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Artificial Intelligence (AI) Research/ Landscape Mapping

A report for
The Scottish AI Alliance
Supported by Scottish Enterprise
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Executive Summary

Introduction

AI – artificial intelligence – is widely recognised as an area of significant economic opportunity.

Scotland has already put in place a number of foundational steps towards capturing the economic benefit of AI including, for example, Scotland's AI Strategy[1] which seeks to realise a vision for Scotland to become a leader in the development and use of trustworthy, ethical and inclusive AI and alongside this the development of The Scottish AI Alliance[2] which provides a focus for dialogue, collaboration and action.

The Scottish Tech Ecosystem Review[3] (STER) identified that Scotland has a strong digital tech ecosystem which has yet to reach the tipping point where growth and investment become self-sustaining. Scottish Enterprise (SE) has created a "national programme" called Digital Scale Up Level Up (DSL). This is a five-year programme which responds to STER. The DSL programme recognises AI supply side development as an area of specific interest.

The implementation of the STER recommendations, combined with SE's DSL Programme, will focus on driving the digital tech ecosystem in Scotland beyond tipping point, increasing flows of global capital, creating more jobs, attracting sustained private investment, and creating more regional growth through digital tech.

This report supports the objectives of Scotland's AI Strategy and STER/DSL tech sector growth ambition by providing a summary of the AI landscape which can help Scottish Enterprise, and partners, to define and drive future actions.

Research Limitations

There were some limitations of the research which are important to note from the outset as these set the context and impact upon the findings and analysis:

- AI taxonomy and company classification – it was agreed, with Scottish Enterprise and partners, that AI incorporates machine learning (ML), natural language processing (NLP), computer vision, cloud computing, speech and audio, and deep learning. However, categorising companies based on these capabilities became difficult as ML is the most widely recognised subfield of AI; thus, there is a bias towards this capability, whilst the other technologies are all either considered to be subfields of ML or will invariably work alongside ML within an AI system which makes it challenging to clearly distinguish between ML capabilities and other AI capabilities. The inclusion of cloud computing was discussed at length as it would generally be considered an enabler of AI rather than an application. However, its importance in terms of providing the computing resources and infrastructure needed to train and deploy AI models at scale

[1] https://www.scotlandaistrategy.com/

[2] https://www.scottishai.com/

[3] https://www.gov.scot/publications/scottish-technology-ecosystem-review/

should not be underestimated. There was also a reliance on companies self-identifying as having these capabilities.

- Desk research – the landscape mapping was primarily based on desk research; thus, there was a dependency on publicly available information via, for example, company websites, LinkedIn and Companies House. The level of information available varied considerably across companies; thus, impacting upon the classification.
- Sector engagement – a small programme of sector engagement was carried out and sectoral representatives were selected based on their expertise relating to the Scottish Enterprise National Programmes. However, the small sample size and alignment with the thematic areas of the National Programmes means that there may be unintentional bias in the analysis towards specific sectors.
- Hype – there is lots of hype and buzz around AI, but it is very early stage in terms of understanding its applications, opportunities and impact.

The Scottish AI Landscape – Key Findings

The main observations of the landscape mapping are:

- The Scottish AI landscape comprises more than 220 companies and 70 research, academic and support stakeholders. Please note that these figures are subject to change as this is a snapshot in time at the point of report production.
- Companies are typically located within Edinburgh and Glasgow which is unsurprising given the related data science capabilities in these locations.
- Machine learning is the major capability field within the Scottish landscape but there is evidence of capability in all other subfields (i.e., NLP, computer vision, cloud, speech and audio, and deep learning) albeit to a much lesser extent.
- Almost half of the company base (44%) target multiple – or 'Various' – markets, whilst health (21%), agriculture and land use (7%), financial & business services (6%), energy (5%) and creative industries (4%) follow as the key target markets; there are 11 other markets targeted by the remainder of the company base.
- Most universities in Scotland are active in AI-related research but, in particular, the University of Edinburgh, University of Glasgow, University of Aberdeen, University of Dundee, University of Strathclyde and Heriot-Watt University.
- Scotland compares relatively well internationally. Areas of particular strength include government leadership and strategy and data and infrastructure while weaknesses include digital capacity and adaptability.
- Scotland's strengths and its ambitions are well aligned with key market opportunities including:

  Health & Social Care

  Scotland's AI capabilities can be capitalised and deployed to support:

  - Clinical diagnosis & treatment pathways
  - Clinical decision making
  - Development of medical devices
  - Development of pharmaceuticals (drug & vaccine discovery and development)

  Energy (including net zero)

  Scotland's AI capabilities can be utilised to support Scotland's transition to a net zero economy through:

- Satellite imagery and earth observation data processing (space data)
- The application of climate technology
- Transforming efficiencies within offshore renewables
- Improving energy efficiency in buildings

Financial & Business Services

Scotland's AI capabilities can be applied to:

- Enable fraud detection
- Support risk management
- Improve customer service
- Facilitate automation & trading
- Develop RegTech

Additional market opportunities also exist within manufacturing and gaming this is because both industries offer huge cross-functional value and support to other industry verticals. Additionally, AI applications within agriculture and land use affords multiple deployment opportunities.

Overall, it is considered that AI is nascent in Scotland, but the foundations exist to enable Scotland to exploit AI opportunities; therefore, Scotland is in a good position to pursue attractive growth opportunities, as described in section 4.4. At a UK level there are also opportunities for Scotland to support the expert AI taskforce[56] which seeks to help the UK build and adopt the next generation of safe AI whilst Innovate UK's AI Funding and Support Programme, BridgeAI[57], can be used to empower Scottish companies to harness the power of AI through support and funding.

A number of action areas have been identified to support and optimise AI capabilities in Scotland, namely:

- Collaboration – cross-sectoral as well as triple helix (industry, academia, public sector) collaboration could advance Scotland's AI capabilities and enable organisations to capitalise on the opportunities it affords for product and service development, optimisation, efficiencies and cost benefits. There is an appetite for collaboration and shared knowledge and exchange which is already being supported by The Data Lab as it is tasked with encouraging triple helix collaboration. But, Scottish Enterprise and its partners could, for example, drive further collaborative by organising a series of networking / matching-making events supported by related funding calls to enable collaborative research and development to be realised.
- Awareness – despite the hype and buzz surrounding AI there remains a need to increase awareness of the potential applications and benefits, particularly at senior levels within organisations and government. The Scottish AI Alliance already make a selection of resources available via its website, but perhaps there are opportunities to work with sectoral organisations to develop sector-specific case studies to demonstrate applications and outcomes. Likewise, initiatives such as, for example, Living with AI[4] and Driving Value from AI[5] aim to increase awareness and these could also be used as a base to continue to raise awareness.

[4] https://www.scottishai.com/living-with-ai

[5] https://learn.thedatalab.com/courses/driving-value-from-ai

- Governance & Ethics – although Scotland scored comparatively well internationally, in terms of governance and ethics the acceleration of AI developments requires continuous review and development of frameworks, standards and ethics to ensure AI solutions can be deployed in an ethical, transparent and trustworthy manner. Scottish Government can play a key role in developing these frameworks, particularly the Digital Ethics Expert Group. Additionally, Scotland could provide input to the development of global standards by engaging in the work of The Alan Turing Institute.

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Prepared By: Ashley Stewart & Jordan Stodart	**Date:** 5th July 2023
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1 Introduction

1.1 Background and Context

AI – artificial intelligence – is widely recognised as an area of significant economic opportunity.

Scotland has already put in place a number of foundational steps towards capturing the economic benefit of AI including, for example, Scotland's AI Strategy[6] which seeks to realise a vision for Scotland to become a leader in the development and use of trustworthy, ethical and inclusive AI and alongside this the development of The Scottish AI Alliance[7] which provides a focus for dialogue, collaboration and action.

The Scottish Tech Ecosystem Review[8] (STER) identified that Scotland has a strong digital tech ecosystem which has yet to reach the tipping point where growth and investment become self-sustaining. Scottish Enterprise (SE) has created a "national programme" called Digital Scale Up Level Up (DSL). This is a five-year programme which responds to STER. The DSL programme recognises AI supply side development as an area of specific interest.

The implementation of the STER recommendations, combined with SE's DSL Programme, will focus on driving the digital tech ecosystem in Scotland beyond tipping point, increasing flows of global capital, creating more jobs, attracting sustained private investment, and creating more regional growth through digital tech.

This report supports the objectives of Scotland's AI Strategy and STER/DSL tech sector growth ambition by providing a summary of the AI landscape which can help Scottish Enterprise, and partners, to define and drive future actions.

1.2 Study Objectives

The objectives of the study were to:

- Develop a company/capability map
- Describe the Scottish supply chain
- Identify market/demand-side opportunities
- Identify potential key partners, organisations or networks

These were addressed through a combination of desk research, data collation and analysis and some limited engagement with sectoral representatives (participants are outlined in Appendix A).

[6] https://www.scotlandaistrategy.com/

[7] https://www.scottishai.com/

[8] https://www.gov.scot/publications/scottish-technology-ecosystem-review/

1.3 Limitations of the Research

There were some limitations of the research which are important to note from the outset as these set the context and impact upon the findings and analysis:

- AI taxonomy and company classification – it was agreed, with Scottish Enterprise and partners, that AI incorporates machine learning (ML), natural language processing (NLP), computer vision, cloud computing, speech and audio, and deep learning. However, categorising companies based on these capabilities became difficult for a number of reasons, as follows:
    - ML is probably the most recognised subfield of AI which means results are heavily biased towards that capability;
    - NLP, deep learning, computer vision, and speech and audio processing, are all either considered to be subfields of ML or will invariably work alongside ML within an AI system which makes it challenging to clearly distinguish between ML capabilities and other AI capabilities (i.e., if a company has deep learning capabilities, they inevitably have ML capabilities);
    - The inclusion of cloud computing was discussed at length as it would generally be considered an enabler of AI rather than an application. However, its importance in terms of providing the computing resources and infrastructure needed to train and deploy AI models at scale should not be underestimated.
    - And, finally, there was a reliance on companies self-identifying as having these capabilities which means some capabilities may be missed.
- Desk research – the landscape mapping was primarily based on desk research; thus, there was a dependency on publicly available information via, for example, company websites, LinkedIn and Companies House. The level of information varied considerably across companies; thus, impacting upon the classification. For example, if a company website referred to machine learning, it was noted that this capability existed. Likewise, if a company denoted NLP on its website this was included as an additional capability. However, if a company only made reference to AI on its website, it was automatically assigned as having machine learning capabilities. And as noted above, this created a bias towards that capability.
- Sector engagement – a small programme of sector engagement was carried out to enable us to obtain sectoral views on the SWOT and comparative analysis as well as discuss potential key market/demand side opportunities to drive Scottish AI supply side growth. The sectoral representatives were selected based on their expertise relating to the Scottish Enterprise National Programmes. However, the small sample size and alignment with the thematic areas of the National Programmes means that there may be unintentional bias in the analysis towards specific sectors.
- Hype – there is lots of hype and buzz around AI, but it is very early stage in terms of understanding applications, opportunities and impact. Additionally, there are more and more technologists that have been involved in its development expressing concerns about the unexpected acceleration of AI systems, particularly artificial general intelligence, and the urgent need to invest in safety and control measures.

2 Scottish AI Landscape

There are various definitions of AI across literature, but the definition contained within Scotland's AI Strategy[6] provided the basis for this study:

"Technologies used to allow computers to perform tasks that would otherwise require human intelligence, such as visual perception, speech recognition, and language translation".

It is important to recognise that the terms AI and machine learning are often used interchangeably, although machine learning is a particular field of AI, as too are the other subfields (illustrated in the figure below). However, almost all AI applications today are built on machine learning.

