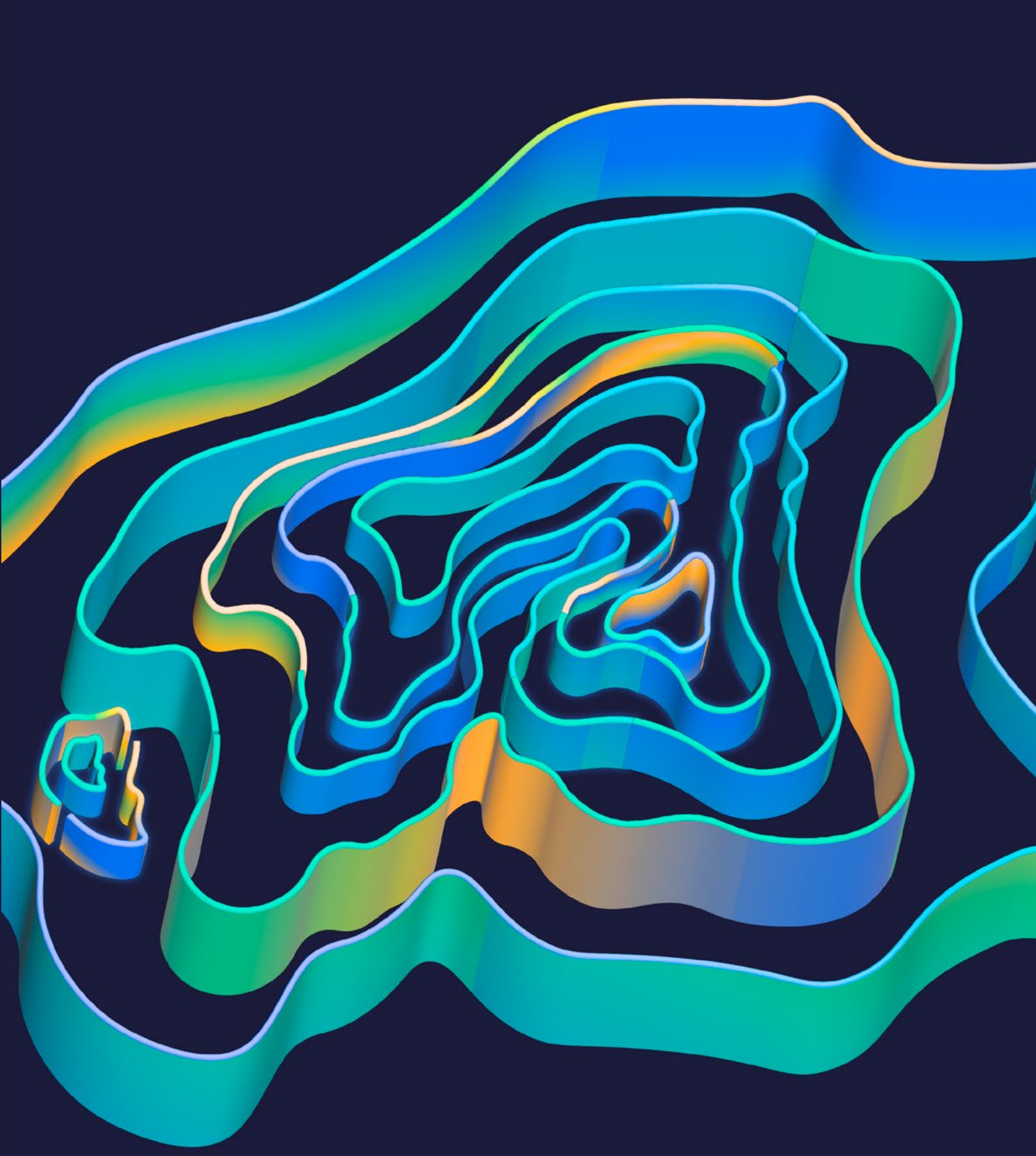


The Nordic State of AI

The 2022 Report

SILO AI

Contents

INTRODUCTION

Welcome to the Nordic State of AI Report 2022. As in previous years, this year's edition provides an overview of the use of artificial intelligence in the Nordic region, with the goal of offering business leaders, academics, policymakers, as well as anyone interested a comprehensive look at what's really going on in Nordic AI.

