daily life (e.g. fitness levels, blood-glucose levels).[lxvi]	• Global healthcare spending is estimated to rise by 4.3% by 2020, reaching $8,734bn.[lxvii] • Hospital spending on analytics is expected to reach $18.7bn by 2020, due to focus on quality and cost reduction.[lxviii] • Pharmaceutical sales are expected to improve between 2016-2020 globally, growing at an average of 4.4%.[lxix] • The European medical technologies market is worth an estimated €100bn, almost a third of the global market.[lxx] • The UK's medical technology market is the third largest in Europe, worth around £7.6bn. The fastest growing segments by revenue are medical imaging, in vitro diagnostics, and drug delivery [lxxi]

Source: SQW analysis

MP3: Future Food Processing

Introduction and scope

6.30 Our area boasts an extremely rich mix of agricultural production because of its combination of hill farming and lowlands. When this is combined with key food processing and manufacturing employers, and supported by the academic excellence of our HEIs, this gives our area a compelling offer in Future Food Processing.

6.31 The food and drink market is becoming increasingly competitive and globalised so our companies must continue to innovate and introduce new products and processes in order to grow and develop. Specific sub-sectors where this innovation is occurring include: chocolate and confectionary; coffee; micro-brewing; and baking. Future Food Processing is also one of our most geographically distributed market priorities.

Scale and concentration of activity

6.32 Sectors associated with Future Food Processing account for around 23,000 jobs in D2N2 – equivalent to 2% of all jobs in our area – and are more concentrated than the GB average. They have also grown faster in terms of both jobs (10% vs. 6%) and business numbers (15% vs. 13%) than the GB average over recent years.

Table 6-8: Count, location quotient (vs. GB) and 2010-2015 % growth – jobs and businesses

Sector	Jobs			Local Units		
	Count (2016)	LQ	% '10-'15	Count (2017)	LQ	% '10-'17
10: Manufacture of food products	20,000	1.7	6%	230	0.9	10%
11: Manufacture of beverages	250	0.2	29%	90	1.4	75%
2222: Manufacture of plastic packing goods	1,500	2.3	50%	35	2.2	40%
8292: Packaging activities	700	0.9	79%	60	0.7	0%
Future Food Processing	**23,000**	**1.6**	**10%**	**415**	**1.0**	**18%**

Source: SQW analysis of BRES and UK Business Counts - Local Units, Nomis

6.33 Almost 6,000 people in our area are employed in the **'Manufacture of bakery products'**, roughly twice the GB average concentration. Key employers include bakers Hovis in Broxtowe, Nottingham based pork pie producer Pork Farms, and Bakkavor Desserts in Newark. Bakkavor recently revealed plans for a £20m expansion, which would take on-site employment to around 2,000.[lxxii]

6.34 The '**Manufacture of cocoa, chocolate and sugar confectionery'** employs over 2,000 people in D2N2, almost four times the specialisation of the UK as a whole. This includes the Alfreton headquarters of chocolates firm Thorntons and New Mills firm Swizzels Matlow. The Swizzels factory has been in New Mills since 1940 and employs approximately 600 people. Examples of innovation taking place there include removing artificial colours from all product lines in 2008 and launching limited editions to commemorate special events such as the Queen's Diamond Jubilee. Chocolatiers Thorntons have embraced the move towards product personalisation by launching a range where both packaging and contents can be customised.

6.35 The '**Production of coffee and coffee substitutes'** is another highly specialised sector in our area, with an LQ of over 10. It is also a growing sector thanks to Nestlé's investment of £325m to transform its plant at Tutbury into a Coffee Centre of Excellence.[lxxiii] The plant is both a major employer, with over 1,000 staff, and a key exporter. Of the 1.8 billion Nescafé Dolce Gusto coffee capsules produced there in 2015, 85% were exported across the world. Nestlé Waters also invested £35m in a state-of-the-art bottling and warehousing plant in Buxton where Buxton Natural Mineral Water and Nestlé Pure Life are produced.

6.36 Although not yet reflected in large employment figures, we also have a growing **brewing** industry incorporating craft brewers and those which are now expanding and modernising such as Thornbridge Brewery with its £1.5m expansion project. Bakewell based Thornbridge's beers have won over 350 awards in regional, national and local competitions. Innovation resulting in new, and sometimes seasonal beers, also occurs at brewers such as Peak Ales and Castle Rock.

6.37 Other key firms with operations in our area include the UK Centre of convenience food manufacturer Greencore in Chesterfield, British Sugar in Newark, and Bolsover based sauce manufacturer Flavour Base. These businesses and more are brought together by the Food and Drink Forum.

Supporting assets and research base

6.38 These considerable industrial strengths are supported by our leading academic research. Sustainable Futures, incorporating sustainable agriculture, is one of Nottingham Trent University's six strategic research themes whilst Future Food is one of six research beacons of excellence at the University of Nottingham. Nottingham's research in this area is centred on global food production, demonstrating an ambition to deliver international impact, and also brings international innovators to D2N2. For example, consultees reported that the University of Nottingham have been in touch with a spin-out company in California producing beef-free burgers. This technology is being promoted to local companies with potential to bring growth to our area.

Discoveries in Nottingham having a global impact

Nitrogen fixing technology that provides a sustainable solution to fertiliser overuse was developed at the University of Nottingham and licenced by start-up firm Azotic Technologies in 2012. From their BioCity offices, Azotic are developing the technology to help crops fix nitrogen from the air, thereby reducing the need for ammonium based fertilisers. It also has the potential to increase crop yields.

A series of recent rice trials in Vietnam has shown positive results. When compared to non-treated seeds, those that had been treated with Azotic's nitrogen fixing technology showed significant yield increases.[lxxiv]

6.39 In addition, both Nottingham HEIs have strengths which are very relevant to D2N2 businesses. For example, the University of Nottingham hosts the International Centre for Brewing Science and, jointly with Birmingham and Loughborough, the EPSRC Centre for Innovative Manufacturing in Food. This conducts industry backed research into novel food manufacturing techniques. Both centres are located at the Sutton Bonington Campus where research into food, plant and crop, nutritional, and agricultural and environmental sciences is concentrated.