2.1 AI - Taxonomy and Supply Chain Model

A taxonomy for AI was developed by exploring the subfields of AI, reviewing a number of existing definitions and supply chain models. These were discussed, at length, with the project team and the following subfields were agreed upon as these also aligned with the definition of AI used by the Scottish AI Alliance:

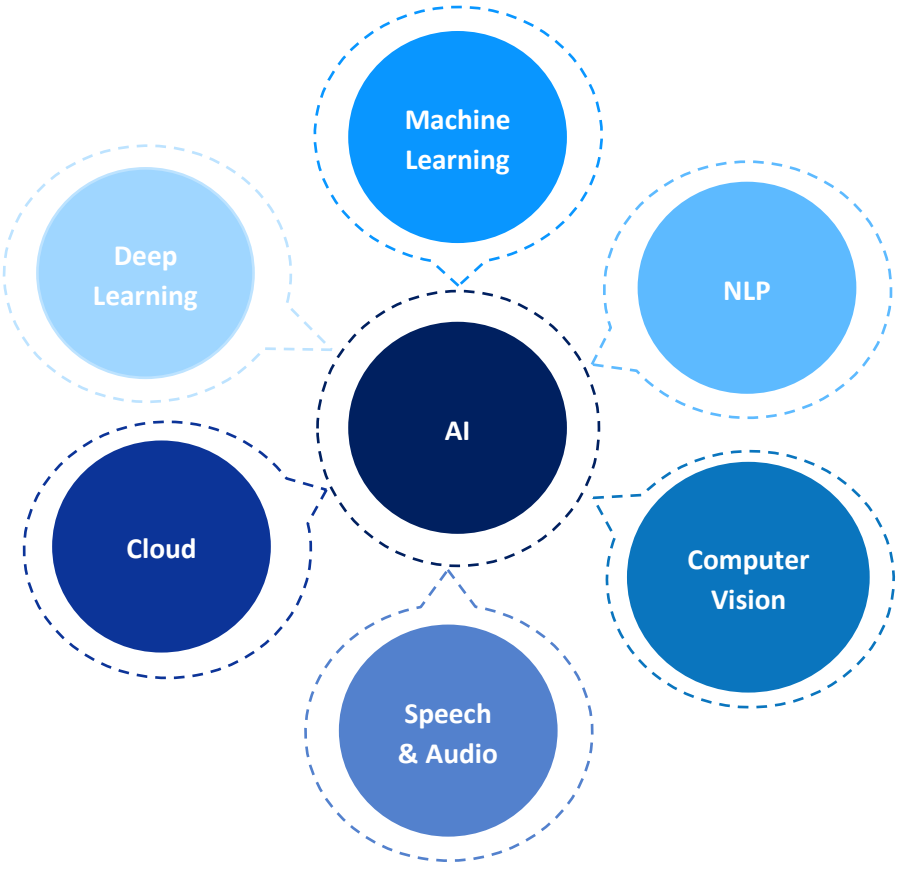

Figure 1: Subfields of AI

As well as defining the subfields of AI, a means of categorising organisations based on 'company type' was also considered as part of the taxonomy. The following 'types' were agreed with the project team.

Type	Definition
Product	A company developing productised AI solutions to solve a specific problem(s) in a specific market(s)
Platform	A company developing AI infrastructure on which AI solutions/applications can be modelled
Consultancy	A company using AI to deliver customised solutions dependent on customer requirements

Figure 2: Company Type Categories

The original intention was to use this taxonomy (subfields and company type) to then develop a supply chain model but given the interconnectedness of the technology subfields and the nature of AI it was determined that a traditional 'linear' supply chain model was not practical or feasible in this instance. We then discussed the concept of creating an infographic to illustrate the composition of the AI landscape, but again due to the nature of AI this was deemed to be less valuable. Therefore, the focus of the study was on identifying companies that had the subfield capabilities and 'types' outlined above and developing the Scottish AI capability database based on this research, as described below.

Note: the Scottish AI capability database is provided as a separate Microsoft Excel document.

2.2 Capability Map

The Scottish AI capability database was developed to map the breadth of both company capability and academic, research and support across Scotland. This was primarily based on desk research as well as collating a number of existing databases held by Optimat, Scottish Enterprise and its partner agencies.

The following criteria was used throughout the development of the database:

Criteria for inclusion

- Actively trading (evidenced via Companies House)
- Scottish base / presence (e.g., registered HQ on Companies House, office listed on website)
- Developing AI products or platform infrastructure or using AI within a consultancy context

Criteria for exclusion

- Not actively trading (i.e., dissolved, liquidation)
- No obvious identifiable presence in Scotland (HQ, listed location on website)
- No obvious identifiable use of AI (e.g., through keyword searches online, exploration of website)

It should be noted that the categorisation of company capability was entirely based on information in the public domain; consequently, areas of capability were determined based on self-identification, as explained previously.

3 Composition of the Scottish AI Landscape

3.1 Overview

As indicated, a database of companies and academic, research and support stakeholders across Scotland was developed based on desk research and the collation of existing databases. Each organisation was researched using available online resources. The taxonomy defined in Section 2 was used to classify organisations based on, for example, their location, company type and AI capabilities (see Section 2.1), and company size.

It is considered that the analysis reflects the scale of the sector in 2023, although it is recognised that the landscape is fast paced and evolving as more and more applications of AI are discovered across a range of sectors. It should be noted, however, that direct engagement with companies was out-with the scope of the study; therefore, the analysis below is based predominantly on desk-based analysis of published information and relevant knowledge within the project team.

The capability mapping database has been provided as a separate file. An introduction is provided to explain the criteria for inclusion and exclusion as well as company type definitions. For each company it details:

- Name
- Overview
- Type
- Target market
- Location
- Head quarters
- Size (micro, small, medium, large enterprise)
- Capabilities (machine learning, deep learning, computer vision, NLP, speech & audio, cloud)

For entries in the academic, research and support ecosystem database, the following details were captured:

- Name
- Overview
- Type
- Area of Expertise
- Location
- Capabilities (machine learning, deep learning, computer vision, NLP, speech & audio, cloud)

The key outputs from the development of this database are:

- More than 200 companies and over 70 academic, research and support stakeholders
- 58% of companies are developing productised AI solutions to solve a specific problem(s) in a specific market(s)
- Key target markets include ‘Various’ (i.e., serve multiple markets), ‘Health’, ‘Agriculture & Land Use’, ‘Financial & Business Services’, ‘Energy’ and ‘Creative Industries’ – 11 other markets were also targeted by the company-base
- Companies and, therefore, AI capabilities are concentrated within Edinburgh and Glasgow
- The company base in Scotland is largely comprised of micro and small companies

- There is a strong academic and research base, with research centres, institutes, programmes and projects dedicated to the exploration of AI.

3.2 Company Analysis

3.2.1 Company Type

As outlined in Figure 2 (above), company types were defined as follows:

- Product – a company developing productised AI solutions to solve a specific problem(s) in a specific market(s)
- Platform – a company developing AI infrastructure on which AI solutions/applications can be modelled
- Consultancy – a company using AI to deliver customised solutions dependent on customer requirements

A breakdown of the AI company base in Scotland by company type is shown below.

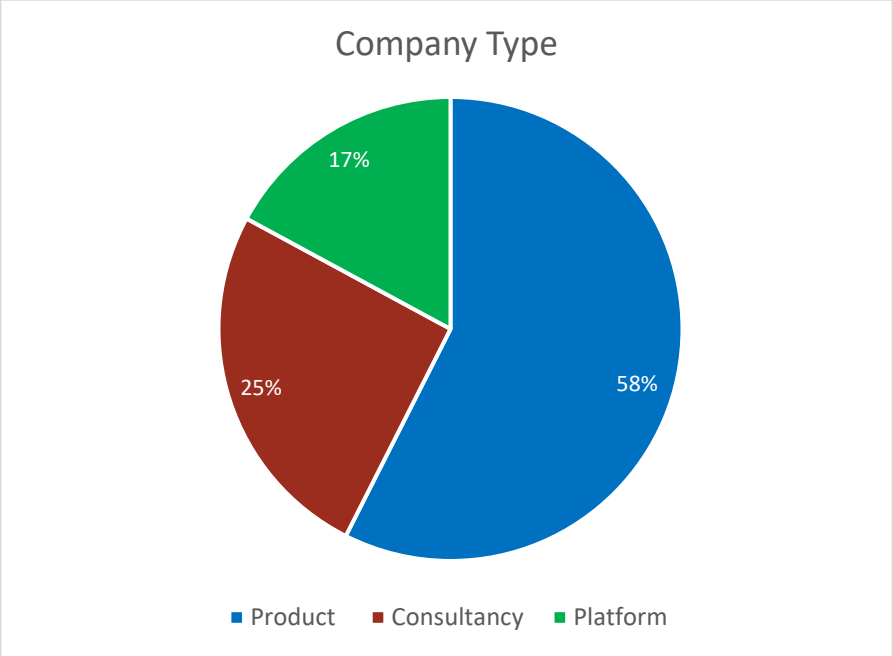

Figure 3: Companies by Company Type

More than half (58%) of the AI company base are classified as 'Product' companies. They develop AI products to solve specific problems in a single or multiple markets. This compares to 'Consultancy' companies, representing 25%, which use AI in the delivery of their product or service to meet particular needs, for example, a digital transformation consultancy that creates AI solutions for individual clients based on a particular set of needs. Finally, 'Platform' companies, making up 17%, comprise AI infrastructure developers, enabling other companies to develop AI products using their platforms.

This market composition can be viewed as a strength as productisation is considered to be more scalable, clearly defined market needs and clearly defined solutions, compared to individual companies leveraging AI to meet individual client needs or infrastructure development which requires a more specialised skill-set which is not considered to be highly scalable.

3.2.2 Target Market

Target market refers to the markets in which the company delivers its products or services. For example, a company that develops an AI-enabled solution to optimise energy usage in residential homes would target the 'Energy' market, while a company that develops AI-enabled remote patient monitoring solutions would target the 'Health' market. A company that uses AI in the delivery of digital transformation consultancy services targets 'Various' markets.

The chart below illustrates the breakdown of the AI company base by their Target Market.

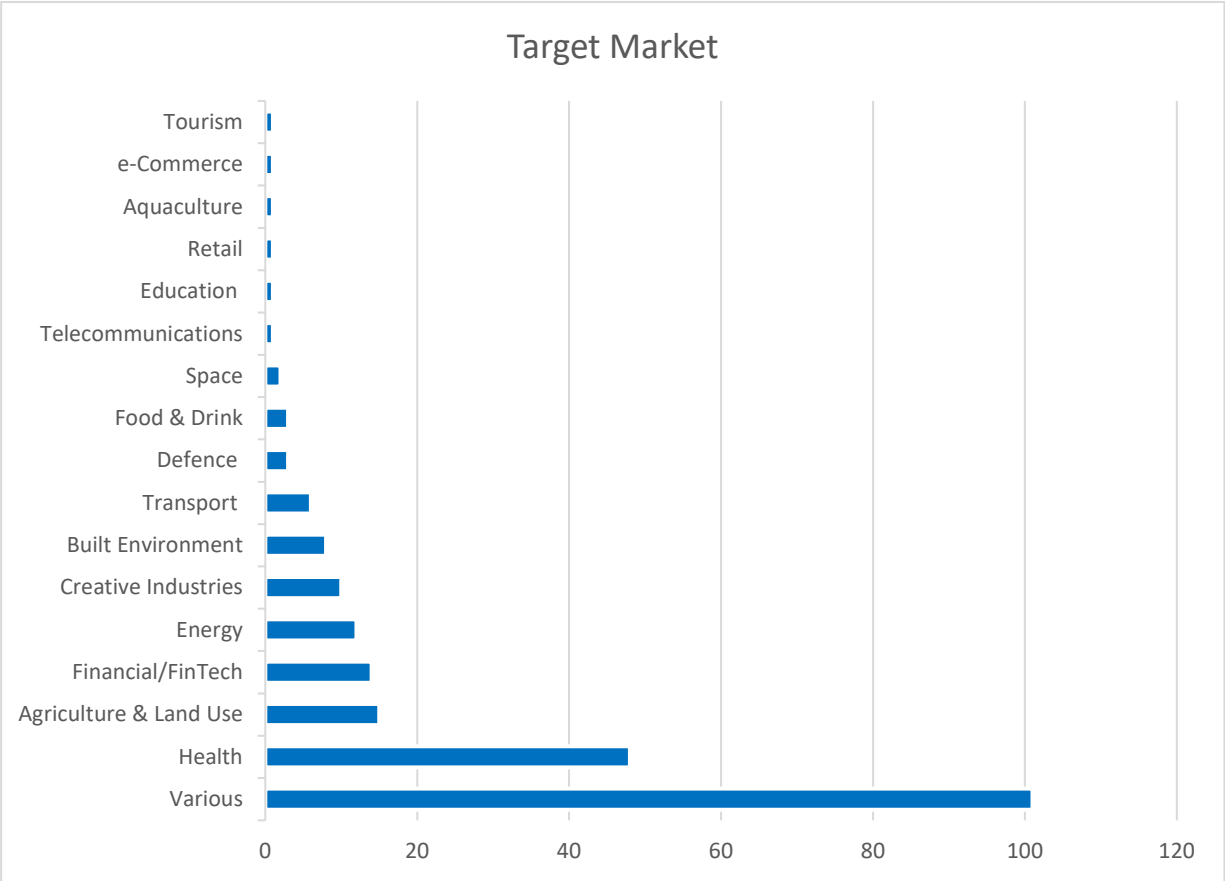

Figure 4: Companies by Target Market

The analysis shows that most companies (44%) target multiple – or 'Various' – markets, indicative of the cross-sectoral or horizontal application of AI-based solutions. There is, however, a concentration of companies targeting the health sector (21%) applications include, for example, companies using AI for drug discovery, to support clinical diagnosis and treatment pathways, for predictive insights based on electronic health record data, and in the manufacture of AI-enabled medical devices. The level of adoption then drops significantly to agriculture & land use (7%), financial & business services (6%), energy (5%) and creative industries (4%). There are 12 other markets which makeup the remaining 17% of the company base's target markets.