We often talk about leveraging networks to reach scale with AI. True to that, we've expanded our collaboration from past years to 15 governmental, research or data organizations across Denmark, Finland, Norway, and Sweden who were involved in the creation of this year's report. We would like to extend special thanks and gratitude to our partners who helped make this report better by providing us with information, interviewees, and local knowledge: AI Pioneer Center in Denmark, Business Finland, Chalmers, Vainu, Danish Industry Digital Futures, Digital Norway FCAI, KTH Royal Institute of Technology NORA, Nordic Innovation, Norwegian Cognitive Center, Silo AI, Smart Innovation Norway, Swedish AI Society, and Women in AI Finland. As a fortunate side product of assembling this report together, we're also strengthening these networks across the region and getting one step closer to the Nordic success of AI.

As readers of last year's report will notice, we have kept the structure of the report similar. The main focus is on the individual and comparative status of AI in the four biggest Nordic countries: Denmark, Finland, Norway, and Sweden. This year's report also contains elements that are important on the overall Nordic level as well as within each Nordic country. Such elements are diversity in technology and the use of AI for environmental sustainability. Stepping still further, this second report of its kind has let us reflect on some of the findings from last year's report and evaluate how the maturity of AI adoption is progressing in the Nordics.

This year's report has been set in motion by First AI Accelerator, the ecosystem branch of Silo AI. As the largest private AI lab in the Nordics, our priority is to narrow the knowledge gap in AI technologies and build new connections that help us together scale Nordic AI.

We hope you will have an insightful reading experience.

Niko Vuokko

First AI Accelerator by Silo AI

1 - The Nordic State of AI

Key findings

INTRODUCTION TO NORDIC STATE OF AI IN BUSINESS

Artificial intelligence is moving from a period of hype and high hopes into a phase of realistic expectations and implementation of AI in production. Today in the Nordics, AI is already bringing value as a key part of products and services. Out of the Nordic companies surveyed for this report, 73% use AI today as part of their core product or service. Close to 65% of companies said AI brings them the most value as improved product or service quality and 66% said AI improves the features and usability of their product or service (Nordic State of AI Survey 2022).

It is estimated that by applying AI technologies, companies can unlock close to €70 billion in value in the Nordics (McKinsey & Company, 2019). While many companies and governments have been exploring the possibilities of using AI, a lack of talent and data continue to pose significant challenges for accelerating the use of AI in the Nordics (Nordic State of AI Survey 2022). Without significant investments into AI in both the public and private sectors, the Nordics risk slowing down their adoption rate of AI technologies. Globally, a silver lining is already visible: according to the PwC 2022 AI Business Survey, 36% of companies globally are already benefitting from implementing AI.

The Nordic State of AI Report 2021 concluded that while the Nordics may be forerunners in AI readiness, ethics, and trustworthiness, the countries were still in the early stages of using artificial intelligence. Though they all hoped to benefit from adopting modern technologies, such as AI, the Nordic countries lacked a clear strategy, not to mention necessary collaborations within the sphere. In this year's survey for Nordic companies, a clearer strategy and more investments were again called for. The Nordic governments vary in their investments and strategies to accelerate the use of AI. While AI is doing well in academia in all of the Nordic countries, general knowledge and education are still lacking (Nordic State of AI Survey 2022).

KEY FINDINGS - OVERVIEW

Company level

- Over 70% of Nordic companies surveyed use AI as part of their product and/or service and most surveyed companies consider improved product or service as the main value AI brings them

- 44% of organizations globally are trying to embed AI into their existing applications and processes (IBM 2022)

- Nordic companies surveyed rely on internal talent when it comes to AI and seem to prefer open source platforms

- Despite the lack of talent identified as key obstacle among Nordic companies, educating existing staff is an overlooked option and most efforts focus on hiring new employees skilled with AI

Global level

- In the Nordics, the three biggest challenges in scaling AI are lack of talent, lack of data, and a lack of shared practices related to data

- More than a quarter of companies surveyed invest 20% or more of their R&D in AI development

- Nordic governments continue to score well in the Government AI Readiness Index but some larger economies have managed to catch up (Oxford Insights 2021)

- All the Nordic countries host one or multiple top European AI-related educational institutions, and the number of academic research published is increasing

- The AI adoption rate is now at 35%, a sizeable increase from 31% last year (IBM 2022: IBM 2021)

- Private investments in AI more than doubled year-on-year in Q1/2022 to $93B globally (CBInsights 2022)

- According to IBM (2022) 66% of organizations globally plan to address climate sustainability with AI while only 25% of Nordic companies surveyed are doing the same

AI INDEX COMPARISON

In this chapter, we explore the Government AI Readiness Index produced by Oxford Insights. Last year in the 2020 index, Nordic countries were placed within the top quartile. Since then, several countries have caught up, e.g. Singapore and Canada (see Figure 1, Oxford Insights 2021).

