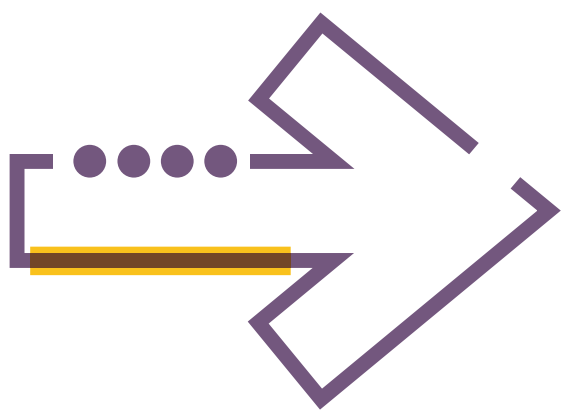THE UNIVERSITY *of* EDINBURGH

DDI **Data-Driven Innovation**

Part of the Edinburgh & South East Scotland City Region Deal

Development Opportunities in Fife

Evolving Data-Driven Innovation and the Entrepreneurial Ecosystem

Preliminary Analysis Report

Doing data right
ddi.ac.uk

Development Opportunities in Fife

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Edinburgh, September 2020
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Foreword

The Kingdom of Fife was once at the heart of Scotland's heavy industries, from the coal mines beneath the earth to the shipbuilding yards that lined the Firth of Forth.

Those traditional stalwarts were supplemented by the grain and the livestock grown and raised on prime agricultural land, and by the fishing boats that landed their catches in the area's numerous harbours.

In more recent years, those primary and secondary industries have been joined by lighter manufacturing – especially in the electronics and food and drink sectors – and by a thriving services sector, ranging from finance through to healthcare.

In 2021, Fife's participation in both the Edinburgh and South East Scotland City Region Deal and the Tay Cities Deal will help the area to access the funding and the partnerships it needs to take the next steps in growing its economy.

Those next steps will use data to drive innovation. By gathering and analysing information, businesses will be able to develop products and services that will better meet the needs of their customers.

This use of data-driven innovation (DDI) is not limited to companies that would traditionally rely on computers and other digital technology. While businesses operating in the finance and in the information and communication technology arenas may be among the first to harness DDI, its applications extend far and wide.

Using sensors to monitor the performance of offshore wind turbines will enable firms in Fife to know when maintenance and repairs will be needed. Sensors will also allow the ageing infrastructure in Scotland's oil and gas industry to be monitored, so it can be decommissioned and recycled at the appropriate moment, completing the links in Fife's circular economy, with some of the structures potentially being decommissioned near where they were built.

Farmers use satellites and computers to monitor weather conditions and determine the optimum paths for tractors to seed, spray, and harvest crops. Manufacturing lines can be made even more efficient by gathering data on the performance of machinery and by analysing procedures and processes on the shop floor.

Public services can be transformed by understanding when and why citizens access services, from education and healthcare through to libraries and public transport. That same data on transport and provision of services such as public toilets can also help to enhance the Kingdom's thriving tourism sector, ensuring visitors have access to the services they need to improve their holidays and trips, turning them into return visitors and ambassadors for Fife.

In this report, Fife's economic development priorities are examined, and links are identified with the expertise available within the University of Edinburgh and its partners. With strong transport links between Fife and the Lothians, the opportunities for the kingdom to tap into the knowledge and experience of academia and support services at the university are immense.

The next steps are to identify the current and potential uses of DDI within Fife and then form those links with the university. Just as black gold in the form of coal and oil drove the kingdom's economy in the past, so too could data drive the innovation needed for Fife's economy of the future.

Jarmo Eskelinen
Executive Director, Data-Driven Innovation, University of Edinburgh/City Region Deal

Cllr David Alexander and Cllr David Ross
Co-Leader, Fife Council

Executive Summary

This report aims to identify opportunities for the University of Edinburgh to develop data-driven innovation (DDI) activities in Fife.

- It identifies the alignment of interests between the university DDI Programme and key private and public organisations in Fife; and,

- It evaluates options, recommending potential next steps.

We identify specific opportunity areas for DDI activities across the eight key sectors identified in the Fife Economic Strategy 2017-2027 (i.e. energy and renewables; manufacturing incl. engineering; finance and business services incl. Fintech; digital technology incl. ICT; tourism, culture and creative industries; food and drink; health and care; construction and civil engineering).

We present the key TRADE (Talent, Research, Adoption, Datasets and Entrepreneurship) opportunities areas that the university can deploy in Fife:
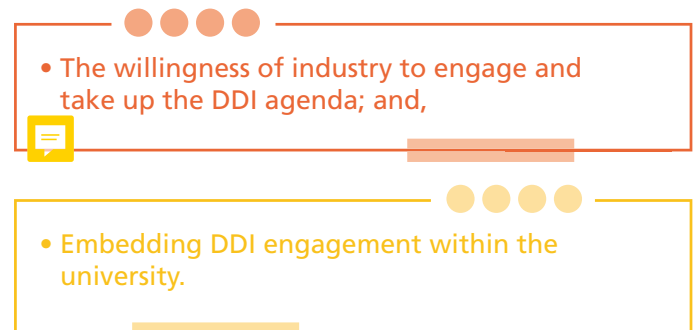
- **Advanced manufacturing for engineering and construction;**

- **Autonomous systems and sensors on marine and airborne platforms;**

- **Data intelligence for enterprise services;**

- **Data-enhanced agriculture/food & drink, distribution and logistics; and,**

- **Smart systems for health and wellbeing.**

The university's capabilities can be deployed in three ways: Physical infrastructure, digital platform and network of partners. In terms of an research and development (R&D) hub as a physical infrastructure (along the lines of the advanced manufacturing research centre model), we see tangible opportunities with advanced engineering and robotics, and automation and autonomous systems applications. This could be developed to establish an educational

hub to accelerate the talent pipeline, embedded in Fife College in collaboration with the University of Edinburgh.

We identify further opportunities for talent through training and skills development (e.g. degree-level apprenticeships, industry-sponsored thesis/projects, CPD, and executive education) with online curriculum development as means to scaling-up provision. There is an enthusiasm across the DDI hubs (e.g. EFI, Bayes Centre, Usher Institute) to develop these opportunities in partnership with Fife College and Skills Development Scotland.

There are two key challenges that need to be addressed:

- The willingness of industry to engage and take up the DDI agenda; and,

- Embedding DDI engagement within the university.

In order to move forward, we recommend a series of gap analyses of the DDI landscape in Fife relating to innovation, entrepreneurship and skills needs. There are wider questions about how to link the DDI Programme to an inclusive growth and social inclusion agenda across the whole City Region. There are relevant approaches existing within the university, including: the widening participation agenda and growing and developing innovative learner pathways; the City Region Deal Inclusive Growth Framework; and Living Lab with participatory methodology and real problem-solving approaches.

The importance of the foresight opportunities for the university with local stakeholders needs to be recognised. Datasets and evidence of impacts on the City Region needs to be developed as part of the DDI Programme, also considering the social benefits of the identified DDI opportunity areas.

List of acronyms

Advanced Manufacturing Research Centre (AMRC)

Artificial Intelligence (AI)

City Region Deal (CRD)

Construction Scotland Innovation Centre (CSIC)

Continuing professional development (CPD)

Data-Driven Innovation (DDI)

Digital Health and Care Institute (DHI)

Edinburgh and South East Scotland City Region Deal (ESES-CRD)

Edinburgh Centre for Carbon Innovation (ECCI)

Edinburgh Future Institute (EFI)

Edinburgh Innovation (EI)

Edinburgh International Data Facility (EIDF)

Edinburgh Living Lab (ELL)

Expression of interest (EoI)

Gross value added (GVA)

Heriot Watt University (HWU)

Higher Education Institution (HEI)

Higher National Certificates (HNCs)

Higher National Diplomas (HNDs)

Information and Communication Technology (ICT)

Internet of Things (IoT)

Knowledge Transfer Partnerships (KTP)

Local Authorities (LAs)

National Manufacturing Institute for Scotland (NMIS)

Research and Development (R&D)

Scottish Enterprise (SE)

Scottish Qualification Authority (SQA)

Scottish Vocational Qualifications (SVQs)

Skills Development Scotland (SDS)

Small and Medium-sized Enterprises (SMEs)

Talent, Research, Adoption, Datasets, and Entrepreneurship (TRADE)

The University of Edinburgh (UoE)

Introduction

The Data-Driven Innovation (DDI) Programme[1] is part of the Edinburgh and South East Scotland City Region Deal (ESES CRD)[2]. At its core, the Programme aims to support organisations and individuals benefit from the cutting-edge research and development in the generation, storage, analysis and use of various forms of data.

The DDI programme aims to "help establish the region as the data capital of Europe, drawing in inward investment, fuelling entrepreneurship and delivering inclusive economic growth"[3]. It will improve digital skills through working with schools, further and higher education, employers, and training providers.

The University of Edinburgh (UoE) has engaged with this research agenda for several decades and has globally been leading expertise in informatics and data science, as well as in the related fields of engineering and natural and social science. UoE and Heriot Watt University are working together, particularly in the area of robotics. The DDI Programme is centred around five innovation hubs (i.e. Edinburgh Future Institute; Easter Bush; National Robotarium; Bayes Centre; Usher Institute)[4]. The Edinburgh International Data Facility (EIDF) project underpins the five innovation hubs, and supports the inclusive growth ambitions of the partnership. In looking towards extending the DDI Programme with partners in the ESES-CRD, this study specifically analyses some of the emerging areas of opportunity for developing the academic, commercial and civic collaboration with partners and stakeholders in Fife, in particular, to address the ambitions of the overarching CRD economic development and inclusive growth agenda.

Fife Council is the third largest local authority in Scotland in terms of population, and is committed to supporting two city deals – the Edinburgh and South East Scotland (ESES) City Region Deal, and the Tay Cities Deal, covering the northeast of Fife. In this study, we will only focus on the ESES City Region Deal, while we are aware of informal arrangements to support potential synergies between the two deals in the coming years. There is one higher education institution located in Fife, the University of St Andrews, while Fife College is a key local skills provider, along with private providers.