6.40 Meanwhile, Nottingham Trent University's Food Authenticity Research and Services are recognised by the government as a UK Centre of Expertise for food authenticity testing. Nottingham Trent's School of Animal, Rural and Environmental Sciences is based at its Brackenhurst Campus. The excellence of Nottingham Trent's research in this area was recognised in 2015 when it was awarded the Queen's Anniversary Prize for Higher and Further Education for research in Food Safety and Food Authenticity.[lxxv]

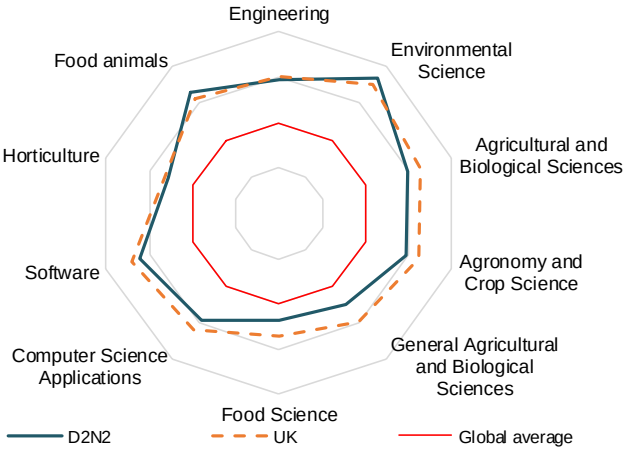
6.41 Southglade Food Park in Nottingham is a key location for start-up and growing food companies, with space to accommodate up to 190 employees in multiple small food companies. Business support is also provided through ERDF funded programmes such as Enabling Innovation. Consultees reported that many local food and drink SMEs had benefitted from being linked to HEI research via this programme. Sector specific support is provided by the ERDF funded FEAST programme. Run by The Food and Drink Forum, it offers businesses access to grant funding, technical support, and business mentoring.

Table 6-9: Further evidence on D2N2's future food processing strengths

Sci Val data

D2N2 performs around the national average for the broad subject areas of Environmental Science and Engineering, but performs below the average for Agricultural and Biological Sciences.

Looking at detailed disciplines D2N2 performs above the national average in Food Animals with a FWCI of 1.66 versus 1.56 for the UK and being responsible for 11% of all scholarly outputs in the area in the UK – far above the 3% of overall outputs that D2N2 produces. The area is on par with the UK in Horticulture, but below the national average for Software, Agronomy and Crop Science, Computer Science Applications and Food Science.



Corporate collaboration (number of co-authored publications)

- Unilever – 19
- ADAS – 18
- Syngenta – 6
- DuPont – 2
- DSM Food Specialties – 1
- NIZO food research – 1
- Novozymes AS – 1
- The Scotch Whisky Research Institute – 1

Research Excellence Framework (REF)

UK ranking by research power

- **Agriculture, Veterinary and Food Science**: Nottingham (2)
- **Biological Sciences**: Nottingham (8)
- **Computer Science and Informatics**: Nottingham (9)
  Geography, Environmental Studies and Archaeology: Nottingham (8)

Innovate UK Funding

- £3.1m of grants offered over 2010/11-16/17 in the Sustainable agri-food protection budget area
  - ➢ 3.2% of UK total in the budget area

Source: analysis of SciVal, REF, Gateway for Research, Innovate UK data and Witty Review

Moving Forward

6.42 Given the manufacturing competencies of our food processes, industrial digitalisation will be a key factor for this Market Priority. In addition to this and the other trends discussed earlier, Table 6-10 identifies key trends within Future Food Processing which our firms and researchers must be responsive to.

Table 6-10: Future Food Processing Trends

Future Food Processing Trends	Scale of Market
• Precision agriculture uses IT, satellites, remote sensing and proximal data gathering to optimise returns and reduce environmental impact[lxxvi] • Smart systems are being developed which contain nanotechnologies that interact with products to extend shelf-life (active packaging) and inform on the quality or safety aspects, including temperature (smart packaging). Nanotechnologies could also provide plasma coatings to increase bacterial resistance.[lxxvii] • In response to increasingly health-conscious consumers, reformulation to reduce salt, sugar and fat will become increasingly widespread.[lxxviii] • The evolution of extraction technologies, bio-transformation and improvements in freezing technology can be used to improve shelf-life.[lxxix] • Developments in processing will allow the development of high quality ingredients from both raw materials and waste side streams.[lxxx]	•It is estimated that demand for food will increase by c.90% by 2050. This includes expected increases in meat consumption in low income countries, and dairy product consumption in developing countries.[lxxxi] • By 2020, revenue in the global packaged food market is expected to reach $3.03tn. Non-alcoholic drinks and baked foods constitute the largest product markets, accounting for 75% of the market value. Baby food and yoghurt are predicted to be the two fastest growers, at 6.4% and 6% respectively.[lxxxii] • Overall, the global groceries market is forecast to reach $11.8tn by 2020. China is expected to be the largest global groceries market followed by the US and India.[lxxxiii]

Source: SQW analysis

MP4: Energy and Low Carbon

Introduction and scope

6.43 The carbon-intensity of the global economy is predicted to halve by 2040, due to tougher regulations and a transition to less carbon-intensive energy sources.[lxxxiv] Combined with worries about resource scarcity this has led to a focus on the energy trilemma: how to ensure the sustainability, affordability and security of future energy supplies.

6.44 In this context, our excellence in academic research, important employers, and the application of innovative low carbon technologies (whether in low carbon and modular construction, district heating or demonstrator projects) form the basis of our strength in Energy and Low Carbon. The D2N2 Energy Strategy, due in March 2018, will help to capitalise on these strengths and unlock decarbonisation related growth opportunities.

Scale and concentration of activity

6.45 Whilst sectors associated with energy are relatively easy to define in SIC code data, it is much harder to do so for low carbon sectors. For example, a given product can be manufactured in ways which are more or less energy, and thus C02, intensive. The following analysis therefore focuses more on energy than on low carbon.