This year Finland (index score 79.23) dropped from 3rd to 4th place, while scoring the highest of the Nordic countries. Finland and the UK were overtaken by Singapore. The United States still leads the index, scoring close to 10 points higher than any Nordic country with 88.16 points (Oxford Insights 2021).

Sweden, scoring second out of the Nordics (index score 78.16), dropped from 5th to 6th place. With the Netherlands scoring just slightly higher than Sweden (78.51), Sweden still ranks the highest among the Nordics in technology (Oxford Insights 2021).

Similarly, due to Singapore's rise, Denmark (76.96) scored 9th. Placing 13th, Norway (index score 76.14) was the only Nordic country to fall outside the top 10. Norway also scored relatively low in technology at 59.25, while the average of the other Nordics in technology was 64.82 (Oxford Insights 2021), which may be due to the way that Norway's economy is structured.

The positive performance of the Nordics in the index can be explained by the countries' internal capabilities.

Figure 1. Country rankings are based on the Government AI Readiness Index 2021

Global Position	Country	Overall Score	Goverment	Technology Sector	Data and Infrastructure
1	United States of America	88.16	88.46	83.31	92.71
2	Singapore	82.46	94.88	66.69	85.80
3	United Kingdom	81.25	85.69	67.69	90.81
4	**Finland**	79.23	88.45	63.85	85.40
5	Netherlands	78.51	80.42	66.17	88.92
6	**Sweden**	78.16	80.76	67.37	86.36
7	Canada	77.73	84.36	63.75	85.08
8	Germany	77.26	78.04	67.68	86.07
9	**Denmark**	76.96	83.50	63.24	84.14
10	Republic of Korea	76.55	85.27	58.49	85.89
11	France	76.41	82.10	60.61	86.53
12	Japan	76.18	81.90	59.31	87.32
13	**Norway**	76.14	84.24	59.25	84.91
14	Australia	75.41	83.79	57.07	85.37
15	China	74.42	83.79	61.33	78.15

European average score

62.09

Nordic average score

77.62

Source: Oxford Insights 2021.

Overall, the Nordics are well-positioned. The results of this index are very similar to the Digital Economy and Society Index (DESI) produced by the European Commission this year, where Norway is not included as it is not an EU country. However, larger economies are catching up. The Nordic countries therefore need to benchmark themselves against other competitors, and develop their capabilities in government, technology, as well as data, and infrastructure to ensure that Nordic companies remain competitive.

The positive performance of the Nordics in the index can be explained by the countries' internal capabilities. For instance, Oxford Insights (2021) praises Finland for its ability to deliver public services and for the integrity

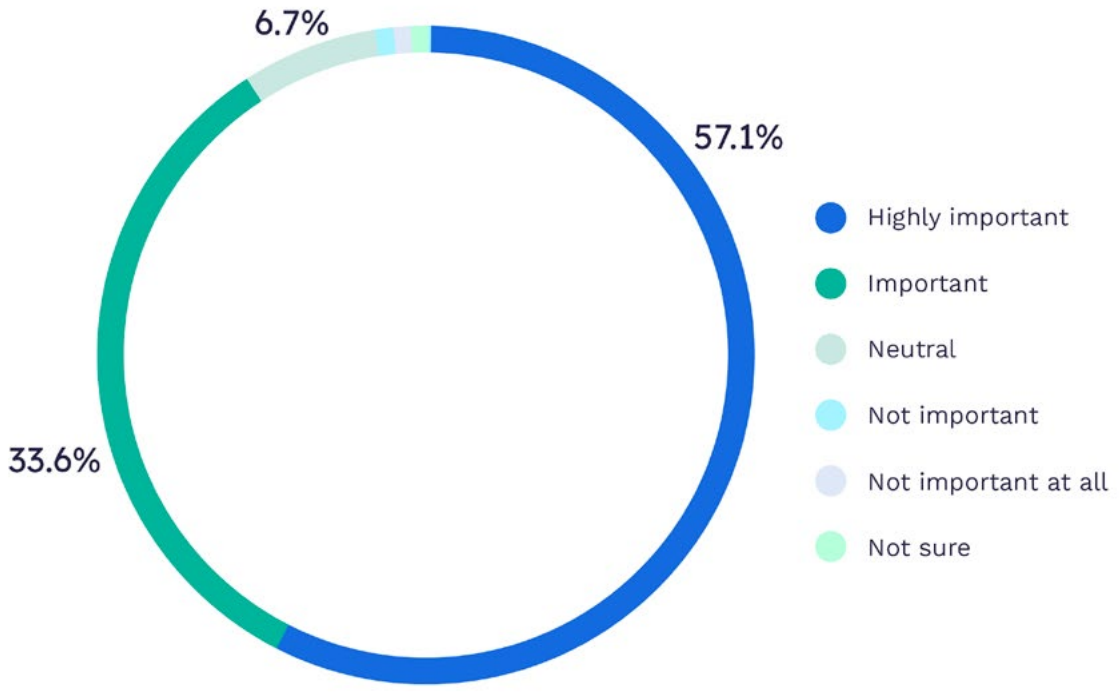
of its policymaking – Finland scored third for government, just behind the United States (Oxford Insights 2021).