3.2.3 Location

Companies have been categorised and mapped based on their location in Scotland, i.e., headquarters or main office. The chart below shows the geographic spread of companies using AI in Scotland.

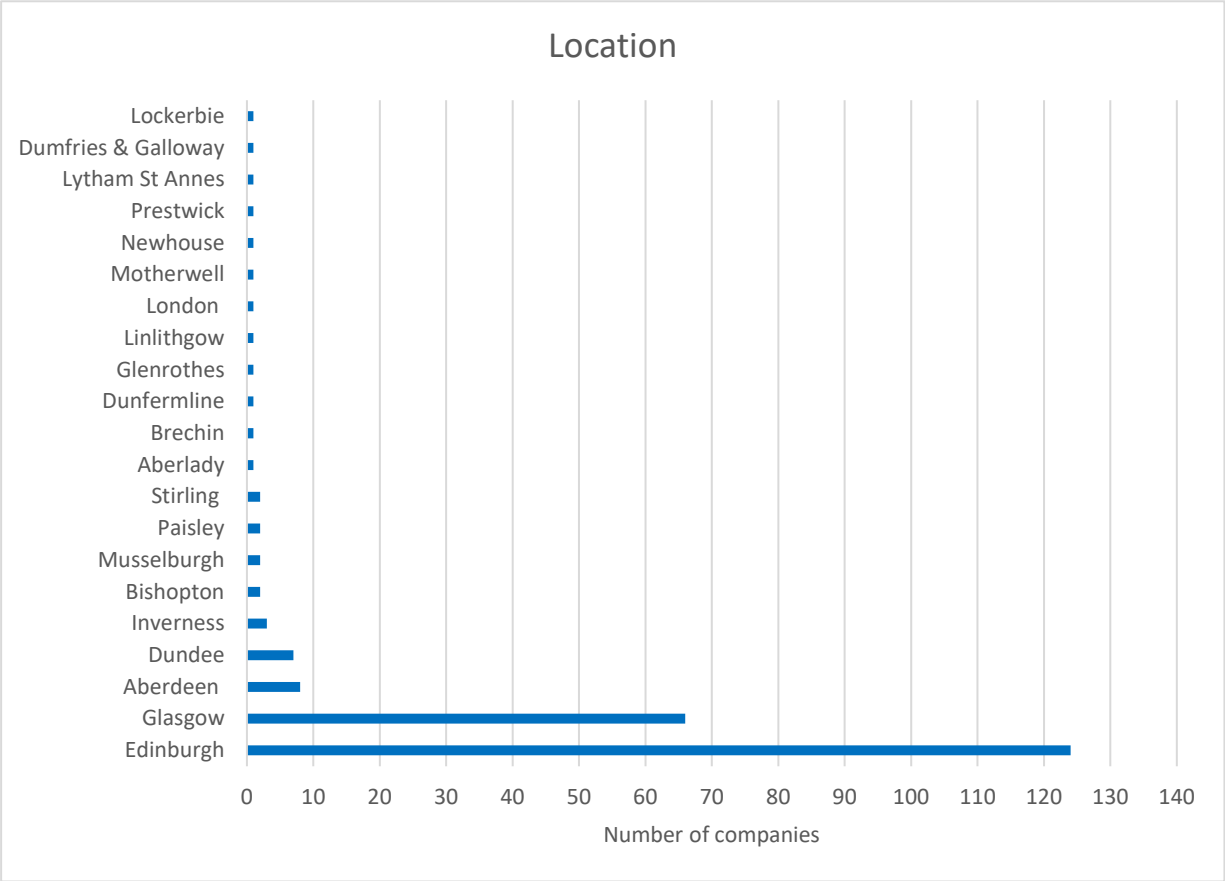

Figure 5: Companies by Location

Companies and, therefore, AI capabilities are concentrated within Edinburgh and Glasgow which is not surprising as this is typically the case with emerging technologies. More than half (54%) of the companies are located in Edinburgh followed by 29% in Glasgow. There are nineteen other locations*, out-with Edinburgh and Glasgow, representing a cumulative 17% of the company base.

*Note: One company has been included in the database that has no obvious Scottish presence (based in Lytham St Annes), but is undertaking activities in Scotland, including trials of its product with Scottish NHS hospitals and usage of the Dumfries and Aberdeen G5 hubs for product development.

Edinburgh is recognised as the capital of data; therefore, there are a number of key assets that entice companies to the city including, for example, The Data Lab - Scotland's innovation centre for data science and AI (a key partner alongside the Scottish Government in the Scottish AI Alliance) and the AI Accelerator based at the Bayes Centre in the University of Edinburgh. Additionally, the National Robotarium[9], located at Heriot-Watt University in partnership with the University of Edinburgh, along-with a number of other AI-related institutes, centres and research groups, act as incentives to setup operations in the region.

[9] https://thenationalrobotarium.com/

3.2.4 Size

The figure below illustrates a breakdown of the company base by company size, measured by number of employees including Micro (<10), Small (<50), Medium (<250), Large (>250).

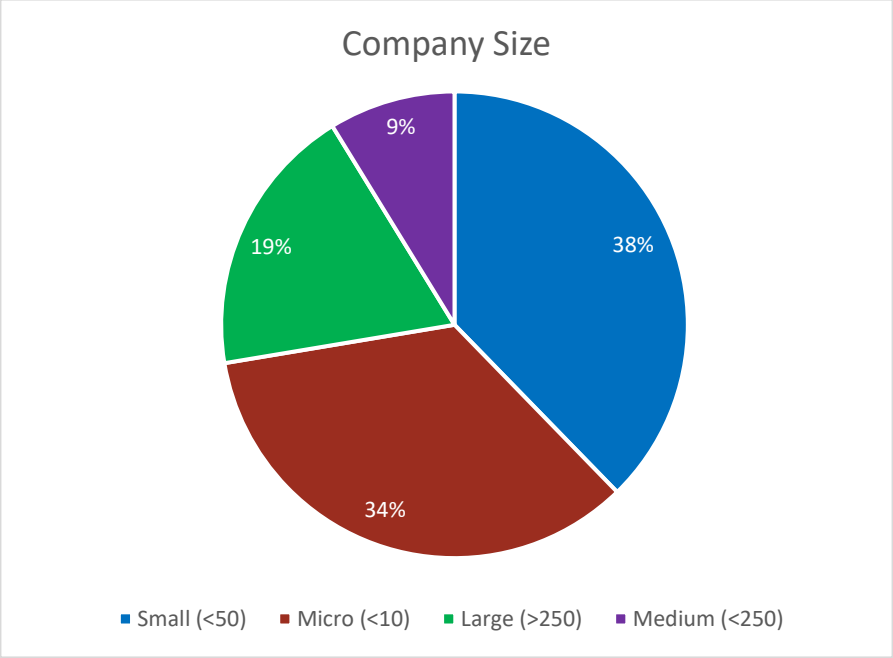

Figure 6: Companies by Company Size (employee numbers)

The AI company base in Scotland is largely comprised of micro and small companies, making up a combined 72%. This is not surprising given the relative nascency of AI in Scotland and the nature of its technology ecosystem. There is, however, a moderate portion of large companies (19%) and a small portion of medium companies (9%) which indicates Scotland has the potential to service both ends of the spectrum, both the innovators (smaller, more agile companies) and the larger incumbents and multinationals. It is worth noting that some of the large companies may have already been based in Scotland and subsequently developed AI capability, rather than relocating to Scotland to exploit its AI capabilities.

3.2.5 Capability

AI capability is broken down into several subfields, specifically: machine learning, deep learning, natural language processing (NLP), speech and audio, computer vision, and cloud computing. These subfields were suggested by The Scottish AI Alliance and agreed upon to provide the taxonomy for the database.

The company base broken down by subfield, and therefore AI capability, is shown in the figure below.

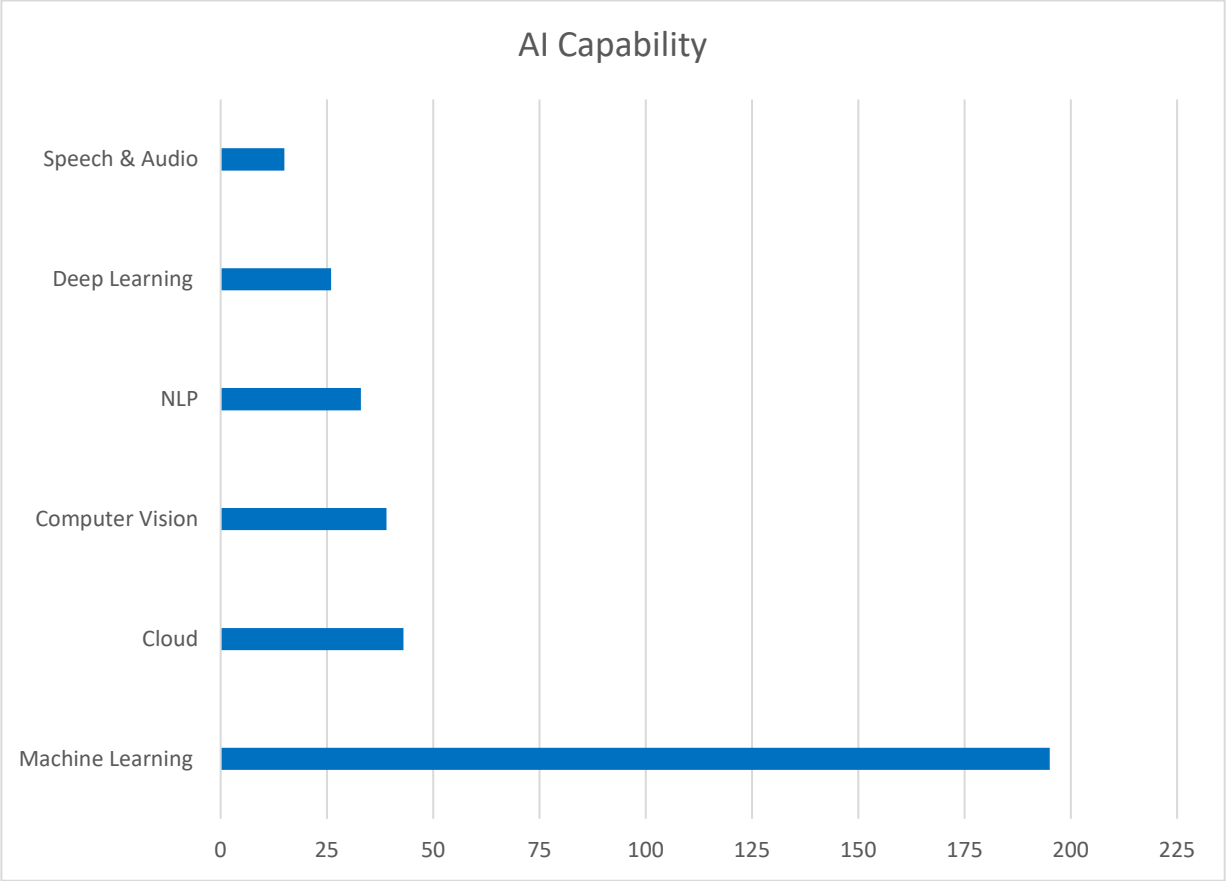

Figure 7: Companies by AI Capability

Desk research was conducted to identify a company's AI capabilities. This involved, for example, reviewing company websites and other online resources (e.g. LinkedIn or Companies House) to ascertain areas of capability and then classifying these against the subfields of AI (defined in Figure 1). Therefore, there were some limitations as categorisation was entirely dependent on a company self-identifying via reference to one or more of the AI subfields within online resources. Additionally, it is acknowledged that most of the capabilities exist as subsets of machine learning and there are many examples where companies simply describe themselves as possessing 'machine learning' capabilities only and do not make reference to any other AI subfields. Therefore, a significant portion of companies are categorised as machine learning which slightly skews the analysis. However, if a machine learning category did not exist, many companies would not be captured in the database, which would misrepresent and mischaracterise the company base in terms of the composition and breakdown of company type, size, location, and capability. Likewise, it is acknowledged that cloud computing is an enabler rather than an application, but its importance in terms of providing the computing resources and infrastructure needed to train and deploy AI models at scale should not be underestimated; hence its inclusion.