The shift away from dependence on traditional industries towards a more service-based economy has been a focus of economic development policy in Fife. The Fife Economy Partnership, Fife Council and the Opportunities Fife Partnership have jointly developed the Fife Economic Strategy 2017-2027 to achieve sustainable and fair economic growth for Fife. In this economic strategy, eight key industrial sectors are identified, which can significantly contribute to high economic growth in the region. This study identifies potential DDI opportunities across these sectors. This study is based on interviews conducted between October and December 2018 with key individual stakeholders including the industry, academic and governmental sectors, as well as the analysis of secondary data sources. More than 30 individuals were consulted (see Appendix A for their names and organisations). Key areas of opportunity are identified by matching the existing and emerging alignment of interests between the university DDI activities and key private and public sectors in Fife. The report concludes by evaluating options and recommending possible next steps.

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1 See https://ddi.ac.uk/ for more information. [all online sources were accessed as of 6 December 2018 unless otherwise stated]

2 The UK and Scottish governments, and regional partners are investing £1.1bn over 10 years in transport, housing, culture, skills and employability and innovation. The regional partners include the six local authorities of Edinburgh, Midlothian, East Lothian, West Lothian, Fife and the Scottish Borders, plus universities and colleges in the region.

3 See https://www.ed.ac.uk/local/city-region-deal; http://www.edinburgh.gov.uk/download/meetings/id/57706/item_86_-_edinburgh_and_south-east_scotland_city_region_deal and http://www.acceleratinggrowth.org.uk/

4 http://www.acceleratinggrowth.org.uk/new-blog/2017/7/20/edinburgh-and-south-east-scotland-city-region-deal-secured
  See https://ddi.ac.uk/about-us/ for DDI Innovation Hubs.

The Fife economic strategy and key economic sectors

As the context for this study, the geographical and industrial profiles of businesses in Fife and their economic activities are analysed drawing on a number of secondary data sources (e.g. Fame database, ONS data) (See Appendix B for details).

The Fife Economic Strategy 2017-2027 has identified eight key areas that can significantly contribute to high economic growth in the region[5] (see Table 1). In this study, we focused on these eight areas to understand the needs of the Fife industry and align them with the capabilities of the University of Edinburgh.

Sector	Enterprises	Turnover (£)	Employment (Nos)
Energy and renewables	----	-----	-------
Manufacturing incl. Engineering [6&7]	835	3.86 bn	15,010
Finance and business services incl. Fintech[16&8]	110	500 m	3,470
Tourism[9], culture and creative industries [10&11]	715	565 m	13,000+
Food and drink [12&13]	655	725 m	6,000
Digital technology incl. ICT[14]	570	271 m	5,220
Health and Care, and Education[15]	495	509 m	14,730
Construction and Civil engineering[16]	1,210	1.04 bn	7,260
Fife Region Total[17]	10,295	12.98+ bn	106,000

Table 1 – Economic activity in the eight key economic sectors as per Fife economy strategy 2017-2027

5 Fife Economic Strategy 2017-2027

6 The manufacturing industry in Fife, Sector Profile 2018; http://www.fifeeconomypartnership.com/wp-content/uploads/sites/10/2018/10/Manufacturing-in-Fife-factsheet-2018.pdfhttp://www.fifeeconomypartnership.com/wp-content/uploads/sites/10/2018/10/Manufacturing-in-Fife-factsheet-2018.pdf

7 https://www2.gov.scot/Resource/0054/00543007.pdf

8 https://www.investinfife.co.uk/content/key-sectors-financial-business/

9 Fife Tourism Strategy 2014-2024; https://www.fifetourismpartnership.org/site/assets/files/2517/tourist_strategy_final_for_screen.pdf

10 Creative Industries in Fife 2016 summary report; http://wordpress.fifedirect.org.uk/fifeeconomypartnership/wp-content/uploads/sites/10/2016/10/Creative-Industries-Fact-Sheet-2016-Summary.pdf

11 Fife Tourism Partnership (autumn 2018), Insight into tourism sector helps plan for future, Fife Business Matters, 44, pp26. https://www.businessgatewayfife.com/sites/bgfife/files/fbm-44-autumn-low.pdf

12 Food and drink in Fife, sector profile 2017; http://wordpress.fifedirect.org.uk/fifeeconomypartnership/wp-content/uploads/sites/10/2016/10/Fact-Sheet_Food-Drink_Profile-2017.pdf

13 Food and drink (autumn 2018), Fife Business Matters, 44, pp11. https://www.businessgatewayfife.com/sites/bgfife/files/fbm-44-autumn-low.pdf

14 Digital sector in Fife, 2018 factsheet; http://wordpress.fifedirect.org.uk/fifeeconomypartnership/wp-content/uploads/sites/10/2018/02/Digital-Sector-Factsheet.pdf

15 Businesses in Scotland 2018. https://www2.gov.scot/Resource/0054/00543007.pdf

16 Businesses in Scotland 2018. https://www2.gov.scot/Resource/0054/00543007.pdf

17 Businesses in Scotland 2018. https://www2.gov.scot/Resource/0054/00543007.pdf

18 Regional Skills Assessment infographic 2018; https://www.skillsdevelopmentscotland.co.uk/media/44997/fife-rsa-region.pdf

Manufacturing, wholesale and retail, and health and social work are the top three employment sectors in Fife in 2018[18]. Given their size, they are expected to add the most gross value over the forecasted period till 2028. Significant contributions to growth are also expected from real estate activities and the construction sector. However, they will not be the fastest growing sectors - over the forecast period the fastest growing sectors are expected to be information and communication, professional, scientific and technical activities and administrative and support services[19]. The public sector is a significant employer in Fife, contributing to 26 per cent of Fife's GVA in 2016, followed by manufacturing (19.5 per cent) and professional and other private services (18.6 per cent)[20]. Health and care is the largest public sector employer in Fife.

In relation to the Scottish economy, Fife is considered as a high productivity and low output region[21]. In 2018, the GVA by Fife was £7.5 billion, which was six percent of Scotland's total national output[22]. Fife's business base is largely made up of micro and small to medium enterprises (SMEs). In Fife, 96 per cent of businesses have fewer than 49 employees and 62 per cent have 0-4 employees[23]. There are only 50 businesses in Fife with more than 250 employees. Moreover, 80 per cent of Fife's productivity comes from these larger companies[24].
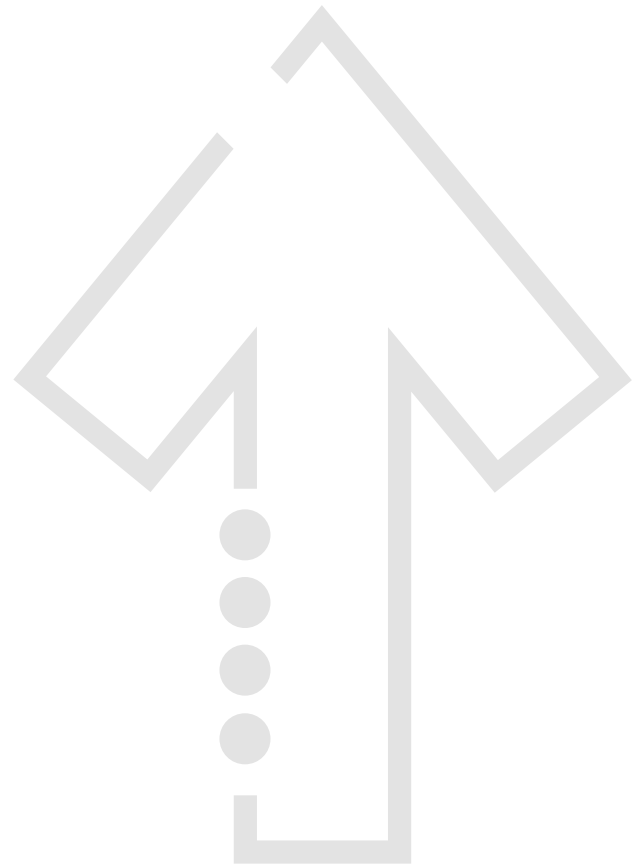
19 Regional Skills Assessment Fife Insight 2017; https://www.skillsdevelopmentscotland.co.uk/media/44099/rsa-indesign-fife-2.pdf
20 Scotland's Economic Performance Fife Council http://www.parliament.scot/S5_EconomyJobsFairWork/Inquiries/PSE016-Fife_Council.pdf
21 Regional Skills Assessment Fife Insight 2017; https://www.skillsdevelopmentscotland.co.uk/media/44099/rsa-indesign-fife-2.pdf
22 Fife Regional Skills Assessment (RSA) Summary Report 2018
23 Fife Business Base 2017; http://wordpress.fifedirect.org.uk/fifeeconomypartnership/wp-content/uploads/sites/10/2017/12/Business-Base-Report-2017.pdf
24 Opportunities Fife Partnership Strategy Refresh and Outline; https://www.opportunitiesfife.org/media/1366/ofp-strategy-2018-2022.pdf

DDI relevance, inclusive growth agenda and challenges to key economic sectors in Fife

The UK Government has pinpointed several areas as key industrial drivers of economic growth. These are: artificial intelligence, additive manufacturing, automation and robotics, smart technology, fourth industrial revolution (4IR) and augmented reality[25]. In realising the growth from these sectors, the UK Government Industry Strategy[26] identifies various grand challenges:

- Put the UK at the forefront of the artificial intelligence and data revolution;

- Maximise the advantages for UK industry of the global shift to clean growth;

- Become a world leader in shaping the future of mobility; and,

- Harness the power of innovation to help meet the needs of an ageing society.

The Scottish Government also has an economic strategy with four priorities that place digital development at the epicentre of future investment and innovation trends[27]. As a result, Scotland has developed a strategic agenda for realising its full potential in the digital arena[28]. Among the key goals of this strategy are:

- **Stimulating innovation, welcoming investment and promoting its digital technologies industries;**

- **Developing internationally competitive, digitally mature businesses across all sectors;**

- **Becoming recognised internationally as a natural test bed for innovation in connectivity; and,**

- **Focusing education and training systems on expanding the existing pool of digital skills and capabilities.**

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25 Department for Business Energy and Industry Strategy, Science & Innovation Audits summary report 2016).
26 UK Government Industry Strategy https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf
27 Scottish Government (2015) Scotland's Economic Strategy https://www2.gov.scot/economicstrategy
28 Scottish Government (2017)Realising Scotland's full potential in a digital world: a digital strategy for Scotland https://www.gov.scot/publications/realising-scotlands-full-potential-digital-world-digital-strategy-scotland/pages/2/

In the context of the Fife economy, each of the eight key economic sectors indicates a growing need and potential demand of DDI; for instance, in the oil and gas industry, sensors, analytics and data reporting are the key areas of future development. One of the perceived challenges is competition with global businesses in other countries that are ahead in the shift toward industry 4.0. Some manufacturing and engineering businesses in Fife have already realised the importance of data-driven innovation and industry 4.0 concepts in their manufacturing processes (e.g. Bosch Rexroth, the Glenrothes DPS Group)[29].