The Oxford Insights Index shows that the Nordic countries should improve their performance in technology. This ranking is based on criteria such as size, innovation capacity, and human capital, with size being the largest lacking area for the Nordics. The US performed the best in technology, likely because the country is home to many technology giants and it produces many rapidly scaling global technology startups (Oxford Insights 2021; CBInsights 2022).

The Index reveals that the Nordic countries should improve their performance in technology.

For the Nordics, there is plenty of room to improve their international tech presence. As a region, the Nordics represent a positive blend of pro-innovation policy and institutional capability. One area contributing to the Nordic success in AI is a governmental AI strategy developed in one way or another in each Nordic country. This analysis of both opportunities and challenges has allowed the accelerated use of AI (Oxford Insights 2021).

Figure 2. The value of AI for the responding organization

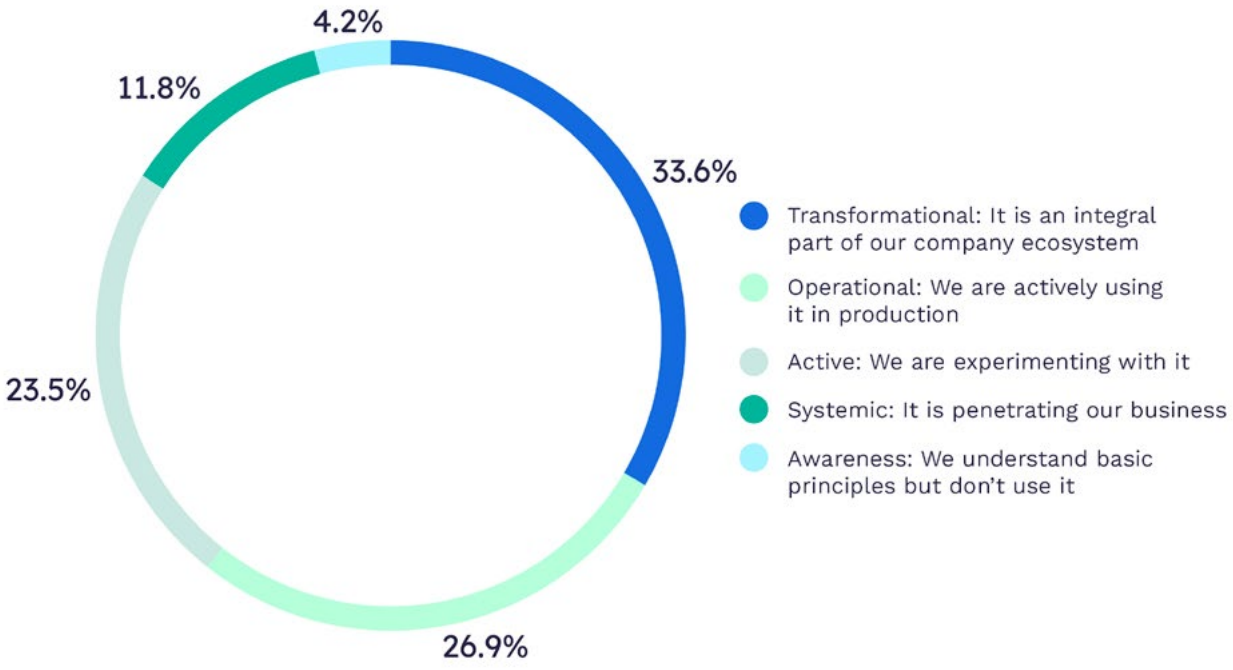


Source: Nordic State of AI Survey 2022.

Both last year and this year the Nordics performed in a similar way, indicating a similar level of adoption of AI, along with a similar AI maturity level. Nordic businesses see AI as an important field of technology (Figure 2.) More than 90% of Nordic companies surveyed replied that AI is either Highly important or Important to their organization (Nordic State of AI Survey 2022).