The Scottish AI capability database (totalling 228 companies) is predominantly made up of companies with machine learning capability (86%). There is a fairly even spread of capability between the other five capability subfields, as follows: cloud, 19%; computer vision, 17%; NLP, 14%; deep learning, 11%; speech & audio, 7%. The evidence suggests that companies with particular AI capabilities, such as computer vision or NLP, are in the minority and in their infancy compared to the more mainstream capability, machine learning. However, as mentioned above, the constraints of the desk research meant it was not

possible to investigate a company's capabilities beyond desk research; thus, there was a dependency on how companies define their AI capabilities (via self-identification). Similarly, it could be argued that machine learning is a more commonly recognised term; thus, there is a preference to use it when promoting a company's products and services to its target market(s).

3.2.6 Summary

The analysis demonstrates the following key strengths:

Characteristic	Strength
Product Development	• Companies developing productised AI solutions to solve a specific problem(s) in a specific market(s)
Target Market(s)	• Applications across multiple / various markets (i.e. horizontal) • Applications within particular sectors including, for example, health, agriculture & land use, financial & business services, energy and creative industries
Location	• Concentrated within Edinburgh and Glasgow – able to tap into data expertise and innovation support more easily
Size	• Ecosystem largely comprises micro and small businesses that are able to operate with agility • Ecosystem boosted with presence of some large players
AI Capability	• Key strengths in machine learning

3.3 Academic, Research and Support Ecosystem

Scotland has academic AI (and related technology) expertise at all major Scottish universities and an internationally respected research community. Likewise, there is also a supportive innovation landscape including the Innovation Centres[10] and AI Accelerator based at the University of Edinburgh, as well as access to innovation & research funding via Scottish Enterprise, Highlands and Islands Enterprise, Innovate UK and Horizon Europe which has resulted in a strong track record of industrial research and development activity.

The academic, research and support ecosystem comprises a number of stakeholder 'types', including Government, Innovation Centres, Research & Innovation Centres, Sector Organisations, Universities and others. More than 70 academic, research and support stakeholders have been identified during the research, as illustrated below.

[10] https://www.sfc.ac.uk/innovation/innovation-centres/innovation-centres.aspx

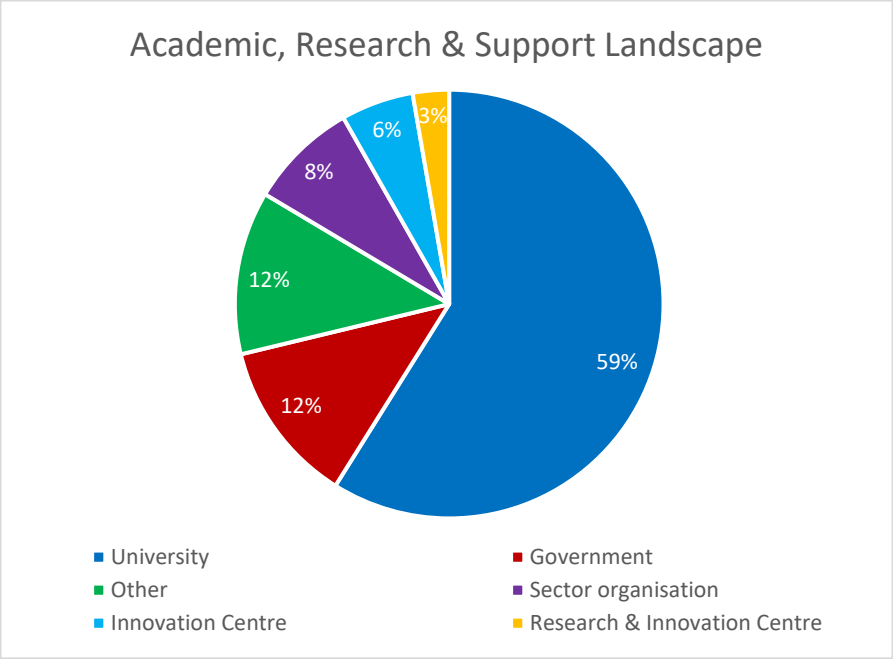

Figure 8: Composition of the Academic, Research & Support Ecosystem

These are outlined within the Scottish AI capability database which is provided as a separate MS Excel document.

4 Market/Demand-side Opportunities

Analysis including a SWOT and comparative analysis was completed in conjunction with sector engagement. This section of the report, therefore, provides a summary of the analysis and describes the market/demand side opportunities discovered through the development of the AI capabilities database as well as through engagement with sectoral representatives. Sector engagement enabled us to gather opinions on demand side opportunities to drive Scottish AI supply side growth (for example, where there might be opportunities to develop collaborations, stimulate innovation and adoption, develop new projects or partnerships etc).

4.1 Sector Engagement

We engaged with 7 sector representatives to understand the current level of adoption of AI within specific sectors, the existing strengths, weaknesses and potential opportunities as well as threats; these are discussed in detail in the sections that follow. A full list of participants can be found in Appendix A.

4.1.1 Sector Representation

Scottish Enterprise's National Programme provided the basis for areas of sector focus, including:

- Digital Scale Up Level Up – comprising financial and business services
- Energy/Net Zero – comprising hydrogen, climate-tech and offshore renewable energy
- Transport – including open transport
- Health for Wealth – including medicines manufacturing
- Scotland in Space – specifically downstream applications

Sector engagement enabled us to obtain sectoral views on the SWOT and comparative analysis as well as discuss potential market/demand side opportunities to drive Scottish AI supply side growth. Additionally, it presented an opportunity to validate the database by cross-checking (to the best of the participant's ability) that no organisations from their sector were potentially missed.

4.2 SWOT Analysis

A SWOT analysis was carried out based on a combination of the landscape mapping and sector engagement. Key findings are discussed in the sections that follow.

4.2.1 Strengths

One of Scotland's key strengths is the Scottish Government's commitment to AI which is underpinned by the launch of a **dedicated strategy**[11] that sets out Scotland's vision for AI in Scotland and identifies the actions Scotland will take to develop and strengthen its AI ecosystem over the next five years. This is further reinforced by the **development of the Scottish AI Alliance**, a partnership between The Data Lab and Scottish Government which is tasked with the delivery of the vision outlined in Scotland's AI Strategy in an open, transparent and collaborative way.

Scotland also benefits from an established and reputable **data science community** that has significant expertise and capabilities which is evident in Edinburgh's growing reputation as the data capital of Europe. This data capability and ambition is further evidenced in the 10-year Data-Driven Innovation programme[12] which will work with partners in government, industry, and educational institutions to make Scotland the number one location of choice for data science startups and data science companies.

There are related **sectoral strengths and capabilities** that utilise AI including, for example, gaming, space (downstream), manufacturing and digital health. Scotland has been one of the leaders of video gaming innovation and has gaming clusters in Dundee, Edinburgh and Glasgow. Similarly, Scotland's space sector is rising faster than anywhere else in the UK, with key downstream strengths in processing satellite data. It too has a dedicated strategy[13] which sets out a vision to make Scotland "*the best place on earth to build a space business".* Additionally, Scotland has a history of healthcare innovation, as well as expertise and research and development excellence. This is evident in the Digital Health & Care Innovation Centre's review of emerging trends in digital health and care which includes AI as a driver of transformation in health and social care. It is also underpinned by Scotland's first-ever digital strategy for health and social care[14] which lays the groundwork for transforming the way members of the public access and use their own data to improve our own health and wellbeing. Likewise, the three regional healthcare innovation test beds in the north, west and east of Scotland will provide facilities and services

[11] https://www.scotlandaistrategy.com/

[12] https://ddi.ac.uk/

[13] https://scottishspace.org/wp-content/uploads/2021/10/a_strategy_for_space_in_scotland.pdf

[14] https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/02/data-strategy-health-social-care-2/documents/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age/govscot%3Adocument/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age.pdf

for health boards, academia, and industry to collaborate and co-create AI solutions; thus, further strengthening AI opportunities within the health and social care sector.

Scotland has **strong R&D activities in industry** together with a number of reputable higher education institutions which are fundamental to **AI related research,** as well as producing a **strong pipeline of talent**. Additionally, the educational ecosystem in Scotland including, for example, the national skills agency alongside the Innovation Centre's support provides continued sector-specific training and upskilling which ensures a **skilled workforce**.

The ecosystem in Scotland facilitates access to both **local and national innovation and R&D funding** as well as **sectoral support** through the National Programmes and the Innovation Centres. Additionally, it benefits from assets such as **Research Data Scotland**[15] which connects researchers to public sector data for the benefit of public good.

Finally, the landscape mapping has identified a community of more than **130 AI product companies** that are developing productised AI solutions to solve a specific problem(s) in a specific market(s) including, for example, health, agriculture & land use, financial & business services, energy and creative industries.

4.2.2 Weaknesses

The **composition of the sector**, consisting predominantly of micro and small companies, indicates that there will be a period of market growth and evolution before saturation point which will make it challenging to make forecasts and predictions about what support to offer during this time. There is also a dominance in Edinburgh and Glasgow and limited evidence of research being translated into commercial / operational opportunities.

There is significant **competition for talent across sectors** as well as challenges in retaining talent. There is also a need for improved awareness (education) of the potential sectoral opportunities/applications, although it is recognised that it is an emerging area of activity.

The impact of **Brexit** and the limited number of Scottish/UK students at Masters level in Data Science/AI also poses problems. Consequently, there is a high risk that international students leave Scotland following their studies with no contribution to the economy beyond their student experience, given the limited 2 year visa. The Data Lab is running a pilot over the summer in this area to encourage graduates to stay and employers to engage with them. However, this highlights both a weakness and an opportunity to widen access to these skills through colleges and other routes.

There is **limited understanding of the benefits of AI at senior levels** within many organisations, including government bodies; thus, reinforcing the need for improved awareness raising of the potential of AI and use case examples to demonstrate applications and value. There is, however, an opportunity to build on existing initiatives such as, for example, Living with AI[16] and Driving Value from AI[17] to continue to raise awareness.

[15] https://www.researchdata.scot/

[16] https://www.scottishai.com/living-with-ai

[17] https://learn.thedatalab.com/courses/driving-value-from-ai

Another problem is the **lack of investment**; companies are unable to scale without more foreign direct investment, business support, publicity and connectivity to vertical markets. Increased investment will enable Scottish businesses to scale as well as target international market opportunities.

Similarly, Scotland has a poor track record in **leveraging funding** from Innovate UK and other UK funding bodies. However, there are opportunities to address this and The Data Lab is currently in discussions with Innovate UK to discuss and explore how this can be addressed.

4.2.3 Opportunities

There are numerous opportunities for Scotland to **drive the development of AI** across key sectors including health and social care, energy (including net zero) and financial and business services. These are explained in detail in section 4.4. There is also the potential for AI to **increase productivity** across a range of sectors by automating routine tasks and freeing up workers to focus on more complex and creative tasks; AI can, therefore, improve overall efficiency and increase output.

AI has the potential to positively impact **sustainability and environmental targets** through the application of predictive analysis. This is particularly relevant to the offshore renewable energy sector which is evolving at pace as a result of major offshore wind projects such as, for example, ScotWind, and requires effective solutions for asset monitoring and maintenance to minimise downtime and reduce costs.

As AI evolves there is an opportunity for the national skills agency and related stakeholders to upskill and reskill to support **future growth of the workforce.** For example, the work being carried out by The Data Lab as part of the City Region Deal's Data Driven Innovation Skills Gateway, **Data Skills for Work**[18] is an initiative that creates routes for those already in work, or returning to work, to develop the skills needed to participate in a data-driven economy. This initiative is being taken to new regions in Scotland so there are opportunities to build on this to drive future skills development. Additionally, the need to widen access to skills at all levels and through a range of different routes is essential given the risk of international students leaving the country (outlined above) following completion of the academic studies. This is particularly important as it is predicted that AI will create 97 million new jobs globally by 2025, according to the World Economic Forum[19].