6.46 Energy and Low Carbon is more concentrated in our area in terms of jobs – with over double the number of jobs as a proportion of total employment compared to GB – but

underrepresented in the number of businesses. This appears to be because of the presence of major industrial player E.ON, which accounts for around 4,500 jobs in 'Distribution of electricity.' E.ON has multiple offices in our area and operates the combined heat and power plant at Nottingham Queen's Medical Centre.

Table 6-11: Count, location quotient (vs. GB) and 2010-2015 % growth – jobs and businesses

	Jobs			Local Units		
	Count (2016)	LQ	% '10-'15	Count (2017)	LQ	% '10-'17
272: Manufacture of batteries and accumulators	0	0.0	-	0	0.0	-
351: Electric power generation, transmission and distribution	6,000	2.4	180%	115	0.8	89%
353: Steam and air conditioning supply	50	1.8	-	0	0.0	-
Energy and Low Carbon	**6,000**	**2.3**	**180%**	**120**	**0.8**	**100%**

Source: SQW analysis of BRES and UK Business Counts - Local Units, Nomis

6.47 Other important employers in the energy sector include Robin Hood Energy (a local authority owned not for profit energy company), Hoval (design and manufacture of commercial heating systems), and Rolls-Royce (nuclear reactor systems for the UK submarine fleet, and a major player in relation to small modular reactors which can also be used in relation to commercial mainstream nuclear power generation).

6.48 Given the complex system integration challenges of incorporating new innovations into energy production, storage and use, real life **demonstrator projects** are particularly important. Our area is distinctive because of the location of several such schemes in and around Nottingham, as Table 6-12 shows.

Table 6-12: Energy demonstrator projects

- **Creative Energy Homes** is a £1.9m project of seven test houses on the University of Nottingham campus. They are living test-sites for leading firms to work with the University to investigate the integration of energy efficient technologies into houses
- The **Community Energy Demonstrator at the Trent Basin** is a large scale regeneration scheme, which includes an integrated smart heat and power micro-grid for low energy demand buildings, ground source heat pumps, and communal battery storage. This is supported by Innovate UK and backed by the University of Nottingham amongst others[lxxxv]
- The University of Nottingham's **Geo-Energy Test Bed** (an Energy Research Accelerator facility) is designated for the testing and 'ground-truthing' of borehole sensors and software
- The **Energy Technologies Building** on the University of Nottingham Innovation Park is itself a low carbon building and also hosts research facilities including a smart grid, a prototyping hall and the UK's first green hydrogen refuelling facility
- The BGS' **UK Geoenergy Observatories** project will create subsurface energy-research test centres to develop new energy technologies (although the first two centres will be outside D2N2)

Source: SQW analysis

6.49 Nottingham's **district heating** network is another distinctive asset. Managed by a wholly owned subsidiary of the City Council, the network's 68km of insulated pipework satisfies the heating and hot water requirements of 4,700 dwellings and over 100 commercial premises in the city.[lxxxvi] One of the largest networks in the country, heat is generated from the burning of domestic and commercial waste at the Eastcroft Energy from Waste facility. Linked to this,

Nottingham based Chinook Sciences have been granted planning permission for their own Energy from Waste facility in north Nottingham. Using the latest version of technology developed in Nottingham known as RODECS, this would transform discarded waste materials into usable energy.[lxxxvii] The RODECS technology is used in plants worldwide and has helped earn Chinook Sciences a place on the FT's 2017 list of Europe's fastest growing companies.[lxxxviii]

6.50 **Low carbon construction and building technologies** are important for both new build and retrofitting existing properties. Illustrating that these are innovation strengths of our area, previous research has found that we have a high innovation capability in the 'built environment', see paragraph 2.28 for details. The headquarters of Bowmer & Kirkland and Gusto Group are in our area, and we also have a number of SMEs operating in the sector too. Specific examples of this low carbon construction in action include the Community Energy Saving Programme in Derby, which saw loft insulation installed in over 1,500 homes. In addition, as part of the Secure Warm Modern programme, over 2,300 Nottingham homes had solar panels installed.[lxxxix]

Supporting assets and research base

6.51 Many of the demonstrator projects referred to above involved extensive input from our HEIs. Our scientific research assets in the Energy and Low Carbon field include:

- The **British Geological Survey** (**BGS)** is a world leading geological survey and the UK's premier provider of authoritative geoscientific data and knowledge for wealth creation, sustainable use of natural resources, reducing risk and living with the impacts of environmental change. It advances understanding of the structure, properties and processes of the solid Earth system through interdisciplinary surveys, monitoring and research for the benefit of society

- The **Energy Research Accelerator (ERA)** is a cross-disciplinary energy innovation hub which brings together the BGS, the University of Nottingham and five other Midlands HEIs. It uses capital assets, data and intellectual leadership to foster collaboration between academia and business. ERA's initial priorities of Geo-Energy Systems, Integrated Energy Systems and Thermal Energy will help deliver the new technologies and behaviours that will demonstrate the transformative effect of collaboration on the energy spectrum

- The **Energy Technologies Research Institute** is a focal point for research and industrial collaborations at the University of Nottingham. Other Nottingham research centres include joint collaborations with BGS on the GeoEnergy Research Centre and Centre for Environmental Geochemistry. The University also hosts the EPSRC Centre for Power Electronics, and the Centre for Doctoral Training in Carbon Capture and Storage and Clean Fossil Energy.

- The University of Derby's **Institute for Innovation in Sustainable Engineering** includes energy and the environment as one of six core themes.

- The **Centre for Energy Innovation** was established at the Health and Safety Laboratory (HSL) in Buxton in 2016. The Centre focuses on enabling the safe

development of innovative energy technologies and has already gained experience in the hydrogen economy, nuclear decommissioning and Liquefied Natural Gas (LNG).

