The Nordic State of AI

The 2021 Report

SILO.AI

Contents

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INTRODUCTION

This is the emergence of an annual, Nordic-level report about the region's state of AI. With three goals in mind, we aim to provide a comprehensive overview of the Nordic AI market, enrich conversations around the topic by narrowing the knowledge gap and catalyze new opportunities by bringing the Nordic communities closer together.

The report starts with a summary of key findings, followed by insights for each country. The country analysis contains an overview of the state of AI in the respective country, PESTEL analysis, deep dives in implementation, R&D, education, and talent. While shedding light on the peculiarities of each country, we also aim to identify the common trends found in a multitude of research papers, other publicly available publications, as well as expert interviews.

As the first annual report of hopefully many future ones, this report could not have been possible without all of our contributors: Silo AI, Aalto University & ITP project, AI Sweden, Amesto NextBridge AS, Business Finland, Copenhagen Capacity, Datapult AI Consultancy, Digital Norway, Finnish Center of AI, Finnish Ministry of Economic Affairs and Employment in Finland, Fremtind Insurance, Halmstad University, KTH Royal Institute of Technology, Maki.vc, Nordic Ninja, Norwegian University

of Science and Technology and Technology Industries of Finland.

We hope you find this report insightful and inspiring while having an eye-opening reading experience about the current Nordic state of AI.

Alexander Törnroth
Lead at First AI Accelerator, by Silo AI.

1- The Nordic State of AI

Key findings

INTRODUCTION TO NORDIC STATE OF AI IN BUSINESS

Artificial Intelligence (AI) will be increasingly important for businesses throughout industries trying to compete by being efficient, responsive, and relevant. So far, the main driver for businesses to adopt AI has been competitive pressure: trying to match competitors' investments in order to keep up with the competition. The upward trend in companies not only utilizing AI but also building their activities and business models around AI is embarking at a rapid pace. This makes AI a key strategic asset for companies of all sizes, rather than a supporting technology in the background that it still was some years ago. The estimate is that almost EUR 70 billion in value can be unlocked in the Nordics by applying AI technologies that are known already today[1].

According to McKinsey & Company (2019), most companies are currently in the early stages of AI adoption, but there is a good starting point for developing leading-edge capabilities incorporating AI-solutions in businesses. Nordic key enablers are educated citizens and digital maturity, agile workplaces and a positive attitude towards AI and innovation. The region's disadvantages are its small size in scale and tech clusters.

The short-term AI opportunities for companies relate to increasing productivity and customized solutions for customers. Meanwhile, the main challenge involves finding and retaining appropriate talent for using AI-enabled solutions[2]. Despite the Covid-19 pandemic, hiring AI-talent has continued to grow again after a dip in 2020[2].

As the use of AI and automation increase, the skills sought after in the workforce change as well. The need for technological skills is estimated to increase, representing up to 17 percent of hours worked by 2030, including both basic digital skills as well as programming and other high-level technical skills[3]. This will require significant organisational changes, including emphasis on continuous learning of employees: employees can be upskilled through internal programs to match the new requirements. This is also one of the strengths of the Nordics, as life-long learning and degrees are highly valued[4].

1. Østergaard et al., 2019 2. Global AI Talent Report 2020 3. Zhang et al., 2021 4. Bughin et al., 2018

KEY FINDINGS - OVERVIEW

Global level

■   All Nordic countries are placed in the top quartile for AI readiness by McKinsey

■   All Nordic countries are ranked in the top10 by Oxford Insights on Government AI Readiness Index. Only US and UK topped Finland, followed by Sweden (5th), Denmark (8th) and Norway (10th). Strengths are a high level of digitalization, skilled workforce, as well as data quality, accessibility and transparency.

■   According to the Global AI Talent study, roughly 2 percent of the worldwide AI talent (Data scientists, Researchers, Data Engineers etc.) seem to reside in the Nordics, Sweden being the largest talent pool.

Govermental level

■   Nordic countries share a unified take on ethical use of AI and prioritization of human wellbeing with AI. However, the lack of joint "Nordic vision", leading to a loss of collaboration possibilities.

■   During 2021 there has been a shift of focus to increase adoption of AI in SMEs1 in all Nordic countries.

■   Level of funding (both public and private) for AI initiatives differs significantly across the region with

Organizational level

■   As of today, over 24000 Nordic organizations are experimenting with AI, of which 4359 organizations are considered to use AI in their day-to-day business.

■   The more advanced Nordic organizations use AI in their core functions, such as Products and services and R&D, creating competitive advantages.

■   The most common obstacles using AI are lack of time and money, and challenges related to data and scaling.
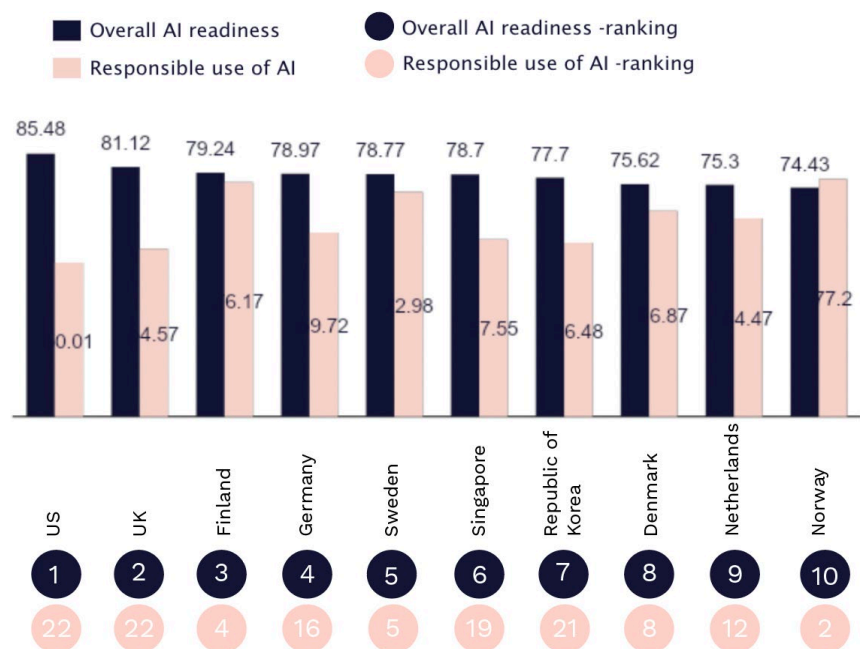
AI INDEX COMPARISON

According to the Government Artificial Intelligence Readiness Index in 2020, the Nordics are well-positioned within top 10 in both overall AI readiness and in the responsible use of AI. Breakdowns of each country can be found in the country-specific sections. All countries' strengths in overall AI readiness were vision, in which all countries scored full 100 points as well as data

Figure 1: Artificial Intelligence Readiness Index Rankings, 2020

Source: Oxford Insights, 2020

representativeness with an average of 96 points across countries. Other strong areas were data availability (90p) and infrastructure (80p). The biggest weakness throughout the countries was the size, which averaged to 37 points.

In terms of responsible use of AI, the Nordics were almost equally strong in privacy, inclusivity, and transparency. Accountability was all countries' core strength with an average of 83 points. The first one in the responsible use of AI -ranking was Estonia with ~80 points.

It seems scoring high on both the overall AI readiness and the responsible use of AI is a difficult task for any country. Since Nordics are doing particularly well in both, it implies that Nordics share a very similar value system even when it comes to AI adoption. Utilizing these common advantages even more in the future will enable increasing AI implementation rates, attracting more investments and building better and more inclusive solutions for the international markets.
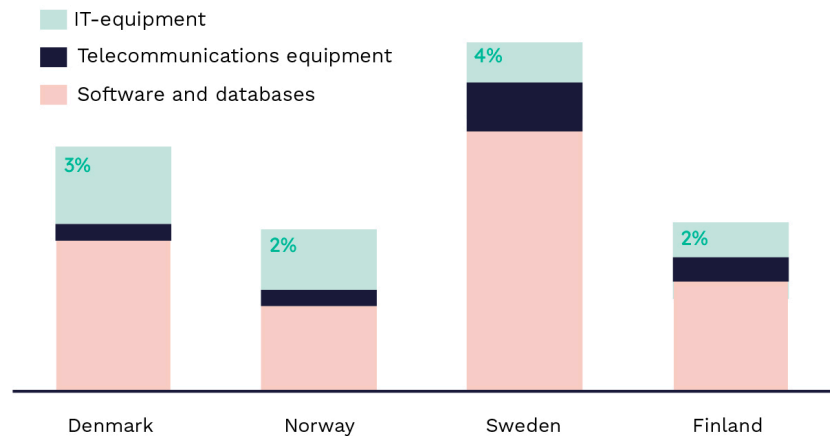
Nordic Investments

All of the Nordic countries have relatively high investments in AI and ICT. ICT investments do not directly give us investments in AI, but do give some indication of the general investments in technology. As a percentage of its GDP, Sweden has the highest investments in ICT, with a particularly high share of investments into software and databases.

According to Eurostat, Denmark had the highest AI investments per capita in the EU, with 42,7 euros. Finland had the 3rd largest investments with 36,4 euros followed by Sweden with 27,6 euros. Finland and Denmark had higher investments in the category

Figure 2: ICT investments as a percentage of the GDP, 2017

Legend:
- IT-equipment
- Telecommunications equipment
- Software and databases

Denmark: 3%
Norway: 2%
Sweden: 4%
Finland: 2%

Source: Ministry of Economic Affairs and Employment, 2021

Figure 3: AI-Investments per Capita (€) in the selected EU Member States, 2018

Denmark: 42.7
Ireland: 36.6
Finland: 36.4
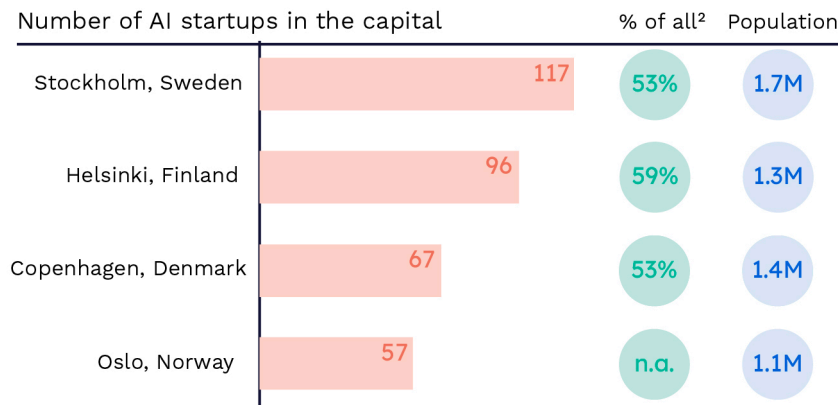Sweden: 27.6
Netherlands: 24.3
Austria: 23.4
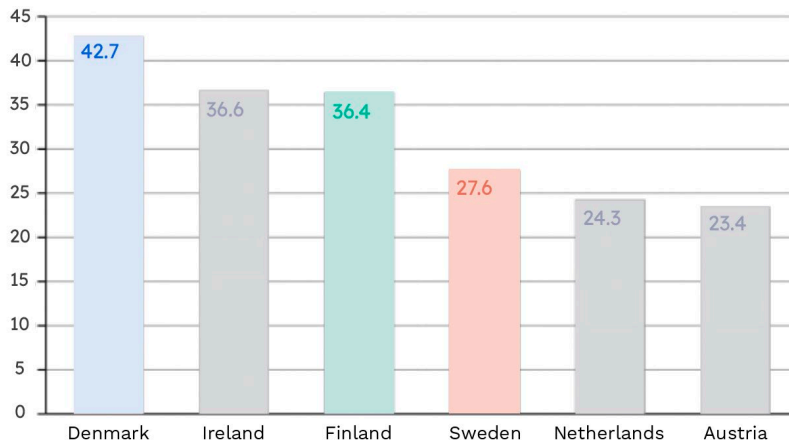
Source: Ministry of Economic Affairs and Employment, 2021

"Talent, skills and lifelong learning" with 77,42 and 70,96 percent respectively, whereas Sweden invested only 30,1 percent in the same category. However, Sweden invested a higher share of 45 percent in "Data, technology and Infrastructure", where Finland invested only 11,6 and Denmark 21,85 percent.

AI Startups & Policy Instruments

Figure 4: AI-Startups in the Nordic Capitals, 2021

Number of AI startups in the capital   % of all²   Population

|			
Stockholm, Sweden	117	53%	1.7M
Helsinki, Finland	96	59%	1.3M
Copenhagen, Denmark	67	53%	1.4M
Oslo, Norway	57	n.a.	1.1M

Source: Statista; OECD.AI Policy Observatory, 2021

Most AI startups are located in the Nordic capitals of where research institutions and universities gather. The Nordic startups are considered equal in terms of investments.

Certain industries might be over-represented and business models might vary, but the core technology and founder teams are great throughout the Nordics[1].

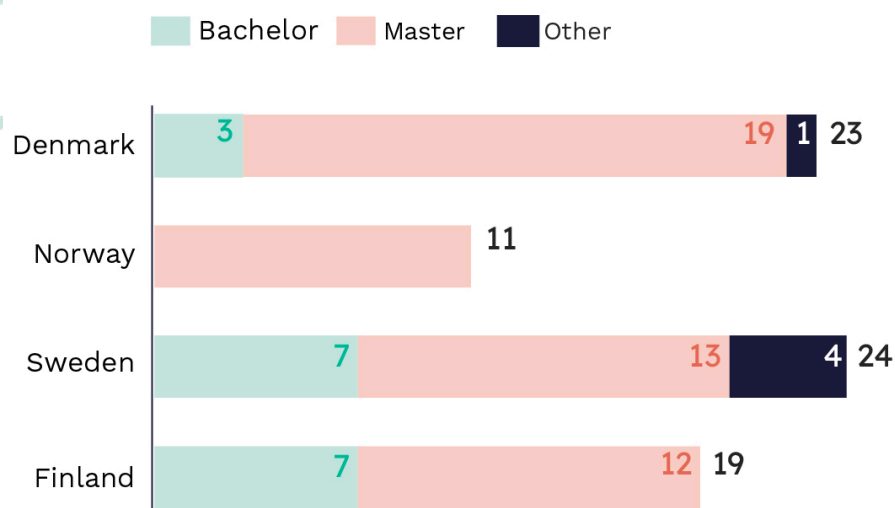*Figure 5: Policy Instruments by Number of Instruments and Budget Category by Country, 2021*
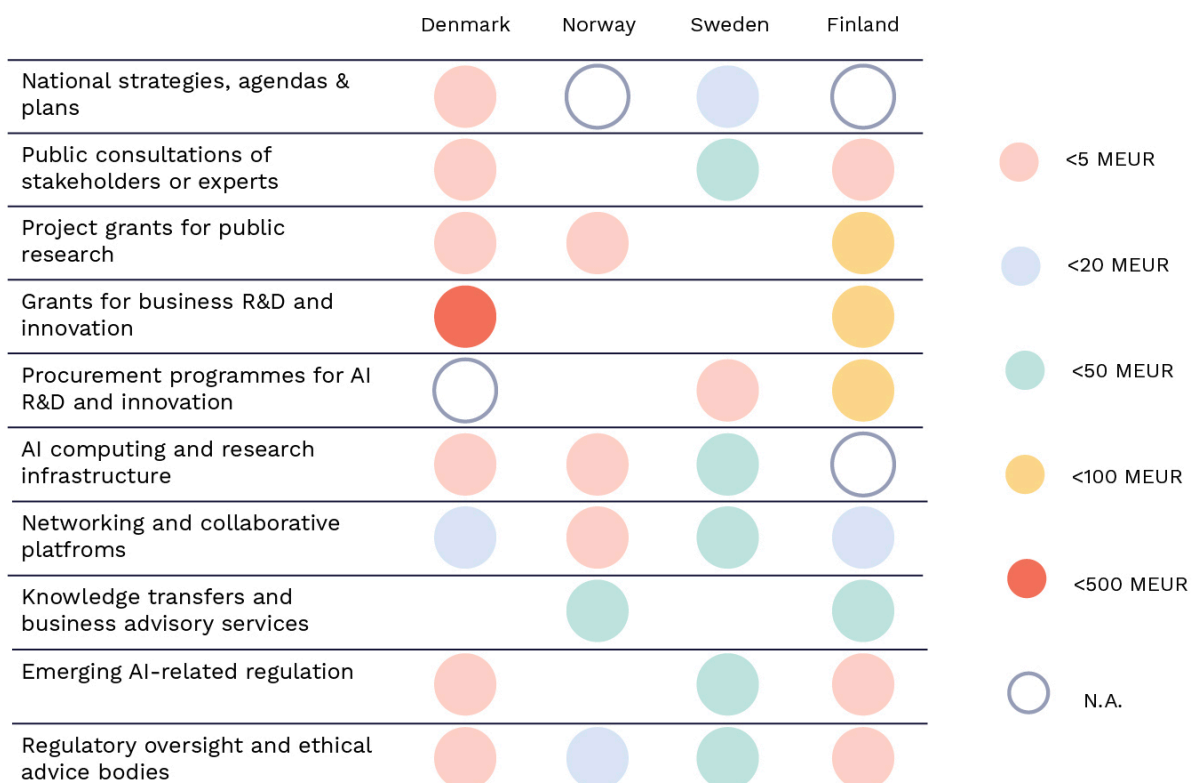
Source: Ministry of Finance & Ministry of Industry, Business and Financial Affairs, 2019; OECD. AI Policy Observatory, 2021

1. Expert interviews 2. % of startups located in the capital area of total startups in the country

Educational Programs

Sweden, Denmark and Finland have been successful in rolling out AI-specific educational programs in all degree levels, a trend that Norway is likely to follow. Although the number of specialized AI programs is not the only indicator of a job well done, it does enable comparison between the countries. Denmark and Finland offer the largest number of specialized programs per capita, followed by Sweden and Norway. It should be noted that the number of programs does not capture the essence of qualitative education and there is no evidence that the number of programs should be increased.

Figure 6: Number of Specialized AI Programs in Nordics, 2019-20

Bachelor   Master   Other

Country	Bachelor	Master	Other	Total
Denmark	3	19	1	23
Norway		11		11
Sweden	7	13	4	24
Finland	7	12		19

Source: Stanford University, 2021

All four countries also offer the *Elements of AI*–online course in their native languages. The course aims to provide all citizens a basic understanding of AI, combining theory with practical experiences. The first industry-specific AI course *AI for Built Environment* was published in Finland in November 2021, continuing the tradition of vastly successful online courses provided free of charge.