There is an opportunity for Scottish Government and its partner agencies to work with civil society to ensure **inclusivity** and tackle any digital inequalities. Civil society must become a critical stakeholder in expediting the benefits of AI and mitigating against its risk by steering AI in a positive direction. This could, for example, include encouraging more diverse and representative datasets while also ensuring privacy rights are protected. This opportunity could also be supported through the Scottish chapter of a UK-wide community interest company, **Diverse AI**[20], which is designed to promote greater diversity and inclusion in AI.

[18] https://thedatalab.com/professional-development/data-skills-for-work-programme/

[19] https://www.weforum.org/agenda/2023/01/why-nurturing-talent-is-key-to-riding-out-the-recession-davos23/

[20] https://www.diverse-ai.org/

Scotland can support the UK's initiative to **shape global standards** for AI[21]. The Alan Turing Institute, supported by the British Standards Institution (BSI) and the National Physical Laboratory (NPL), is piloting a new UK government initiative to lead in shaping global technical standards for AI.

There is an opportunity for **collaboration** between industry, academia and the public sector to develop AI products and solutions that address challenges in specific markets. The Data Lab is already working to encourage triple helix collaboration and its activities could act as a catalyst for further collaboration. For example, collaboration could also occur between clusters, such as FinTech Scotland and Space Scotland, to enable knowledge sharing and exchange of ideas and opportunities. FinTech Scotland, in particular, has exhibited an appetite for these collaborative opportunities as it believes cross sectoral collaboration enables shared knowledge and generates new opportunities. Likewise, there is also a desire to collaborate with government and policy makers, for example, the offshore renewable energy sector is keen to de-risk potential AI projects by ensuring the policy landscape is favourable and government backs opportunities for wider adoption of AI solutions across the sector.

4.2.4 Threats

The **displacement of roles** in particular sectors is a threat. For example, a PwC report for the Department for Business, Energy and Industrial Strategy indicated that around 7% of existing UK jobs could face a high (over 70%) probability of automation over the next 5 years, rising to around 18% after 10 years and just under 30% after 20 years[22]. This includes projected estimated net employment reductions in wholesale and retail, finance and public administration sectors in the short to medium term. However, AI will also create many jobs through the boost it gives to productivity and economic growth; thus, the need for skills development to ensure a pipeline of talent is essential to exploit such opportunities.

One of the most pressing threats to AI adoption is **privacy and security issues**, particularly the handling of personal data as AI systems collect and process vast amounts of data. There is a risk that this information could be mishandled, either through intentional breaches or accidental leaks. Additionally, there is also the potential for AI systems to be hacked or manipulated as AI systems become more complex and autonomous; thus, the risk of cyber-attacks increases.

As well as the technical security issues outlined above, there are also **ethical concerns** surrounding AI decision-making. The ability to process vast amounts of data means that AI systems have the potential to make decisions that are biased or discriminatory which could lead to unfair treatment of certain individuals or groups, exacerbating existing social inequalities. These technical and ethical concerns can also inhibit the rate of adoption. These can, however, be overcome by engaging with civic society (as discussed above) to ensure inclusivity in datasets and ensuring that AI development is guided by a strong framework of privacy and security principles including measures to protect personal data, such as encryption and secure data storage, as well as protocols for handling data breaches and cyber-attacks.

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[21] https://www.gov.uk/government/news/new-uk-initiative-to-shape-global-standards-for-artificial-intelligence

[22] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1023590/impact-of-ai-on-jobs.pdf

The **lack of standards and standardisation** within AI is a current threat, but the work of The Alan Turing Institute (referenced above) to develop standards will play a crucial role in the adoption and effective governance of AI technologies and the development of such standards will be a vital tool to help unlock the economic potential of AI, including establishing a common language for all to use.

These can be presented in a typical SWOT matrix as follows:

STRENGTHS	WEAKNESSES
Scottish Government's Commitment to AI including development of dedicated AI Strategy as well as the development of the Scottish AI Alliance and the Scottish Health and Industry Partnership AI Hub.	Predominantly small and micro companies within the community
Strong data capabilities and community as well as a growing international reputation with Edinburgh cited as the data capital of Europe	Dominance of companies located within Edinburgh and Glasgow
Related sectoral capabilities that utilise AI including gaming, space (downstream) and digital health	Commercialising research - translating research into commercial / operational opportunities
Supportive innovation landscape including the innovation centres, access to innovation & research funding via Scottish Enterprise, Innovate UK and Horizon Europe which has resulted in a strong track record of industrial research and development activity	Talent - cross-sector competition for talent as well as challenges retaining talent
Strong community of AI product companies (developing productised AI solutions to solve a specific problem(s) in a specific market(s))	Brexit - few Scottish/UK students at Masters level in Data Science/AI. Thus, there is a high risk that international students boomerang out of the country with no contribution to the economy beyond their student experience, given the limited 2 year visa.
Academic AI (and related technology) expertise at all major Scottish educational establishments - internationally respected research community	Still a need for more awareness (education) of the potential sectoral opportunities/applications
Scotland has a vibrant entrepreneurial community that is very innovative and companies have strong diversification capabilities and a willingness to pivot to exploit new opportunities	Limited understanding at senior level of many organisations including government bodies
	Lack of investment - financial support for businesses to scale.
	Scotland has a poor track record in successfully leveraging Innovate UK and other UK funding
OPPORTUNITIES	**THREATS**
Drive the development of AI across key sectors including health and social care, energy (including net zero), financial and business services as well as manufacturing, gaming and agriculture & land use.	Displacement of roles in particular sectors
Potential to increase productivity across a range of sectors through application of AI	Privacy and security issues of AI and the handling of personal data - need for compliance with data regulations and legislation
To work with civil society to ensure inclusivity and tackle any digital inequalities	Ethical concerns are a barrier to adoption
To positively impact sustainability and environmental targets	Public opinion - perception of AI can often be negative and raises concerns around ethics, safety, etc.
To upskill and reskill to support future growth of the workforce	Lack of standards and standardisation within AI is prohibiting adoption
Support the development of international standards for AI	
Collaboration between industry, academia and public sector to develop AI products and solutions that address challenges in specific markets.	

Figure 9: SWOT Analysis

4.3 Comparative Analysis

The Government AI Readiness Index[23] (2022) provides a useful baseline for comparing countries based on government's readiness to implement AI in the delivery of public services. The index is based on ranking the following criteria:

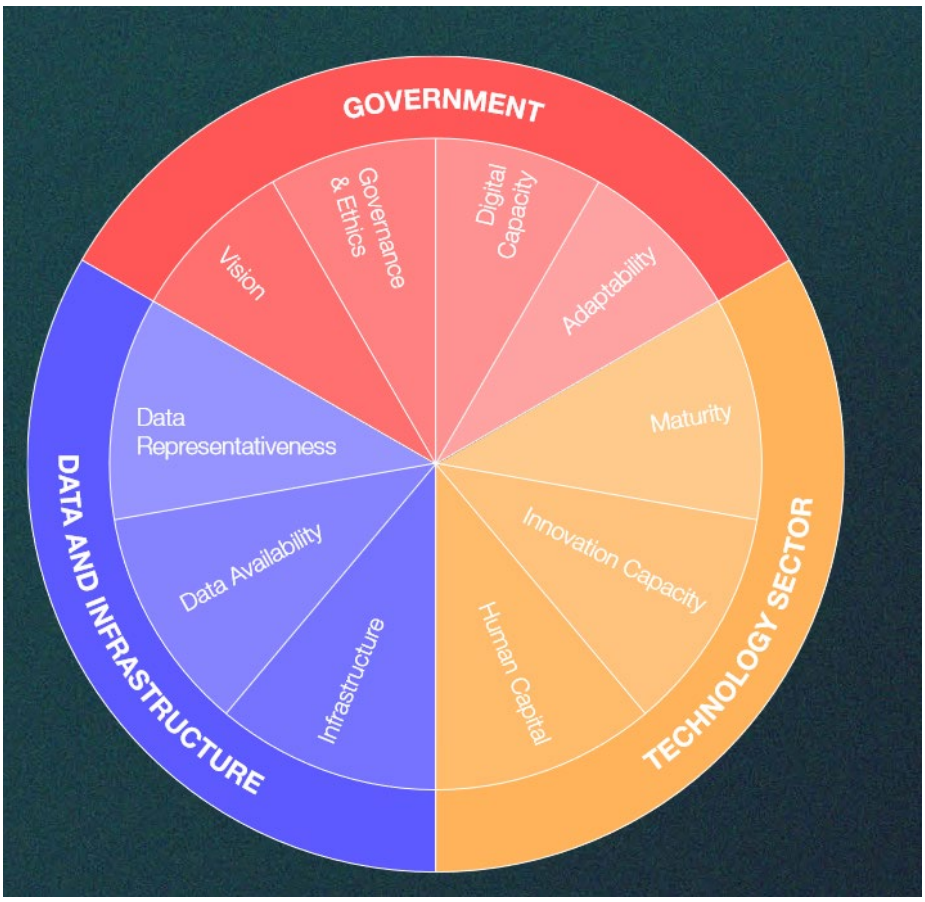

Figure 10: Readiness Factors and Pillars – Criteria

The three pillars are defined as follows:

1. Government pillar: a government should have a strategic vision for how it develops and manages AI, supported by appropriate regulation and attention to ethical problems (governance & ethics). Moreover, it needs to have strong internal digital capacity, including the skills and practices that support its adaptability in the face of new technologies.
2. Technology pillar: a government depends on a good supply of AI tools from the country's technology sector, which needs to be mature enough to supply the government. The sector

23 https://static1.squarespace.com/static/58b2e92c1e5b6c828058484e/t/639b495cc6b59c620c3ecde5/1671121299433/Government_AI_Readiness_2022_FV.pdf

should have high innovation capacity, underpinned by a business environment that supports entrepreneurship and a good flow of research and development spending. Good levels of human capital— the skills and education of the people working in this sector—are also crucial.

3. Data & Infrastructure pillar: AI tools need lots of high-quality data (data availability) which, to avoid bias and error, should also be representative of the citizens in a given country (data representativeness). Finally, this data's potential cannot be realised without the infrastructure necessary to power AI tools and deliver them to citizens.

The 2022 Government AI Readiness Index finds that:

- **Global Leaders:** USA tops the index, but Singapore leads in two out of three pillars. The UK is third.
- **Regional shakeup:** Western European countries make up fewer than half of the top 10 countries for the first time as three East Asian countries achieve top 10 positions.
- **Government Pillar:** AI strategy work is dominated by middle income countries.
- **Technology Sector Pillar:** AI skills are global, with future developers emerging in a diverse set of countries.
- **Data & Infrastructure Pillar:** Changes to the D&I Pillar expose which governments are taking an active role in supporting data availability and puts three East Asian countries at the top of the dimension.

The matrix below provides a summary comparison of Scotland against the top 5 ranking countries from the 2022 Index. The full analysis is provided as a separate Microsoft Excel document.

Country	TOTAL	GOVERNMENT					TECHNOLOGY SECTOR				DATA AND INFRASTRUCTURE			
		Vision	Governance & Ethics	Digital Capacity	Adaptability	TOTAL	Maturity	Innovation Capability	Human Capital	TOTAL	Infrastructure	Data Availability	Data Representativeness	TOTAL
Scotland	**75**	**100**	**80**	**70**	**63**	**78**	**40**	**75**	**61**	**59**	**81**	**82**	**98**	**87**
United States of America	**86**	100	89	83	73	86	85	93	67	82	88	80	100	89
Singapore	**84**	100	84	91	83	90	55	78	73	69	92	91	99	94
United Kingdom	**79**	100	88	74	65	82	53	77	67	66	84	84	97	88
Finland	**78**	100	89	84	78	88	42	72	63	59	88	82	89	86
Canada	**77**	100	87	79	71	84	52	77	65	64	83	78	90	84
*Ireland**	**71**	100	63	61	55	70	54	58	61	58	80	77	98	85

Figure 11: Comparative Analysis

Please note: *There are 12 countries in between Canada and Ireland, including France, Japan, Netherlands, Denmark, Norway, Sweden and Germany. Ireland was included by way of illustration as it has, for example, similar geography and population size (etc.) to Scotland and the two countries are often compared due to these similar characteristics.

This analysis is based on expertise and knowledge of the project team as well as engagement with sectoral representatives and the available indicator evidence referenced within the Government AI Readiness Index[24] (2022).