6.52 The University of Derby also supports activity in this field through the ERDF funded D2EE project and the Low Carbon Business Network. Working with Derby City and County Councils it offers low carbon product development support from the Institute for Innovation in Sustainable Engineering, low carbon business development workshops, and low carbon energy efficiency grants for SMEs. In addition, the part ERDF funded Energy for Business project (ETC6) run by the University of Nottingham provides businesses with university support. This includes specialist advice from academics, student placements, and bespoke training. Meanwhile, dedicated business space is provided by the Nottingham Sustainability and Enterprise Centre at New College Nottingham.

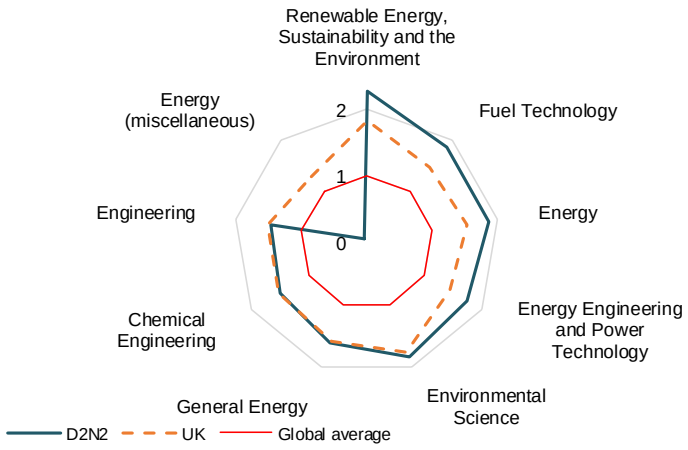
6.53 The strengths of our area are also supported by National Grid's Learning and Development Centre in North Nottinghamshire, which offers training on electricity and gas transmission. Further evidence is provided in Table 6-13.

Table 6-13: Further evidence of D2N2's strengths in energy and low carbon

Sci Val data

D2N2 performs above the national average in the broad subject area of Energy with a FWCI of 1.85, compared to 1.53 in the UK. D2N2 outperforms the UK in the related area of Environmental Science and is around the average for Chemical Engineering and Engineering.

Looking at detailed disciplines, D2N2 performs above the national average in Renewable Energy, Sustainability and the Environment, Fuel Technology, Energy Engineering and Power Technology, and on a par with the national level in General Energy.



Corporate collaboration (number of co-authored publications)

- E.ON – 5
- EDF – 3
- Siemens – 3
- Guangdong Power Grid Corporation – 2
- Petrobras – 2

Research Excellence Framework (REF)

UK ranking by research power

- **Chemistry**: Nottingham (10)
- **General Engineering**: Nottingham (3)
- **Geography, Environmental Studies and Archaeology**: Nottingham (8)

Witty Review

Institutions ranked in the top 20 in the UK for their field weighted citation impact:

- **Nuclear**: Nottingham (2)
- **Oil and gas**: Nottingham (19)
- **Offshore wind**: Nottingham (7)
- **Energy Storage**: Nottingham (4)

Research Council Funding

Research area	% UK funding 2010-15	Value of funding (£m)

• Engineering and physical sciences (EPSRC)	• 3%	• 179
• Natural Environmental (NERC)	• 2%	• 148

Innovate UK Funding

- £3.3m of grants offered over 2010-16 in the Energy budget area
  - ➢ 2.2% of UK total in the budget area
- £1.2m of grants offered over 2010/11-16/17 in the Low impact buildings budget area
  - ➢ 1.8% of UK total in the budget area

Source: analysis of SciVal, REF, Gateway for Research, Innovate UK data and Witty Review

Moving forward

6.54 Consultees reported that the D2N2 LEP had secured funding from BEIS to develop an Energy Strategy. This will be supported by an additional £1m from BEIS to the Midlands Engine to support the implementation and commercialisation of projects identified in energy strategies across the region.

6.55 Key trends for partners to be aware of in doing this are included in the table below. Other topics identified by consultees include decarbonising fossil fuel, hydrogen, community energy and geo energy. In addition, three private companies are investigating the potential for hydraulic fracturing (fracking) to extract gas and oil from shale rock in Derbyshire, and permission has already been granted for this in Nottinghamshire.[xc] Environmental concerns will need to be managed carefully if this opportunity is to be exploited more widely.

Table 6-14: Energy and Low Carbon Trends

Energy and Low Carbon Trends	Scale of Market
• Low-carbon futures will create a greater role for systems thinking and integrated design[xci], especially as the energy mix diversifies into a range of technologies with vastly different profiles and an increasing reliance on distributed generation.[xcii] • The UK plans to invest £265m in smart information systems to reduce the cost of electricity storage, develop new ways of balancing the grid, and advance demand response technologies.[xciii] • Growth in microgeneration and small energy projects targeting individual and rural energy needs with renewable technology applications.[xciv] • Non-fossil energy sources are expected to dominate electricity generation to 2060, particularly wind and solar power. [xcv] • The use of nuclear power will increase intensively in developing nations. Nuclear energy is expected to increase by over half from 2014 to 2040. [xcvi]	• World energy consumption is expected to increase by 28% by 2040.[xcvii] • Global electricity demand is projected to increase by 85% from 2010 to 2040. [xcviii] • World electricity generation is predicted to increase by 70% from 2011 to 2030.[xcix] • Solar and wind energy is predicted to account for 20-39% of power generation in 2060, up from just 4% in 2014.[c] • Global investment in the power sector is forecast to be $21tn up to 2040, with over 40% in transmission and distribution networks.[ci] • The worldwide energy storage market is expected to quadruple to $6bn by 2020.[cii]

Source: SQW analysis

7. Conclusions – key strengths, challenges and potential action areas

7.1 The purpose of the D2N2 SIA process was to identify (through a fine grained review of the available evidence) existing and emerging areas of science and innovation excellence that will contribute towards our primary strategic goal of boosting the local economy's long-term productivity performance. More specifically, the evidence base and the associated priority areas highlighted within the SIA Framework are designed to help inform both policy-makers and investors on D2N2's exciting science and innovation-led opportunities as we seek to maximise our growth potential and enhance our international competitiveness.