The transition to Industry 4.0 is not an even process. Three key issues are identified namely, adoption of DDI, attraction and retention of skilled labour, and automation. In the Fife economy, more than 80 per cent of the companies are small and medium size. Whilst large organisations may have been adopting robotics and flexible manufacturing systems for many years, small and medium-sized enterprises (SMEs) may be lagging behind due to lack of awareness and resource constraints.

Another perceived challenge for SMEs in Fife is the skills agenda. The availability and quality of skilled labour for manufacturing, engineering and construction has been recognised as a key challenge - along with the ageing workforce. Attraction and retention of talent is one of the major issues, especially for SMEs. There is a new challenge of investing in retraining and upskilling existing workers as digitalisation and automation change the nature of workplaces. There are a few recent locally embedded skills initiatives, particularly in health and care sector and fintech sector, with the involvement of businesses in Fife and Fife College (see p.14).

The Scottish Government's (2015) economic strategy states: "increasing growth and tackling inequality are mutually supportive"[30]. The Fife Council Business Charter provides a framework for the working relationship between Fife Council and local businesses, both improving the economic performance and reducing inequalities[31]. At the CRD level, an analysis of the City Region's inclusion challenges identified the five thematic interventions:

- **Accelerating inclusive growth;**

- **Removing the physical barriers to growth;**

- **Community benefits through procurement;**

- **Targeted skills interventions; and,**

- **Social benefit through innovation[32].**

There is no one-size-fits-all approach to tackling these issues and realising opportunities related to DDI as part of the inclusive growth agenda, given the rapidly changing technological landscapes as well as local socio-economic and demographic challenges. Given the University of Edinburgh's focus on relevant DDI agendas, and its desire to engage with the needs and aspirations of local partners, there is a potential that the DDI Programme can play a significant role in improving the local industry's economic performance and enhancing the inclusive growth agenda.

This study built up on the existing "DDI Programme Impact Pathways" model (Appendix C). Based on the analysis of the data and information collected in this study, we developed a preliminary model of DDI deployment in Fife and used it as a conceptual framework (Appendix D).

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29 Industry 4.0- Revolutionising Manufacturing Fife Business Matters, Issue 44. pp 16-18 2018. http://www.propertyebrochures. co.uk/fbm/issue44/issue44.html#p=16

30 Scottish Government (2015) Scotland's Economic Strategy.

31 See the objectives set out in the Fife Council Business Charter https://businesscharter.fife.scot/ [02/04/19]

32 https://www.sestran.gov.uk/wp-content/uploads/2018/01/2018-09-21-Item-B1.-Edinburgh-South-East-of-Scotland-Region-Deal.pdf [30/04/19]

Matching key sectors in Fife with UoE DDI capability

In Table 2, the eight key sectors identified by Fife's Economic Strategy 2017-2027 are presented alongside key industry actors. Local opportunities and some of the challenges for these sectors are identified. Key issues addressed in skills in Fife are identified in *italics* These are matched with the UoE's DDI capabilities and potentials. For the full information, see Appendix E.

Key Sector in Fife Economic Strategy 2017-2027	Fife Industry strength/opportunity and challenges	UoE's DDI capability and potential

Energy and renewables	Oil and gas large players (e.g. Babcock, TechnipFMC, Oceaneering, Burntisland Fabricators) and supply chains;
	
	The Levenmouth Demonstration Turbine (ORE Catapult);
	
	Global Energy Inc.
	
	Queensway Park Data Centre Campus.
		• Orca Hub (joint HW-UoE / Robotarium venture)
		
		Sensors, analytics and data reporting are key areas for future development:
		
		  – Manufacturers: Quality Control
		
		  – Operations: Predictive Maintenance (based on statutory requirements)

Manufacturing incl. Engineering	Sensors and big data as one of emerging supplementary themes regarding materials and machine design. *Availability and quality of skilled labour as a challenge; ageing workforce.*	• "Industry Forth" (2018) FASTBLADE-Babcock; Engineering + Informatics and +EI; SDS + SE + Invest in Fife / Fife Council + companies (EoIs) Fife College linked in through SDS. Advanced Manufacturing Innovation Centre, proposed in 2018, with main themes: – Industry 4.0 – Manufacturing engineering – Welding – Metallurgy and composites – Machining – Scientific services – Nuclear AMRC
Finance and business services incl. Fintech	Payment services e.g. Ingenico Group; Renovite Technologies; FIS Global; Payment Centric The Fife Fintech Skills Academy (Fife Council, Fife College, fintech industry in Fife; Fintech Scotland)	EPPC-Data Lab project with Paywizard • Data Lab • Fintech Scotland • Centre of Excellence for Cyber Security Research, Informatics

Table 2 – Matching key sectors in Fife and DDI capability at UoE

Key Sector in Fife Economic Strategy 2017-2027	Fife Industry strength/opportunity and challenges	UoE's DDI capability and potential
Digital technology incl. ICT	e.g. Semifab, Exterity, Artilium, TDK-Micronas, Paywizard, BITwise, RG Wire and Cable; CDL vehicle information services; itek; EAF	• AI and blockchain accelerator at Bayes Centre • Centre of Excellence for Cyber Security Research • Edinburgh Living Lab
Tourism, culture and creative industries	Relatively fast average annual growth of 2.6 per cent – creative industry but limited impact; Tourism – job growth expected.	Links between DDI and creative industry in Fife (e.g. Fife College, Create in Fife; Fife Craft Association) being sought e.g. digital informatics; informatics; Bayes; EPCC; ECCI. Data-driven marketing and forecasting for tourism industry.
Food and drink	Food and drink - Ports and logistics e.g. Diageo - spirits manufacturer drinks industry (whisky), global distribution centre in Fife (near Leven)	Ports and logistics – Data integration across the various business units – links to Bayes Centre Other areas • Geoscience • Easter Bush (potential to develop smart farming links through DDI agritech programmes)
Health and Care	NHS Fife; commercial care providers *Gap between lower skills and post-graduate level skills* *Futurequipped* by DHI; CSIC and FE Colleges; upskilling and new curriculum development covering health, construction and ICT	Data health work with NHS Fife (Usher Institute) – NHS fellowship in Fife – Healthcare innovation funding bid – working with NHS in Fife, Borders – *UG PG curricula with health data; online course for scaling up* The Advanced Care Research Centre – Data analytics, IoT/sensors, AI/Robotics, therapeutics ; With LAs, NHS, University, Colleges; care providers, industry; Potential opportunity for an outreach demonstration site
Construction and Civil engineering	Large scale construction e.g. Queensferry Crossing/Jacobs Housing construction/off-site and automated/robotised construction – Lack of digitisation A substantial increase in employment expected in construction	Civil engineering / Centre for future infrastructure; CPD courses and masters programme. Procurement office–Climate KIC

Table 2 – Matching key sectors in Fife and DDI capability at UoE[33]

33 This table is mostly focused on opportunities in the private sector. However, the potential role of the public sector should not be ignored (as clearly highlighted in the Scottish Government's Digital Strategy. While Health &Social Care are mentioned here, there probably are other public sector opportunities for driving innovation around data. More research is required to identify them. For example, the CivTech pilot has demonstrated the potential for engaging small businesses in developing solutions to public service challenges. See https://www.gov.scot/publications/realising-scotlands-full-potential-digital-world-digital-strategy-scotland/pages/2/

Opportunities for data-driven innovation in Fife

Building on the information presented in Table 2, through communications with a variety of academic and professional colleagues across the university, a series of key areas of opportunity have been identified. Among these opportunity areas, we highlight activities, which already have links to partners in Fife.

Specifically, our attention has been drawn to the university's scientific expertise and technological competences in the following five thematic opportunity areas:

- **Advanced manufacturing for engineering and construction;**

- **Smart systems for health and wellbeing;**

- **Autonomous systems and sensors on marine and airborne platforms;**

- **Data intelligence for enterprise services; and,**

- **Data-enhanced agriculture/food and drink, distribution and logistics.**
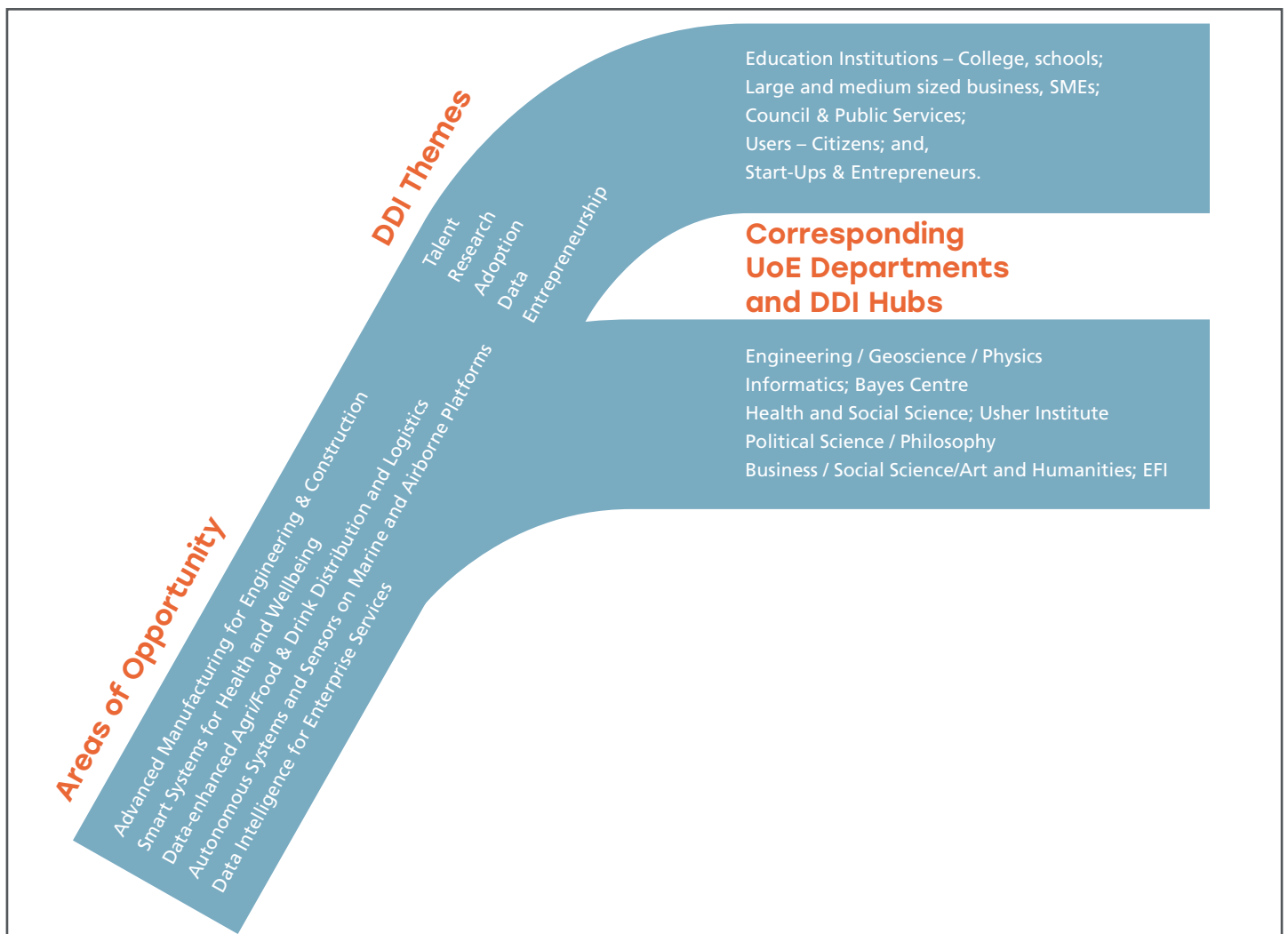
The conceptual framework is presented below:

Figure 1 – A schematic of the opportunity areas and corresponding key stakeholders at UoE and in Fife

Advanced manufacturing for engineering and construction

There are opportunities in advanced manufacturing for machine engineering, for the university and industry in Fife, to develop renewable energy machinery, as well as to build, maintain and de-commission other oil and gas and maritime systems. This led to the School of Engineering and Bayes Centre submitting a proposal "Industry Forth" for the Strength in Places Fund[34] in summer 2018 with a proposal to build an advanced manufacturing innovation centre in Rosyth in collaboration with Babcock. The partners included Babcock, Scottish Enterprise, Invest in Fife and Fife Council. Skills Development Scotland (SDS) and Fife College were also partners.

Opportunities are sought between the School of Engineering and SDS to develop and deliver innovative learning pathways in partnership with Fife College and industry. This would provide a future opportunity to establish an educational hub embedded in Fife College to accelerate the talent pipeline, including:

- Offering degree-level apprenticeship training in engineering (SoE), data science (SoI/Bayes Centre) and entrepreneurship/innovation and entrepreneurship (Business School); and,

- Further access to education programmes at the University of Edinburgh (MSc/MEng/PhD/EngD) with CPD options.

There are also opportunities in off-site, automated and robotised manufacturing within the construction industry, especially in relation to fabricated panels, roofing systems and timber engineering.

Autonomous systems and sensors on marine and airborne platforms

The School of Geosciences' near-earth observation activities, currently with a significant base at Fife airport, would be an excellent start-point to develop an ambitious R&D programme of networked autonomous systems and advanced sensors[35]. This relates in particular to marine and airborne platforms, either mobile (e.g. drones and submersibles) or fixed infrastructure (e.g. road and rail network, energy installations, telecommunications). By working with partners in construction and energy sectors and utilising expertise in engineering, robotics and AI, opportunities could be found in a variety of applications in IoT enabled infrastructure resilience, advanced sensory materials and autonomous mobile platform deployment. Significant market opportunities are arising through decommissioning of oil and gas infrastructure, the expanding renewable energy sector and a predictive real-time road, rail, power and telecommunications system maintenance.

Smart systems for health and wellbeing

The Usher Institute is developing a collaboration with NHS Fife. The College of Medicine is developing curricula for both undergraduates and postgraduates with health data, aiming to scale these up through online courses for local clinical professionals. In addition, UoE has a part-time HN/degree route with Fife College and the NHS in biomedicine. The Advanced Care Research Centre (ACRC)[36] may offer a new opportunity to connect DDI Programme, the private sector, NHS boards, local authorities, colleges and care providers, and SDS.

NHS Fife has been awarded an eHealth Insider award for Patientrack, an electronic monitoring and early warning system that has significantly reduced cardiac arrests in Fife[37]. Fife Health & Social Care Partnership runs the Well programme[38] and is currently investigating opportunities to expand this digitally.

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34 The proposal was not selected to develop the full-stage bids. See Strength in Places Fund https://epsrc.ukri.org/newsevents/news/strengthinplacesfund/ [28/04/19]

35 We were informed about a potential bid/proposal being developed to support the Space and Satellites sector, which would involve looking at developing a local ecosystem for building remote sensing/geospatial data capture devices. This is at very early stages, but we understand it would link to the autonomous systems and sensors work, and to the expanding the precision engineering capacity.

36 The Advanced Care Research Centre (ACRC) https://ddi.ac.uk/projects/advanced-care-research-centre/

37 Patienttrack NHS Fife https://www.ehealth.scot/case-studies/patientrack-nhs-fife/

38 The Well programme provides physical integrated hubs for health and social care services.

There may be opportunities to combine healthcare and sensor technologies for home healthcare to tackle the societal challenges of an ageing society. In terms of upskilling digital skills in these fields, Futurequipped is a pilot project delivered by the Digital Health and Care Institute (DHI) and Construction Scotland Innovation Centre (CSIC) and FE colleges in Scotland including Fife College. The project focusses on upskilling and new curriculum development covering health, construction and ICT along with the digitisation of home healthcare technologies.

Data-enhanced agriculture, distribution and logistics
There are opportunities to link these sectors with the system engineering and analytics expertise at the University. This could lead to significant new applications for data-enhanced agriculture, distribution and logistics.

Data intelligence for enterprise services
Building on the existing financial services, businesses and critical public and private enterprise-level data handling solutions, a significant expansion of the work in data intelligence for enterprise services may be possible, perhaps through partnering with Queensway Data Centre in Glenrothes. EPCC with its existing industry links, would be a core competence of the university in this area.

In an area closely related to DDI, the recently developed Fife Fintech Skills Academy is one of the innovative approaches adopted by payment service businesses in Fife with partners including Fife Council, Fife College, and Fintech Scotland to respond to the specific skills gap in payment services and upskilling workforces to meet the new data-driven financial services.

Addressing the TRADE outputs

The proposed areas of opportunity in different ways cover all target DDI sectors and key TRADE performance indicators[39]. In particular, working with partners such as Fife College and schools[40], the university can support a leading talent development programme by targeting wider cohorts of data literacy as set out in the DDI Skills Gateway Project.

Such partnerships can enhance data literacy in Fife by supporting the development of schools and college curriculums, supplying critical expertise and by providing opportunities for executive education, CPD courses and graduate apprenticeship schemes[41].

The university is currently identifying a number of areas that impact "learner progression and pathways", including apprenticeships, SVQs, HNCs and HNDs – and associate/articulated student degrees. A recent project in advanced manufacturing aims to deliver training to colleges and industry on realising the potential for Industry 4.0. The university is also delivering a data science enhancement to modern apprenticeships in financial services and healthcare, and working with the Scottish Qualification Authority (SQA) and Skills Development Scotland (SDS) to develop the next generation of data science qualifications (HNC/HND Data Science) and apprenticeships. The main catalyst for the university is the development and delivery of graduate apprenticeships in data science and cyber security, and new opportunities are being sought in engineering.

Furthermore, by co-locating academics and practitioners, building on existing **research** capability, new avenues for directly impactful, applied/near to market research and **adoption** are likely to arise. Specifically, working with big business, such as the engineering prime Babcock, spirits giant Diageo or energy lead Burntisland Fabrications, who have capacity for investment into expanding the knowledge base for innovation, the University can also play a key role in enhancing new opportunities for DDI. This may include shaping the responsible, sustainable and inclusive research agenda for the future.

Support for SMEs with Business Gateway Fife, the Scottish Manufacturing Advisory Service (SMAS) and other business support organisations need to be enhanced to make them aware of data opportunities. The SME managers whom we interviewed told us that they prefer to train their workforce through ongoing learning "by experience" due to highly specialised nature of their businesses. These may pose additional challenges when SMEs try to adopt DDI in their operation. At the same time, they welcome opportunities for hosting university staff to enhance the innovativeness of their R&D and manufacturing processes through adoption of new technologies, knowledge and practices.

With Fife's upcoming data centre, the university's unique expertise in data acquisition, storage, processing and management can be brought to bear in order to improve public services and modernise data infrastructure available to businesses across the region. In addition, the university can critically facilitate the development of ethical and legal consensus around co-creation and use of data between citizens, public sector and private enterprises.

39 See https://ddi.ac.uk/data-talent-for-industry/our-growth-plan/

40 Knowledge Sharing Schools and the Newbattle model are some of the examples.

41 Skills linkages can be further explored as part of the broader commitments within the Integrated Regional Employability and Skills programme. http://www.acceleratinggrowth.org.uk/ires

Finally, by pushing the envelope in innovative R&D and business development, we believe a range of new opportunities for entrepreneurship will emerge. Collaboration with incubation spaces and accelerator facilities is important in order to build and support entrepreneurial capability of local industry. The university could contribute to growth acceleration opportunities within the Fife's innovation hubs and enterprise zones, through its business development services by supporting networking and skills exchange, and providing expertise to business formation and growth. Developing DDI related managerial capacity and leadership skills of local businesses is also an area the University could contribute through CPD courses and executive education.