It is clear from the analysis that Scotland performs best within the Data and Infrastructure pillar and comparatively well within the Government pillar. However, it scores relatively low compared to the leading countries in the Technology Sector pillar. Scotland's ranking is discussed in line with the three index pillars in more detail below.

4.3.1 Government Pillar

The Government pillar relates to a country's strategic vision for how it develops and manages AI, supported by appropriate regulation and attention to ethical problems (governance & ethics). Moreover, a country needs to have strong internal digital capacity, including the skills and practices that support its adaptability in the face of new technologies.

This pillar incorporates the following dimensions and key questions:

Dimension	Key Question
Vision	Does the government have a vision for implementing AI?
Governance and Ethics	Are there the right regulations and ethical frameworks in place to implement AI in a way that builds trust and legitimacy?
Digital Capacity	What is the existing digital capacity within government?
Adaptability	Can the government change and innovate effectively?

Vision

In line with the leading countries in the index, Scotland has a dedicated AI Strategy, and the Scottish Government is committed to implementing its vision for AI in Scotland. Scotland has a lead start due to strong foundations including academic excellence in related technology fields, a growing technology sector with an ambition to realise the opportunities afforded by AI across a range of sectors. However, Canada is viewed as pioneer on AI policy as it published its first strategy in 2017 and a Directive on Automated Decision-Making in 2019, long before most other countries. Canada's progress can be characterised as a move from policy creation to the implementation and monitoring stage of AI policy. The country has continued its tradition of leadership by announcing a second phase of its Pan-Canadian AI Strategy, which largely focuses investment on AI R&D.

24 https://static1.squarespace.com/static/58b2e92c1e5b6c828058484e/t/639b495cc6b59c620c3ecde5/1671121299433/Government_AI_Readiness_2022_FV.pdf

Governance and Ethics

The USA and Canada both score highly in the Government pillar in the index; however, it is reported that the two countries in the region take very different approaches in this area. For example, the USA has multiple documents that meet the index's standards for a national AI strategy and ethical principles, but these documents are generally tailored to specific government departments or activities rather than a single overarching strategy. In addition, the US still has no single data protection authority akin to Canada's Office of the Privacy Commissioner, and data privacy in the US is still governed by a patchwork of laws with varying rules for different types of personal data.

Likewise, despite Singapore's overall high ranking it has a relatively lower score in this dimension which suggests that more legislative work is needed to ensure citizens see the benefit from and are protected against any possible harms of public sector innovation taking place.

In contrast, Scotland has a dedicated Digital Ethics Expert Group which is working to achieve Scotland's aspirations as an ethical digital nation. The Expert Group has reviewed evidence and provided recommendations which will support and inform future policy. The output of which is a report[25] to advance the vision of an Ethical Digital Nation as set out in Scotland's Digital Strategy (Digital Directorate, 2021) which aims to develop strategic and actionable recommendations for an Ethical Digital Scotland, informed by the best available evidence, expert knowledge and insights from multiple public sector organisations and stakeholders.

Likewise, the Data Protection Act 2018 is the UK's implementation of General Data Protection Regulation (GDPR) regulates and protects the processing of personal data about individuals by using the law to protect data and the way it is used by third parties and by recognising that personal data is a valuable asset which must be safeguarded and actively managed.

Digital Capacity

The Digital Directorate within Scottish Government is committed to ensuring that digital is at the heart of everything the government (national and local) does. This includes transforming public services and there is a vision of a modern public sector, open to collaboration, transformation, and accessing shared, high quality digital platforms designed around people. The development of the Digital Support Hub[26] provides support and knowledge for building better digital services for the people of Scotland. Likewise, mygov.scot [27] is a place to publish information about and gain access to public services in Scotland, alongside gov.scot. Whilst the Payments Platform[28] aims to be a standard online solution for re-use across the public sector. This long-term, co-creation project, involving many partners, is

[25] https://www.gov.scot/binaries/content/documents/govscot/publications/independent-report/2022/11/building-trust-digital-era-achieving-scotlands-aspirations-ethical-digital-nation/documents/building-trust-digital-era-achieving-scotlands-aspirations-ethical-digital-nation-digital-ethics-expert-group-report/building-trust-digital-era-achieving-scotlands-aspirations-ethical-digital-nation-digital-ethics-expert-group-report/govscot%3Adocument/building-trust-digital-era-achieving-scotlands-aspirations-ethical-digital-nation-digital-ethics-expert-group-report.pdf

[26] https://digitalsupporthub.service.gov.scot/s/

[27] https://www.mygov.scot/

[28] https://digitalsupporthub.service.gov.scot/s/article/scottish-government-payment-service

redefining how payments are made across the Scottish public sector. These examples demonstrate Scottish Government's digital capacity but still Scotland scores low in comparison to, for example, Singapore. Singapore is an example of an innovative and committed approach to digital government, paired with a business-friendly legislative environment. This results in productive public-private partnerships to support public sector innovation. For example, the recent partnership between Singapore's National Office for AI and Google Cloud, which aims to build the government's AI capabilities, including through AI and machine learning training for public sector officers.

Adaptability

In comparison to the leading countries in the index, Scotland scores modestly in terms of its adaptability. However, the project examples given above demonstrate Scottish Governments willingness to adapt to evolving technologies and changing needs of civic society. The Digital Support Hub has an initiative called Once for Scotland[29] which is a collaboration of public sector bodies working to find shared solutions to challenges in order to steer and accelerate innovation to create mutual benefits across the sector which should enable Scotland to achieve a higher ranking in this dimension going forward. Again, however, Singapore is an example of best practice due to the government's willingness and ability to solve problems using AI. Singapore's high scores reflect its track record of a dedicated and coordinated effort to implement AI in government since the publication of its National AI Strategy in 2019.

4.3.2 Technology Pillar

The Technology pillar relates to the supply of AI tools from the country's technology sector, which needs to be mature enough to supply the government. The sector should have high innovation capacity, underpinned by a business environment that supports entrepreneurship and a good flow of research and development investment. Good levels of skills and education within the sector are also crucial.

This pillar incorporates the following dimensions and key questions:

Dimension	Key Question
Maturity	Does the country have a technology sector capable of supplying governments with AI technologies?
Innovation Capacity	Does the technology sector have the right conditions to support innovation?
Human Capital	Are there the right skills in the population to support the technology sector?

Maturity

In contrast to, for example, the USA, Scotland scores modestly. This is because the USA leads the global landscape in technology innovation and has a thriving AI community. For example, the number of AI companies has doubled since 2017 and there are approximately 13,398 artificial intelligence startups in

[29] https://digitalsupporthub.service.gov.scot/s/article/once-for-scotland

the United States, according to Tracxn Technologies[30]. Nonetheless, Digital Technology is one of Scotland's fastest growing sectors for inward investment and the sector comprises almost 14,000 companies[31]. This landscape mapping study has identified more than 200 companies in Scotland with AI capabilities; thus, there is scope for Scotland to grow its AI capabilities further which will ensure it is capable of supplying governments and industry with AI technologies in the future.

Innovation Capacity

As indicated in the SWOT analysis Scotland has a strong research and innovation landscape that is underpinned by the Innovation Centres which have been designed to encourage collaboration between companies, academic and public sector organisations. This means innovative products can be designed and tested in real world scenarios. Additionally, public sector support for business innovation is provided by Scotland's enterprise and skills agencies – Scottish Enterprise (SE), Highlands and Islands Enterprise (HIE), Skills Development Scotland (SDS), the Scottish Funding Council (SFC) and South of Scotland Enterprise (SOSE). With this in mind, Scotland scores competitively against the leading countries in the index. Unsurprisingly, however, the USA is the highest scoring country due to its healthy startup ecosystem and the available support for the creation of novel AI applications which results in a strong supply of early-stage companies.

Human Capital

In terms of skills, Scotland also scores comparatively well against its counterparts in the index. Singapore, in particular, is leading the way for Southeast Asia with the highest score. As well as a digitally able market, the index scores point to a supply of technically-skilled workers, with the South East Asia region scoring above the global average for the Human Capital dimension, and Singapore, Taiwan, and Malaysia all performing particularly well in this dimension. However, Scotland benefits from its national skills agency which aims to support the people and businesses of Scotland to develop and apply their skills. This is underpinned by the Digital Economy Skills Action Plan (DESAP)[32] which draws on research, insight, and expertise to highlight the digital economy skills opportunities which will support Scotland's economic vision of becoming a wellbeing economy: thriving across economic, social, and environmental dimensions, and one that delivers economic prosperity for all Scotland's people and places. Additionally, Scotland has world-class universities and innovative further education colleges which have developed the reputation for producing a talented digital workforce.

4.3.3 Data & Infrastructure Pillar

AI tools need lots of high-quality data (data availability) which, to avoid bias and error, should also be representative of the citizens in a given country (data representativeness). Finally, this data's potential cannot be realised without the infrastructure necessary to power AI tools and deliver them to citizens.

This pillar incorporates the following dimensions and key questions:

[30] https://www.eweek.com/big-data-and-analytics/ai-market/

[31] https://www.sdi.co.uk/business-in-scotland/find-your-industry/digital-and-technology-industries

[32] https://www.skillsdevelopmentscotland.co.uk/media/50035/digital-economy-skills-action-plan.pdf

Dimension	Key Question
Infrastructure	Does the country have a good technological infrastructure to support AI technologies?
Data Availability	Is there good availability of data that could be used to train AI models?
Data Representativeness	Is the data available likely to be representative of the population as a whole?

Infrastructure

From a technological infrastructure perspective Scotland is on par with the leading countries in the index due to the £463m invested in the Digital Scotland Superfast Broadband programme which has extended fibre broadband access to more than 950,000 homes and businesses across Scotland. Over 95% of premises in Scotland can now benefit from faster speeds. The programme has also transformed access to broadband in rural areas. Additionally, the £25m Scottish 4G infill programme is addressing mobile 'notspots' (areas where no mobile coverage is available) in remote communities across Scotland, from the Scottish Borders to Shetland and Orkney. Likewise, Scotland's Infrastructure Investment Plan adopts a wide, encompassing definition of infrastructure. It extends beyond the fibre, masts and small cells needed to meet our connectivity needs, to encompass digital platforms, online public services and data architecture.

Core infrastructure is required for AI including, for example, data centres, graphic processing units and cloud computing and Scotland already has key assets in place including, for example, the Edinburgh International Data Facility[33] which is a collection of computational, data management and safe haven services supported by the Data Driven Innovation Programme. There is also the opportunity for "Green" Data Centres in Scotland underpinned by renewable energy; this is being currently explored by the Scottish Futures Trust and Scottish Government[34].

Likewise, the Scotland 5G Centre which is a partnership between industry, academia and government, will ensure Scotland moves forward quickly on 5G adoption and innovation. The Centre will be Scotland's national platform for collaboration, innovation and knowledge sharing across all aspects of 5G from research to delivery and exploitation. This is further enhanced by Scotland's 5G Strategy[35] which sets out the vision for 5G and Scottish Government's commitment to embracing the opportunities to establish Scotland as a forward-looking digital nation. Furthermore, all seven major cities in Scotland are working to become Smart Cities.

In combination, this demonstrates Scottish Government's commitment to ensuring good technological infrastructure exists to enable and support the adoption and exploitation of emerging technologies such

[33] https://www.ed.ac.uk/edinburgh-international-data-facility

[34] https://www.scottishconstructionnow.com/articles/report-identifies-new-opportunities-for-data-centres-in-scotland

[35] https://www.gov.scot/publications/forging-digital-future-5g-strategy-scotland/

as AI. However, Singapore leads the way due to its high levels of digital connectivity, underpinned by world-class IT infrastructure including cloud infrastructure which is essential to accelerate innovation and is one of the reasons countries like Singapore are able to move faster than others as the country places a national focus on infrastructure and rapid adoption of cloud technology which provides access to high performance computing, storage and easy, but secure accessibility to data.

Data Availability

As the data capital of Europe, Scotland scores well in relation to the availability of data that could be used to train AI models. However, this dimension also includes open data which is where Scotland's ranking falls short. For example, the Open Data Strategy has not been updated since it was published in 2015, but it is recognised within the Digital Strategy that public sector open data enables efficiency gains and cost savings, as people, businesses and developers can consume open data to create products that can be used to for decision making at a variety of levels. In contrast, the Republic of Korea, Japan, and Singapore are leaders in this dimension (and score highly) as a result of well-connected populations, comprehensive open data policies, and taking a whole-of-government approach to data governance. In contrast, the USA scored lower than Scotland in the analysis, but a recent White House policy guidance instructed that all federally funded research and, crucially, any datasets behind it, should be made free and publicly available without delay. This could contribute greatly to data availability and lower barriers for private or public sector organisations to use big data and AI going forward.