Figure 7: Number of Specialized AI Programs, 2019-20
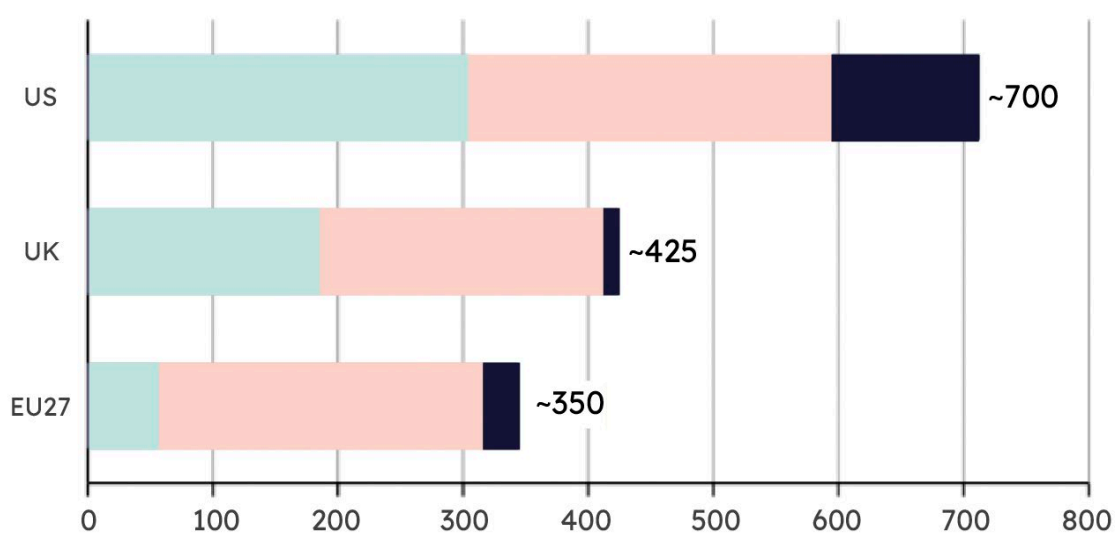
Source: Stanford University, 2021

In Sweden, the national *AI Competence for Sweden* -initiative was launched to improve and develop the education and competence of AI in Sweden. In the initiative, ten universities collaborate and offer a knowledge platform where interested parties can find information about educational AI-opportunities.
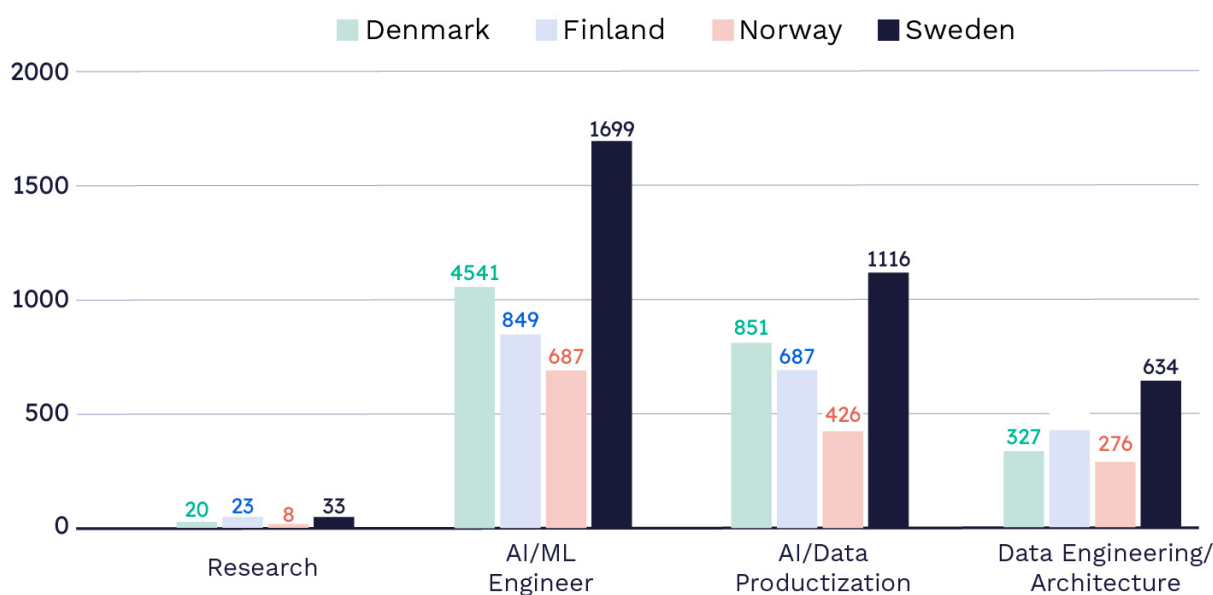
Talent

The Global AI Talent Report 2020 looks at the talent market on a global scale. The report lists the size of the talent pool for the following technical roles that make up the value chain of developing an AI product: Research, AI/ML Engineer, AI/ML Productization and Data Engineering/Architecture.

The size of the talent pool is determined by data from social media which, in turn, is based on titles (e.g. "data scientist" and keywords for skills (e.g. "machine learning" + "tensorflow"). In total, the report counted 477.956 people worldwide.

When comparing the Nordic talent numbers to the worldwide we can see that all titles makeup close to two percent of the total talent pool. AI/ML Engineers tops the list, maybe not that surprisingly due the region's long history of engineering.

Figure 8: Talent in the Nordics by role

Source: Calculated by FAIA, based on numbers from the Global AI Talent Report 2020.

When looked at differences on country level it seems that the talent pool in Sweden is by far the biggest while Norway being at the opposite end. The low number of researches is due to the fact that the data only represents those researches who continue to research professionally in the private sector (worldwide approximately 4000 people).

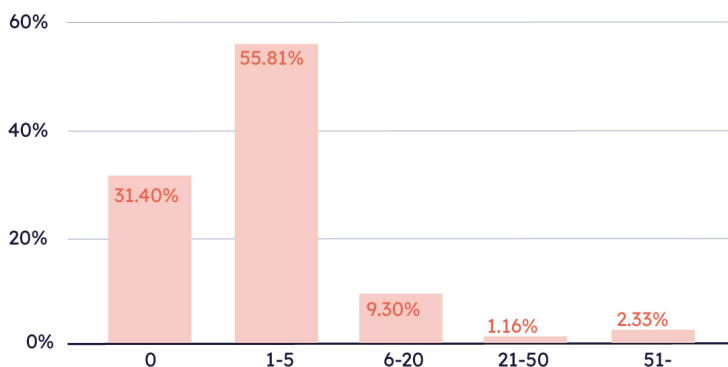According to the Global AI Talent Report

Figure 9: Nordics as % of total talent worldwide
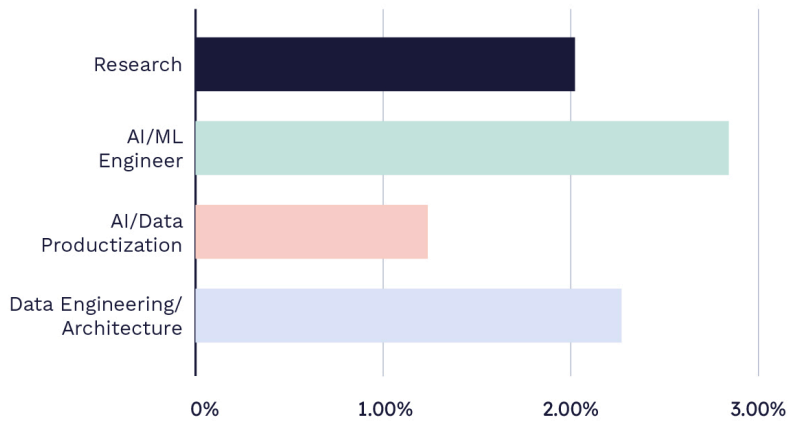
Source: Calculated by FAIA, based on numbers from the Global AI Talent Report 2020.

~70% of companies using AI aim to recruit more talent within the next year.

Figure 10: How many people do you intend to recruit within the next 6 months
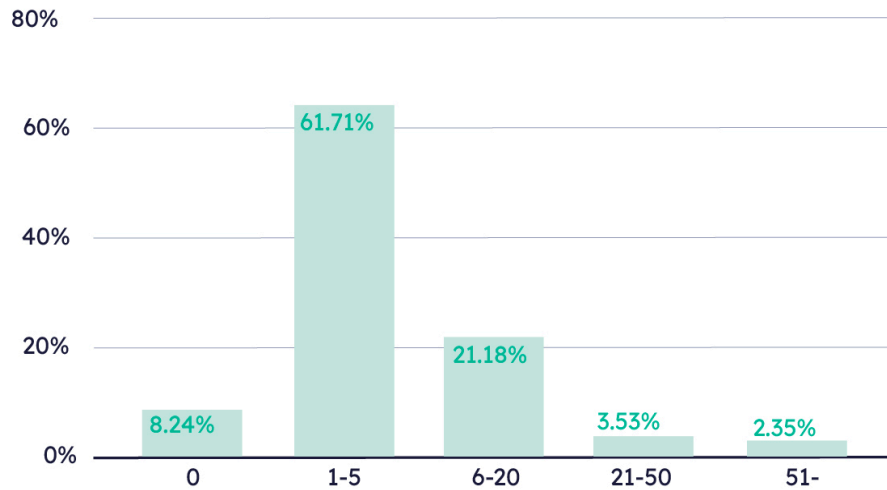

Source: Nordic State of AI 2021 Survey, FAIA

2020, the demand for skilled technical people was stable pre-2020, but fell 20-30% during the pandemic. Especially the demand in Sweden seem to have taken the biggest hit, while Norway and Finland are somewhat of outliers.

Our own survey shows, that most of the companies using AI on daily basis have small teams of tech experts, as almost 65% of the companies only have 1-5 employees whose main tasks relate to working with AI. The data is not showing any major variance between the Nordic countries.

There seems to be a shift of talent demand

Figure 11: Number of employees focusing mainly on ML/AI

Source: Nordic State of AI 2021 Survey, FAIA

at the end of 2021, whereas most companies aim to recruit additional tech people within the next 6 month. The amount of new recruits is planned to be kept low as 56 percent of the organization aims to recruit 1-5 more people. However, when you take into account the initial team size this would mean a considerable increase as AI team size would double in most organizations.

The survey organizations represent mostly SMEs and startups, explaining the small team sizes.

Use of AI

To understand the use of AI within Nordic organizations we used a model developed by researchers organization ETLA. For comparable numbers we utilized Vainu.io data to determine the total number of organizations using AI. Vainu data is collected from an organisations external communication channels based on selected keywords (e.g. "machine learning", "deep

Figure 12: Nordic Organizations utilizing AI
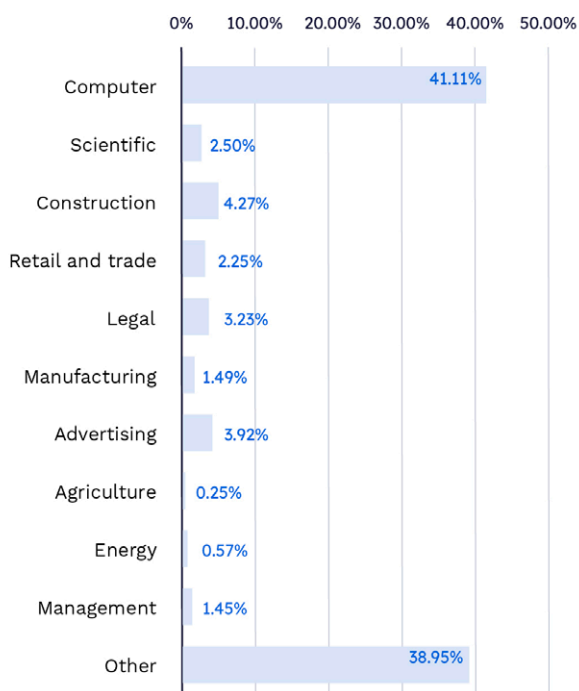
Source: Nordic State of AI 2021 Survey, FAIA

learning"), in other words: if an organisation have used any of the selected words it will merge on the list.In total, we counted 24.820 organizations in the Nordic (see figure 12), whereof the majority (ca.68 percent) is headquartered in Finland and Sweden.
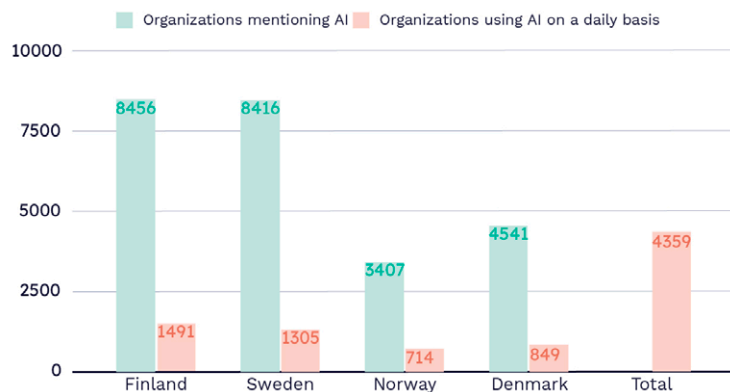

Figure 13: AI Implementation by number of companies in top 10 industries, 2021

Source: Nordic State of AI 2021 Survey, FAIA

Each of the ca. 25 thousand organisations were then analysed to determine whether it is using AI on a daily basis, taking into account criteria such as products and services, team composition and expertise, as well as size of the organization. Organisations who do not meet these criterias are deleted, group companies are aggregated (eg. H&M may have several subsidiaries but is counted as one), and organizations which are not headquartered in the Nordics are also deleted. **In total there are 4359 organisations who use AI on a daily basis.** The numbers includes both firms that develop AI technologies as well as firms that utilize AI. It does not take into account all firms who had run minor pilots, in such a case the number would be significantly higher.

Figure 14: Use of AI per organisational function
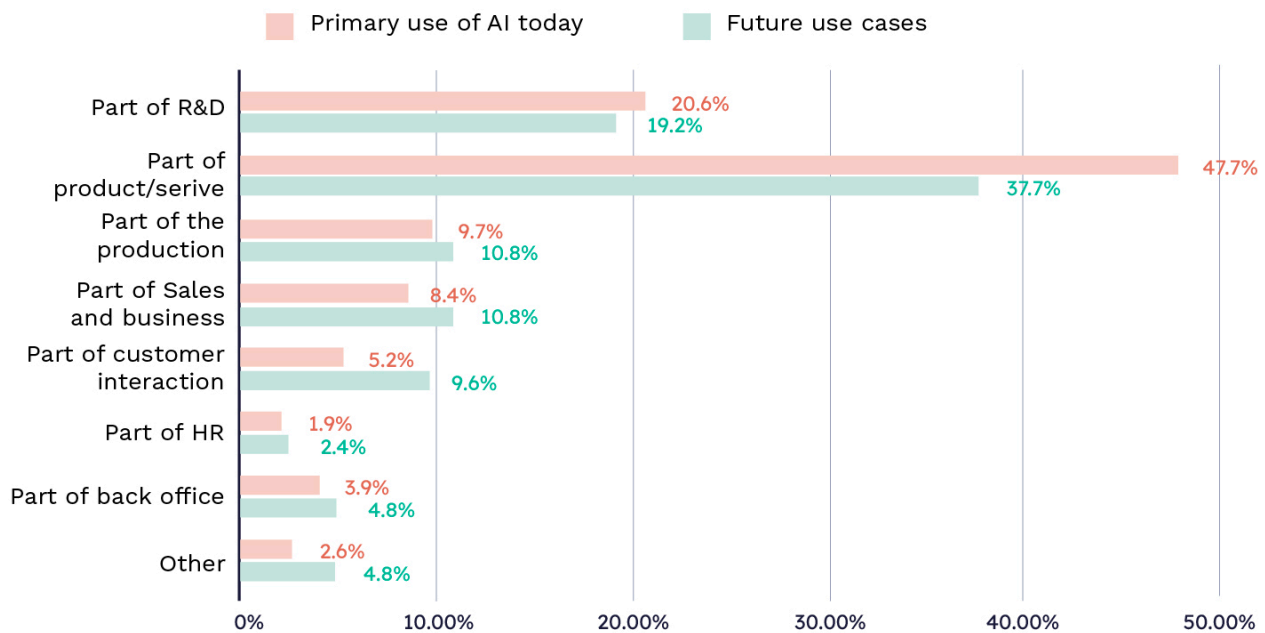
Source: Nordic State of AI 2021 Survey, FAIA

Also, when we examine AI implementation in industry (figure x), based on the Vainu data, we can see that, unsurprisingly, "Computer Engineering, Software and IT" stand for the biggest chunk, but more interestingly the use AI is thereafter distributed evenly between industries ranging from Construction & Engineering to Manufacturing and Management Consulting. Surprisingly "Health" as a industry do not make the top 10 although considered by many as one of the strong suits of the region.

What is interesting is that investments in AI seem to compound to a small number of organizations. This finding is rather worrisome, as AI could be a factor seen to increase the knowledge gap, or the digital divide, between organizations.

Looking into application of AI in Nordics, the main story of 2021 is not so much any specific industry or use case as is the breadth of activity and a clear transition into more confident AI investments. **During 2021, Nordic companies gained significant steam in applying AI, with many industry flagships moving on from exploratory use of AI and strategy work into scaling the use of AI** and focusing on cost efficiency of the development programs with MLOps investments.

On another positive note, Nordic organizations seem to leverage AI withincore functions, especially Part of product and services (47,7 percent) and R&D (20,6 percent). This is significant because, in theory, investing in R&D as well as product and services should increase competitiveness. These are also most certainly tailor made solutions and therefore harder to mimic and copy by others, compared to using somewhat ready solutions for example in customer care.

*Figure 15: Future investments into AI*

Do you think that you will see more AI related technologies in your company within the next 12 months?

No
10.6%

Yes
89.4%
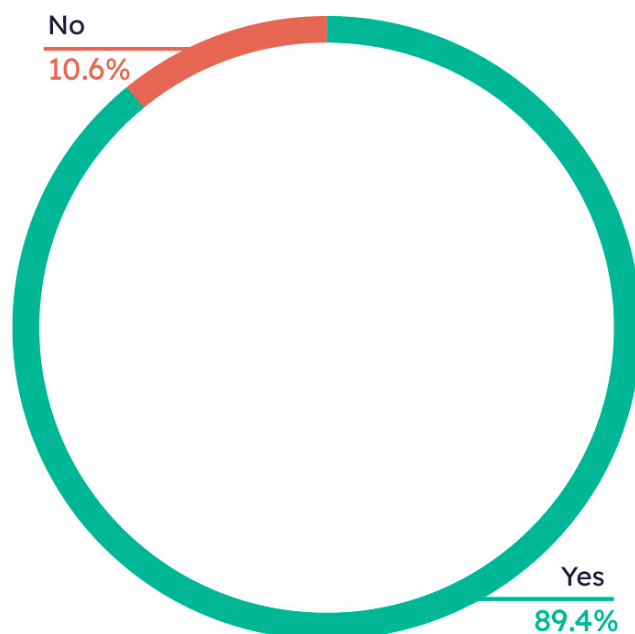
Source: Nordic State of AI 2021 Survey, FAIA

Surveyed companies intend to keep on investing in different AI technologies, as almost 90 percent think they will see more solutions in their companies within the next 12 months. Future investment also seem to flow towards R&D (19,2 percent) and Product and Services (37,7 percent). This trend, and increased investment, brings AI into a more strategic role in companies. On the other hand, these product initiatives often take AI into more challenging internet-of-things or embedded system contexts and to using less structured sensor data, increasing the need for broader and cross-functional collaboration around AI.