7.2 The SIA has intentionally sought to focus solely on those elements of the D2N2 ecosystem that are directly related to science and innovation activity. However, as set out in our refreshed Strategic Economic Plan, the D2N2 area has many other distinctive features and strengths that help us to compete globally for talent and investment. It is important that these assets continue to be developed and invested in, whilst at the same time, we must redouble our efforts in tackling the key gaps and underlying weaknesses within our business environment.

Areas of comparative advantage

7.3 The **D2N2 SIA Framework** has been developed to highlight the way that the Innovation Ecosystem, Enabling Competencies and Market Strengths identified through this audit process interact with and complement one another.

7.4 The evidence review has identified three **Enabling Competencies** that characterise our economy, and where we have a concentration of scientific and innovation assets and expertise across the private and public sectors. The Enabling Competencies, which are summarised below, underpin our specific Market Priorities and must continue to be supported.

- Manufacturing is changing to incorporate a much broader value chain and improved production techniques. With major industrial players and rapidly growing SMEs across the different manufacturing sub-sectors, our area is at the forefront of **Advanced Manufacturing and Engineering**. This capability is supported by genuine research excellence that spans our universities.

- As digital technologies become increasingly pervasive across all sectors of the economy, the way industries operate is changing. This includes the increasing adoption of digital techniques, the derivation of value from analysis of 'big data', and the emergence of the internet of things. Our strengths in **Digital Technologies and Data** include a developing tech cluster in Nottingham focused on computer games, financial data management and analysis, and e-health, with growing activity in satellite applications.

- **Systems Integration** involves research into the development of products, processes, and services and their subsequent implementation to enable 'whole systems' approaches to a wide range of economic and social activities. Our capability in this area is particularly evident in relation to energy, but is also relevant to smart cities

and many of our major manufacturers. This competency is also underpinned by a significant consultancy and technical testing and analysis business base.

7.5 The four **Market Priorities** identified in this SIA (see below) combine established world class strengths with significant scope for future growth and development.

- **Next Generation Transport** - Major industrial strengths and research excellence are evident in our aerospace, automotive and rail sectors. Our business base covers the full spectrum from R&D through to production and after sales service
- **Life Sciences and Healthcare** – A broad base of strengths have been evidenced, with a clear spatial opportunity around Nottingham's expanding cluster. Our strengths include biotech and pharma, alongside med tech and wellbeing
- **Future Food Processing** - The food and drink market is becoming increasingly competitive and globalised so our companies must continue to innovate and introduce new products and processes to survive. Specific sub-sectors where this innovation is occurring include: chocolate and confectionary; coffee; brewing; and baking
- **Energy and Low Carbon** - Our excellence in academic research, important employers, and the application of innovative low carbon technology (whether in low carbon construction, district heating or demonstrator projects) form the basis of our strength.

Ecosystem challenges

7.6 To maximise the potential of our distinctive science and innovation strengths, including our world-class 'anchor' institutions such as the University of Nottingham, Rolls Royce, Bombardier, and Toyota, we must address some difficult challenges. This includes:

- improving access to finance for our ambitious scale-ups
- strengthening and realigning our skills base (in the context of industrial digitalisation and the data revolution)
- embedding a more pervasive culture of innovation across *all* parts of our economy
- supporting our major corporates to undertake increased levels of R&D activity locally.

7.7 These four specific weaknesses or gaps in our ecosystem are explored further below.

7.8 Whilst publicly funded UK wide and D2N2 specific financial support programmes operate in our area, consultees identified a **need to improve access to finance for our ambitious scale-ups.** In relation to private finance, this view is supported by data from the BVCA as discussed in Section 4. A lack of appropriate finance means that the growth rate of our scale-ups will suffer, perhaps because our businesses cannot invest in the capital equipment necessary for growth or because they lack the funding to take forward promising R&D projects. It may also deter academics from forming start-ups and/or employees of large firms from creating spin-outs if they are faced with access to finance barriers. This is a challenge

across many areas of the country, and the D2N2 LEP will need to work closely with government to tackle it.

7.9 Our workforce skills profile is another important challenge. Capital funding for research and innovation infrastructure can only take us so far unless it is part of an integrated approach including tackling skills issues. In our area, fewer people have higher level qualifications than the national average and graduate retention could also be improved, although this is linked to the number of local employers demanding graduate level talent. With an eye on the future and industrial digitalisation in particular, **we must strengthen and realign our skills base**. This is because digital literacy will become increasingly important in helping us to close the productivity gap. Advanced digital skills are essential if we are to take fully the exciting cross-sectoral opportunities presented by our Enabling Competencies of Digital Technology and Data, and Advanced Manufacturing and Engineering. In addition, basic digital skills are important across all other sectors of our economy.

7.10 Our third challenge area is around **embedding a more pervasive culture of innovation across all parts of our economy**. Whilst our SIA Framework is important in highlighting genuine areas of science and innovation excellence, by definition it places the spotlight on sectors/technology areas which are already more innovative than those not included in the framework. However, broader evidence cited in Section 2 shows in general our businesses undertake relatively low levels of innovation. Therefore, to close our productivity gap, SMEs and supply chain firms in all sectors and areas of D2N2 must be supported to engage in more innovative activity.

7.11 Many internationally significant manufacturing firms have major operations in our area. Indeed, this is one of the most distinctive characteristics of the D2N2 economy. However, consultees reported that not all of them undertake significant R&D locally, and instead focus more on *process* innovation in their D2N2 plants. Our final challenge is thus to **support our major corporates to undertake increased levels of R&D activity locally** and to collaborate more with SMEs and/or academics based in our area through more 'open' innovation models. Not only will this create higher value jobs, it will also help us to create a more productive and resilient economy - one which is better equipped to withstand major economic 'shocks'.

Moving forward – potential action areas

7.12 It is important to remind ourselves that we are not facing these challenges alone. Neighbouring LEP areas and indeed many other parts of the UK also face similar issues and are responding in different ways. By adopting an evidence-based, focused and outward-facing approach, we can build effective collaborations and connect science and innovation capabilities for the benefit of our business base in a post Brexit environment. This is particularly true for the wider Midlands Engine where there are clear technology and sectoral complementarities. For example, the two High Value Manufacturing Catapult centres and the Energy Systems Catapult in the West Midlands are valuable resources which, although outside the D2N2 boundary, are highly relevant to our science and innovation intents. Similarly, as we grow and develop our life sciences cluster in Nottingham, we will strengthen links with the key assets and expanding firms at Charnwood.