Data Representativeness

Scotland's relatively small size and population makes it simpler to ensure that the data available is generally representative of the population compared to some of the other leaders in this dimension. However, despite the USA being approximately 40 times bigger than the UK it has the highest ranking in this category; thus, demonstrating its commitment to ensuring data that available data is representative of the entire population.

4.3.4 Summary

In summary, Scotland benefits from a dedicated AI Strategy and the development of the Scottish AI Alliance which will drive forward the delivery of the strategy. Likewise, there are regulations and ethical frameworks in place to implement AI in a way that builds trust and legitimacy in Scotland; thus, ensuring that Scotland scores comparatively well with the leading countries in the index. However, it falls short in digital capacity and adaptability because although related initiatives and projects are underway, Scotland is behind the curve in comparison to, for example, Singapore which has adopted an innovative and committed digital approach to government. Likewise, despite having strong innovation capabilities Scotland's technology sector has a lower maturity level compared to the leading countries, primarily due to the success and much healthier start-up ecosystem of both USA and Singapore which benefit from supportive business legislation as well as the implementation of AI technologies to support government. However, Scotland does have the national skills agency and reputable academic institutions which can drive human capital to support growth going forward. Finally, the analysis demonstrates that Scotland has the infrastructure necessary to power AI tools and deliver them to citizens; thus, there is the foundations in place to enable Scotland to realise the opportunities afforded by AI, as outlined in the following section.

4.4 Opportunities

Based on a combination of the SWOT analysis, discussions with sectoral representatives and the comparative analysis, a number of market opportunities exist for Scotland in the following three pre identified areas of interest for Scottish Enterprise and partners.

4.4.1 Health and Social Care

Scotland has a strong digital health and care ecosystem that supports research, innovation, and the adoption of AI into clinical practice.

Three regional healthcare innovation test beds in the north, west and east of Scotland provide access to all the country's health boards. These coordinated regional hubs provide facilities and services for health boards, academia, and industry to collaborate and co-create AI solutions. They work closely with the Safe Haven and Biorepository networks to give AI innovators safe and secure access to healthcare data, and with both the Innovation Design Authority and Accelerated National Innovation Acceleration collaborative to scale solutions nationally.

University and NHS patient, public and practitioner engagement groups create a safe space for discussions on the safety, ethics, fairness, bias and transparency of AI in health and care.

And as noted previously, the Digital Health & Care Innovation Centre's review of emerging trends in digital health and care includes AI as a driver of transformation in health and social care. Additionally, Scotland has high quality health data as a result of cradle to grave patient records, underpinned by a unique patient identifier assigned to everyone registered with a GP practice which generates some of the highest quality longitudinal data in the world. It also has a tradition for healthcare innovation; therefore, the following opportunities exist to build on this foundation and apply AI in the health and social care sector:

- AI for **clinical diagnosis & treatment pathways** for patients. An example of this has already taken place through a partnership between the University of Edinburgh, Edinburgh Napier University, NHS Lothian and Lenus Health that have joined forces to create a new digital pathway to improve emergency cardiac care[36]**.** This, therefore, represents opportunities for companies within the Scottish AI capability database to develop similar solutions and foster partnerships that will enable and support clinical diagnosis & treatment pathways across a range of medical conditions.
- AI for **clinical decision making support** based on AI generated insights. Blackford Analysis[37] provides access to the widest available portfolio of imaging AI solutions via its single dedicated platform. It currently has more than 90 contracted AI solutions across more than 30 partner vendors and 7 radiology sub-specialities. The platform provides access to the key health and analysis information which can help radiologist clinicians, non-radiologist clinicians, IT departments and administrators.

[36] https://www.digitalhealth.net/2023/01/nhs-scotland-uses-ai-to-improve-emergency-cardiac-care/

[37] https://www.blackfordanalysis.com/

- Scotland's HealthTech industry comprises more than 250 companies[38]; therefore, there are opportunities for the development and application of AI-based **medical devices.** This opportunity is underpinned by the Medical Device Manufacturing Centre[39], a partnership between Heriot-Watt University, the University of Edinburgh, the University of Glasgow and Robert Gordon University, which provides medical device developers and manufacturers with the advice, technical expertise, and facilities to translate a medical device idea / concept into a commercial product.
- AI for **pharmaceuticals (drug and vaccine development)** in Scotland. Exscientia[40], a leading AI-driven drug discovery company is an example of a company that is combining the latest AI techniques with experimental innovation to engineer a new set of processes for drug discovery. There are over 30 companies in Scotland developing therapeutics and collaborating with partners. The Medicines Manufacturing Innovation Centre[41], a collaboration between CPI, University of Strathclyde, UK Research & Innovation, Scottish Enterprise and founding industry partners, AstraZeneca and GSK, underpins the opportunity for AI-based drug discovery as it will ensure the UK is a technology and innovation leader in pharmaceutical manufacturing.

In summary, Scotland has the foundations in place to capitalise on AI in health and social care, underpinned by robust healthcare data and a supportive innovation landscape and ambitious companies. By taking a 'triple helix' approach bringing together public, private and academia there is the potential for Scotland to realise AI applications in health and social care by moving from the research phase towards commercialisation and implementation of AI into clinical practice.

4.4.2 Energy (including Net Zero)

AI is transforming the energy sector. Energy networks have challenges in ensuring the supply is managed in a world of increased flexibility and greater numbers of market players. Consequently, there are opportunities to provide this through better use of data and AI. Scotland is well placed to exploit energy-related AI applications due to its emerging climate tech ecosystem and growing space sector and the benefits AI and related technologies can provide, including the delivery of specific, actionable intelligence about the environmental risks; thus, supporting Scotland in its efforts to meet net zero targets. There are, therefore, specific opportunities for Scotland in the following areas:

- **AI and space data**; satellite imaging and earth observation data can be used to tackle climate change and the recent Scotland Can Do 'Applying Space Data to the Net Zero Economy[42]' research and development challenge demonstrates Scotland's innovative space-based solutions. The challenge will help a range of companies to accelerate their transition to net

[38] https://www.lifesciencesscotland.com/health-technology

[39] https://mdmc.hw.ac.uk/

[40] https://www.exscientia.ai/

[41] https://www.uk-cpi.com/about/national-centres/medicines-manufacturing-innovation-centre

[42] https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/business-grants/applying-space-data-to-the-net-zero-economy

zero. Scotland's space sector is thriving and there is an opportunity to exploit these capabilities to support Scotland's move towards a green economy.

- **AI and climate tech**; 'climate tech' cuts across a number of sectors, including, for example, energy, built environment, agriculture and land, and transport. There is evidence of Scottish companies applying AI across these sectors to reduce carbon emissions and support the transition to net zero. For example, Opex Group supports companies in carbon intensive energy industries to decarbonise operations through AI solutions; Integrated Environmental Solutions (IES) uses AI for building performance optimisation; Intelligent Growth Solutions (IGS) develops AI-enabled vertical indoor farms delivering optimal crop growing conditions; and Vahanomy is developing AI-driven data solutions for the EV charging infrastructure ecosystem.
- AI for **offshore renewables** presents opportunities for Scotland's renewable energy sector which is thriving. Scotland is a leader in renewable energy; the application of AI technologies could dramatically transform efficiencies and ultimately support the drive towards achieving net zero targets. There are specific opportunities relating to optimising energy production and distribution from wind and solar as well as for asset monitoring and predictive maintenance to ensure efficient operations. For example, AI is already being used to boost efficiencies of RWE's Robin Rigg wind farm in Scotland.[43]
- AI presents opportunities to identify and implement **energy efficiency** measures in buildings. This is particularly important as energy use in homes account for 14% of UK emissions. IRT, a Dundee based organisation, improves energy efficiency through thermal imaging data capture and analysis and have recently demonstrated how AI can be used to improve energy efficiency and tackle the climate crisis. It has worked with Robert Gordon University to create a solution that is expected to speed up the pre-processing of images by 10x. This solution has the potential to accelerate the decarbonisation of the UK's built environment and improve the quality of housing stock in the UK while reducing energy bills for consumers[44]. This is an opportunity which Scotland's AI community could expand upon particularly as 9% of companies in the Scottish AI capability database are targeting the built environment and energy markets.

In summary, Scotland has a well-established energy sector that is underpinned by unrivalled natural resources as well as an ecosystem comprising more than 700 renewable energy scientists, engineers and academics[45]. The Net Zero Technology Centre is working to develop and deploy technologies that reduce emissions, unlock the potential of an integrated energy system and propel the energy industry towards a digital, automated, decarbonised future. AI can play a crucial role in helping Scotland to achieve its net zero targets by optimising energy product and consumption, improving energy efficiency and enabling asset monitoring and predictive maintenance. Likewise, space data can also be used to support efforts to achieve a net zero economy.

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[43] https://www.oedigital.com/news/504057-ai-to-boost-efficiency-of-scotland-s-first-offshore-wind-farm

[44] https://www.pbctoday.co.uk/news/digital-construction/ai-tackling-the-climate-crisis-housing-energy-efficient-the-data-lab/111276/

[45] https://www.sdi.co.uk/business-in-scotland/find-your-industry/energy-industries

4.4.3 Financial & Business Services

Scotland has a thriving financial and business services sector with over 2,000 financial businesses including more than 200 FinTechs, both local and international[46]. Our analysis and sector engagement has highlighted the following opportunities for AI within the sector:

- AI can be used for **fraud detection** in financial transactions by using algorithms and voice biometrics to identify suspicious patterns and behaviours. The Royal Bank of Scotland has used AI to tackle fraud and protect customers with voice biometrics[47]. By using a voice biometric solution RBS scans all inbound calls and alerts agents to potential fraud. As well as a library of 'bad' voices, RBS now has a whitelist of genuine customer voices that can be used for rapid authentication, without the need for customers to remember passwords and other identifying information. This is one example of fraud detection that could be applied to other areas within Scotland's financial and business services sector.
- AI can be used to support **risk management** in financial and business services through predictive modelling and analysis. Encompass, a Glasgow based firm, has already made strides towards developing an AI platform, with R&D support from Scottish Enterprise, which will enable it to help its customers to quickly and accurately find risk-relevant information about their customers, organisations and investments from a wide pool of data[48]. There are opportunities to develop AI-based solutions across the financial and business services sector to reduce operational risks associated with meeting compliance and regulatory standards.
- AI being used to improve **customer service** is probably one of the most common (and longest standing) applications of AI within the financial and business services sector. For example, RBS first piloted an AI text-based robo-service technology to answer customer questions back in 2016[49]. Since then, however, AI technologies and tools have evolved and AI is widely implemented to provide 24/7 support, quicker response times, and a personalised service to customers whilst saving organisations human resource and delivering efficiencies. The breadth of the financial and business services sector in Scotland could be benefiting from such AI-based solutions to improve customer service and operational savings and efficiencies.
- A key application of AI in FinTech is **automation of trading** which primarily involves using pre-programmed algorithms or instructions to make trading decisions based on market data. Multiple factors are considered by the AI system, such as market trends, news events, and economic data, to make quick and informed trading decisions. This is a result of the benefits of machine learning which can identify patterns and make predictions for future market movements based on the aforementioned data (e.g., market trends and news events).
- **RegTech** is an evolving area where AI can prove beneficial. As alluded further above, AI can be deployed to support risk and compliance management by leveraging broad sets of data, often

[46] https://www.sdi.co.uk/business-in-scotland/find-your-industry/digital-and-technology-industries/financial-services-and-fintech

[47] https://www.nuance.com/asset/en_us/collateral/enterprise/case-study/cs-royal-bank-of-scotland-en-us.pdf

[48] https://www.insider.co.uk/news/encompass-handed-2m-grant-ai-21421015

[49] https://www.ft.com/content/fca8c484-e071-11e5-9217-6ae3733a2cd1

in real time, and automating compliance decisions. Moreover, an increased adoption of AI in RegTech has seen an expansion of use cases cutting across banking, securities, insurance and other financial services, and covering a range of applications, such as identity verification, anti-money laundering checks, fraud detection, risk management, and stress testing. AI can, therefore, improve compliance quality, reduce costs, and enhance the integrity of the sector.

There are additional opportunities that came to light from discussions and analysis, as outlined below.