According to the existing customer relationship management data on the UoE industry links in Fife, there are different forms of university-industry engagement, including collaborative research, CASE studentships, knowledge transfer partnerships (KTPs), projects managed by Interface (e.g. innovation vouchers), consultancy and staff secondment. However, we do not know how these engagement forms co-exist and evolve over time. There might be synergistic relationships across each of the TRADE components (e.g. research, adoption and training). In order to understand the impacts of DDI activities over time, close monitoring of KPIs and links across KPI metrics is needed.

There remain wider questions to be addressed about how to link DDI programme to inclusive growth and social inclusion agenda. There are relevant approaches existing within the University, including:

Skills provision, the widening participation agenda and an interest in growing existing, and developing innovative learner pathways;

- **Procurement office - City Region Deal Inclusive Growth Framework; and,**

- Living Lab with participatory methodology and real problem solving approaches.

Wider social impacts of the identified DDI opportunity areas need to be identified, which can be found not only in Fife but across other local authorities in the City Region and beyond. A policy question remains: what policies and actions are needed to be undertaken for all to realise the benefits of such inclusive growth?

Capabilities delivery model

The university's DDI, as well as any other expert innovation capabilities, can be deployed to a target economic sector through one of three types of strategic pipelines: physical infrastructure; digital platform; and network of partners. All three are, of course, not exclusive to each other, dependent on investment of resources and personnel, and require careful calibration.
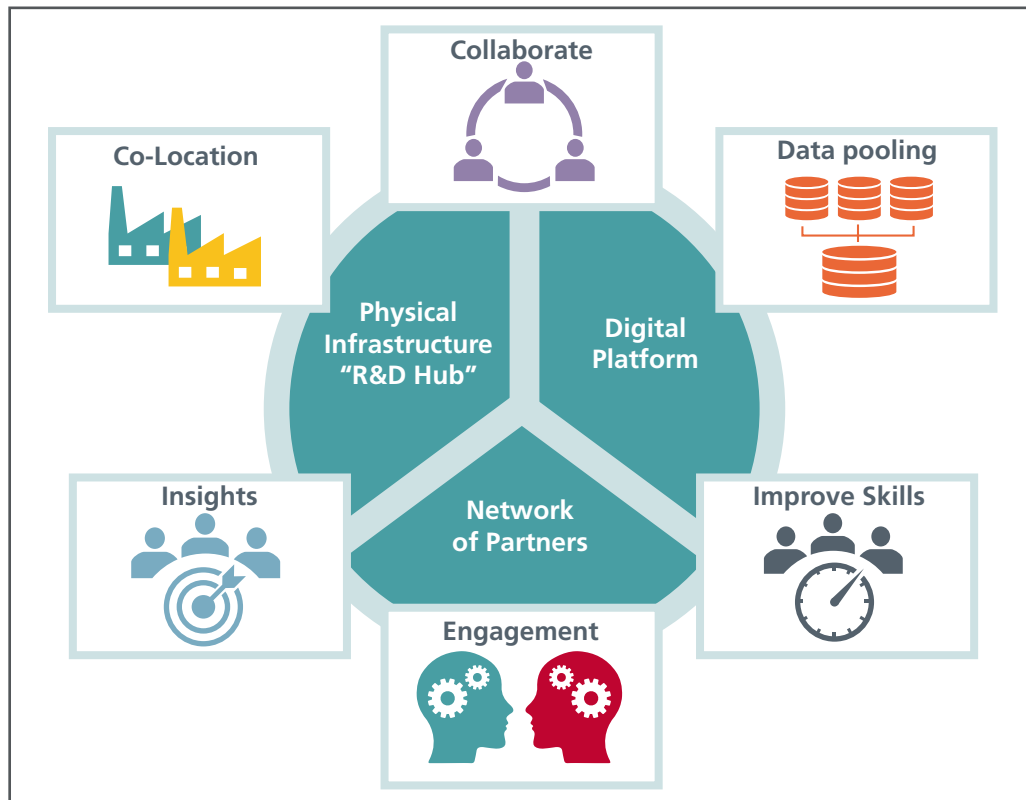
Figure 2 – The Capabilities Delivery Model coupled with DDI KPI themes

Physical infrastructure, e.g. an "innovation hub"[42], can provide an intensive and permanent basis for collaboration, with substantial and long-lasting effects. Such an infrastructure would benefit from the co-location of various stakeholders, including researchers and business developers, with firms and partner organisations[43]. In particular, such a physical presence in the local ecosystem embeds the university's R&D capacity in the geographical area, rather than relying upon continuous transfer from the central institutional base outside the area (in this case, from Edinburgh to Fife).

Laying down physical infrastructure in particular opens up opportunities for a more persistent and informal engagement with a variety of stakeholders, with a range of creative and open-ended opportunities emerging in the region (e.g. enterprise hubs in Glenrothes and Kincardine). Challenges remain in terms of "inclusive innovation", particularly, SME engagement and management of adopting technology, which could serve as a conduit to inclusive growth.[44]

42 Some examples in the UK include Advanced Manufacturing Research Centre (AMRC) at the University of Sheffield (https://www. amrc.co.uk/) , and the National Manufacturing Institute for Scotland (NMIS) with the University of Strathclyde as the anchor university (https://www.gov.scot/policies/manufacturing/national-manufacturing-institute-for-scotland/) . At the NMIS, the skills proposition includes Foundation Apprenticeships, Modern Apprenticeships, and Graduate Apprenticeships, postgraduate training and the CPD and upskilling of existing staff(https://www.skillsdevelopmentscotland.co.uk/news-events/2017/june-2017/ innovation-in-manufacturing/) .

43 See Bruce Katz and Julie Wagner (2014) "The Rise of Innovation Districts: A New Geography of Innovation in America". https:// www.brookings.edu/wp-content/uploads/2016/07/InnovationDistricts1.pdf

44 Andrew Haldane (2018), The UK's Productivity Problem: Hub No Spokes https://www.bankofengland.co.uk/-/media/boe/files/ speech/2018/the-uks-productivity-problem-hub-no-spokes-speech-by-andy-haldane

Key codified knowledge and skills can also be transferred over various non-direct routes, with the aid of digital platforms. These are particularly important in reaching a mass audience of (potential) partners, or if such audience is geographically dispersed including rural areas. This would, for instance, be important in addressing opportunities in distributed economic systems, such as in agriculture, transportation or energy generation. Though sometimes criticised for its (necessarily) limited level of two-way engagement and exchange, virtual platforms are powerful tools in scaling up provisions in a fast-paced environment, where on-demand access to information and mobile application are essential.

By developing a network of partners, the university's expertise can be embedded in a wider ecosystem through those key organisations, who are willing and able to integrate and further develop the expertise on offer by the university. The university is currently developing its strategic partners in order to build holistic relationships from strategic perspectives. For instance, the provision of executive education and CPD courses can be developed across the university, going beyond the business school, by engaging with strategic partner organisations, including the leadership development opportunities in the DDI areas. We also note relevant work undertaken by the university's procurement office, in particular examining community benefits policies within the City Region Deal Inclusive Growth Framework.[45]

Across these three pipeline models, the identification of appropriate partners, engagement channels and available resources will be the key. These partners can be not only industry but also local government, colleges, and non-governmental organisations, and can vary significantly in their size, capabilities and level of engagement with the programme. Importantly, this requires extensive and patient development of ties with partners, as well as between them, and a significant commitment within the university's counterparts to adapt to local requirements when working with them. Good practices of partnerships are also found in other cities, such as Newcastle City Futures (NCF)[46]. For the University of Edinburgh to take the opportunities in Fife forward, links with Fife Council, NHS Fife, SDS, along with Fife College, Scottish Enterprise, the Scottish Funding Council, and the innovation centres may be strengthened further in order to catalyse such a network of partners approach.

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45 CRD partners are working collectively with the University to maximise social benefits through the procurement.

46 Led by Newcastle University partnered by Northumbria University, the NCF comprises 22 partners covering public, private and third sectors in the city. Newcastle University focuses its research expertise around the societal challenges of "Ageing", "Sustainability" and "Social Renewal", producing not just excellent research but practical and realistic solutions to problems society faces today. http://www.newcastlecityfutures.org/about-us/

Conclusion – challenges and recommendations for next steps

As this is a preliminary feasibility study, the conclusions and recommendations are limited in terms of the scope and level of details. Such a study needs to be supplemented with further research in order to define and detail the possible pathways for the exploitation of opportunities presented.

"Key opportunity areas related to DDI are identified in relation to the Fife industry profiles (see Table 2). In particular, there are opportunities in advanced manufacturing for engineering and construction, mainly to co-develop renewable energy machinery, as well as to build, maintain and de-commission oil and gas and maritime systems – and to accommodate off-site, automated and robotised manufacturing within the construction sector, especially in relation to fabricated panels, roofing systems and timber engineering. This has already led to the School of Engineering and Bayes Centre working closely with Babcock. It also links closely to other opportunities in developing autonomous systems and sensors on marine and airborne platforms, such as infrastructural intelligence and remote sensing for precision agriculture and construction engineering. Another example is smart systems for health and wellbeing, including the Advanced Care Research Centre, with an opportunity for collaboration with Fife College. Noting Fife's large service economy, in particular, payment services, developing collaboration with recent initiatives such as the Fintech Skills Academy would lead to new solutions in data intelligence for enterprise services. By working with the significant, yet somewhat dispersed agricultural, distilling, retail and hospitality sector, data-enhanced agriculture/food & drink, distribution and logistics solutions can be developed with both local partners as well as global businesses.

These opportunities would also support the development of a skills ecosystem, by growing and developing innovative learner pathways, and would lead to significant improvement of outcomes for widening participation through strategic partnerships. Also, opportunities for executive education and CPD courses are recognised in the areas related to DDI. There are two key challenges that need to be addressed externally and internally:

- **Willingness of industry to engage and take up the DDI agenda**

- **Embedding DDI engagement within the university.**

These include potential issues with engaging industry stakeholders in Fife, particularly SMEs, and establishing links to the industry's DDI needs, demands and interests. For the university, understanding the complexity of the local skills landscape, connecting with specific local SMEs and supply chain systems may take time and effort, and prove to be challenging. Collaboration with organisations such as SMAS, Interface, innovation centres, Business Gateway, and Fife College could pave a way for future complementary opportunities. The models of governance and partnerships for business support as well as resource issues require consideration both at local and national levels.