When it comes to maturity, our survey confirms what Oxford Insights (2021) states: the Nordic countries are at the higher stages of AI maturity. According to our survey, one-third of companies surveyed saw themselves on the highest level and less than 5% chose the lowest level (see Figure 3; Nordic State of AI Survey 2022). The maturity levels in our survey were based on Gartner's AI Maturity Model (Gartner 2020).

Figure 3. Organizational AI maturity levels



Source: Nordic State of AI Survey 2022.

One-third of companies surveyed saw themselves on the highest level of AI maturity and less than 5% chose the lowest level of simply being aware of AI.

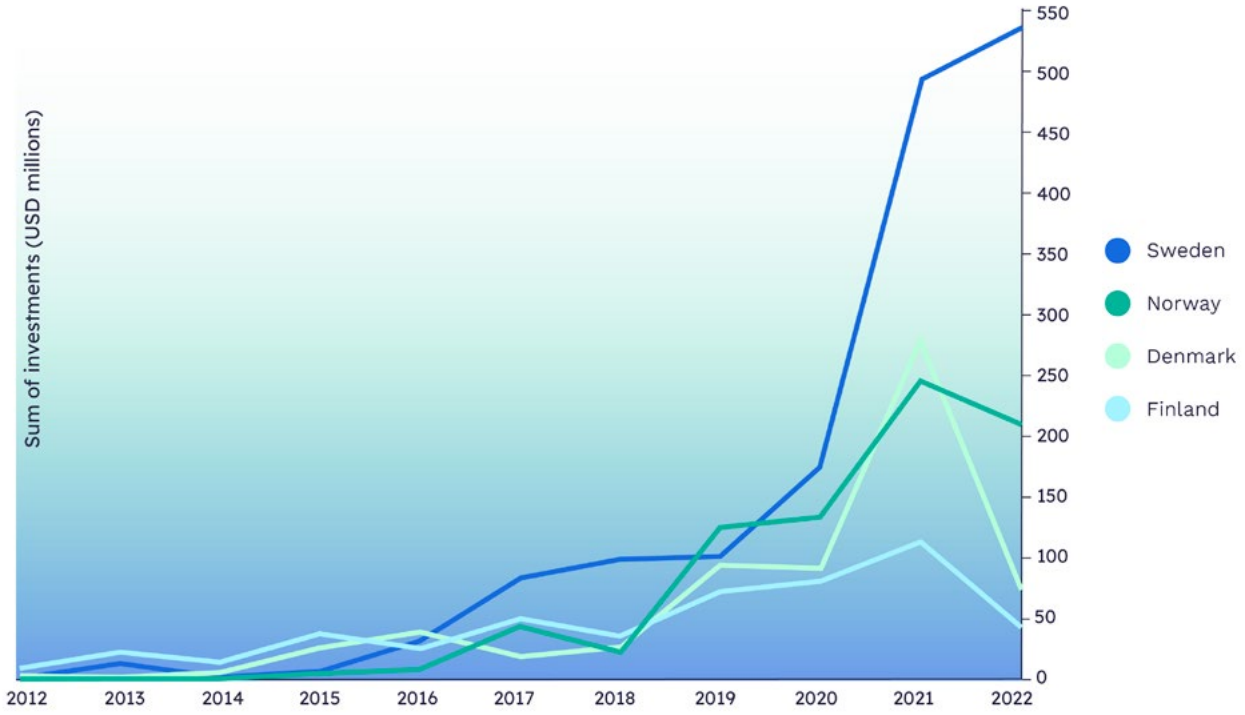
NORDIC INVESTMENTS

The Nordic countries have significantly increased their venture capital investments in AI in recent years (Figure 4). In Sweden, VC investments have more than doubled in just two years from less than $200 million in 2020 to over $500 million in 2022. VC investments in Sweden are currently about $50 per capita, while in the US the same investments account for $300 per capita. (Word Bank 2022; OECD.AI 2022).

In Denmark, VC investments in AI have also grown substantially between 2020 and 2021. Norway's VC investments are less than those in Sweden or Denmark, however, the country increased its AI investments by $100 million between 2020 and 2021. Despite a slight decline forecasted for 2022, Norway's investment trend is still upward.

Finland stands out with the least invested VC euros - barely exceeding $100 million. Since 2019, Finland's VC investments in AI have been the lowest in the Nordics. Overall, Nordic VC investments in AI are expected to decrease in 2022, with the exception of Sweden (OECD.AI 2022).

Figure 4. VC investments in AI by country



Source: OECD.AI 2022.

Looking at Nordic VC investments by industries, we can note that the focus differs from one Nordic country to another.