4.4.4 Manufacturing

Manufacturing is important to Scotland's economy and accounts for more than 169,000 jobs[50]. It cuts across several sectors from health and social care, food and drink, transport, textiles, net zero industries, and more. The National Manufacturing Institute Scotland (NMIS) can play a pivotal role in supporting the implementation of AI-based manufacturing through its Digital Factory and centres including the Advanced Forming Research Centre (AFRC), Digital Process Manufacturing Centre and the Lightweight Manufacturing Centre. NMIS works with manufacturing businesses of all sizes from across Scotland, the wider UK, and beyond making it easier for them to access innovative technologies and connecting them with our widespread national and international network of world-leading industry and academic experts and collaborators. Thus, there is potential for NMIS to play a pivotal role in accelerating the implementation of AI to enable predictive maintenance, improve quality control, improve process optimisation, optimise supply chains and extend automation and robotics within manufacturing. Again, there are potentially collaborative opportunities between, for example, NMIS and sector-based organisations to showcase the potential applications of AI in manufacturing.

Likewise, the Smarter Manufacturing Data Hub[51], and testbed is led by Ulster University and backed by £50m of government funds and business co-investment. The funding is part of the £300m Made Smarter Innovation Challenge, designed to support the development and increased use of new and existing industrial digital technologies, such as artificial intelligence and virtual reality. One of the 16 testbeds is based at NMIS[52] and brings together specialist technology providers and manufacturers to harness manufacturing data and highlight the accessibility of Industry 4.0 for companies of all size. The Data Lab[53] is leading data science efforts for the Hub and is helping to maximise this opportunity for Scottish manufacturers and others in the Scottish innovation ecosystem as it will engage with them to drive collaboration and access to the innovation fund with a specific focus on SMEs. This will include CENSIS, the National Manufacturing Institute for Scotland (NMIS) and manufacturing sector teams at Scottish Enterprise and Highlands & Islands Enterprise.

Additionally, the Medicines Manufacturing Innovation Centre (MMIC) is also pertinent to manufacturing as it too can advance the application of AI specifically within pharmaceutical manufacturing. Again, collaboration between, for example, regional healthcare innovation test beds, the Digital Health & Care Innovation Centre and the MMIC could accelerate implementation of AI into clinical practice.

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[50] https://www.gov.scot/policies/manufacturing/

[51] https://smdh.uk

[52] https://www.nmis.scot/what-we-do/collaborative-projects/smart-factory-innovation-hub/

[53] https://thedatalab.com/news/data-science-delivery-manufacturing-innovation-hub/

4.4.5 Gaming

Scotland is one of the top games and software developer locations in the world and has a reputation for being a pioneer and leader in gaming innovation. There are also a number of expert support organisations including, for example, Creative Scotland, Scottish Game Developers Association, The Scottish Games Network and the Scottish Animation Network all of whom strive to support the growth of the sector. Scotland's games studios are pioneering in the use of data to enhance user experiences, observe player behaviours and drive monetisation. This makes it a sector which offers huge cross-functional value and can support other industry verticals; however, there is a need to foster, encourage and support greater links between the games industry and the wider tech community to realise the full potential of AI and gaming.

4.4.6 Agriculture and Land Use

There is evidence of AI penetrating the agriculture and land use markets, deployed for a range of reasons, including harnessing earth observation data to make decisions about sustainable land use, vertical farming and precision farming solutions enabled by AI, and forestry and land mapping services that support carbon sequestration.

Sector organisations like the Scottish Agricultural Organisation Society (SAOS)[54] have prioritised climate change and recognise the importance of making farming practices smarter, more efficient and sustainable. Projects are already active in this area, such as the CarbonPositive[55] platform which is spearheaded by SAOS together with the James Hutton Institute and Forest Research and aims to collate data on carbon sequestration and natural capital to identify the level of environmental asset being managed on-farm at both national and individual farm level. AI can play a role in such projects, helping capture and analyse emissions data to support the transition to net zero in our farming and land use sectors.

4.5 Prioritisation of Opportunities

Based on the analysis carried out in this study, a number of AI opportunities have been identified for Scotland. These have been assessed using the criteria detailed in the following table.

[54] https://saos.coop/

[55] https://saos.coop/what-we-do/carbonpositive

Criteria	Description	Scoring		
		5	3	1
Market Growth	Predicted future growth in demand	High	Medium	Low
Ease of Market Access	The ability of Scottish companies to access the market	Easy	Moderate	Challenging
Time to Market	Timescale for market development	Short	Medium	Long
Scottish Capability	Existing Scottish industry capability	Strong	Moderate	Weak
Ease of Developing Capability	The ability of the Scottish industry to develop relevant new capability	Easy	Moderate	Challenging
Alignment with Strategy	Consistency with ***AI Strategy***	Strong	Moderate	Weak
Alignment with Scottish Assets	Existence and suitability of Scottish infrastructure and other Scottish industries to support growth	Strong	Moderate	Weak

Figure 12: Opportunity Selection Criteria

Using these criteria, the ***most attractive opportunities*** (highlighted) can be presented as follows which could be used by Scottish Enterprise, and partners, to inform, define and drive future actions.

Sector	Application	Market Attractiveness			Capability		Strategic Fit		Score
		Market Growth	Ease of Market Access	Time to Market	Scottish Capability	Ease of Developing Capability	Alignment with National Programmes	Alignment with Scottish Assets	
Health & Social Care	Clinical decision support	5	2	3	3	3	4	5	**25**
	Medical devices	5	3	2	4	4	4	3	**25**
	Clinical diagnosis & treatment pathways	5	2	2	4	3	4	5	**25**
	Pharmaceuticals (drug & vaccine development)	4	1	1	3	3	3	5	**20**
Energy (including net zero)	Space data	5	3	4	5	4	5	4	**30**
	Offshore renewables	4	3	3	4	3	4	4	**25**
	Energy efficiency	4	3	2	4	3	4	4	**24**
	Climate Tech	4	3	2	4	3	4	3	**23**
Financial & Business Services	Customer service	5	2	3	5	4	4	4	**27**
	Fraud detection	4	3	2	4	4	4	4	**25**
	Risk management	4	3	2	4	4	4	4	**25**
	RegTech	4	1	1	3	3	4	3	**19**
	Automation & trading	4	1	1	2	3	4	3	**18**

Figure13: Prioritisation of Opportunities

5 Key Partners, Organisations and Networks

The Scottish AI capability database has more than 70 research, academic and support stakeholders listed which provides a starting point for developing partnerships within Scotland. There are, however, organisations out-with Scotland that also merit engagement including, for example:

- The Alan Turing Institute – advancing world-class research into AI, its applications and its implications for society, building on its academic network's wealth of expertise
- JISC – National Centre for AI – accelerating the adoption of AI across the tertiary education sector
- Office for AI – a unit within the Department for Science, Innovation and Technology responsible for overseeing implementation of the National AI Strategy

- NHS AI Lab – the lab is accelerating the safe adoption of AI in health and care, and also hosts a community of practice (NHS AI Virtual Hub) for people to interact and share knowledge and ideas about AI technology in health and social care
- Deloitte AI Institute – the institute will help organisations transform with AI through cutting edge research and innovation

As indicated throughout the body of the report, there are opportunities for collaboration between organisations that could potentially advance and accelerate AI-based R&D and innovation; thus, leading to greater levels of understanding across sectors as well as improved levels of adoption.

6 Conclusions

This study has assessed the AI landscape including the current scale and market / demand-side opportunities which can help Scottish Enterprise, and partners, to define and drive future actions. Key conclusions are:

- The Scottish AI landscape comprises more than 220 companies and 70 research, academic and support stakeholders.
- Companies are typically located within Edinburgh and Glasgow which is unsurprising given Edinburgh's related data science capabilities.
- Machine learning is the major capability field within the Scottish landscape but there is evidence of capability in all other subfields (i.e., NLP, computer vision, cloud, speech and audio, and deep learning) albeit to a much lesser extent.
- Almost half of the company base (44%) target multiple – or 'Various' – markets, whilst health (21%), agriculture and land use (7%), financial & business services (6%), energy (5%) and creative industries (4%) follow as the key target markets; there are 11 other markets targeted by the remainder of the company base.
- Most universities in Scotland are active in AI-related research but, in particular, the University of Edinburgh, University of Glasgow, University of Aberdeen, University of Dundee, University of Strathclyde and Heriot-Watt University.
- Scotland compares relatively well internationally. Areas of particular strength include government leadership and strategy and data and infrastructure while weaknesses include digital capacity and adaptability.
- Scotland's strengths and its ambitions are well aligned with key market opportunities including:
  Health & Social Care
  Scotland's AI capabilities can be capitalised and deployed to support:
    - Clinical diagnosis & treatment pathways
    - Clinical decision making
    - Development of medical devices
    - Development of pharmaceuticals (drug & vaccine discovery and development)

  Energy (including net zero)

  Scotland's AI capabilities can be utilised to support Scotland's transition to a net zero economy through:

    - Satellite imagery and earth observation data processing (space data)

- The application of climate technology
- Transforming efficiencies within offshore renewables
- Improving energy efficiency in buildings

Financial & Business Services

Scotland's AI capabilities can be applied to:

- Enable fraud detection
- Support risk management
- Improve customer service
- Facilitate automation & trading
- Develop RegTech

- Additional market opportunities also exist within manufacturing and gaming this is because these industries offer huge cross-functional value and support to other industry verticals. Additionally, AI applications within agriculture and land use affords multiple deployment opportunities.

Overall, it is considered that AI is nascent in Scotland, but the foundations exist to enable Scotland to exploit AI opportunities; therefore, Scotland is in a good position to pursue attractive growth opportunities, as described in section 4.4. Additionally, at a UK level the recent UK government announcement of an expert AI taskforce with an initial £100 million in funding to help the UK build and adopt the next generation of safe AI further demonstrates both the UK Government's commitment to the AI sector and the potential opportunities the technology affords the economy[56]. Furthermore, the recent announcement of Innovate UK's AI Funding and Support Programme, BridgeAI[57], which aims to provide £100 million in funding to AI innovators to develop new, trusted AI services and technologies for businesses, also highlights opportunities. The funding is targeted at four high growth potential sectors including agriculture, construction, transportation, and the creative industries due to the transformative change that could be realised with AI adoption. Both the expert taskforce and the funding and support programme can also be utilised to advance Scotland's capabilities and foster sectoral growth.

A number of action areas have been identified to support and optimise AI capabilities in Scotland, namely:

- Collaboration – cross-sectoral as well as triple helix (industry, academia, public sector) collaboration could advance Scotland's AI capabilities and also enable organisations to capitalise on the opportunities it affords for product and service development, optimisation, efficiencies and cost benefits. There is an appetite for collaboration and shared knowledge and exchange which is already being supported by The Data Lab as it is tasked with encouraging triple helix collaboration. But, Scottish Enterprise and its partners could, for example, drive further

56 https://www.gov.uk/government/news/initial-100-million-for-expert-taskforce-to-help-uk-build-and-adopt-next-generation-of-safe-ai

57 https://iuk.ktn-uk.org/programme/bridgeai/

collaborative by organising a series of networking / matching-making events supported by related funding calls to enable collaborative research and development to be realised.

- Awareness – despite the hype and buzz surrounding AI there remains a need to increase awareness of the potential applications and benefits, particularly at senior levels within organisations and government. The Scottish AI Alliance already make a selection of resources available via its website, but perhaps there are opportunities to work with sectoral organisations to develop sector-specific case studies to demonstrate applications and outcomes. Likewise, initiatives such as, for example, Living with AI[58] and Driving Value from AI[59] aim to increase awareness and these could also be used as a base to build upon to raise awareness.
- Governance & Ethics – although Scotland scored comparatively well internationally, in terms of governance and ethics the acceleration of AI developments requires continuous review and development of frameworks, standards and ethics to ensure AI solutions can be deployed in an ethical, transparent and trustworthy manner. Scottish Government can play a key role in developing these frameworks, particularly the Digital Ethics Expert Group. Additionally, Scotland could provide input to the development of global standards by engaging in the work of The Alan Turing Institute.

[58] https://www.scottishai.com/living-with-ai

[59] https://learn.thedatalab.com/courses/driving-value-from-ai

Appendix A: Sector Engagement – Participants

Please note that due to GDPR restrictions only the organisation names are included below:

	National Programme Focus	Organisation
1	Digital Scale Up Level Up	Fintech Scotland
2	Energy/Net Zero	Scottish Enterprise – hydrogen
3		Scottish Enterprise – climate tech
4		OREC
5	Transport	Open Transport Initiative
6	Health for Wealth	Medicines Manufacturing Innovation Centre
7	Scotland in Space	Scottish Enterprise

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