7.13 In response to the challenges and opportunities around commercialisation, knowledge exchange and innovation-led cluster development evidenced in this report, a number of

targeted priority investment areas have emerged. These are presented below for the D2N2 LEP and partners to consider in more detail. The £115m Strength in Places Fund announced in the Industrial Strategy may provide a potential source of finance for some of these action areas. Note that we have not sought to include energy specific actions so as not to pre-empt the D2N2 Energy Strategy, which is due to be launched in March 2018.

- **Improving access to finance**
  - Creation of a dedicated D2N2 life science investment fund for early stage firms
- **Strengthening and realigning our skills base**
  - Promotion of digital skills through a 'careers in manufacturing' programme targeted at school children right up to computer science graduates or post-graduates. A key emphasis will be on showcasing how the world of manufacturing is changing and the exciting career paths available
- **Embedding a more pervasive culture of innovation**
  - Develop an integrated spin out programme for D2N2's major anchor institutions (with the support of Rolls Royce, Boots, Bombardier, Toyota, Nestle and the University of Nottingham etc.) to create a more open and collaborative innovation culture
  - D2N2 should make the case for hosting one of the Digital Innovation Hubs identified in the recent Industrial Digitalisation Review. There is an exciting opportunity to bring the major manufacturing firms in and around Derby together with the emerging digital tech and med-tech clusters in Nottingham
- **Supporting our major corporates to undertake increased levels of R&D activity locally to maximise the long-term beneficial economic impact of our anchor institutions**
  - Create the D2N2 R&D attraction programme. Target major technology and innovation-led corporates in the area that are not currently undertaking significant R&D activity locally e.g. liaise with relevant R&D teams (usually outside of the UK) and make the case for them to relocate some R&D functions to D2N2. This would represent a long-term investment, but the prize could be a very significant one.
  - The three universities within the D2N2 area are also significant economic 'actors' in their own right. They each have an international reach and play an important role in promoting and championing the D2N2 offer to the rest of the world. More detailed work should be undertaken to explore how partners can support the HEIs to maximise their beneficial economic impact locally.

7.14 A previous consultation exercise undertaken by the D2N2 LEP also identified a number of potential action areas of relevance to the SIA Framework. The longlist of ideas is presented overleaf.

Table 7-1: Potential action areas previously identified by the D2N2 LEP

Transport Innovation Accelerator	The development of a Digital Design Centre based around a high performance computing facility to support development of advanced engineering methods to underpin 'right first time' design to support the competitiveness of UK aerospace and automotive industry. Investment in a suite of test equipment across Midlands universities to support development of next generation aero and automotive engines. Developing plans around the electrification of transport which will place Nottingham as a leading research centre in the components and systems required to deliver electrical propulsion in both automotive and aerospace. This includes a facility to test systems up to 10MW of power which will be internationally significant.
Advanced Manufacturing	Creation of an industry 4.0 demonstrator, building on the existing automated assembly demonstrator in the Aerospace Technology Centre (a platform that can support the development of advanced manufacturing).
Transport Technologies	Focus on supply chain development, for example building and strengthening local supply chains by partnering with OEMs, and tier 1 and 2 suppliers. One of the goals will be to support 're-shoring' and further strengthen the engineering supply chain in the D2N2 area. Partnering with industry to: • develop and raise the profile of new provision, e.g. degree level apprenticeships, to enable the East Midlands to capitalise on the opportunities associated with HS2. • develop an incremental and sustained approach to innovation e.g. organisational culture, management and leadership skills to assist with business sustainability and productivity • further develop the Entrepreneurship and Innovation Research Group to increase levels of entrepreneurship in the D2N2 economy Transport simulation and modelling for advanced digital design and validation Using digital technologies to support increased levels of transport security
Medical Technologies and Pharmaceuticals	Building on partnerships with large companies, e.g. those with whom our HEIs have co-authored publications, to work with our PhD students for the development and dissemination of research in chemistry and medical science, partnering with employers to increase the levels of KTP placements in this sector Support the medical and pharmaceutical cluster to develop and strengthen e.g. access to data to inform long term strategic planning, management of intellectual property and associated protocols to protect IP
Imaging for Precision Medicine	Building on Nottingham's recognised expertise in MRI to develop innovative imaging that will revolutionize precision medicine and produce a step change in clinical outcomes. An initial investment will develop an ultra-high field system to provide the required resolution to develop applications in precision medicine.
Medicine and Lifesciences Collaboration Facility	New facility on to encourage industry to embed themselves temporarily close to University researchers to enable them to deliver joint projects, especially where they require specialized equipment. This would provide complimentary facilities to existing incubators such as BioCity and provide easy access for SMEs to rapidly develop new therapeutics as well as support long term engagement with strategic partners such as GSK. The new facility would house a range of enhanced university labs, including Target Identification & Validation, Cell Signalling Medicinal Chemistry and Structural Biology, which may specific provision for industry access.
Future food	Collaborative examples include the development of new technologies for robotics, the dissemination of existing automation technologies with the output of increasing competitiveness and productivity of the sector. Partnering with industry to: • Use digital manufacturing to develop new products, e.g. smart packaging • to develop new products at Nottingham Trent University's Brackenhurst Campus e.g. functional foods to deliver health benefits to consumers • develop 'seed bed' innovative food and drink products to support growth • support packaging development and design and increase the uptake of innovative technologies e.g. to improve food safety and reduce waste in the supply chain
Future food	Development of a food systems manufacturing facility to support the processes of novel ingredients and processing for nutrition. This would provide additional facilities to support new product development by SMEs and be aligned closely to key needs of UK food manufacturers.
Digital	Supporting the advancement of the digital economy and applying existing expertise in this area to increase the levels of adoption of new and novel digital technologies across a range of sectors.

Source: SQW summary based on previous D2N2 consultation

Annex A: Consultees

A.1 The table below presents a list of consultees interviewed as part of this study.