Figure 16: Obstacles when using AI
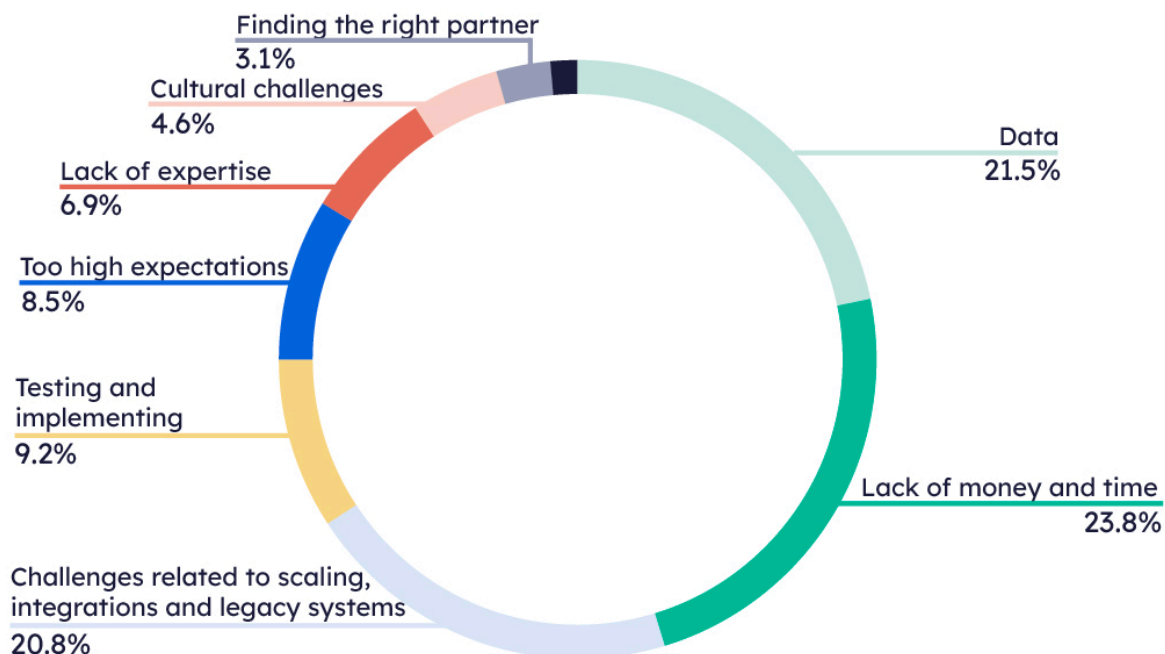
Source: Nordic State of AI 2021 Survey, FAIA

Organizations tend to face different challenges when it comes to integrating AI into operations. In the Nordic State of AI 2021 survey, and the conducted expert interviews, we looked mostly into mid-tier companies and startups and their obstacles.

On a broad note, more companies have clarity on use cases they want to pursue, but lack of resources, such as time and money, and lack of data remains the biggest obstacles.

Compared to last years results (note: last years survey only included companies from Finland) there are clear changes. The most obvious one is that companies nowadays better understand what can be achieved and what are the limitations with AI. However, the rise of "lack of money and time" to be number one obstacle is surprising, as it did not even make top 10 last year.

Another (positive) surprise is the low figure of "Expertise" being an obstacle. One reason for this may be the characteristics of the surveyed companies: they are all companies that use AI on daily basis and therefore expected to have own AI experts within their organizations.

Technology

When examining different AI technologies on a wider perspective the Nordics have always been strong in research, and solutions, related to computer vision and natural language processing (NLP). If looked at one specific global trend - autonomous vehicles - Nordic countries have specific strengths and exceptional experience in the development of intelligence and early autonomy for mobile machines beyond public roads, including e.g. mining and forestry machines and marine vessels.

When taking a more closer look at on what and who's technologies Nordic companies are use different vision and NLP based technologies top the list. All in all companies use a wide range of different technologies as shown in figure 17.
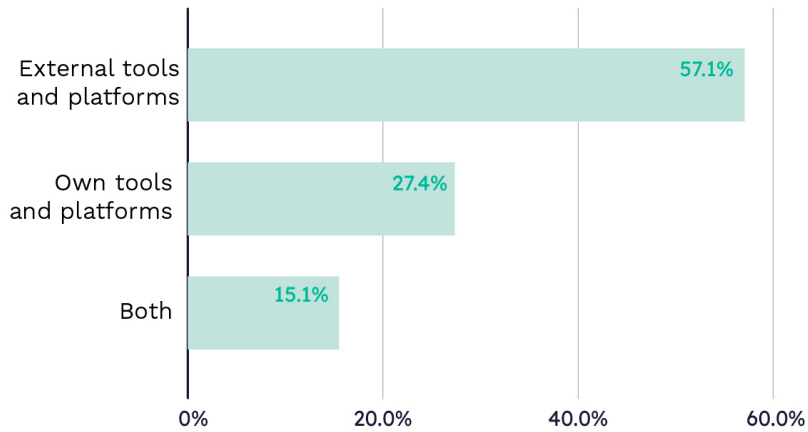
Figure 17: Primary tech you use
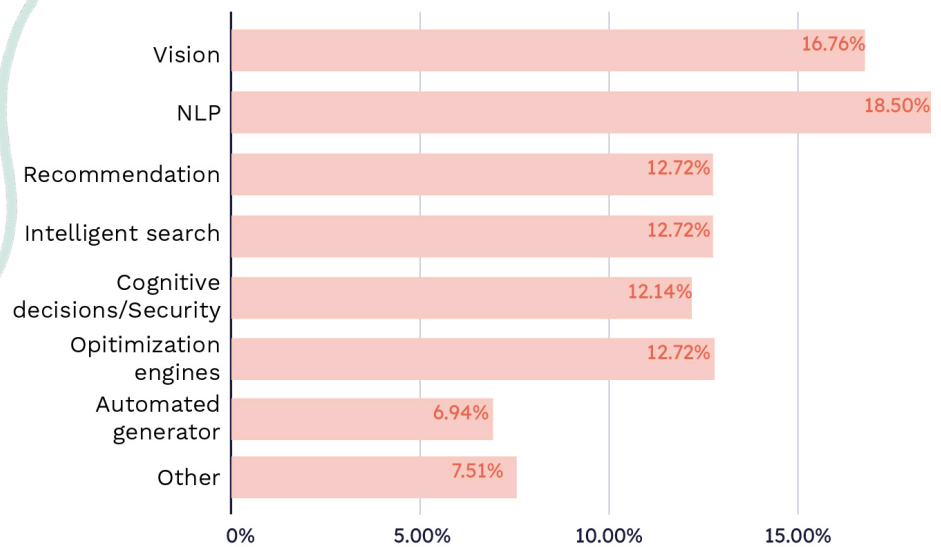
Source: Nordic State of AI 2021 Survey, FAIA

Figure 18: Tools used when developing AI

Source: Nordic State of AI 2021 Survey, FAIA

Considering different tools and platforms used when utilizing and building AI, most companies seem to exploit external ones, such as the ones from Google and AWS for an example (figure 18).

Further, when taking into account the range of AI utilized in Product and Services, as well as R&D, it does not come by as a surprise that almost a third of companies rely on tools and platforms they have created themselves. This may reflect how smaller players plan to build competitive advantage through their own customized tooling, but also the challenge in producing tooling that scale beyond the simpler AI use cases.

Research

Privacy in AI use has always been a topic close to Nordic interests. The past year has not only highlighted its need but also elevated the concerns to a broader context. First, the upcoming EU regulation brings attention to dataset fairness and sets requirements for AI practitioners to not only consider personally identifiable information but understand and manage their datasets as a whole. Another challenge comes from monitoring AI model quality during the increasingly large-scale operational use of AI. These topics fit well with traditional Nordic values and high-end engineering expertise, but they've also become acute issues for AI practitioners in need of academic answers.

As another dilemma for AI research in smaller nations and research centers, building ever larger and more expensive AI models have become the enabler of key advances not only in AI for natural language but with computer vision and reinforcement learning. Should our response be national, Nordic, European, or push for and allow progressive privatization of AI research?

Accessibility of AI research is not the only area where the need for collaboration among the like-minded is being highlighted. 2021 has become the watershed moment for researchers and practitioners in acknowledging how AI may be used for offensive and defensive purposes. Beyond securing AI itself, AI is enabling novel attack vectors to not only new digital innovations but to physical equipment deployed decades ago.

Nordic companies have generally been at the forefront of investments into data collection and processing. But now as AI algorithms are driving new product initiatives, these algorithms are also setting disruptive new requirements for system design and data capabilities. For example, products with hardware are being augmented with novel AI features, but how to design the hardware and data now so that future algorithms can be deployed on them in 3 years' time and upgraded across long product lifetimes? A key challenge for early data innovators in Nordics is in leveraging their strong talent base and avoiding stranded investments and data assets while upgrading their technology to enable current and especially future AI use cases.

² ⁻ Country Reports
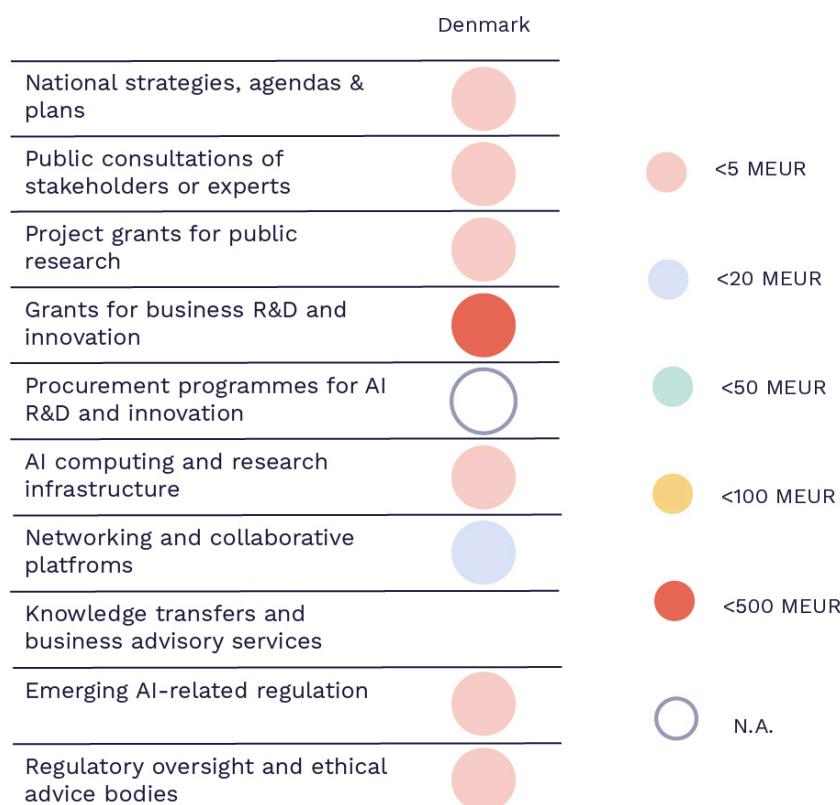
Denmark, Norway, Sweden
Finland

DENMARK

As one of the most digitised countries in the EU, Denmark offers great opportunities to test and apply new technologies. Although Denmark scores high in global surveys looking at "Digitalisation", there is a lack of direct investments in AI and AI ecosystem building, as well as shortage of AI specialists.
In 2019 Danish Government launched National Strategy for Artificial Intelligence that contains 24 initiatives across the public and private sector aimed at strengthening the development and use of artificial intelligence in Denmark. In 2018, the Danish Government has also launched a Strategy for Denmark's Digital Growth. All in all, the strategy allocates 1 bn. DKK for initiatives running until 2025.

By 2025, the vision is to be a world leader in responsible and ethical use of AI – where the right to privacy, security and transparency takes first place.

The strategy includes several initiatives, such as Principles for responsible development and use of artificial intelligence, Common Danish language resource, Signature projects in the public sector, more open public-sector data for artificial intelligence and stronger investment in Danish businesses. Policy includes various instruments such as national strategies; consulting; grants for research, R&D and innovation; awareness campaigns; data sharing; networking and others (Figure 19).

Figure 19: Policy Instruments by Amount and Budget, 2021

Denmark

National strategies, agendas & plans

Public consultations of stakeholders or experts

Project grants for public research

Grants for business R&D and innovation

Procurement programmes for AI R&D and innovation

AI computing and research infrastructure

Networking and collaborative platfroms

Knowledge transfers and business advisory services

Emerging AI-related regulation

Regulatory oversight and ethical advice bodies

<5 MEUR

<20 MEUR

<50 MEUR

<100 MEUR

<500 MEUR

N.A.

Source: Ministry of Finance & Ministry of Industry, Business and Financial Affairs, 2019; OECD.AI Policy Observatory, 2021

Overview

Figure 20: Denmark's Ranking in Digital and AI-Adoption Among OECD and European Countries

✓ Strong position on parameters related to the first wave of digitalization

— Weaker position on the next wave of digitalization

1 Use of digital public systems	8 Diffusion of big data and AI technology
1 Digitalization of business	8 AI readiness
1 Citizens view of AI	8 Goverment AI readiness
2 ICT-specialist skills	
3 Technology rediness	
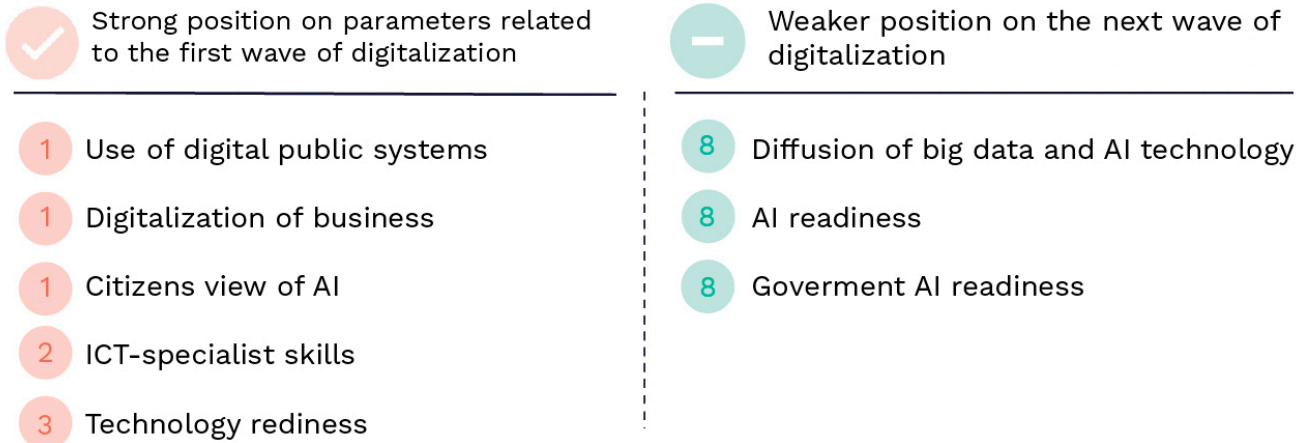
Source: McKinsey&Company Report, 2019; European Commission, OECD.AI Policy Observatory, 2021, Oxford Insights, 2020

Denmark has a extremely strong focus on the development of responsible artificial intelligence. There are two working groups – Denmark Disruption Council and Data Ethics Council. Danish AI strategy priority areas are Healthcare, Energy and utilities, Agriculture and Transport.

The main research organizations are The Artificial Intelligence Centre (SCIENCE AI Centre), IT University of Copenhagen, Danish Centre for Applied Artificial Intelligence, Copenhagen Natural Language Understanding Group (University of Copenhagen). There are several active initiatives in the Danish AI sector today -Denmark national strategy for Artificial Intelligence, Denmark Digital Hub, Data Ethics Toolbox, Denmark as member of the EUREKA Clusters AI, Declaration on AI in the Nordic-Baltic region.

FOCUS AREAS FOR AI IN DENMARK

- A responsible foundation for artificial intelligence

- More and better data

- Strong competencies and new knowledge
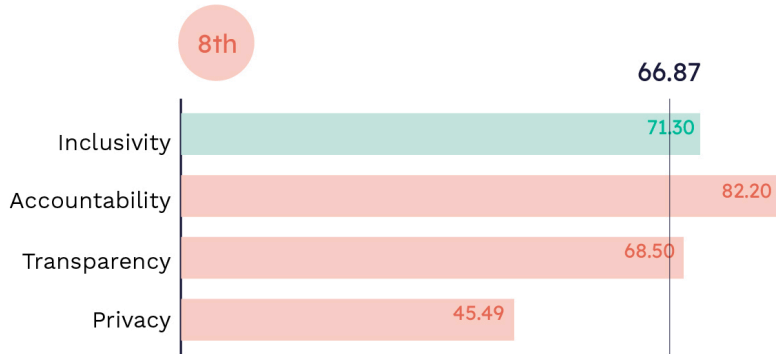
- Increased investment

AI Readiness - Index Comparison

Figure 21: AI Readiness –Breakdown
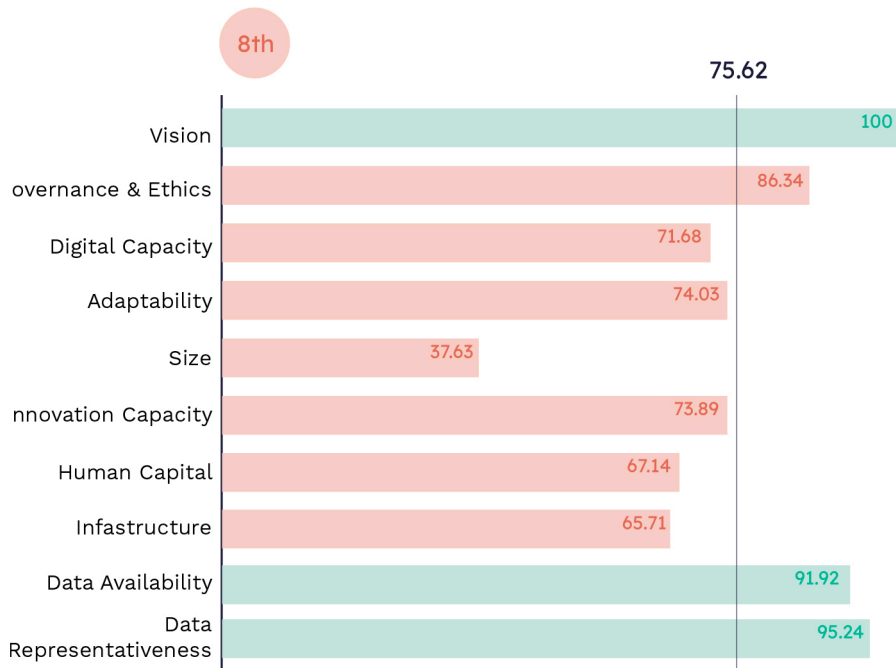
Source: Oxford Insights, 2020

Figure 22: Responsible Use of AI –Breakdown

Source: Oxford Insights, 2020

According to the Government Artificial Intelligence Readiness Index in 2020, Denmark is ranked 8th in the world and 5th regionally. Denmark is highly appreciated for its strategic vision. Denmark actively working on defining the goals, objectives and practical measures for its digitalization and AI adoption strategy – there are several policies in place, for instance, National Strategy for Artificial Intelligence (2019) and Strategy for Denmark's Digital Growth (2018). Moreover, as Denmark possesses a significant amount of open-source social, economic and environmental data, Denmark is highly rated for data representativeness and availability.
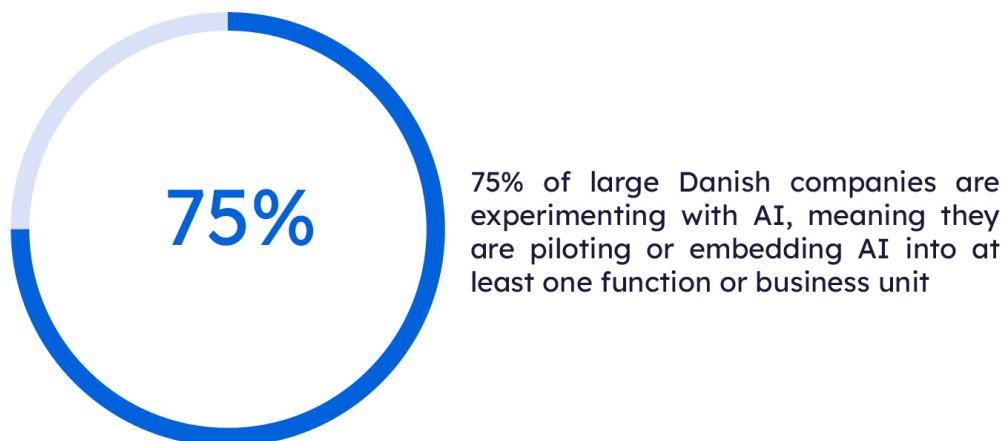
The current focus of the national AI strategy underlies in the development of ethical AI, technological solutions should serve and improve the quality of life of Danish citizens. Denmark is ranked 8th for responsible use of AI, highly rated for accountability, inclusivity and transparency of AI utilization.