Internally, the university also needs to examine how DDI engagement opportunities can be embedded in its current and future activities. It is acknowledged that financial incentives alone are not sufficient for academics to increase research collaboration with businesses and to bridge the gap between industry and societal needs. Time, support and an environment encouraging of engagement are recognised as some of the factors that foster academic-business collaboration[47]. Better understanding is required regarding how markets for academic DDI expertise can be formed, developed and sustained.

Critical questions relate to linking the DDI Programme to inclusive growth and social inclusion agenda, and how to capture wider social impacts of the identified DDI opportunity areas, which need to be mapped out and expressed in emerging programme delivery plans and associated KPIs. In order to explore how to take these opportunity areas further through external and internal stakeholder engagement, we suggest the deployment of the Living Lab methodology[48]. Such an inclusive approach can bring together internal and external capacity and align interests through design-driven exercises, to form concrete projects and partnerships by exploiting the opportunities. Another example is the public policy forum catalysing dialogues across public sector leadership.

There are opportunities to link TRADE components - research and adoption to talent and entrepreneurship opportunities through developing datasets. The opportunity for the university to engage with foresight issues needs to be recognised and better deployed in collaboration with the Council and other local stakeholders. Datasets and evidence of impacts on the City Region need to be built as part of the long-term development of the DDI Programme.

Recommendations
In order to move forward, the key next step is to better understand the most promising areas for collaboration identified in this report, as opportunities for DDI in Fife (e.g. advanced manufacturing; health and wellbeing). The identification, awareness raising and implementation of 'digital skills' within these areas and key industry sectors (e.g. fintech, health and care, and engineering) is also imperative.

Focusing on these areas, this report recommends:
- **Review current DDI landscape in Fife across the key sectors and beyond;**
- **Gap analysis of the current DDI landscape relating to innovation, entrepreneurship and skills needs in Fife;**
- **Review current University of Edinburgh/academic partners' capacity and capability to develop collaborative projects in Fife (see Table E1 in Appendix E);**
- **Develop 1-3 pilot projects for each area/sector, to build collaborative partnerships and develop capacity for engagement, particularly targeting SMEs to enhance a wide range of data literacy and digital skills; and,**
- **Evaluate the projects and design future activities, in order to promote the uptake of skills and technology related to DDI by local businesses and other partners.**

This would help focus and prioritise activities and resource allocation over the next phase of the DDI programme, moving from six months, 18 months to three year plans. Understanding the capacity of local businesses and academics to take on collaborative projects is the first step. Matching and aligning resources to the life cycles of projects, availability of physical infrastructure and indigenous technology capacity of identified key sectors and the opportunity areas would help refine the focus for successful DDI adoption projects in Fife.

Further contact
Proposals to be taken forward through the DDI programme are developed through a business case approach. To take forward any of the opportunities identified in this report, or any other ideas that this report has triggered, the first step should be to contact the DDI team at the City Region Deal Data-Driven Innovation Programme Delivery Office at: **ddi@ed.ac.uk**

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47 Drew Evans and Carolin Plewa (2016) 'Academics do want to engage with business but need more support' https://theconversation.com/academics-do-want-to-engage-with-business-but-need-more-support-62902
48 Edinburgh Living Lab https://www.edinburghlivinglab.org/

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Acknowledgements

Appendix A: Sources of Data and Analysis

Primary Data Sources and Groups of Informants

Interviewees in Fife

- Fife Council (Economy, Planning and Employability Services)
- Fife College (Principal, Director of Faculty of Engineering, energy and mathematics, Business Development)
- A small number of advanced manufacturing companies
- Developing the Young Workforce Fife Engineering/ STEAM Business Breakfast, 6 November 2018

Scottish Organisations

- Skills Development Scotland
- Innovation Centres (DataLab; Digital Health and Care Institute; Construction Scotland IC)
- Scottish Engineering
- Fintech Scotland
- Interface

University of Edinburgh

- DDI programme team, Hub Leads
- DDI related BDMs and academics at Bayes Centre, EFI, Easter Bush, and Usher Institute
- Edinburgh Innovation
- Edinburgh Living Lab
- Professional services across the University
- A roundtable discussion (Bayes Centre, 4 December 2018, with Craig Skeldon, Douglas Graham, Laura Mckie, Jeff Steynor, Peter Hayakawa, Catherine Magill, Tony Venus, Helen New)

Secondary Data Sources

Information sources in Fife includes:

- Fife Economic Strategy (2017-2027) (Fife Economic Partnership)
- Invest in Fife
- Regional Skills Assessment

Information sources at University of Edinburgh includes:

- Edinburgh Innovation CRM data related to projects in Fife provided by Edinburgh Innovation

Table A1 List of informants – External organisations

Individuals	Organisation
Keith Winter Gordon Mole Morag Miller Iain Shirlaw	**Fife Council** (Economy, Planning and Employability Services)
Hugh Hall Chris Cooke Nick Inglis Jan Thomson Krystyna Marett Lewis Gale	**Fife College**
John Penman	**Fife Fabrications;** Manufacturing Champion for the Fife Economy Partnership
Dillon Russell	**Quality Precision Electronics LTD**
William Scott	**Skills Development Scotland** (Key Sector Manager: Engineering)
Adam Turner	**DataLab**
George Crooks Sanna Rimpiläinen	**Digital Health & Care Institute**
Sarah Buchanan	**Construction Scotland Innovation Centre**
Shelley Breckenridge	**Interface**
Paul Sheerin	**Scottish Engineering**
Stephen Ingledew	**Fintech Scotland**

Table A2 List of informants – The University of Edinburgh informants

Individuals	
Michael Rovatsos Craig Skeldon Simon Marr	**Bayes Centre**
Nick Mills	**Usher Institute**
Douglas Graham	**Edinburgh Future Institute**
Helen Dundas	**Easter Bush**
Alan Hughes	**University of Edinburgh Business School**
Jeff Steynor Frank Mill	**School of Engineering**
Laura Mckie Berndan Mcguckin	**Edinburgh Innovation**
Peter Hayakawa	**Procurement Office**
Catherine Magill	**Edinburgh Living Lab**
Tony Venus Helen New	**Apprenticeship**
Katrina Castle	**Strategic Partnerships and Transitions**
Kostas Kavoussanakis	**EPCC**

Appendix B: Economic Activity in Fife

Fife is the 4th largest economy among the 32 local authorities in Scotland[49]. It is home to 370,300 people and makes a significant contribution to the Scottish economy with an annual business turnover of around £13.6 billion. Fife supports over 9,700 businesses and around 152,000 jobs[50].

The Fife region can be classified into 27 different types of geographical data zones[51]. The main classification used by Fife council is the 7 Area Committees, namely: City of Dunfermline, Cowdenbeath, Glenrothes, Kirkcaldy, Levenmouth, North East Fife and South West Fife. However, Fame database[52], which we used to gather information on active businesses in Fife, identifies 12 geographical areas as shown in Figure B1. The concentration of firms in the twelve areas can be grouped into four further categories as follows;

- **West Fife:** Dunfermline and Kirkcaldy shows the highest number of geographic concentration of companies consisting of 3259 (36.8%) and 1245 (14.1%) respectively.

- **Central Fife:** Glenrothes also shows higher concentration with 1001 (11.3%) companies.

- **East Fife:** In this part, St. Andrews and Leven also show reasonable geographic concentration of companies with 686 (7.8%) and 652 (7.5%) respectively.

- The rest of seven areas across Fife incorporate the remaining 1192 (13.5%) of companies with Inverkeithing and Kelty being the least concentrated areas.

Figure B2 presents the actual sector-wise distribution of firms in Fife based on UK SIC 2007 industrial classification system, as per fame database (For more details see table A1. The data shows that the highest number of firms are active in professional, scientific and technical activities (16%) followed by construction (13%), manufacturing (11%), wholesale & retail (10%), administrative support (9%), other services (8%) and, information and communication (7%).
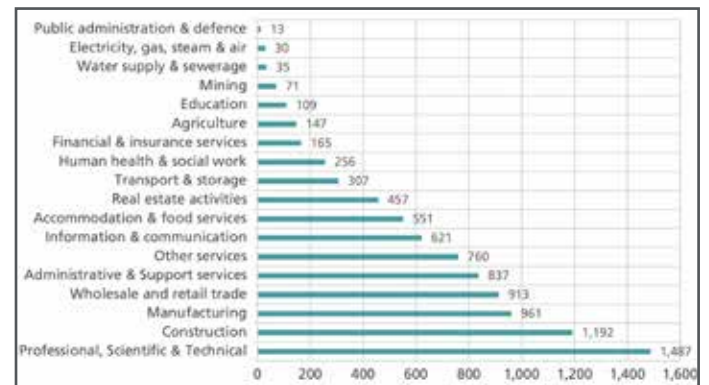
Figure B2: UK SIC 2007 Primary Industry Classification (fame database)

Figure B1: Number of Enterprises per Geographical Area (fame database)

49 Market overview-Mark Robertson; https://www.investinfife.co.uk/files/market-overview-by-mark-roberston,-ryden.pdf
50 Fife Economy Partnership, http://www.fifeeconomypartnership.com/economic-information-2
51 KnowFife Dataset; Understanding Fife's Geographies, https://knowfife.fife.gov.uk/
52 Fame Database; https://www.bvdinfo.com/en-gb/our-products/data/national/fame

Figure B3: UK SIC 2007 Secondary Industry Classification (fame database)

Table B1: UK SIC 2007 Secondary Industry Classification (fame database)

Activity (prim. UK SIC 2007)	Number of companies
Specialised construction activities	769
Office administrative, office support and other business support activities	571
Retail trade, except of motor vehicles and motorcycles	541
Activities of head offices; management consultancy activities	482
Computer programming, consultancy and related activities	469
Architectural and engineering activities; technical testing and analysis	463
Real estate activities	457
Food and beverage service activities	440
Other personal service activities	429
Other manufacturing	394
Other professional, scientific and technical activities	334
Construction of buildings	332
Wholesale and retail trade and repair of motor vehicles and motorcycles	186
Wholesale trade, except of motor vehicles and motorcycles	186
Sports activities and amusement and recreation activities	178
Human health activities	176
Land transport and transport via pipelines	152
Repair and installation of machinery and equipment	138
Warehousing and support activities for transportation	132
Legal and accounting activities	126
Crop and animal production, hunting and related service activities	122
Accommodation	111
Manufacture of fabricated metal products, except machinery and equipment	109
Education	109
Financial service activities, except insurance and pension funding	107
Services to buildings and landscape activities	97
Civil engineering	91
Creative, arts and entertainment activities	58
Activities auxiliary to financial services and insurance activities	52
Employment activities	48
Social work activities without accommodation	47
Travel agency, tour operator and other reservation service and related activities	46
Rental and leasing activities	46
Mining support service activities	44
Publishing activities	42
Information service activities	41
Manufacture of food products	39
Activities of membership organisations	38
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	36
Motion picture, video and television programme production, sound recording and music publishing activities	33