Table A-1: List of consultees

Name	Organisation
Alan Fewkes	Nottingham Trent University
Andrew Collinson	Food and Drink Forum
Ben Sumner	University of Nottingham
Dan King	Nottingham Trent University
Darren Clarke	Medilink East Midlands
Emma Kelly	University of Nottingham
Edward Peck	Nottingham Trent University
Elaine Clark	East Midlands Rail Forum
Fred Paterson	University of Derby
Mark Chivers	Boots
Matthew Bust	Woodhead Construction Company
Michael Cunliffe	Midlands Aerospace Alliance
Mike Baulcombe	RIBA
Neil Horsley	CleanTech Business Ltd
Nick Antonopoulos	University of Derby
Nick Freeman	Toyota
Paul Harris	Rolls Royce
Richard Worrall	University of Nottingham
Toby Reid	BioCity
Will Tanner	Bombardier

Source: SQW

Annex B: Notes and references

[i] https://www.midlandsengine.org/wp-content/uploads/2017/02/Midlands-Engine-SIA-Volume-1-Report-01-Nov-1.pdf
[ii] The study team would like to thank the University of Nottingham for providing Sci Val data
[iii] Nominal Gross Value Added by Local Enterprise Partnership, 1997-2015, ONS, June 2017
[iv] Location quotient by sector shows the concentration of employment in a given sector in D2N2 relative to GB e.g. an LQ of 2.0 means that employment in this sector is 2x as concentrated in D2N2 as in GB overall
[v] There is a discontinuity in the BRES data due to a change in the methodology – the more comprehensive dataset covers 2015-2016 and the less comprehensive version covers 2009-2015. The % change is therefore presented using the latter dataset to show a longer time series.
[vi] The Contribution of Rolls-Royce to the UK Economy in 2015, Oxford Economics. 2015. http://careers.rolls-royce.com/united-kingdom/about#locations
[vii] The D2N2 Productivity Gap, Kellner (University of Nottingham), 2017
[viii] Creating healthier, more productive workplaces through targeted public policy, Totterdill (UKWON), 2017,
[ix] Industrial Strategy White Paper, HM Government, 2017, page 20
[x] https://www.topuniversities.com/university-rankings/world-university-rankings/2018
[xi] The Economic Impact of Britain's Global University. The University of Nottingham, 2015
[xii] Note that this is different to the Research Fortnight 'Power Rating' which measures "how the university's Quality Index score relates to the top performing university" https://www.theguardian.com/news/datablog/ng-interactive/2014/dec/18/university-research-excellence-framework-2014-full-rankings
[xiii] Note that non 'core' science and innovation subjects, e.g. Arts and Humanities, have been removed
[xiv] https://www.quotientsciences.com/news/quotient-sciences-acquires-pharmaterials/
[xv] Data from Gateway to Research, excludes Innovate UK funding. Data downloaded in early Summer 2017
[xvi] http://www.bgs.ac.uk/about/commendation.html
[xvii] Made Smarter Review 2017, Juergen Maier, 2017
[xviii] World Energy Outlook. IEA, 2014 and Desertification: The Invisible Frontline, UNCCD, 2014
[xix] An OECD Horizon Scan of Megatrends and Technology Trends in the Context of Future Research Policy, OECD, 2016 and The CEO's 360 Degree Perspective: Healthcare 2020, Frost and Sullivan
[xx] Life & Health Sciences Northern Ireland Capability Assessment & Foresight Report, Matrix Northern Ireland Science and Industry Panel, 2015 and The Future of Rail 2050, Arup, 2015
[xxi] Energy Systems and Electric Vehicles, Urban Foresight, 2016 and Sustainable manufacturing for the future: Investigating the current and future landscape across the food and drink industry in Great Britain, Cranfield University and Coca Cola Enterprises, 2015
[xxii] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/662541/industrial-strategy-white-paper-print-version.pdf
[xxiii] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415573/BIS-15-46-UEZ-pilot-evaluation.pdf
[xxiv] The Boots Enterprise Zone, Boots, 2016
[xxv] www.biocity.co.uk/reports
[xxvi] https://www.midlandsengine.org/british-business-bank-launches-first-120million-tranche-midlands-engine-investment-fund/
[xxvii] Note that Rolls-Royce figure may be inflated because of the 'headquarters effect.' Funding applications may use the Rolls-Royce head office in Derby as the address, even though the innovative activity will take place at a Rolls-Royce plant elsewhere in the country.