Implementation

Denmark is focusing on AI implementation in both private and public sectors with the support of academia and research hubs. According to goals and vision formulated in the *National Strategy* Danish businesses should achieve growth through developing and using AI, while the public sector should exploit AI to offer world-class services. McKinsey states that 75% of large Danish companies are experimenting with AI, while more than 20% of them include AI as a core part of their corporate strategy.

Danish companies adopt various AI technologies – more than one third of all companies that were a part of McKinsey 2018 survey are using sensors connected to Internet. Danish enterprises also commonly use satellite-based services, big data analysis, robotics and other advanced technologies.
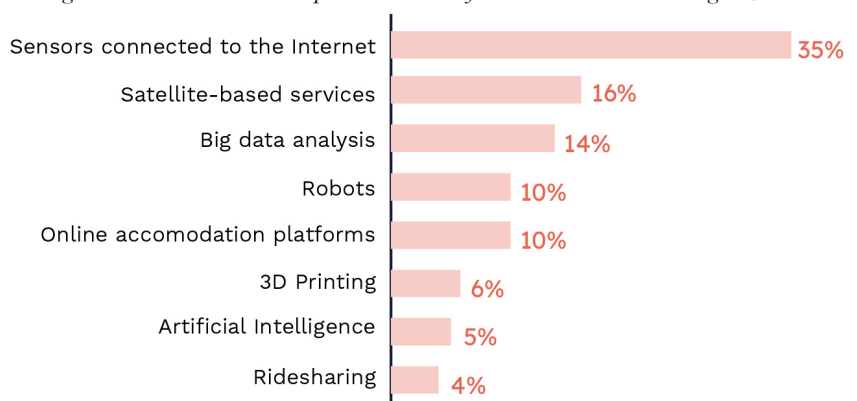
Figure 22: AI-Adoption Among Large Danish Enterprises, 2019

75%

75% of large Danish companies are experimenting with AI, meaning they are piloting or embedding AI into at least one function or business unit

Source: McKinsey&Company Report, 2019; Expert Interview

In general, AI implementation is based on principles of value creation for individuals, businesses and public sector. AI is used in the areas of healthcare, environment studies, education, equality and inclusion, energy and infrastructure, security, public and social services.

Figure 23: Danish Companies' Use of Advanced Technologies, 2019

Technology	%
Sensors connected to the Internet	35%
Satellite-based services	16%
Big data analysis	14%
Robots	10%
Online accomodation platforms	10%
3D Printing	6%
Artificial Intelligence	5%
Ridesharing	4%

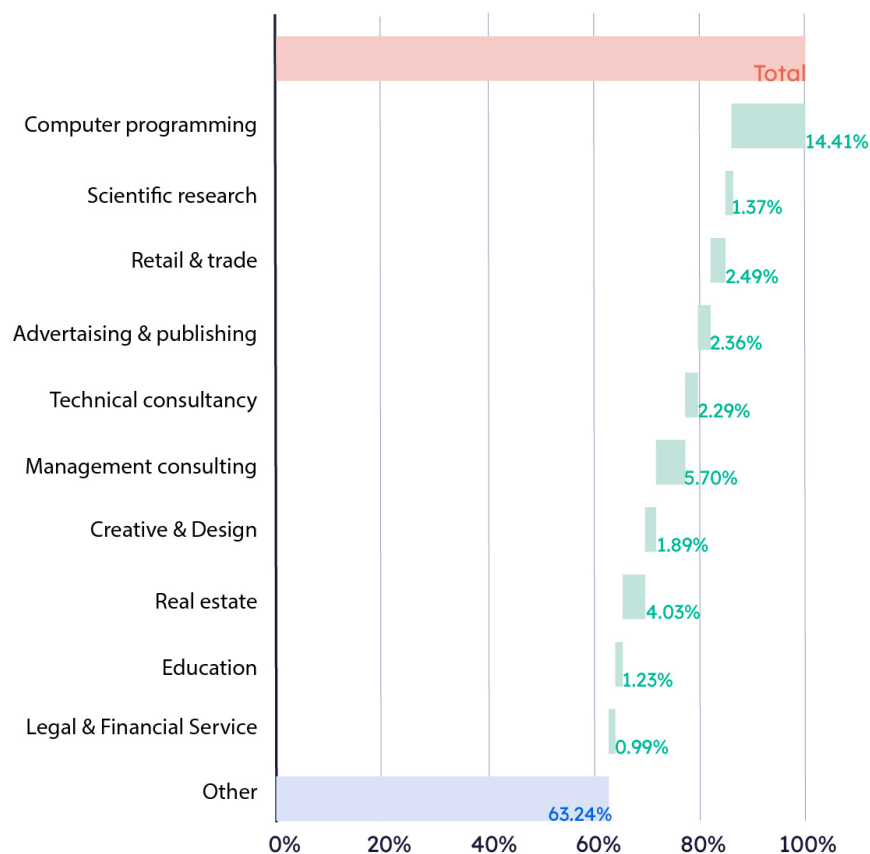*Source: McKinsey&Company Report, 2019; Expert Interview*

We have studied 4540 companies in Denmark mentioning utilizing AI. Further analysis reveals that ca 19 percent of these companies, 890 in total, have built their own AI solutions which ares used on a daily basis.

According to Vainu.io industry classification, top 3 Danish industries using AI are computer programming (14%), business and management consultancy (6%), and Construction and Real Estate (4%).

AI is extensively used by tech start-ups, consulting companies as well as large corporations.

There are several major areas for further AI technologies exploitation – for example, in marketing AI solutions are used for customer service management, individualized offering, pricing and promotion. In supply chain management and manufacturing AI helps with predictive maintenance, analytics and supply chain optimization. Moreover, AI is used across various Danish industries for task automation, risk management, analytics driven accounting, predictive service, product development and other fields.

Figure 24: AI Implementation by Main Industries in Denmark, 2021

Source: McKinsey&Company Report, 2019; Expert Interview; Vainu.io data analysis by FAIA

Research & Development

Denmark has several top research groups and programs within disciplines such as engineering, cognitive systems and bio-medicine. According to "The National AI Strategy plan" the aim is to invest 200 million EUR into AI research. For instance, the section for Cognitive Systems at DTU Compute's research in machine learning has been used by the Danish hearing aid manufacturer Widex for its product "EVOKE", which is the world's first hearing aid with real-time machine learning, able to learn from users' input and adapt in real-time to specific listening situations.
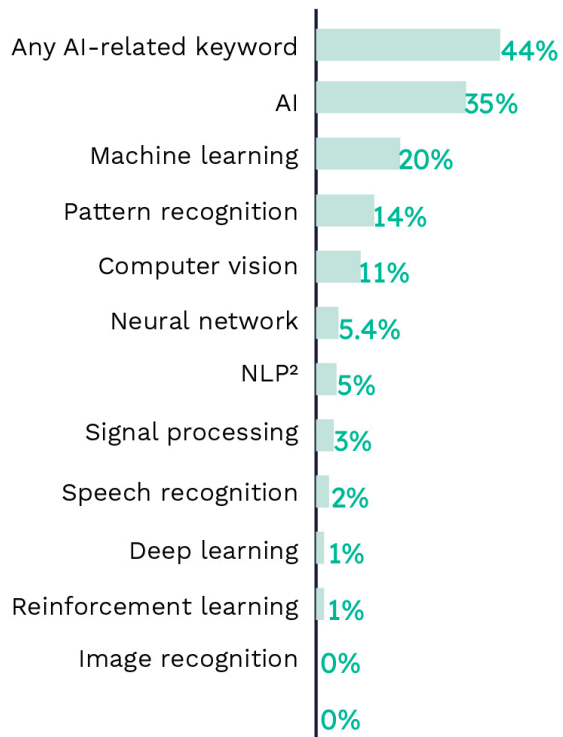
Looking at AI-related research projects at Danish universities, almost 90 percent are related to application of AI rather than developing the underlying technology. The most popular applications are in health and biotech (~25 percent), energy and environment (~10 percent) and agriculture (~5 percent).

Figure 25: Research in Denmark in Selected Disciplines, 2019

Discipline		Description
Statistics & Mathematics	A	Basic Algorithms Research Copenhagen at UCPH works with fundamental algorithmic research
Engineering	B	SDU Robotics has unique expertise within several sub-areas i.e. welfare & surgical robotics and industry application
Cognitive	C	DTU Compute and DTU Health Tech have developed the first real-time hearing aid system with machine learning
Enviromental	E	The research project "EcoSense" has developed sensing and visualization methods to reduce environmental footprints
Bio-Medicine	F	Two Lundberg centers (CIMBI & CINS II) have pioneered neuroimagining with i.e. a smartphone brain scanner
Social Science	G	Copenhagen Center for Social Data Science at UCPH brings together different disciplines to explore new possibilities
Humanities	H	A research area, robophilosophy, explores the interaction between humans, robotics and society

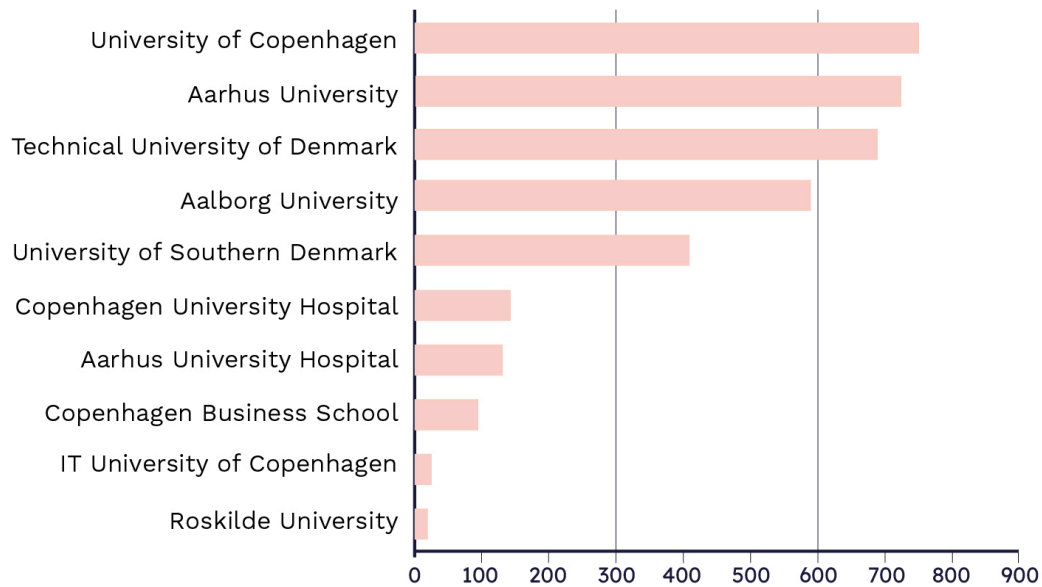*Source: McKinsey&Company Report, 2019*

Figure 26: Research Focus of Danish Researchers[1], 2019

Category	Percentage
Any AI-related keyword	44%
AI	35%
Machine learning	20%
Pattern recognition	14%
Computer vision	11%
Neural network	5.4%
NLP[2]	5%
Signal processing	3%
Speech recognition	2%
Deep learning	1%
Reinforcement learning	1%
Image recognition	0%
	0%

Source: McKinsey&Company Report, 2019; OECD.AI Policy Observatory, 2021; Expert Interview

In addition to research being undertaken at the individual universities, there are a range of collaborative research projects within AI. One of the most notable AI-related research initiatives is the "Danish Center for Big Data Analytics driven Innovation" (DABAI), which has a total budget of around DKK 115 million. DABAI is a partnership between computer science researchers at three Danish universities, Danish IT companies with big data competences, and a number of government institutions. The centre aims to develop techniques for big data analysis to be applied, focused on practical cases with a large business and societal potential. Initial cases will be focused on societal data, educational data, and food supply chain data.

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1. N = 427, see more details from the source report   2. NLP = Natural Language Processing

Figure 27: Publications by AI-Research Institution, 2021

Source: McKinsey&Company Report, 2019; OECD.AI Policy Observatory, 2021; Expert Interview

Other exciting Danish AI research initiatives are Digital Research Center Denmark and Copenhagen University (CU) AI Pioneer Center, that are building platforms for collaborative research, increase the educational capacity for digital specialists and strengthen Denmark's competitiveness in computer sciences with a heavy focus on AI. The CU AI Pioneer centre has received €47 million rom Carlsberg Foundation, Novo Nordisk Fonden, Danish National Research Foundation and others. According to the McKinsey 2019 report, 443 researchers in Denmark (excluding PhD students) are doing research in AI or are using AI methods. More than 1/3 of the respondents of McKinsey 2019 survey among Danish researchers claimed that their research has a general focus. Top AI-related specific research topics in Denmark are Machine Learning (20%), pattern recognition (14%), computer vision (11%). Universities with the most R&D activity (based on the number of AI-related publications) are University of Copenhagen, Aarhus University, Technical University of Denmark and Aalborg University.

Education

Danish universities are leading in Europe in specific AI sub-disciplines and are ramping up their AI teaching activities. Focusing on computer science, several Danish universities are among leading universities within fields adjacent to AI. Denmark has three universities within the European top 15 when it comes to theoretical computer science (TCS) and two top 10 universities in Human-Computer Interaction. Denmark also has a top 3 university in cryptography and a top 5 university in Natural Language Processing. There 23 AI specialized educational programs in Denmark with 3 Bachelor and 19 Master degrees.

3 out of Europe's top 15 universities within theoretical computer sciences are from Denmark
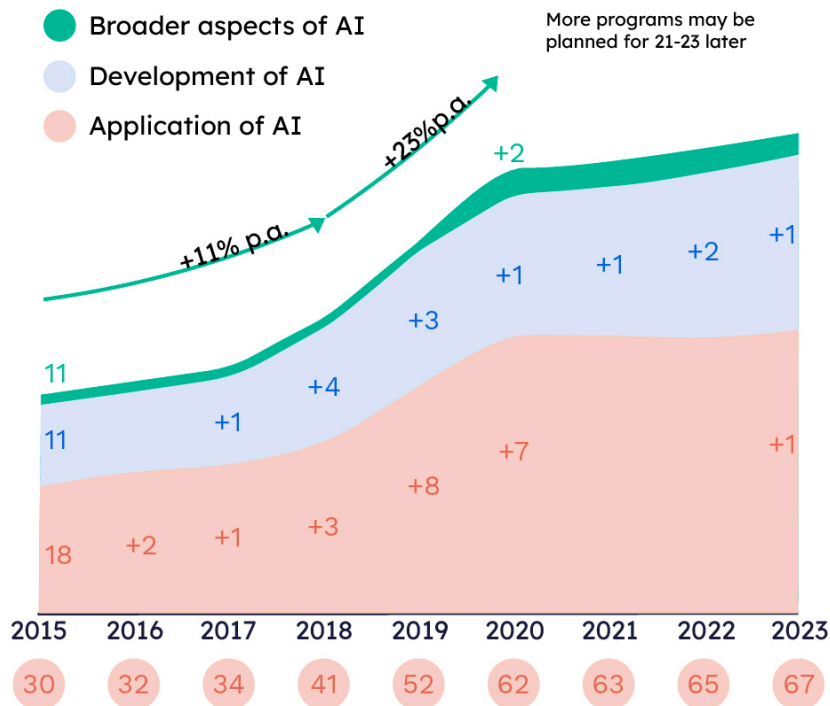
Figure 6: Number of Specialized AI-Programs, 2019-20
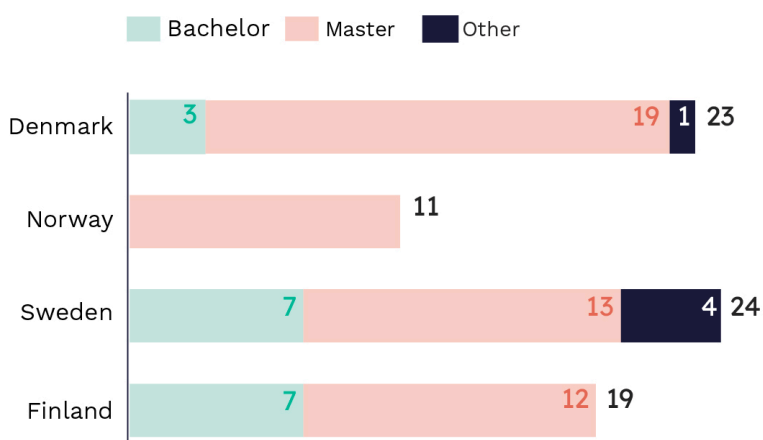
Source: McKinsey&Company Report, 2019; The Danish AI style, 2018; Stanford University, 2021

The Danish government focuses on strengthening industry access to Science, Technology, Engineering & Mathematics (STEM) talent and thus introduced several initiatives to secure that businesses future talent needs will be met. In 2020, the number of STEM students admitted to Danish universities increased by 50% compared to 2009 data.