Table B1: UK SIC 2007 Secondary Industry Classification (fame database) continued

Activity (prim. UK SIC 2007)	Number of companies
Manufacture of computer, electronic and optical products	33
Manufacture of beverages	33
Residential care activities	33
Telecommunications	31
Electricity, gas, steam and air conditioning supply	30
Security and investigation activities	29
Scientific research and development	29
Advertising and market research	28
Veterinary activities	25
Manufacture of machinery and equipment n.e.c.	24
Waste collection, treatment and disposal activities; materials recovery	24
Manufacture of rubber and plastic products	22
Residents property management	18
Extraction of crude petroleum and natural gas	18
Manufacture of furniture	18
Manufacture of other transport equipment	17
Postal and courier activities	16
Libraries, archives, museums and other cultural activities	16
Manufacture of electrical equipment	15
Printing and reproduction of recorded media	15
Fishing and aquaculture	13
Public administration and defence; compulsory social security	13
Forestry and logging	12
Manufacture of basic metals	12
Manufacture of other non-metallic mineral products	12
Repair of computers and personal and household goods	11
Manufacture of textiles	9
Manufacture of paper and paper products	8
Manufacture of wearing apparel	7
Water collection, treatment and supply	7
Other mining and quarrying	7
Manufacture of motor vehicles, trailers and semi-trailers	6
Manufacture of chemicals and chemical products	6
Insurance, reinsurance and pension funding, except compulsory social security	6
Water transport	5
Programming and broadcasting activities	5
Activities of extraterritorial organisations and bodies	4
Activities of households as employers of domestic personnel	3
Gambling and betting activities	3
Remediation activities and other waste management services	3

Table B1: UK SIC 2007 Secondary Industry Classification (fame database) continued

Activity (prim. UK SIC 2007)	Number of companies
Undifferentiated goods- and services-producing activities of private households for own use	2
Air transport	2
Manufacture of coke and refined petroleum products	2
Manufacture of tobacco products	2
Manufacture of leather and related products	2
Manufacture of basic pharmaceutical products and pharmaceutical preparations	2
Mining of metal ores	1
Mining of coal and lignite	1
Sewerage	1
All	**8,912**

Appendix C: DDI Programme Impact Pathway
(Source: the University of Edinburgh DDI Programme, 2018)
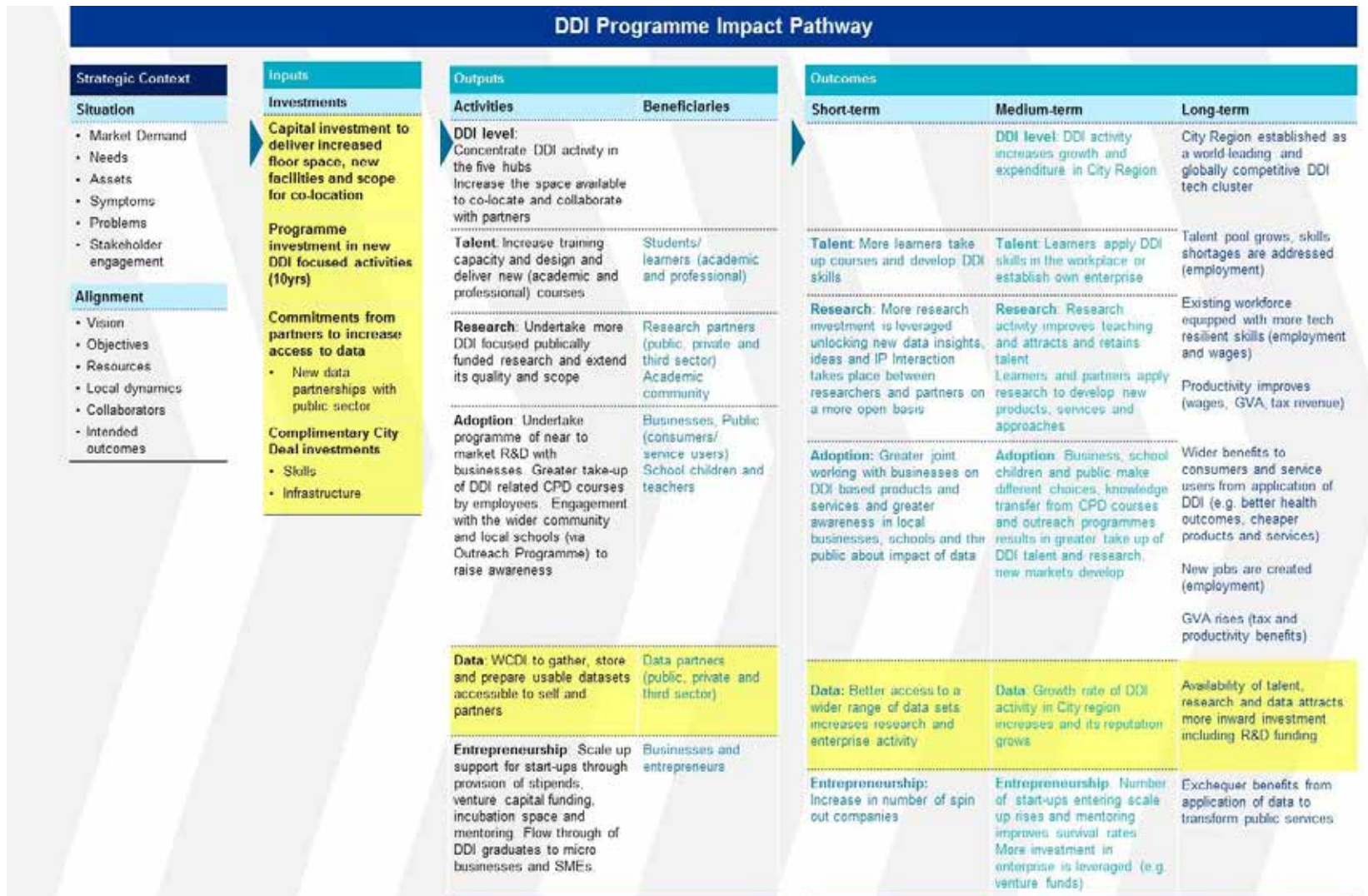
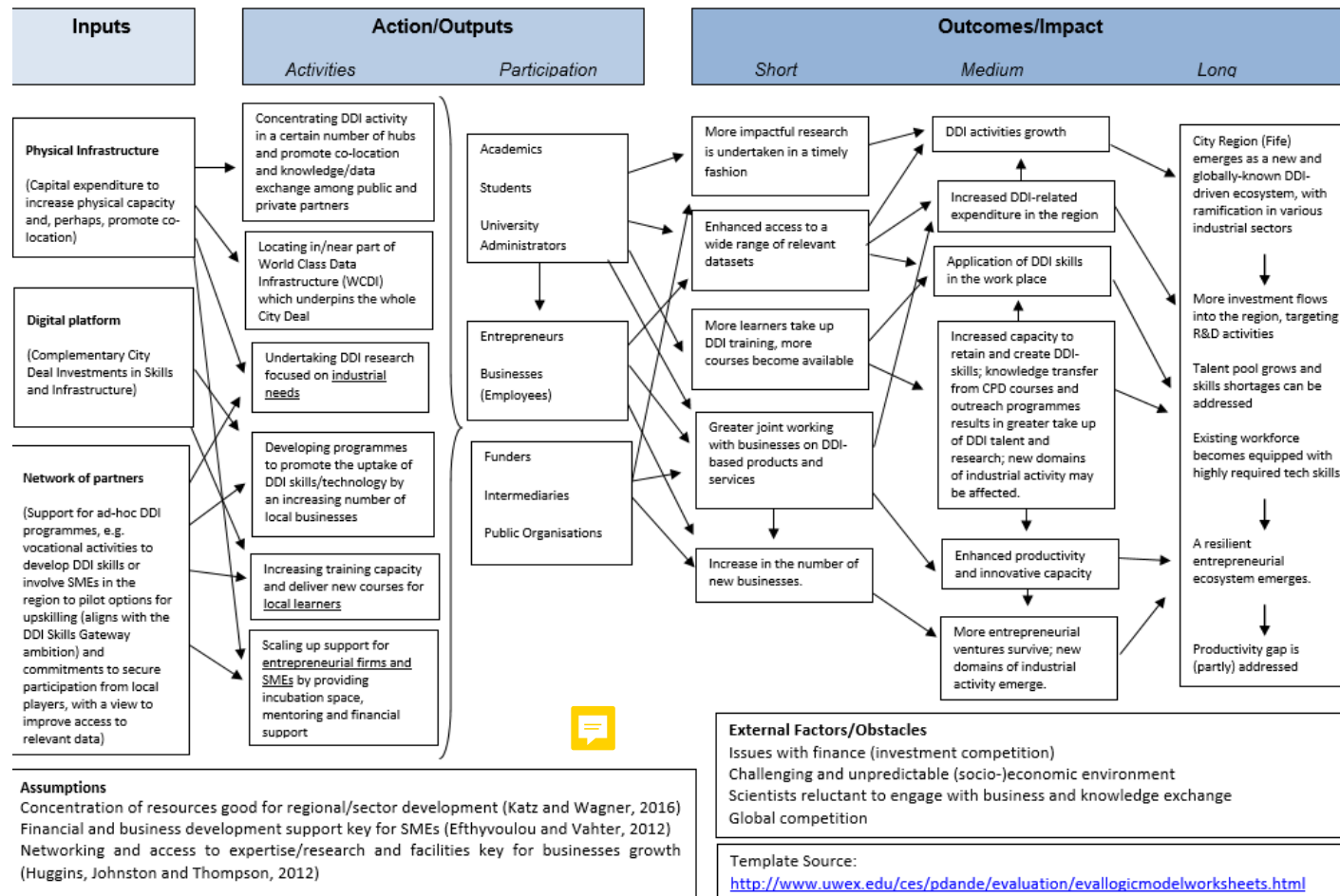# Appendix D: DDI Programme Impact Pathways model developed in the study in Fife