VC INVESTMENTS IN AI BY INDUSTRY – TOP 3 INDUSTRIES

Denmark: 1) Media, social platforms and marketing 2) Business processes and support services 3) Consumer products

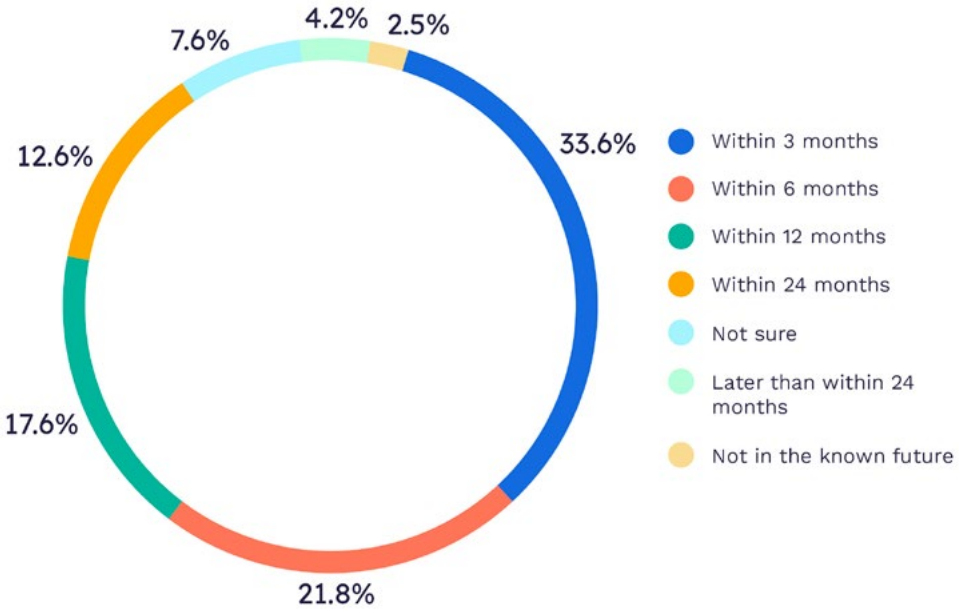
Finland: 1) IT infrastructure and hosting 2) Healthcare, drugs and biotechnology 3) Business processes and support services

Norway: 1) Business processes and support services 2) Robots, sensors, IT hardware 3) Mobility and autonomous vehicles

Sweden: 1) Logistics, wholesale and retail 2) Energy, raw materials and utilities 3) Media, social platforms and marketing

In our Nordic State of AI survey (Figure 5), roughly a third of respondents said that they expect to adopt new AI solutions within 3 months. Half of the companies surveyed expect to see new AI technologies adopted within the next 6 months (Nordic State of AI Survey 2022). However, one-quarter of respondents replied that the adoption of new AI technology takes more than a year or that they do not know when this will happen. Compared to the value seen in using AI technologies (Figure 2 in the previous chapter), the pace is not fast enough. Looking at gross domestic expenditure on R&D, Sweden is the clear leader of the Nordic countries, while Norway invests significantly less in R&D (Figure 6). What's worth noting is also Finland's significant drop from 3.7% to 3.0% of GDP between 2010 and 2020, while all the other Nordics have increased their spending.

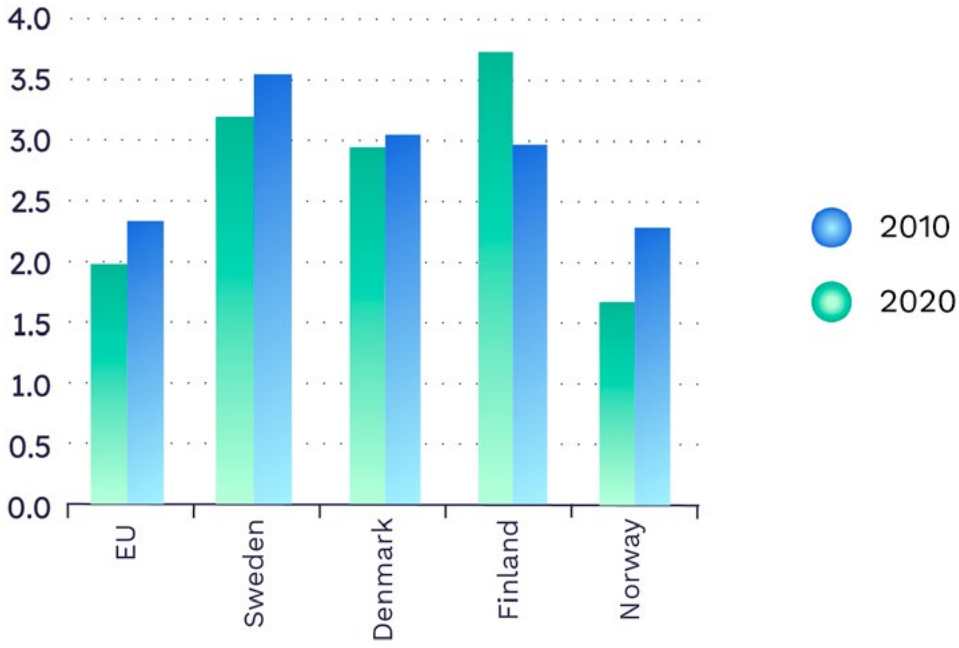
Figure 5. Adoption of AI-based technologies in products or services