Figure 28: AI-Related Programs at Danish Universities, 2019

- Broader aspects of AI
- Development of AI
- Application of AI

More programs may be planned for 21-23 later

Source: McKinsey&Company Report, 2019

In recent years, new study programmes in Data Science, Algorithms, AI and IT & Cognition have been launched. With the growth of new study programs in AI, the number of graduates is expected to grow 11% annually every year towards 2025. 41% of these graduates will hold a bachelor's degree and 59% will have master's degrees. In addition to new study programs, there is also an increased focus on offering specialisations within AI to existing study programs in related fields such as robotics and autonomous systems.

Danish universities currently offer more than 300 courses related to AI. ~40% of these courses train students to develop the underlying algorithms and software (e.g., "Introduction to Machine Learning and Data Mining" at DTU and "Advanced Topics in Machine Learning" at University of Copenhagen). Almost half of the courses (47%) relate to the application of AI (e.g., "Machine Learning for Media Technology" at Aalborg University and "Big Data Analytics" at Copenhagen Business School). The remaining courses relate to the broader aspects of AI, such as "AI and Ethics" at University of Southern Denmark or "Introduction to Robophilosophy" at Aarhus University.

Talent

The high pace of AI adoption and development challenges Denmark with rising demand for AI specialists. According to McKinsey 2018 report more than 50% of the Danish companies that took part in the survey claim that talent gap and lack of qualification are the main constraints when it comes to AI implementation.

On one hand, there is a big number of highly educated specialists and visioners with doctoral degrees, on the other hand there is a rising demand for engineers which may end up in a talent gap in the next few years. McKinsey survey of Danish AI startups shows that people with the skills to develop the underlying algorithms and software are the scarcest talent resource - 45 percent report that this is the type of talent they lack the most, versus 23 percent reporting that they primarily lack people with the skills to apply AI/design

advanced use cases. Therefore, Denmark needs initiatives to attract specialists from other countries, such as Copenhagen Capacity that support foreign companies, investors and talents in making a successful start in Greater Copenhagen primarily in the life science, tech and green energy industries.

Denmark has several areas of expertise where it has been a front runner for several years – these are natural language processing, algorithms and complexity, data mining and machine learning and human centered AI. In 2018 McKinsey analyzed more than 2 million LinkedIn profiles to identify the unique Danish skillset – results show that people with AI skills tend to have an intimate knowledge of one or more AI technologies. The most common AI-specific skills among Danish profiles are NLP[1] (28% of profiles), signal processing (25%) and machine learning (23%).

Figure 29: Deep Analytical and AI-Specific Skills in Denmark, 2019
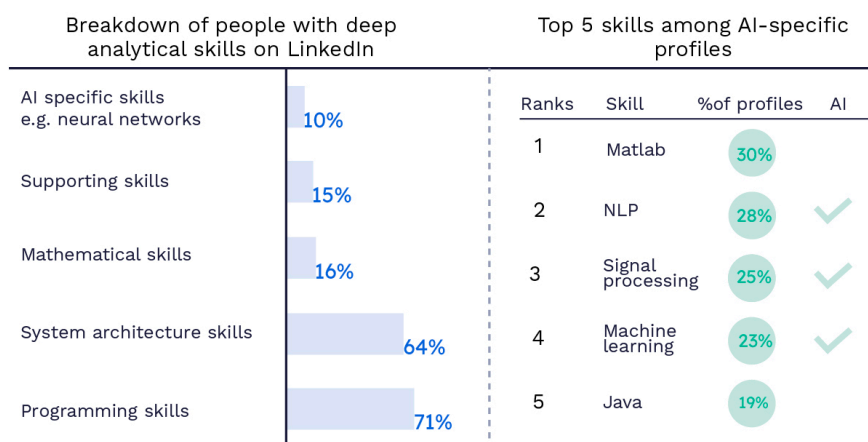
Source: McKinsey&Company Report, 2019; Ministry of Foreign Affairs of Denmark, 2021, Expert Interview
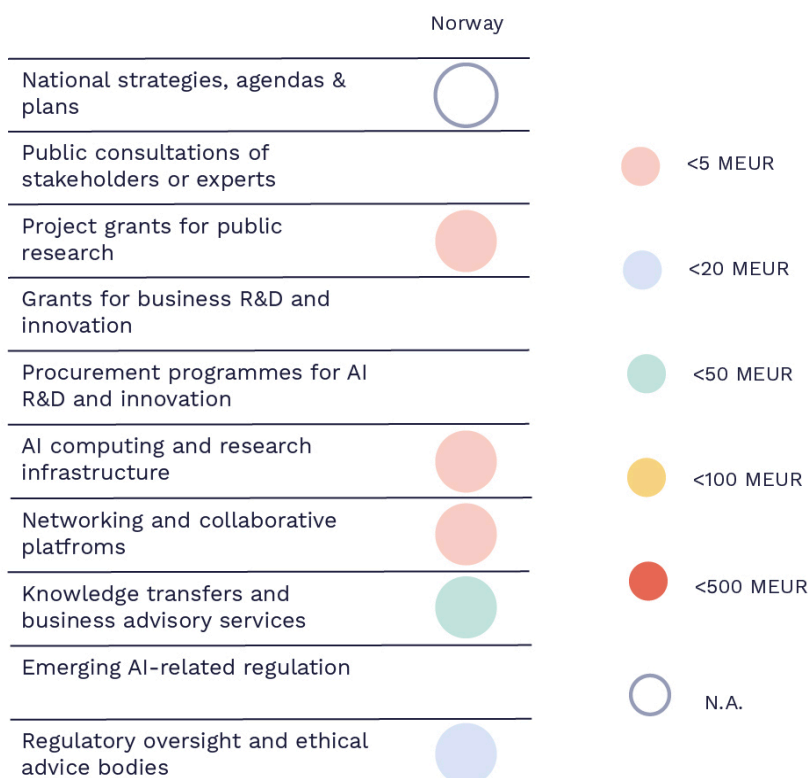
NORWAY

The Norwegian government launched *National Strategy for Artificial Intelligence* in January 2020, illustrating opportunities and challenges, including hopes to attract major international customers and cloud services to establish their data centers in Norway.

Norway is well known for its energy industry worldwide – The adaptation of AI in a such competitive industry will increase the efficiency of processes and directly affect the sustainability and future of the country.

In addition, Norway will invest in sectors with substantial competitive advantages: health, seas, oceans, public administration, and mobility.

The use of Norway's National eHealth solutions has highlighted the importance of digital and technology usage in the healthcare sector, and Norway has established various solutions such as e-prescriptions, Core Journals, helsenorge. no and new e-health models. The government also plans to invest NOK 189 million in national collaboration solutions in 2021[1].

*Figure 30: Policy Instruments by Amount and Budget, 2021*

Another highlight is the AI-specific regulatory sandbox project which was launched in March 2021 with the aim to help companies comply with the EU's General Data Protection Regulation. This project will allow companies to develop and test out AI technologies in a sandbox environment that comply with the data protection regulations[2].

Source: Ministry of Local Government and Modernisation, 2020; OECD.AI Policy Observatory, 2021

AI Readiness - Index Comparison

*Figure 31: National Strategy for AI Policy Elements*
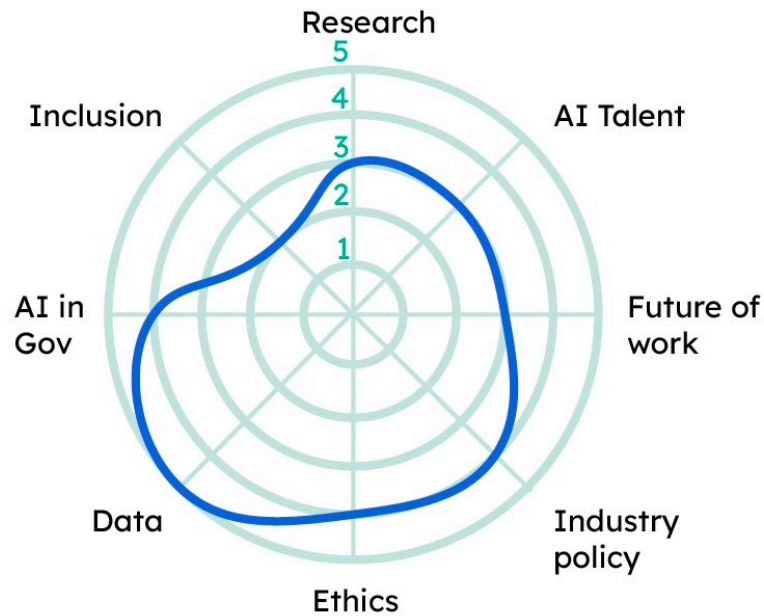
Source: Ministry of Local Government and Modernisation, 2020

The National Strategy for AI policy elements is in line with the findings of AI readiness Index, listing Data, Ethics and Industry Policies as cornerstones of the Norwegian AI ecosystem, while talent and research seen as less strong (see figure 31 and 8 for more information).

Figure 32: AI Readiness –Breakdown
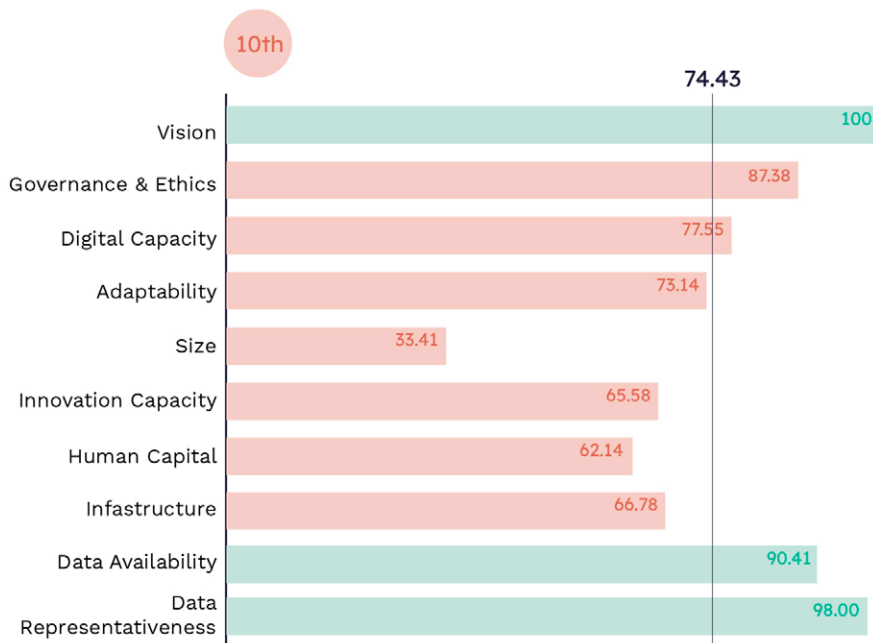
Source: Oxford Insights, 2020

AI Readiness figures break down the information of how the Norwegian government takes advantage of the AI-powered transformation. According to the Government Artificial Intelligence Readiness Index 2020, Norway is ranked 10th worldwide and ranked2nd for responsible use of AI.

As the figures illustrate, Norway scores high on data and ethics-related categories, highlighted in figure 32 and 33. Norway aims to become the destination for data-focused initiatives, and the figures support Norway's ambition to proceed towards its goals. In the field of responsible use of AI Norway is a frontrunner in leading the initiatives.

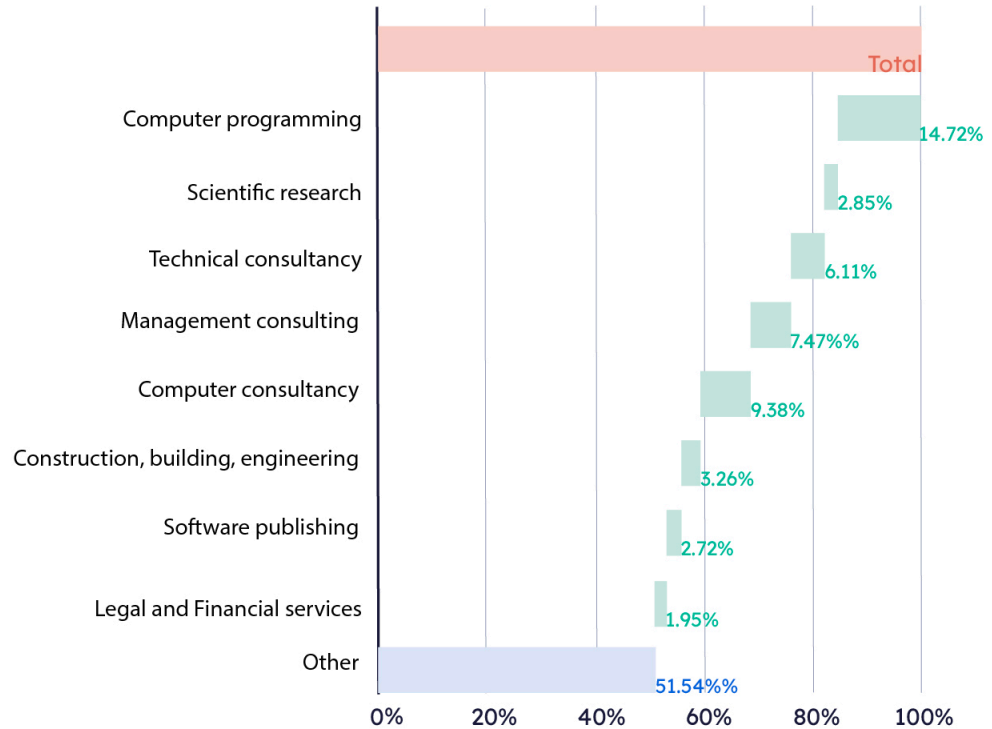*Figure 33: Responsible Use of AI –Breakdown*
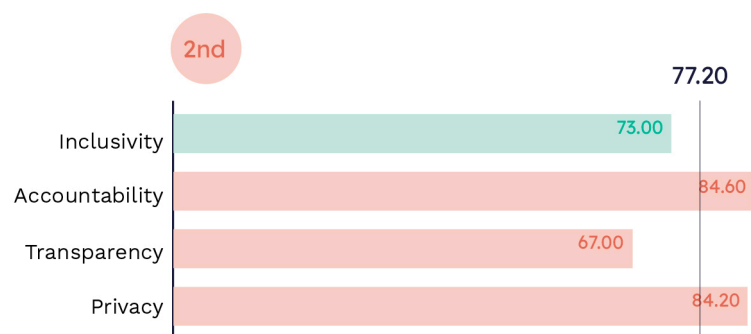
Source: Oxford Insights, 2020

Implementation

Figure 34: AI Implementation by Main Industries in Norway, 2021


Source: Expert Interview #2, Vainu.io data analysis by FAIA

We have analysed the data from Vainu.io to find out the state of AI implementation in various industries in Norway. Currently, there are 2208 companies that mention using AI. On further analysis, taking into account team composition, size of company and offering, we estimate that 714 companies have developed their own AI solutions and/or utilize in their daily operations. The top industries with the most AI use are Computer Programming (15%), Computer consultancy (9%) management consultancy (7%), and Technical consultancy (4%).

Out of the Nordic countries analyzed, Norway seems to have the least amount of companies utilizing AI. In the industry expert interviews, it was mentioned that most SMEs in Norway do not use AI in their operations while many startups focus on AI solutions. In the public sector, AI is often utilized in the tax field to increase efficiency and speed of tax review. In the private sector, mostly tech companies understand and make use of AI tools.

Figure 35: Top 3 AI Usages Among Enterprises by Business
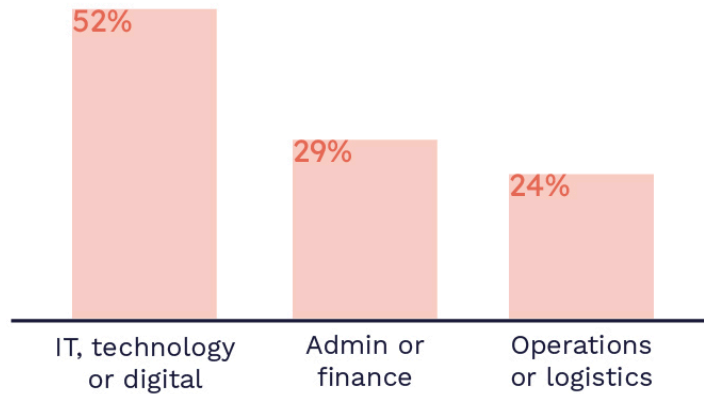
Source: Statista, 2018

*Figure 36: Relevant Uses of AI Among Enterprises in Norway, 2018*
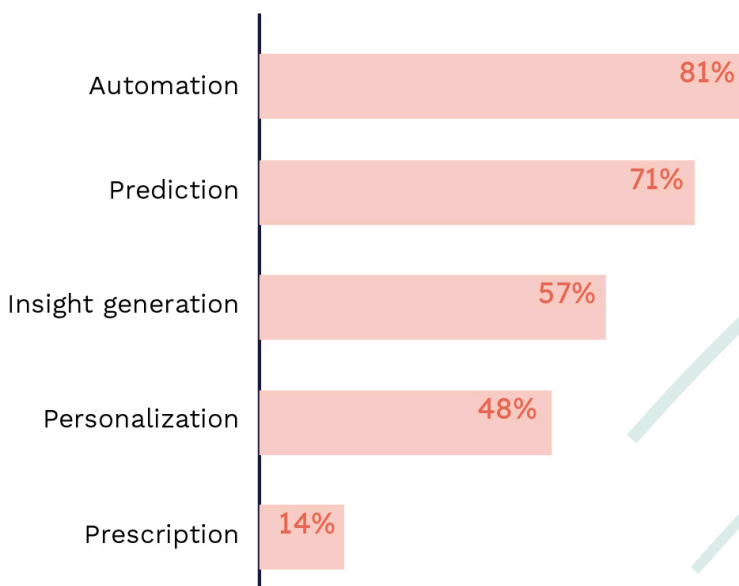
Source: Statista, 2018

As indicated in interviews and figures, AI is mostly used in technology related enterprises in Norway today. The figures suggest that the IT/Technology/Digital function has been the frontrunner in using AI in Norway. 81% of enterprises in Norway that use AI focus on automating their tasks, and 61% utilize AI to predict the future.