Programme: **DDI - Potential Impact Pathways in Fife**
Situation: *From our Development Opportunities in Fife analysis, it is possible to observe the potential for matching between emerging DDI needs of local industry players with the DDI capabilities within the University. Moving forward we envisage the development of DDI Programme Impact Pathways, linking TRADE KPIs with outcomes/impacts as suggested in the logic model below*

Inputs	Action/Outputs		Outcomes/Impact		
	Activities	Participation	Short	Medium	Long

Inputs

Physical Infrastructure

(Capital expenditure to increase physical capacity and, perhaps, promote co-location)

Digital platform

(Complementary City Deal Investments in Skills and Infrastructure)

Network of partners

(Support for ad-hoc DDI programmes, e.g. vocational activities to develop DDI skills or involve SMEs in the region to pilot options for upskilling (aligns with the DDI Skills Gateway ambition) and commitments to secure participation from local players, with a view to improve access to relevant data)

Activities

Concentrating DDI activity in a certain number of hubs and promote co-location and knowledge/data exchange among public and private partners

Locating in/near part of World Class Data Infrastructure (WCDI) which underpins the whole City Deal

Undertaking DDI research focused on industrial needs

Developing programmes to promote the uptake of DDI skills/technology by an increasing number of local businesses

Increasing training capacity and deliver new courses for local learners

Scaling up support for entrepreneurial firms and SMEs by providing incubation space, mentoring and financial support

Participation

Academics

Students

University Administrators

Entrepreneurs

Businesses (Employees)

Funders

Intermediaries

Public Organisations

Short

More impactful research is undertaken in a timely fashion

Enhanced access to a wide range of relevant datasets

More learners take up DDI training, more courses become available

Greater joint working with businesses on DDI-based products and services

Increase in the number of new businesses.

Medium

DDI activities growth

Increased DDI-related expenditure in the region

Application of DDI skills in the work place

Increased capacity to retain and create DDI-skills; knowledge transfer from CPD courses and outreach programmes results in greater take up of DDI talent and research; new domains of industrial activity may be affected.

Enhanced productivity and innovative capacity

More entrepreneurial ventures survive; new domains of industrial activity emerge.

Long

City Region (Fife) emerges as a new and globally-known DDI-driven ecosystem, with ramification in various industrial sectors

More investment flows into the region, targeting R&D activities

Talent pool grows and skills shortages can be addressed

Existing workforce becomes equipped with highly required tech skills

A resilient entrepreneurial ecosystem emerges.

Productivity gap is (partly) addressed

External Factors/Obstacles
Issues with finance (investment competition)
Challenging and unpredictable (socio-)economic environment
Scientists reluctant to engage with business and knowledge exchange
Global competition

Template Source:
http://www.uwex.edu/ces/pdande/evaluation/evallogicmodelworksheets.html

Assumptions
Concentration of resources good for regional/sector development (Katz and Wagner, 2016)
Financial and business development support key for SMEs (Efthyvoulou and Vahter, 2012)
Networking and access to expertise/research and facilities key for businesses growth (Huggins, Johnston and Thompson, 2012)

Appendix E: Matching Key Sectors in Fife and Opportunity Areas for DDI Programme

The following table is based on information from "Fife's Economic Strategy 2017-2027" and interviews conducted by the Study team between October and November 2018, merged with our analysis on the UoE research centres and DDI opportunity areas in Fife.

Table E1 Analytical mapping of economic activity and university research and development activity linked to form the key opportunity areas

Opportunity Area	Key Sector in Fife Economic Strategy 2017-2027	Fife Council support areas	Fife Industry strength/ opportunity and challenges	UoE capability related to DDI and potential	Fife College, other HEIs and other relevant stakeholders	UoE Research Centres	UoE key DDI contacts
Advanced Manufacturing for Machine Engineering	Energy and renewables	• Increase Modern Apprenticeship; explore opportunity for Foundation and Graduate Apprenticeship • Upskilling workforce • Improve links between education and businesses • Oil and gas decommissioning; • Investment in Energy Park Fife Phase 3 • Increase Modern Apprenticeship; explore opportunity for Foundation and Graduate Apprenticeship • Upskilling workforce • Improve links between education and businesses	Oil and gas large players (e.g. Babcock, FMC, Oceanearing, Burnt Island Fabricators) and supply chains; The Levenmouth Demonstration Turbine (ORE Catapult); Global Energy Inc	• Orca Hub (joint HW-UoE / Robotarium venture) Sensors, analytics and data reporting are the key areas of future development (currently weak links to DDI, but a great opportunity, as there is a significant need): • Manufacturers: Quality Control • Operations: Predictive Maintenance (based on statutory requirements)	• St Andrews Eden Campus spin-offs Energy Park Data Centres	UK Carbon Capture and Storage Research Centre (UKCCSRC) Edinburgh Centre for Carbon Innovation (ECCI); National Centre for Earth Observation (NCEO) FloWave Industrial Doctorate Centre in Offshore Renewable Energy (IDCORE) Scottish Microelectronics Centre Edinburgh Materials Microanalysis Centre (EMMAC)	Bayes; EI

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Autonomous Systems and Sensors on Marine and Airborne Platforms	**Manufacturing incl. Engineering**		Sensors and big data as one of emerging supplementary themes to material and machine design; Availability and quality of skilled labour as a challenge; ageing of workforce;	• "Industry Forth" / FASTBLADE-Babcock Engineering + Informatics and +EI; SDS + SE + Invest in Fife / Fife Council + companies (EoIs) Fife College linked in through SDS. Advanced Manufacturing Innovation Centre, proposed in 2018, with main themes: - Industry 4.0 - Manufacturing engineering - Welding - Metallurgy and composites - Machining - Scientific services - Nuclear AMRC			

DDI Data-Driven Innovation

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Data Intelligence for Enterprise	Finance and business services incl. Fintech	• Assist Fintech companies to develop new products and services • Attracting Fintech firms	Payment services e.g. Ingenico Group; Renovite Technologies; FIS Global; Payment Centric	• Fintech Scotland • Centre of Excellence for Cyber Security Research, Informatics EPPC-Optos project; EPPC-Data Lab project with Paywizard	The Fintech Skills Academy launched in September 2018 with Fife Council, Fife College, Fintech industry; Fintech Scotland • Data Lab	Edinburgh Parallel Computing Centre (EPCC) Human Communication Research Centre (HCRC)	EFI; Bayes/EPCC Informatics
	Digital technology incl. ICT	• Increase FE and HE places for future workforce • Increase Modern Apprenticeship; explore opportunity for Foundation and Graduate Apprenticeship • Support IoT • Big Data analysts demands • New businesses	Semfab, Exterrity, Artilium, TDK-Micronas, Paywizard, BITwise, RG Wire and Cable; CDL vehicle information services; itek; EAF	• AI and Blockchain accelerator at Bayes Centre • Centre of Excellence for Cyber Security Research • Public policy forum • Living Lab	• Data Lab Edinburgh Napier University's Cyber Academy • Civtech – SMEs	The Credit Research Centre	Bayes; EFI DDI team ELL
	Tourism, culture and creative industries	• Develop skills pathways – progression to higher skilled jobs • New digital platforms	Creative industry - Create in Fife; Fife Craft Association Strong arts and craft sector Four theatres	Links between DDI and creative industry in Fife being sought e.g. digital informatics; informatics; Bayes; EPCC; ECCI.	Fife College – creative industry, fashion	Digital Humanities Centre for Service Excellence Digital Curation Centre (DCC) ECA Product Design DISIGN Centre for Design Informatics (CDI)	Informatics, Bayes; EFI

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Data-enhanced Agri/ food Distribution and Logistic	**Food and drink**	• Ensure a flow of engineers into food and drink manufacturing • Fife Food Port, storage and distribution project at Rosyth and other ports	Food & drink - Ports and logistics e.g. Diageo - spirits manufacturer Drinks industry (whiskey), global distribution centre in Fife (near Leven)	Ports and logistics - Data integration across the various business units Other areas of food & drink • Geoscience • Easter Bush [Not much link with Fife, but possibly some links through Agri EPI and SRUC in Smart farming]	Queen Margaret University	FRIED	Bayes Easter Bush
Smart	**Health and Care**	• Fill employment and skills demands • Develop skills pathways – progression to higher skilled jobs	NHS Fife; commercial care providers Gap between lower skills and PG level skills	Data health work with NHS Fife - NHS fellowship in Fife - Healthcare innovation funding bid – working with NHS in Fife, Borders - UG PG curricula with health data; online course for scaling up The Advanced Care Research Centre – Data analytics, IoT/sensors, AI/Robotics, therapeutics ; With LAs, NHS, University, Colleges; care providers, industry; Demonstration site development with Fife College	Futurequipped by DHI; Construction Scotland Innovation Centre and FE Colleges; upskilling and new curriculum development covering health, construction and ICT Queen Margaret University	Usher Institute for Population Health and Informatics Centre for Research on Environment, Society, and Health (CRESH); Centre for Cognitive Ageing and Cognitive Epidemiology Edinburgh Centre for Research on the Experience of Dementia Centre for Dementia Prevention The Physical Activity for Health Research Centre (PAHRC) Mason Institute for Medicine, Life Science and the Law (MI)	Usher Institute; EI

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	Construction and Civil engineering	• *Invest in Apprenticeship* • Fife Supplier Development Programme for SMEs • Fife's Affordable Housing Programme • Encourage Innovation through academic links • Transition to low carbon economy	Large scale construction e.g. Queensferry Crossing/Jacobs; Housing construction - Lack of digitization Increase in employment expected in construction Off-site, automated and robotised manufacturing within the Construction industry - especially in relation to fabricated panels, roofing systems and timber engineering.	Centre for future infrastructure; CPDs and Masters programme. Procurement office – Climate KIC	Edinburgh Napier University; Institute of Sustainable Construction	BRE Centre for Fire Safety Engineering (CFSE); Edinburgh Centre for Carbon Innovation (ECCI); OPENspace	Bayes