Source: Nordic State of AI Survey 2022.

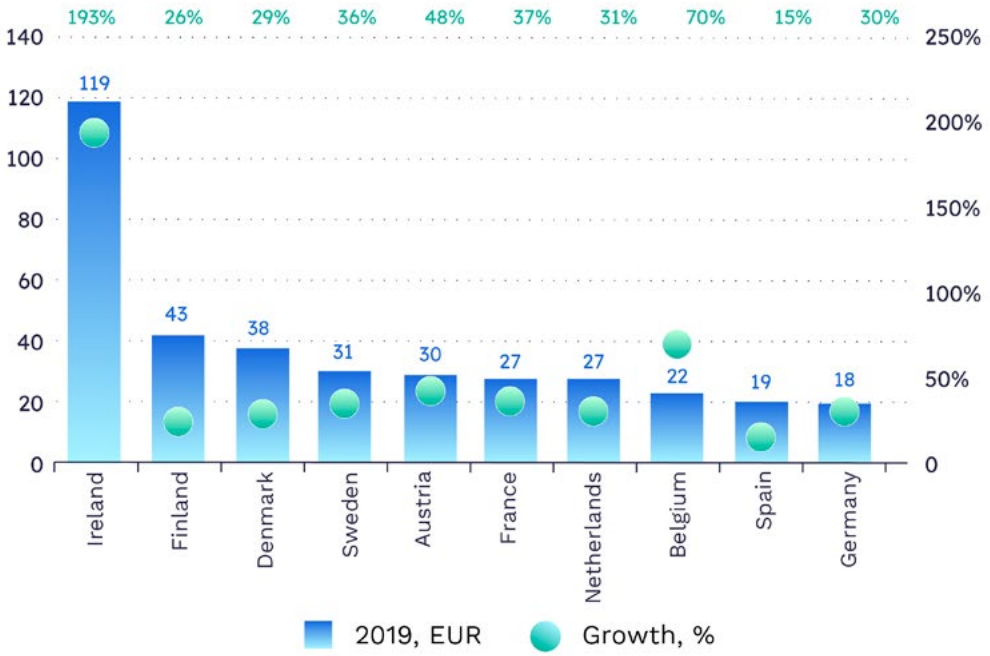
The Nordic countries rank high in AI investments per capita (Figure 7). In 2018 and 2019, Finland, Denmark, and Sweden all increased their AI spending in the public and private sectors. Sweden's spending on AI increased by 36% per capita from 2018 to 2019. Norway is missing from the EU-based data (European Commission 2022).

Figure 6. Gross domestic expenditure on R&D, 2010 and 2020



Source: Eurostat 2020a.