Research & Development

Figure 37: Consumption of ICT R&D
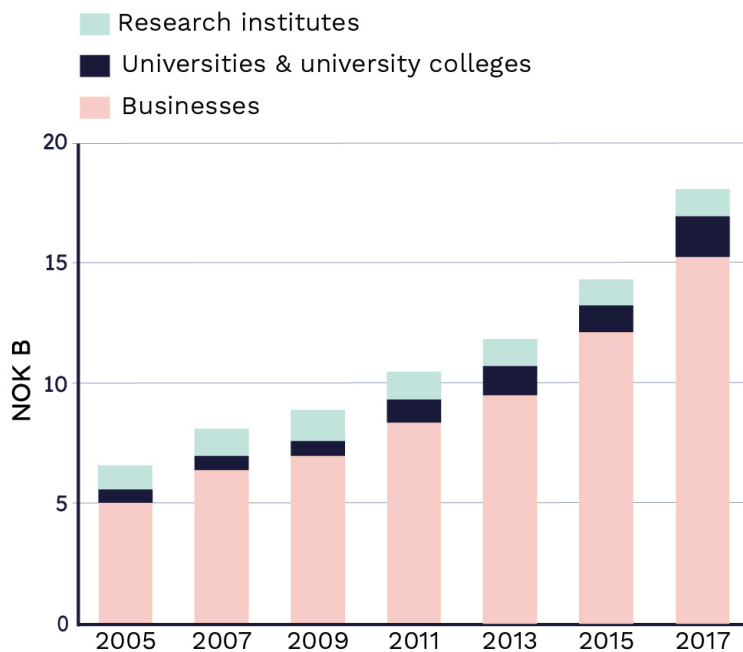
Source: Ministry of Local Government and Modernisation, 2020

Various educational institutions and other organizations have been leading R&D, and there has been substantial growth in investment in the last few years. The investment has increased from NOK 8 billion in 2007 to NOK 18 billion in 10 years, where the education sector has the most growth.

The Norwegian Research Center for AI Innovation (Nora AI) is the largest academic initiative on AI innovation in Norway which they launched in October 2020. The research area focuses on Management & Technology, AI in Society, Trustworthy AI, AI for Personalization, AI for Language Technologies, AI for Streaming & Sensor-based Data, Hybrid AI Analytics, Data and Platform for AI. Their primary focus of research centres around the sustainability and trustworthiness of AI.

The research strategy focuses on creating a more joint approach from both academia and industry with a focus on trustworthiness to create better, safer, and ethical AI systems. The government plans to continue supporting ICT research.

Education

The government has increased allocations to ICT-related programmes and increased the student size since 2015. Since 2018, there has been an increase in the number of educational institutions offering programmes focusing on Artificial intelligence; from 2020, more than 350 new study places are developed and dedicated to the study areas of AI, robotics, and data science.

Figure 6: Number of Specialized AI Programs, 2019-20

Bachelor   Master   Other

Denmark   3   19 1   23
Norway   11
Sweden   7   13   4 24
Finland   7   12   19

Source: Stanford University, 2021

As stated in the national strategy report, Norwegian Open AI Lab at NTNU has launched "Elements of AI" in Norwegian, as well as other free online courses focused on artificial intelligence. The program aims to provide as much information as possible about AI.
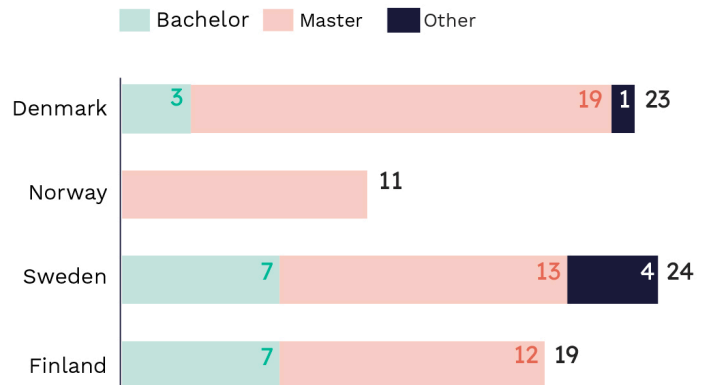
Regarding the availability of programs in the higher education system, there is a significant lack of support in creating AI programs at the bachelor level. The government has been putting in efforts to establish more programs at the higher education level, increasing the investment into secondary institutions.
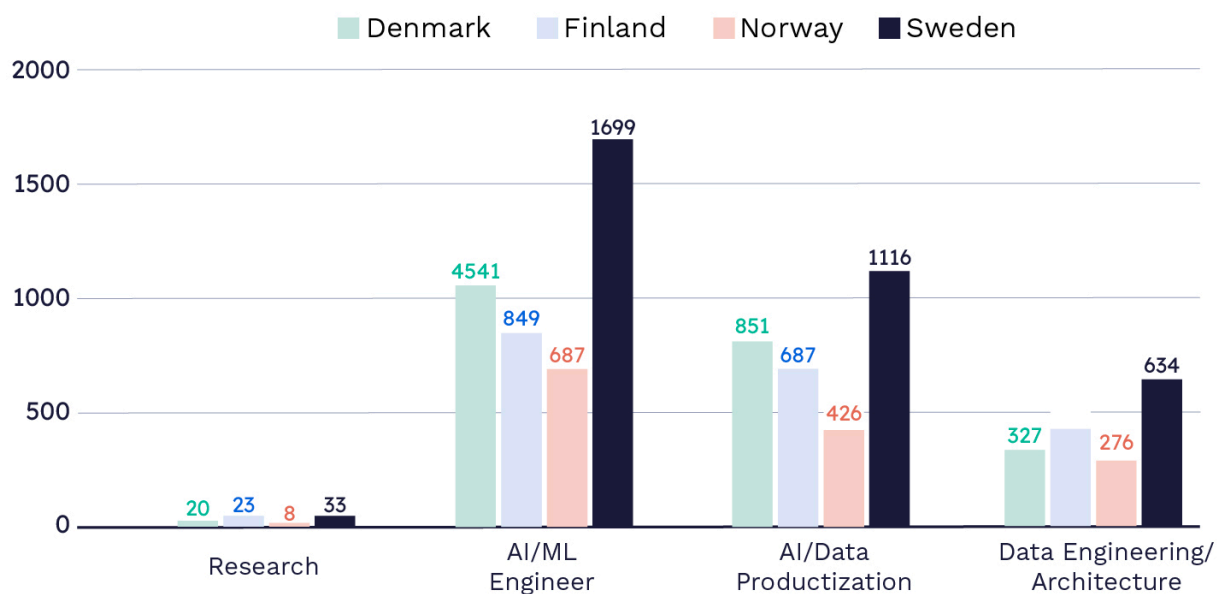
Talent

According to the Global AI Talent Report 2020 the demand for skilled technical people was stable pre-2020, but fell 20-30% during the pandemic. Norway is, however, a bit of an outlier and the demand has been booming also during the pandemic. This indicates that many companies and organizations have been shifting their focus towards identifying and understanding the potential of AI.

As Norway is showing the smallest amount

of organizations utilizing AI at scale. The talent pool is also smaller compared to its neighboring countries(figure 8).

This is mainly due to the fact that the Norwegian AI ecosystem is young and still developing. As, for an example, Nora.ai recently been established, we can expect rapid progress an increased amount of funds being directed towards AI activities.

Figure 8: Talent in the Nordics by role

Source: Calculated by FAIA, based on numbers from the Global AI Talent Report 2020.

SWEDEN

The Swedish government released its national AI strategy in 2018, called National approach to artificial intelligence. As AI provides a possibility to gain competitive advantage internationally, the goal of the government is to make Sweden a leader in harnessing AI opportunities in order to increase the level of welfare and competitive advantage. In the national AI strategy four main conditions for AI use are highlighted. These include:

1. education and training,
2. research,
3. innovation, and
4. framework and infrastructure.

Access to data is seen as crucial for AI development, along with data spaces and data transfer abilities, as well as computational power, like Sweden's supercomputer resources.

The framework and infrastructure are seen especially important. This includes coherent and strategic AI policymaking to create a favourable climate for AI development, the need for Sweden to push for national and international standards and regulation, and the development of open data and its digital infrastructure. Another important area for Sweden is the theme of sustainability in AI, whichmeans that AI applications should be ethical, safe, secure, reliable and transparent.

Strengths highlighted in the PESTEL1-analysis include Sweden's high amount of AI-initiatives, its dynamic economy and highly educated workforce. In the deep-dive sections we also see that a relatively high share of Sweden's GDP into innovation and AI, and that Sweden has an increasing supply of specialized AI programs. These observations show that although Sweden - or any other Nordic country for that matter - cannot compete directly with the largest economies, Sweden has made real progress in becoming one of the top countries when it comes to artificial intelligence.

Figure 38: Number of skilled technical people in the Nordics
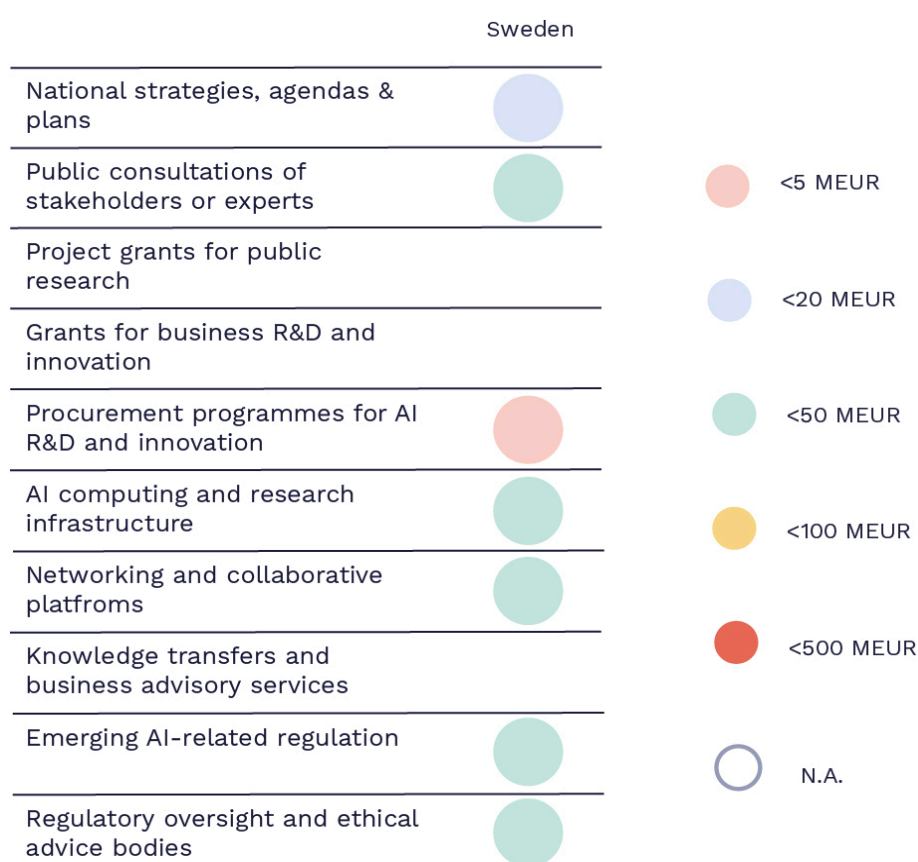
Source: Ministry of Finance & Ministry of Industry, Business and Financial Affairs, 2019; OECD.AI Policy Observatory, 2021

Some of the most notable domestic AI initiatives include AI Sweden (national centre for applied AI research), AI Agenda by RISE (Research Institutes of Sweden) and AIDA (Analytic Imaging Diagnostic Arena). With 10 ongoing initiatives and a relatively high investments into AI development, Sweden has a very favourable political climate for AI.

AI Readiness - Index Comparison

In the Government AI Readiness Index 2020 by Oxford Insights, Sweden was ranked 5th in AI readiness in the world behind the US, UK, Finland and Germany with a score of 78,77. Sweden has made very noticeable advancements, as it placed 6th in 2019 and 11th in 2017. Sweden excelled especially in three categories: vision, infrastructure and data representativeness. Infrastructure and availability and quality of data are both areas that are highlighted in the national AI strategy as well.

Sweden's position in the Global AI Index has skyrocketed last years. "

*Figure 39: AI Readiness –Breakdown*
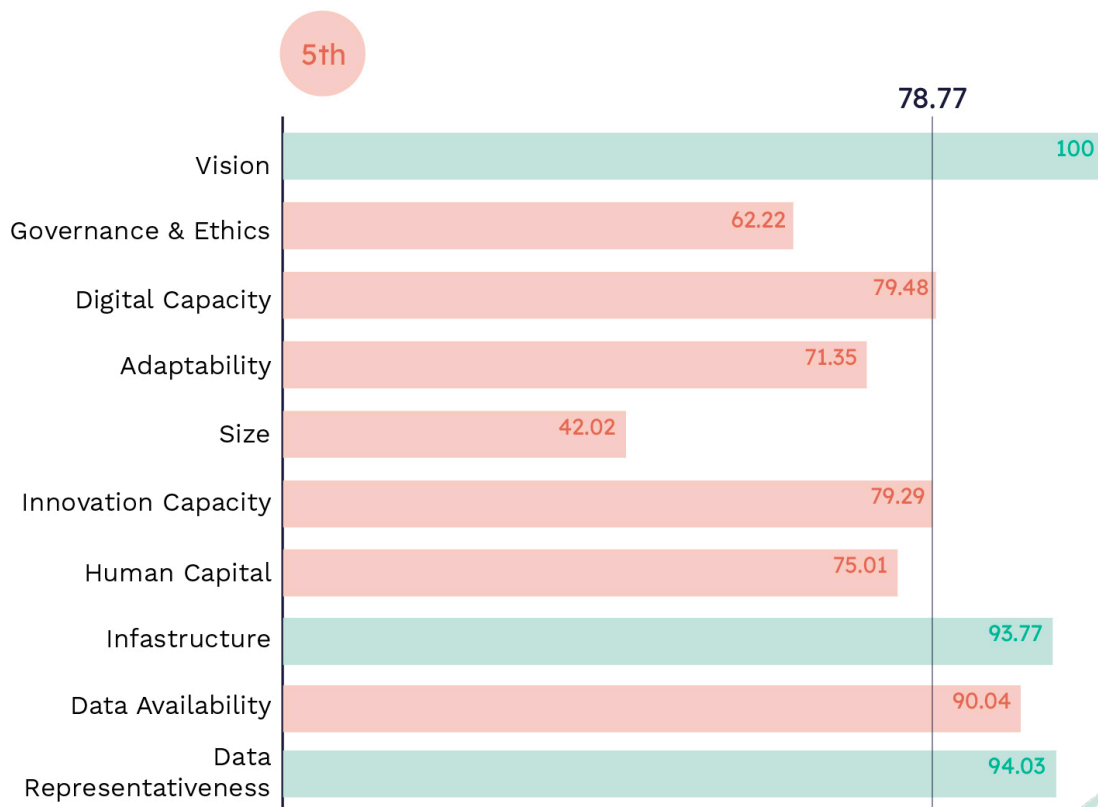
Source: Oxford Insights, 2020

In terms of responsibility Sweden received the same rank of 5th place with a score of 72,98. Inclusivity and transparency are the areas where there is the most room for improvement, and these are also areas that were mentioned in the national strategy.

One of Sweden's strengths is its relatively high level of digitalization and well-developed IT infrastructure for data. As Sweden also has a high level of technical skills and automation, this gives AI development a good basis. However, interviews with representatives of Swedish companies in a 2018 report by Vinnova highlighted, that the automation is often based of older technology[1].

Figure 40: Responsible Use of AI –Breakdown
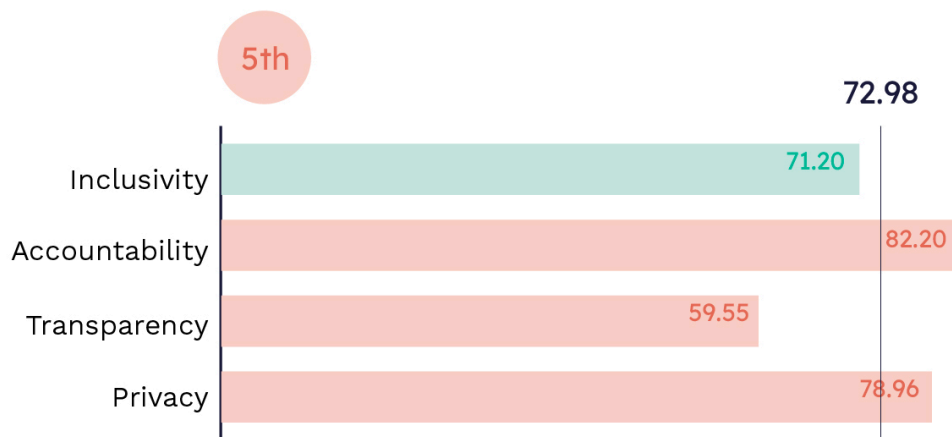
5th

72.98

|	Score
Inclusivity	71.20
Accountability	82.20
Transparency	59.55
Privacy	78.96

Source: Oxford Insights, 2020

Implementation

From the keyword search based on Vainu.io data, a total of 6273 companies that potentially use AI were identified. Out of these, approximately 1300 use AI on a daily basis. The top five industries that utilize AI are computer programming (12%), management consultancy (9%), computer consultancy (9%), and technical consulting in industrial engineering (5%) as well as advertising and design (3%).

Overall, all forms of consultancy totalled to nearly 35 percent of the companies. This could indicate that many companies do not possess the required knowledge and competency to use and develop AI solutions themselves, but rather seek for outside assistance.
In the interviews conducted with AI experts from Sweden, it was also highlighted that the level of AI implementation varies greatly between industries. Digital-first companies tend to have better understanding of AI and it might also be a part of their core business idea. This also applies to start-ups, who more often use creative and innovative solutions. According to a Tracxn Technologies, Sweden had 221 AI start-ups in 2021 compared to Finland's 172 and Denmark's 126[1].

Figure 41: AI Implementation by Main Industries in Sweden, 2021
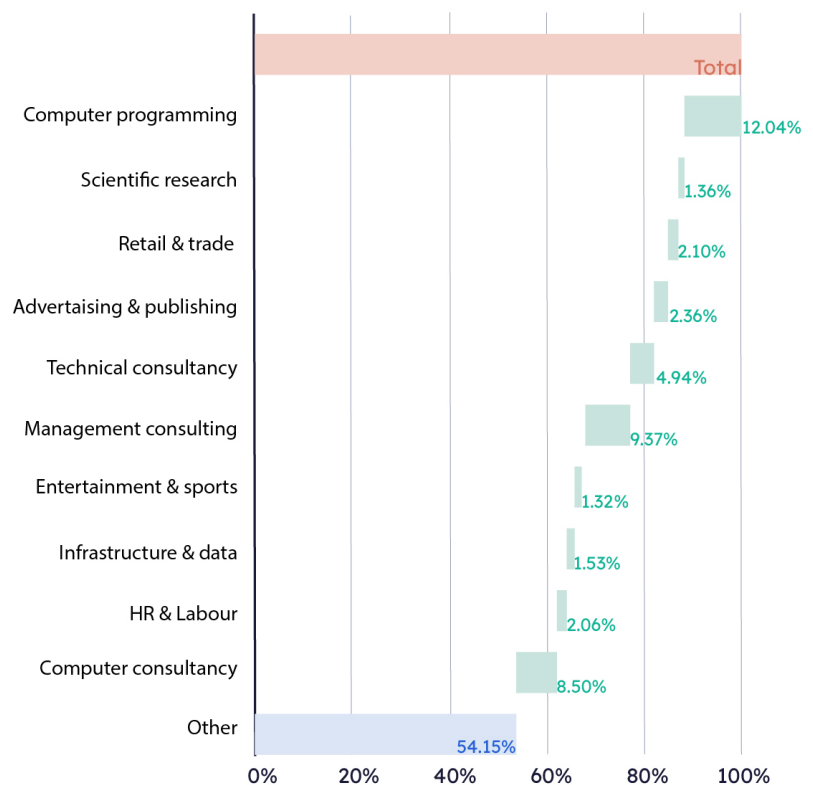

Source: Vainu.io data analysis by FAIA

Research & Development

In 2020, Sweden's innovation agency Vinnova has funded AI projects by around 67,5 million euros, with a national budget of at least another 55 million euros until 2024[1]. As of April 2021, Vinnova is funding a total of 256 projects related to AI. A part of this funding (around 10 million euros between 2020-2024) is directed to AI Sweden, the national centre for applied AI research and innovation, whose purpose is to accelerate the use of AI, co-locate competence and run projects of national interest[2]. AI Sweden works with almost 70 partners from all sectors[1]. In 2018, AI investments per capita in the EU member states, Sweden was in 4th place behind Denmark, Ireland and Finland, with 27,6 euros[3].