[xxviii] A dash in the 'funding received directly' column indicates that the organisation received an unknown amount of funding.
[xxix] https://www.epsrc.ac.uk/skills/students/centres/profiles/
[xxx] https://www.derby.ac.uk/business-services/training/development/higher-apprenticeships/ https://www.ntu.ac.uk/services-for-business/skills/apprenticeships/ntu-degree-apprenticeships
[xxxi] The Great British Brain Drain. Where graduates move and why. Centre for Cities, 2016
[xxxii] Ofsted (2016) https://www.gov.uk/government/news/ofsted-issues-warning-about-education-in-the-east-midlands
[xxxiii] Report of Professor Sir Adrian Smith's review of post-16 mathematics, DfE, 2017 https://www.gov.uk/government/publications/smith-review-of-post-16-maths-report-and-government-response
[xxxiv] https://www.gov.uk/government/publications/post-16-maths-participation
[xxxv] A report on skills mismatches in Derby, Derbyshire, Nottingham, Nottinghamshire. Centre for Progressive Capitalism (2017)
[xxxvi] http://www.pesri.net/blog/?p=3442
[xxxvii] https://www.gov.uk/government/publications/autumn-budget-2017-documents/autumn-budget-2017
[xxxviii] http://www.d2n2lep.org/write/Documents/INNOVATION_SECTOR_FINAL_-_Oct_2014_(Signed)_II.pdf
[xxxix] Made Smarter Review 2017, Jurgen Meier, 2017
[xl] http://www.toyotauk.com/toyota-in-the-uk/, http://newsroom.toyota.eu/toyota-announces-new-investment-in-its-uk-car-plant3/
[xli] Annual Scaleup Review, ScaleUp Institute, 2017
[xlii] Tech Nation 2017, Tech City UK, 2017
[xliii] https://gamesmap.uk/#/map
[xliv] Space TEC Interim Evaluation Report, Yitong Liu, 2017
[xlv] http://www.creativequarter.com/
[xlvi] Derby & Nottingham Metropolitan Strategy 2030, Derby and Nottingham City Councils, 2017
[xlvii] http://www.toyotauk.com/toyota-in-the-uk/supplier-relations.html
[xlviii] http://www.nottingham.ac.uk/aerospace/projects/cleansky/index.aspx
[xlix] See https://www.rolls-royce.com/media/press-releases/yr-2017/28-11-2017-airbus-rr-and-siemens-team-up-for-electric-future.aspx and https://hvm.catapult.org.uk/impact/case-studies/the-off-highway-intelligent-power-management-ohipm-project/ for example
[l] Rail Outlook Study 2013-2022, Frost and Sullivan, 2013
[li] Lightweight, heavy impact, McKinsey & Company, 2012
[lii] Winners of £51 million Government Competition to Develop World-Leading Self-Driving Car Testing Infrastructure Unveiled, Department for Business Energy and Industrial Strategy, 2017.
[liii] Connected Car Report 2016, PWC, 2016
[liv] Top 5 selling BEV analysis, European Alternative Fuels Observatory, 2017
[lv] Fast Track to the Future, Rail Supply Group, 2016
[lvi] Low Carbon and Renewable Energy Economy Survey, final estimates: 2015, ONS, 2017
[lvii] The UK Automotive Sector: core briefing, Automotive Council UK, 2017
[lviii] https://data.worldbank.org/indicator/IS.AIR.PSGR?end=2016&start=1970&view=chart
[lix] Reach for the skies: A Strategic Vision for UK Aerospace, Aerospace Growth partnership, 2012
[lx] Market Forecast for Connected And Autonomous Vehicles, Catapult Transport Systems, 2017
[lxi] https://www.ntu.ac.uk/research/research-themes/materials , D2N2 Growth Deal 3, D2N2
[lxii] "Top drugs by sales revenue in 2015: Who sold the biggest blockbuster drugs?", Pharmacompass
[lxiii] 2017 global life sciences outlook, Deloitte, 2017
[lxiv] Medical Devices: Equipped for the Future? A. T. Kearney, 2014
[lxv] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[lxvi] Healthcare in 2065, Deloitte, 2015
[lxvii] World Industry Outlook, Healthcare and Pharmaceuticals, Economic Intelligence Unit, June 2016
[lxviii] "Healthcare analytics market to reach USD18.7 billion by 2020", news release, Medical Market Research, August, 2016, in

https://www.whatech.com/marketresearch/medical/192126-healthcare-analytics-market-worth-18-7-billionby-2020

[lxix] World Industry Outlook, Healthcare and Pharmaceuticals, Economist Intelligence Unit, June 2016

[lxx] The European Medical Technology Industry in Figures, MedTech Europe, 2015

[lxxi] Medical technology in the UK, Invest in Great: HM Government, 2017

[lxxii] http://www.thebusinessdesk.com/eastmidlands/news/2007109-food-manufacturer-reveals-plans-create-270-notts-jobs

[lxxiii] https://www.nestle.ie/media/pressreleases/tutbury-opening

[lxxiv] http://www.azotictechnologies.com/index.php/news-and-insight/latest-news/positive-rice-trials-in-vietnam and https://biocity.co.uk/company/azotic-technologies

[lxxv] The third area of research recognised was X-ray based security scanners

[lxxvi] Precision Agriculture: An Opportunity for EU Farmers – Potential Support with the CAP 2014-2020, EU, 2014

[lxxvii] http://www.fponthenet.net/article/131610/Taking-a-glimpse-into-the-future-of-the-food-production-process.aspx

[lxxviii] Reformulation Guide: Spotlight on Sugars, Leatherhead Food Research, 2016

[lxxix] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016

[lxxx] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016

[lxxxi] Global Food Security 2030, European Commission, 2015

[lxxxii] World Packaged Food - Market Opportunities and Forecasts, 2014 – 2020, Research and Markets, 2015

[lxxxiii] http://www.igd.com/Research/Retail/Global-grocery-markets-our-forecasts-to-2020/

[lxxxiv] The Outlook for Energy: A View to 2040. ExxonMobil, 2016

[lxxxv] https://www.trentbasin.co.uk/the-development/community-energy/

[lxxxvi] https://enviroenergy.co.uk/district-energy/

[lxxxvii] https://www.endswasteandbioenergy.com/article/1403381/go-ahead-nottingham-waste-gasification-plant

[lxxxviii] http://www.chinooksciences.com/2017-05-17-chinook-features-on-the-ft-1000#.Wh2Ehkpl-Uk

[lxxxix] http://www.d2n2lep.org/write/D2N2_Low_Carbon_Action_Plan.pdf

[xc] https://www.derbyshire.gov.uk/environment/planning/planning_policy/minerals_waste_development_framework/shale_gas/default.asp

[xci] Low-Carbon Energy Futures: A Review of National Scenarios, Trottier Energy Futures Project, 2013

[xcii] Sustainable Energy Horizon Panel Report, Matrix, 2013

[xciii] The Clean Growth Strategy: Leading the way to a low carbon future. HM Government. 2017

[xciv] Energy to 2050: Scenarios for a Sustainable Future. OECD/IEA, 2003

[xcv] World Energy Scenarios, World Energy Council, 2016

[xcvi] The Outlook for Energy: A View to 2040. ExxonMobil, 2016

[xcvii] International Energy Outlook 2017, EIA, 2017

[xcviii] The Outlook for Energy: A View to 2040. ExxonMobil, 2016

[xcix] Rethinking Energy: Towards a new power system. IRENA, 2014

[c] World Energy Scenarios, World Energy Council, 2016

[ci] World Energy Outlook. IEA, 2014

[cii] 2016 Utilities Industries Trends, PWC, 2016