Figure 42: Publications by AI-Research Institution, 2021
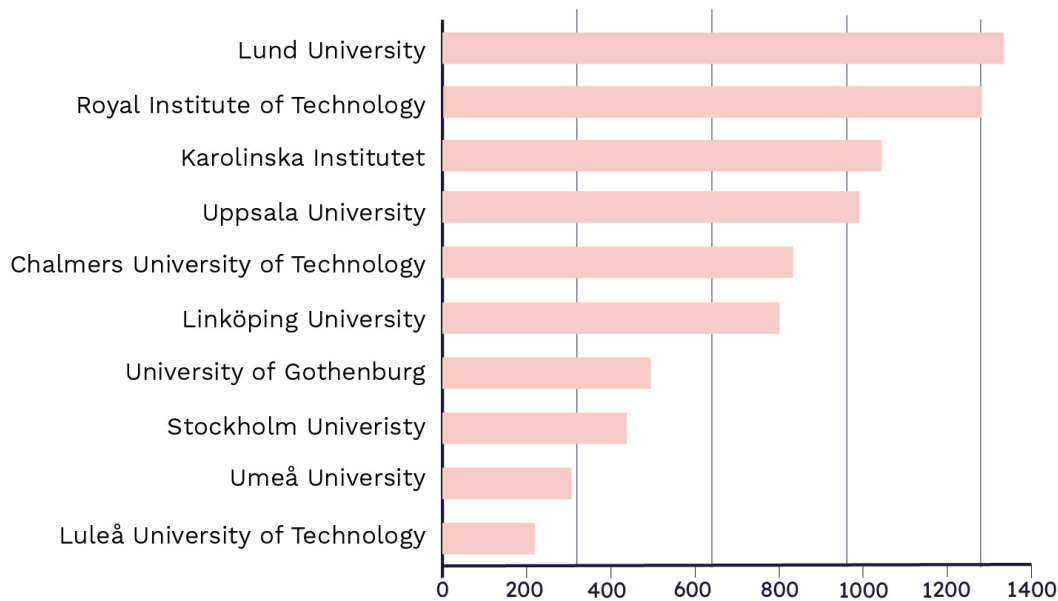
Source: Oxford Insights, 2020

> *Sweden's investments into R&D as a share of its GDP,*
> *is one of the highest shares in the world*

As a rule, Sweden invests more than 3 percent of its GDP into R&D, with investments from the public sector adding up to around 0,8 percent of Sweden's GDP, one of the highest shares in the world[4] Around 70 percent of the funding comes from the private sector. The latest data from the World Bank from 2014 show that Sweden invested 3,16 percent of its GDP into R&D, placing it 5th in the world and only topped by Finland in the Nordics[5]. By far the largest R&D program in Sweden is the Wallenberg AI, Autonomous Systems and Software Program (WASP) launched in 2015, funded mostly by Knut & Alice Wallenberg Foundation and run in cooperation with five partner universities,

which include Chalmers University of Technology, Linköping University, Lund University, KTH Royal Institute of Technology, and Umeå University. The program will run at least until 2030 with a funding of 5,5 billion SEK, of which 4,2 billion SEK comes from the Knut and Alice Wallenberg foundation[6].

The top (75th percentile) institutions in AI research in Sweden have published a total of 7762 publications during the last 10 years. The top three universities are Lund University, Royal Institute of Technology and Karolinska Institutet with 1331, 1282 and 1045 publications respectively.
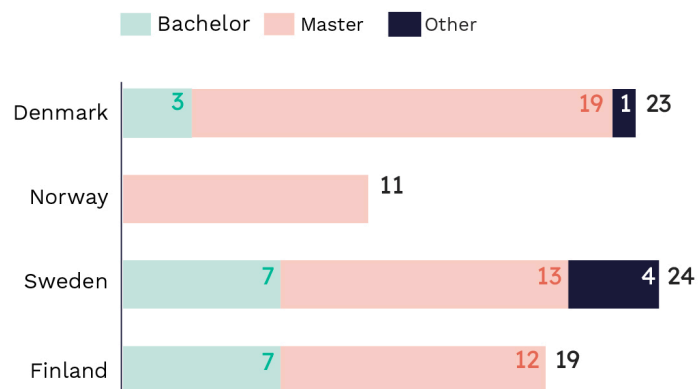
Education

To bring innovations and ideas into practice, the national AI strategy of Sweden emphasizes the need for "a strong link between research, higher education and innovation in the field of AI". Sweden recognizes the shortage in AI expertise both nationally and internationally, and in order to meet the growing demand, Sweden's higher education institutions are already improving their education offer[1]. In recent years, Sweden's educational institutes have introduced several new programs for AI and machine learning education. Different universities offer various AI-related master's programs, such as data engineering, machine learning, robotics and language technology. Most bachelor's programs are focused on computer science but are still connected to AI.

Sweden has also launched a national initiative called AI Competence for Sweden to improve and develop the education and competence of artificial intelligence in Sweden. In the initiative, ten universities work together, offering a knowledge platform consisting of a joint home page with information about different AI-related educational opportunities as well as regular meetings among the key people from he participating universities. The overall aim of the initiative is to "improve the possibilities of working professionals to learn about AI, thus improving the competitiveness of Swedish companies and increasing the welfare provided by public organisations"[2].

According to the 2021 AI Index Report, Sweden is placed 4th in number of specialized AI programs. As stated before, most of these are master's level programs, with less than 10 bachelor's programs available.

Figure 6: Number of Specialized AI Programs, 2019-20

Bachelor   Master   Other

Country	Bachelor	Master	Other	Total
Denmark	3	19	1	23
Norway		11		
Sweden	7	13	4	24
Finland	7	12		19

Source: Stanford University, 2021

Talent

Like many other countries, Sweden is also struggling with the scarcity of talent in artificial intelligence. Sweden has a lot of knowledge in data-driven processes and data science, but the rapid development of AI has resulted in lack of sufficient competence in AI and machine learning[1]. Universities are trying to catch up to the rising demand and are providing more programs for computer sciences and AI. There is still, however, a need for more AI-specialists with "a high academic background". The potential of the Swedish workforce lies in its technology-friendliness and high level of technological skills.

One way to get implications of Sweden's AI talent pool is to look at worker's educational backgrounds such as information and communications technology). In 2020 7,5 percent (379 700 employees) of the employed workforce in Sweden were ICT specialists[1].

This placed Sweden in 2nd place out of all EU member states with Finland in 1st place with 7,6 percent. These numbers have a link to employment in general as well, and of course do not directly relate to the level of skills related to AI, but rather give some implication on the potential of the Swedish workforce.

The previously discussed national initiative called AI Competence for Sweden provides funds for developing courses specifically targeted for working professionals. During the first years between 2018-2020, a total of 106 courses were offered on the portal, some of which were delivered multiple times. Most of the provided courses were short, intense and free of charge, as they have to match the needs of managers, decision makers and developers[3]. These courses are intended to support life-long learning of artificial intelligence along side private actors in this area.

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1. Eurostat: ICT Specialists in employment, accessed 2021,; 3. Heintz et al., 2021

A Deep Dive - Telecommunications Industry

Telecommunications is an industry Sweden is well known for, and is generally very advanced in. In the 2020 Digital Economy and Society Index (DESI) report Sweden was found to be a "forerunner in very-high capacity connectivity in Europe", and has a 4G coverage in 100 percent of its households. Its fibre to the premises (FFTP) coverage also reached a 77-percent coverage, compared to the 34% average in the rest of EU[1].

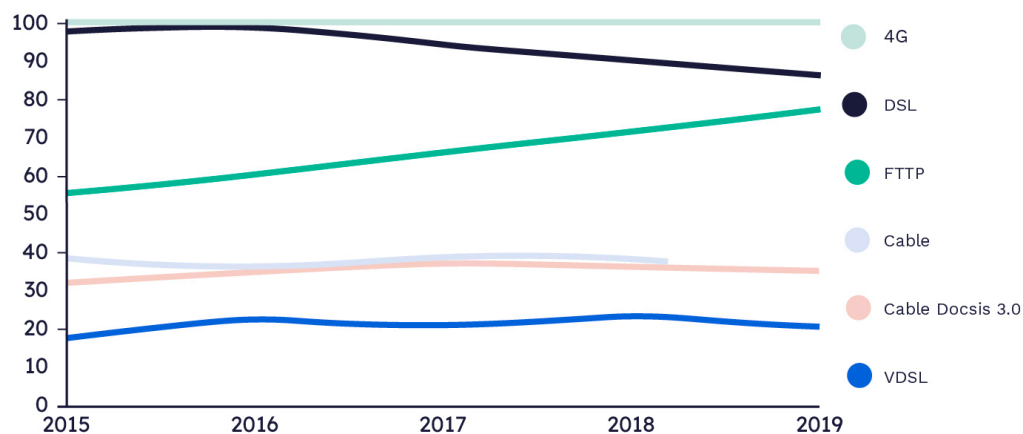*Figure 43: Coverage of each type by % in Sweden, 2020*

Figure 43: Coverage of each type by % in Sweden, 2020

Sweden has a long history of developing telecommunications technologies, and the industry's importance cannot be overstated. It is one of the largest industries of the Swedish economy and in 2019 the industry's revenue added up to 2,498 billion euros[2]. Major companies in the industry include for example Ericsson, Telia, Tele2 and Eltel. By turnover, Ericsson was the 4th largest company in Sweden behind Volvo AB, Volvo Car AB and H&M Hennes & Mauritz AB with 227 216 million SEK[3].

This importance of telecommunications transfers to AI as well, where some of Sweden's core AI competencies lie in. According to Vinnova, Ericsson has been dominating Sweden's AI related patenting for quite a long time, with 132 patents between 2012-2017[4]. Automation as well as developing new services are some of the most important drivers for companies. Key conditions for developing AI in the sector include open-source software, access to data and Open Application Interfaces, as well as collaboration between academia and companies.

According to our interviewees, collaboration between larger tech companies and academia like Ericsson According to our interviewees, collaboration between larger tech companies like Ericsson and academia is very active in Stockholm, including long-term and high-risk research. According to our interviewees companies also have the advantage of having incorporated AI into their business quite a lot earlier than some other industries. This also helps them with recruitment, as it is easier to build on existing in-house competence rather than starting from nothing.
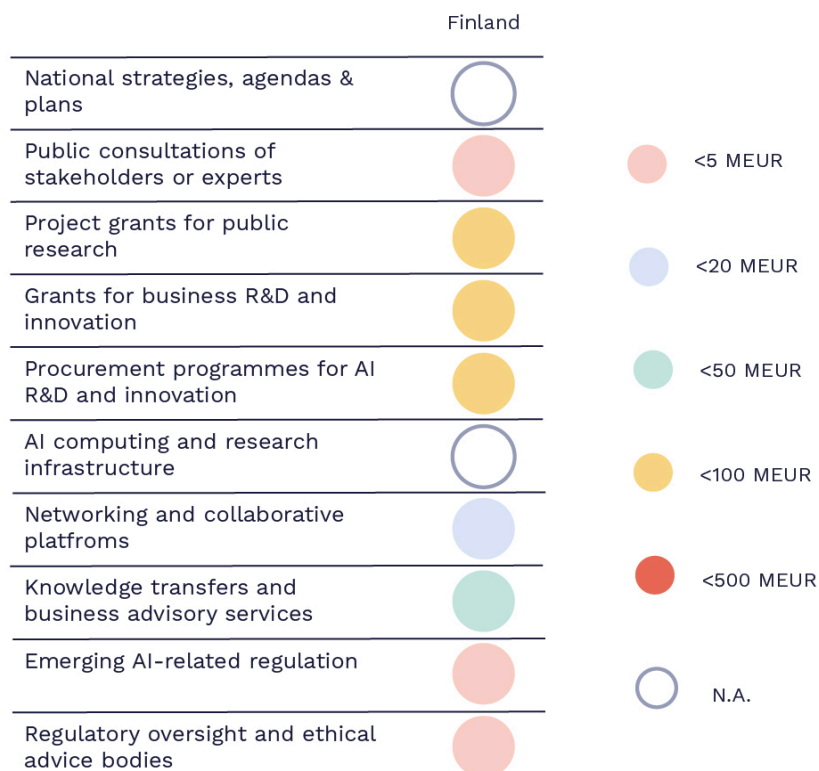
FINLAND

Finland published its national AI strategy in 2017, as one the first countries in the world. The strategy has been updated continuously, with a strong focus on transitioning from high-level guidelines and ideas to actual implementation. Although the upcoming years from 2021 to 2023 will embark on this journey, the ultimate impact will be seen after 5 to 10 years.

Finland has a relatively large AI ecosystem, especially when it comes to machine learning. As a small country, Finland has succeeded by being agile and smart, and thus it has been able to utilize and concentrate on its core strengths. Notably, Finland (i.e., FCAI1) was chosen to be part of the European AI-community of ELLIS among the first batch and is the only Nordic country chosen in the top30 units, which speaks for itself[2].

The new kid on the Finnish national AI strategy block is the "AI 4.0" Programme. The Program's first interim report set focus on data-driven circular economy solutions and data economy-related legislation. Additional focus areas are the ability to implement AI solutions, as well as increased funds for R&D.

Figure 44: Policy Instruments by Amount and Budget, 2021

Source: Source: Ministry of Economic Affairs and Employment, 2021 & 2019 & 2018 OECD.AI Policy Observatory, 2021

AI Readiness - Index Comparison

Finland, as one of the long-standing forerunners in digitalization in the EU, has a strong foothold to deploy the most recent AI solutions from the technological point of view.

According to Oxford Insights and the International Research Development Centre's (IRDC) AI Readiness Index 2020, Finland ranks 3rd in the world right after the United States and the United Kingdom. Last year, Finland ranked 5th, which implies a huge advancement. In the breakdown of the score, Finland's strengths are vision, data representativeness and infrastructure, while development areas are size, human capital and innovation capacity.

Figure 45: Responsible Use of AI – Breakdown

4th

76.17

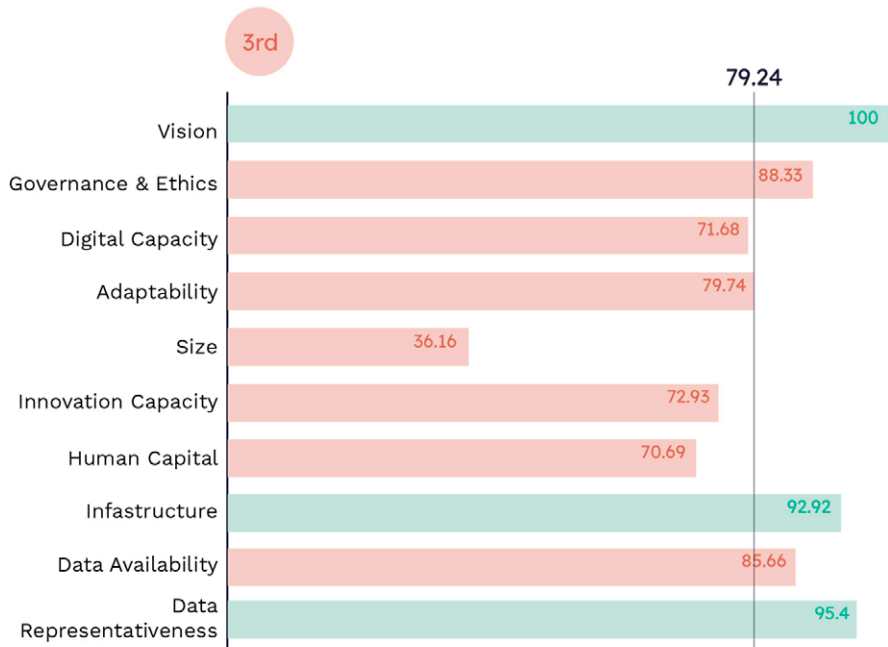| Inclusivity | 72.60 |
Accountability	82.20
Transparency	73.68
Privacy	76.20
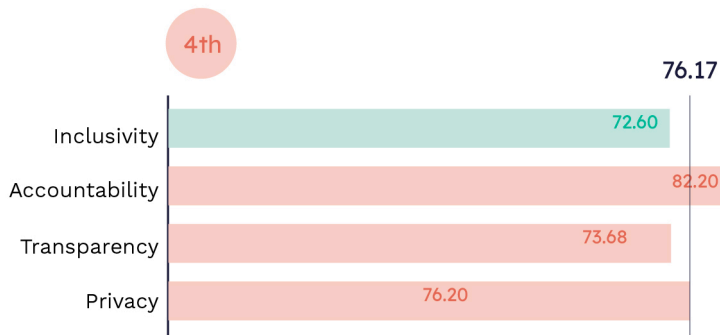
Source: Oxford Insights, 2020

In terms of responsible use of AI, Finland ranks 4th with the score of 76 points. In the responsible use of AI breakdown, Finland scored excellently in accountability and equally well in privacy, transparency and inclusivity, although all of these are still in need of increased focus in the near-future.

Figure 46: AI Readiness – Breakdown

To conclude, it is important for Finland to continue ranking high in both of these indices, as the combination actually demonstrates the future leaders in AI. Paying close attention to bridging the gap between weaknesses and strengths and continuing to pave the way in the responsible use of AI will ascertain remarkable future opportunities.

3rd

79.24

Vision	100
Governance & Ethics	88.33
Digital Capacity	71.68
Adaptability	79.74
Size	36.16
Innovation Capacity	72.93
Human Capital	70.69
Infastructure	92.92
Data Availability	85.66
Data Representativeness	95.4

Source: Oxford Insights, 2020

Investment

Legend:
- IT-equipment
- Telecommunications equipment
- Software and databases
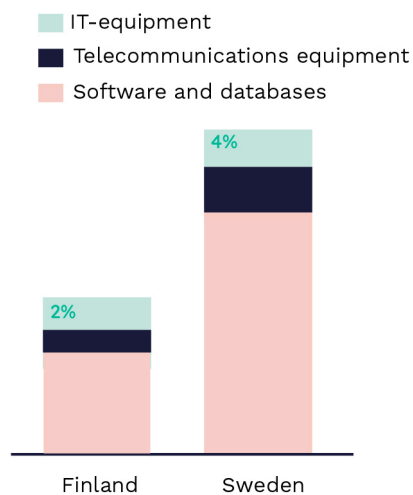
Source: Ministry of Economic Affairs and Employment, 2021, World Economic Forum, 2019

While the AI 4.0 Programme is guiding Finland from the Covid-19 crisis towards an AI-enabled sustainable, green and digital future, Finland's economic productivity has lagged behind ever since 2008, and can still be seen as one of the country's weaknesses. In the 2020 Digibarometer, Finland has declined three rankings in terms of investments in businesses and in previous years, ICTinvestments in relation to the GDP have been half of the percentage of neighbouring Sweden's.

Business Finland's AI Program has funded companies with over 100 MEUR during 2017 – 2021. From January 2021 to August 2021, ~10MEUR has been distributed to 25 AI initiatives. Out of the 200 companies funded by the program, 90% fall into AI-category and the rest into platform and data economy –category[1].

AI-leadership is strengthened by investing in selected preeminent technologies such the new supercomputer (HCP[2]) in Kajaani, that enable the generalisation of AI applications, data-based value creation, and increased high-technology start-up activities.

1. Expert Interview; HCP = High Performance Computing

Implementation

From the keyword search based on Vainu. io data, a total of 8456 companies that potentially use AI were identified. Out of these, approximately 1500 use AI on a daily basis. The top five industries that utilize AI are computer programming (17%), construction and real estate (14%), management consultancy (9%), legal and financial services (6%) and advertising and design (5%).

According to recent research, 12% of companies employing over 10 people currently use some AI-enabled solutions, which is above the average in EU (~7%)[1].

Figure 48: AI Implementation by Main Industries in Finland, 2021
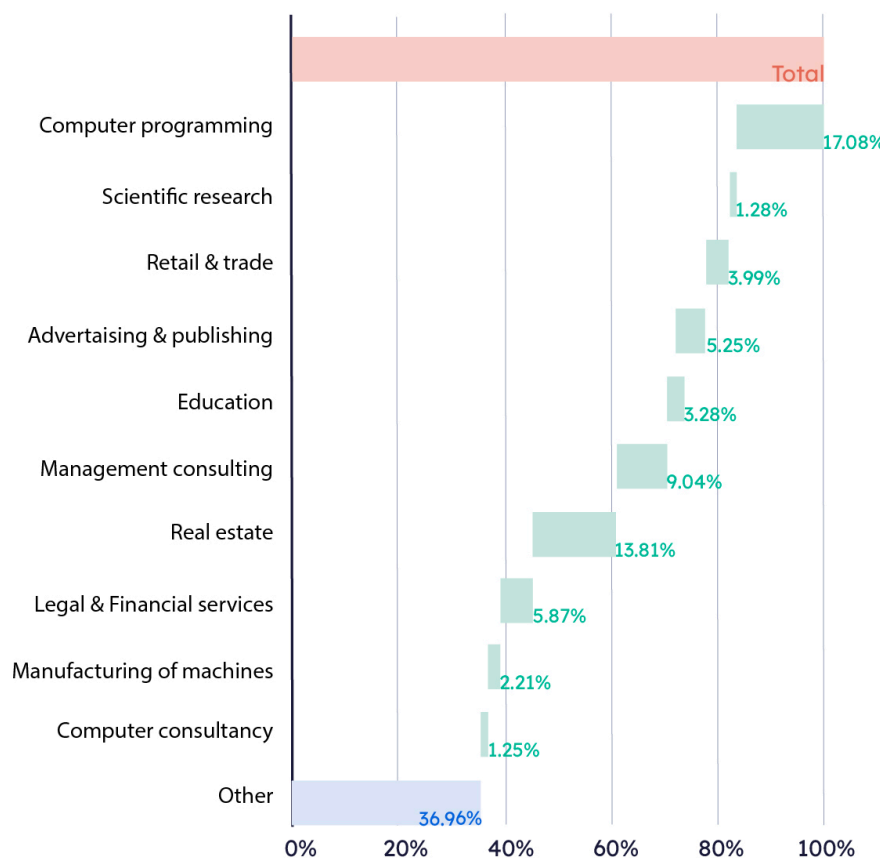
Source: Ministry of Economic Affairs and Employment, 2021; Vainu.io data analysis, by FAIA

THE NORDIC STATE OF AI

In difference to other Nordic countries, we have been analysing the state of AI in Finland since 2017 which allows us the luxury of comparison. A steady growth in companies using AI is evident, as is shown in figure 49. After a few quiet years (2019 and 2020) there seems to be a clear upswing for 2021 where a lot of companies have gone from experimenting with AI into scaling of AI.

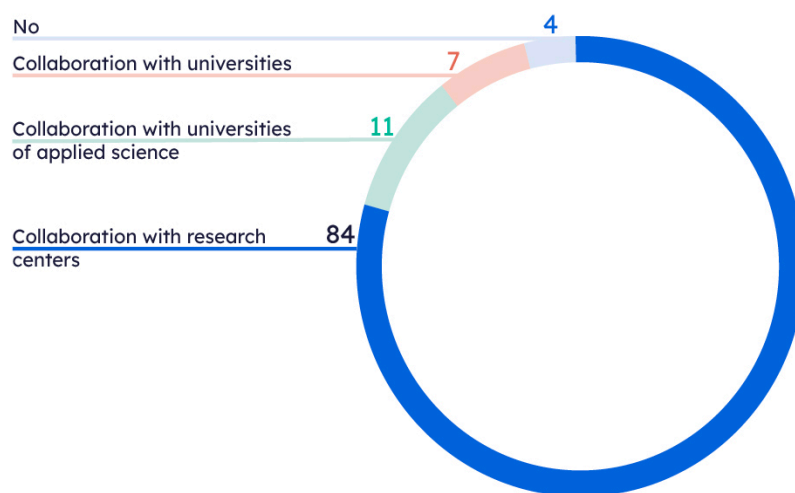*Figure 49: Annual growth of Companies using AI in Finland*
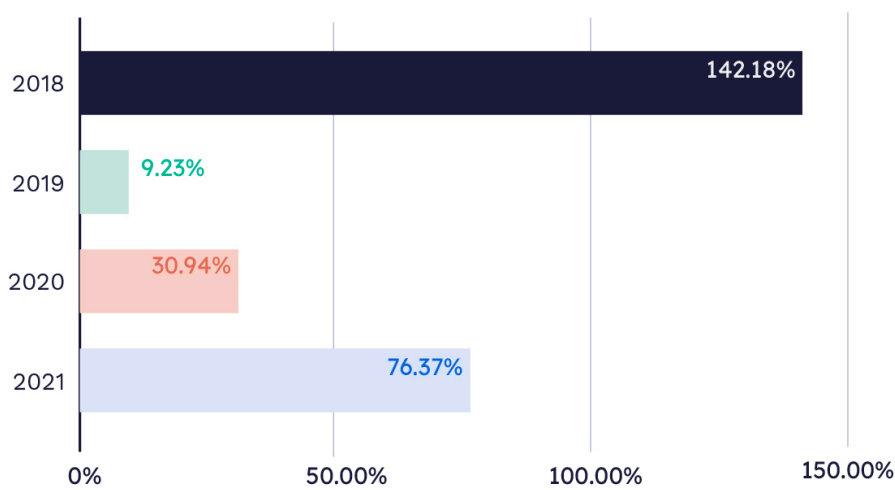
Source: Ministry of Economic Affairs and Employment, 2021; Vainu.io data analysis, by FAIA

Although Finland ranks excellently in the upper quarter in implementation in Europe, the pace needs to be accelerated by investing more, especially into education and research[2].

Research & Development

The Finnish Ministry of Economic Affairs and Employment highlights that the success of research and development (R&D) projects comes down to the degree of collaboration between research institutes and those offering the digital services and solutions. One of the main initiatives is the creation of experimentation platforms in order to offer companies the opportunity to explore new solutions before implementation1. While the Ministry of Economic Affairs and Employment plans to alleviate this by increasing the number of test environments by 20% from 2020, they predict that the increase in the number of companies and projects using the test environments grows by over 30%.

Figure 50: Innovation Collaboration of Finnish SMEs, 2019

No   4
Collaboration with universities   7
Collaboration with universities   11
of applied science
Collaboration with research   84
centers

*Source: Ministry of Economic Affairs and Employment, 2021by FAIA*

Finland's 5G test network is a combination of multiple companies R&D-environments' wireless data communications experimentation platforms. As a part of AI 4.0 Programme, this network will be updated and the utilization rate is ramped up by 30%. This enables the development of applications combining AI and tele-communications, taking into account new phases of 5G as well as the emerging standards of 6G technology.

Finnish Center for AI (FCAI) has identified three dimensions where the Finnish AI research has focused and succeeded on2. Firstly, optimizing the performance of Deep Neural Networks (DNNs) is important for a small country such as Finland, since the costs of computing increase non-linearly we will need alternative and more efficient technical solutions. Secondly, Finland has focused on Trustworthy AI, an initiative to solve the complex challenges that stem from connecting ethics and values to AI. Finally, creating solutions for the Human-Machine interactions is especially valuable since the role of AI is always a supporting one. While AI might be able to solve a sub-problem of a larger entirety, erasing some manual parts of the task involved, the role of a human cannot easily be made obsolete. Understanding these encounters is valuable in creating real-life solutions.

Education

Finnish citizens represent a highly educated and tech-savvy population. There are many opportunities for AI education, which is also one of Finland's strengths. Recent years have been spent reforming education systems towards providing high-quality AI courses in addition to courses in communication and social skills, problem solving and creativity. Elements of AI is a series of free online courses created by the Finnish IT strategy and consultancy company Reaktor and the University of Helsinki. In addition, there is an online introduction course to Python. These courses together should guarantee a basic AI literacy across the Finnish population. Moreover, there are new Bachelor's and Master's programmes that include courses in AI as well as incentives for teachers to include the use of AI in their courses and teaching methods.

Figure 6: Number of Specialized AI Programs, 2019-20
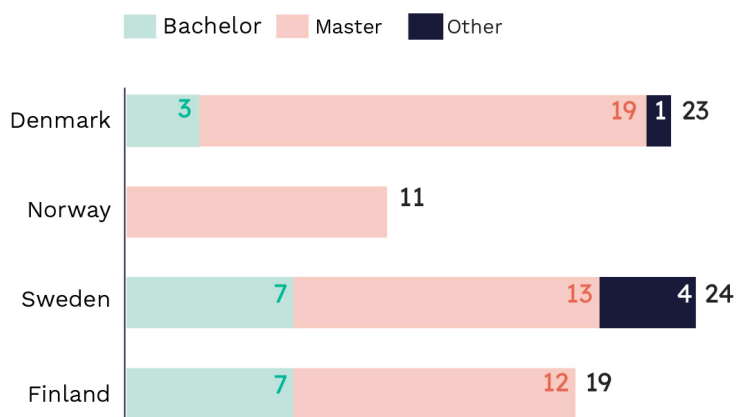

Source: Stanford University, 2021

FCAI[1] is one of the Academy of Finland Flagships. In addition to major scientific, societal and economic impact, FCAI has a crucial educational role in increasing the competence of both Finland's workforce and the general public. This is done e.g. through Master's and doctoral programmes, various MOOC courses for the wider public, as well as through collaboration with industry and other stakeholders in the society. Continued support of the academia and AI research specifically is crucial if AI is to be a disruptive force that contributes to Finland's success as a pioneer[2]

Since 1 million Finns are expected to need reskilling to adapt to changes in occupational structures, targeting the working-age population is especially important. Promoting lifelong learning opportunities and tools for further education makes it possible to close the gap between available skills and the needs of the labour market.

Talent

*Figure 8: Talent in the Nordics by role*
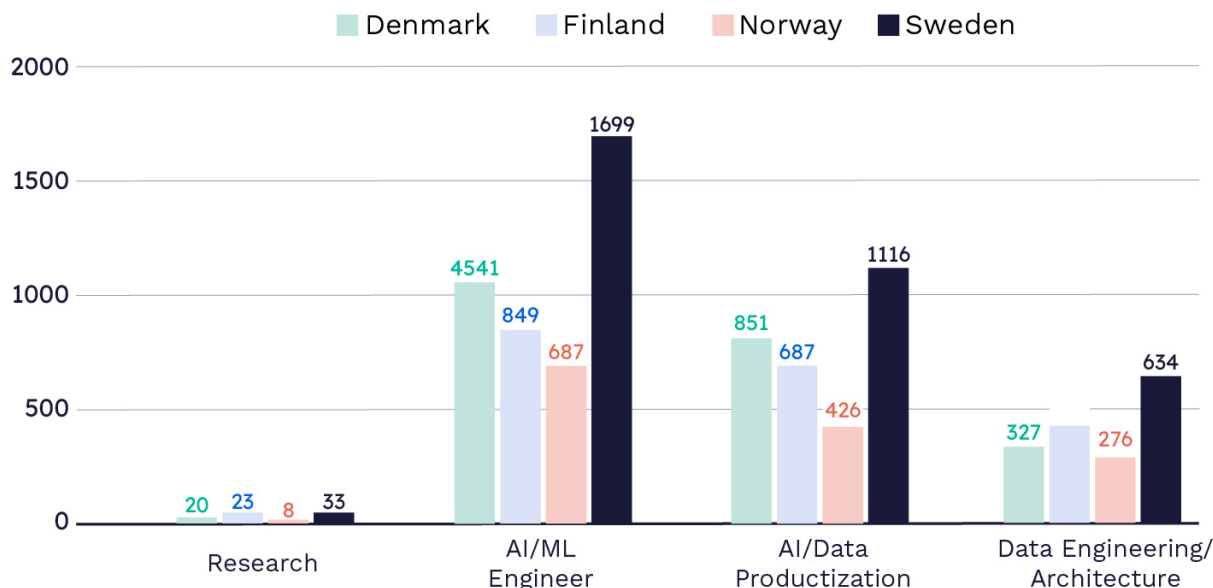
Source: Ministry of Economic Affairs and Employment, 2021; FAIA & Silo.AI, 2020; Business Finland, 2021

Finland's talent lies mostly in tangential fields, such as signal processing, electronics, radio technology, theoretical algorithm research and 5G/6G-technologies, which creates relatively good fundaments for generating more AI-expertise. In addition, Finland ranks second in integrating digital solutions to business, especially when it comes to cloud-services.

If this transfer of talent from the research to the industry is successful, it will enable creating value to businesses through AI-solutions. In order to capitalize on this underlying talent, Finland will have to rely on its strength of collaboration between the private and the public sector, different industries and organizations in Finland and throughout the Europe. While Finland has succeeded in the technological talent acquisition, more knowhow is needed in communications, R&D, and sales and marketing.

Although Finnish startups are often sold to overseas quite quickly, even more important for Finland's talent ecosystem would be to foster the culture of serial entrepreneurship[1]. This enables the talent to remain in Finland and would also attract some foreign talent to the Nordics.
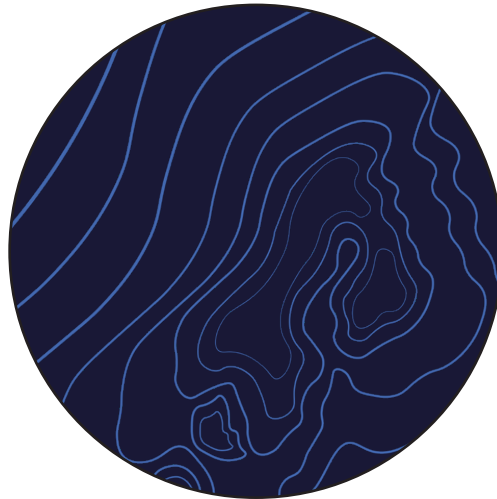
Conclusions

To conclude the very first Nordic State of AI-report, it feels an understatement to say that this is still the early days for what will be seen from the Nordic AI. While this is only the beginning, Nordics truly are a forerunner region in the field, especially when it comes to overall AI readiness combined together with AI ethics and trustworthiness. **Nordic values can indeed be seen shining through all AI implementation and research, which is unquestionably one of the core strengths of the region.**

Going forward, it is not only for the benefit of this report, but of the region as a whole, to continue and strengthen the collaboration between the countries. **As of today, we are lacking a joint vision for the Nordics.** The statement is not meant to undermine great common initiatives, such as the Declaration on AI in the Nordic-Baltic Region, but to ensure continued unity and growth, we need to see an increasing number of real life implementation and R&D –focused projects.

We should create a common vision and make it our strength. The relatively small size of the Nordic AI market, combined with a low-hierarchy society, hide one thing that bigger players and market lack: the ability to come together. The joint vision, in addition with a set of shared Nordic values can help pave the way for an AI-enabled future for all.

Source: Calculated by FAIA, based on numbers from the Global AI Talent Report 2020.

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3 - Appendices

METHODOLOGY

LITERATURE REVIEW AND QUALITATIVE DATA

First, we conducting a literature review and analysis on existing quantitative and qualitative research papers on AI in the different Nordic countries. The selected research papers were chosen carefully in order to get as reliable and topical information as possible, while still getting a broad and diverse overview of the topic at hand.

QUANTITATIVE DATA

Quantitative research papers and data were given a high priority to get a precise snapshot of the current state of Nordic AI. In addition to online sources, we received data from Vainu. io that were collected by searching through organizations' external communications in each country with 26 AI-related keywords. We received approximately ~40,000 rows of raw data, which were cleaned, sorted out, and analysed to determine each country's implementation levels, most important industries, types of companies using AI, as well as market size by the number of companies. After the first round on data cleaning ~25000 organisations were determined to mention using AI in a reliable way. The website of these organisations were then manually examined, and based on subjective analysis of team size and composition, size of organization and the

offering (products and services) we estimated that ~5000 companies utilize AI on daily basis in their operations.

SURVEY METHODOLOGY

A survey was sent to ~300-500 organizations in each country to determine where AI is applied, how big the AI teams are, plans of further investments, recruiting needs as well as challenges developing and integrating AI solutions. We received 93 answers, which of 11 were dismissed due to insufficient data.

INTERVIEW METHODOLOGY

A total of 20 Interviews were conducted throughout four sectors of academia, public sector, business sector and investor.

All of the expert interviews were conducted in semi-structured qualitative interview -style. In addition, the interview contents were reviewed and analysed in order to determine contradicting opinions with other interviews, with literature research and quantitative data. These insights are embedded in the report.

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This report was put together by Silo AI in collaboration with numerous organizations focusing on AI – thank you for your support! If you would like to get involved in this annual report or discuss its findings, get in touch with Silo AI Head of Growth Kati Kinnunen at kati.kinnunen@silo.ai or at +358 50 381 9977.

Silo AI

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