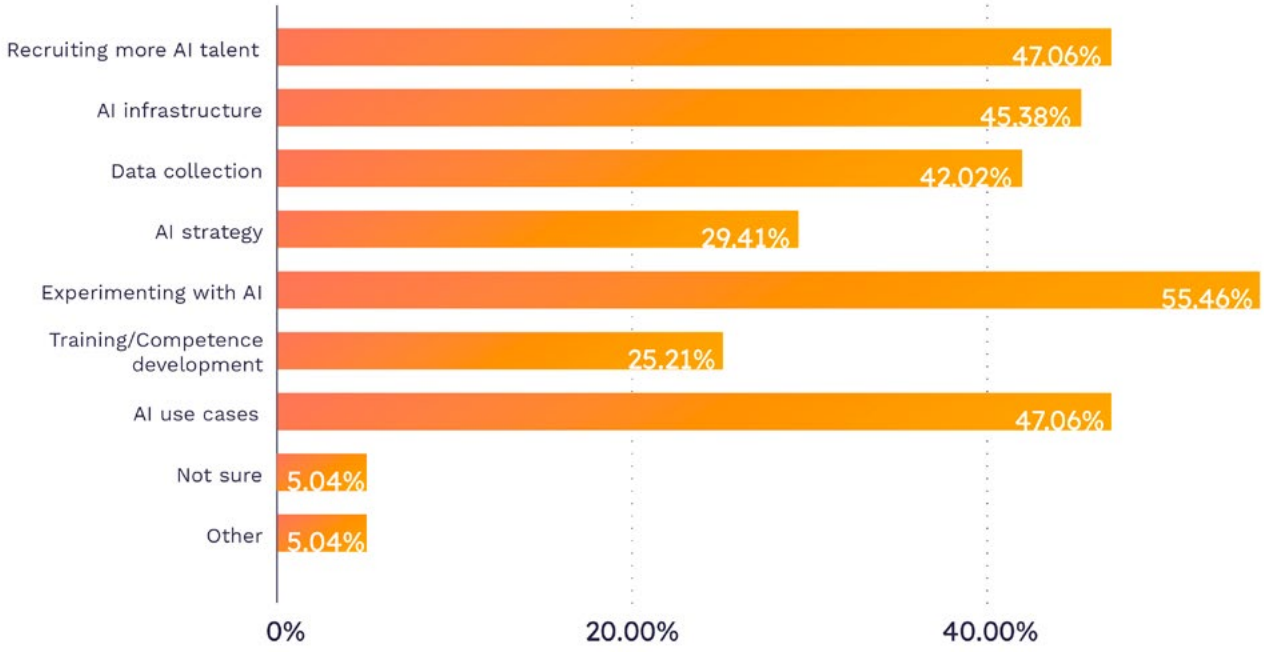
Figure 7. AI Investments per capita by country (EUR) in 2019 and growth (%) between 2018 and 2019



Source: European Commission 2022.

Our survey shows that Nordic companies invest in all facets of AI (Figure 8). However, there's a clear need for concrete implementation and use cases. Many companies invest in experimenting and in finding AI use cases (Nordic State of AI Survey 2022).

Figure 8. Investments in AI during the upcoming 6 months



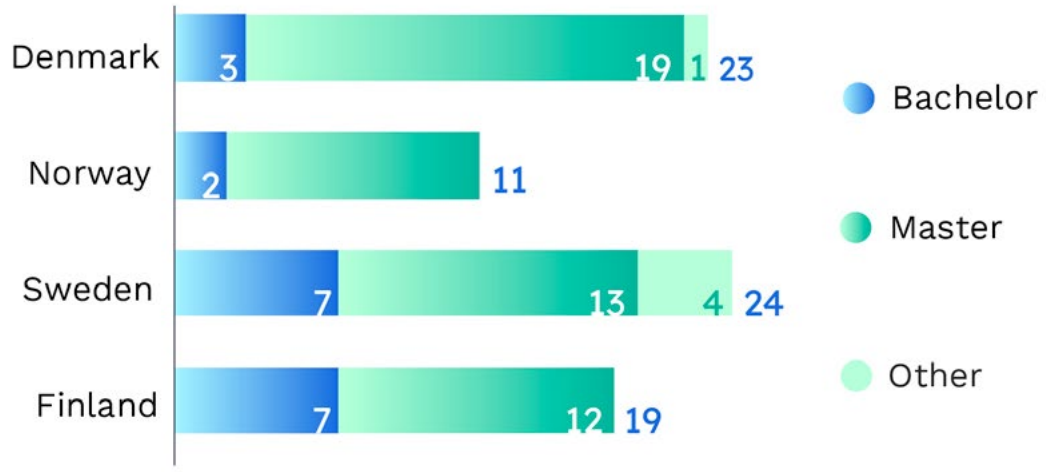
Source: Nordic State of AI Survey 2022.

EDUCATIONAL PROGRAMS

The Nordics have been a significant hub for technology education and research for decades. Additionally, universities have broadened their offerings to match the increasing demands for technical, data, and AI resources. Most of the available programs are at the master's level, which is also the prevailing trend in the EU27 countries (Stanford University 2021). In 2020, Sweden was offering the largest number of courses at the university level, whereas Norway had the fewest. Recently, Norway has added two bachelor-level courses (NORA.ai 2022).

As seen in Figure 9, AI is well represented in specialized course selections in Denmark and Sweden. Norway has the lowest number of specialized programs and it has only one top 100 European AI university (Nordic Innovation 2022; Edurank 2022). Most of the courses in the EU27 countries are master's level courses, whereas in the US there are specialized AI programs equally for bachelor's and master's degrees (Stanford University 2021). Having only master's-level courses could create a barrier to entry to some courses as they require at least a bachelor's level of education to enter unless the skills are incorporated into bachelor's programs too.

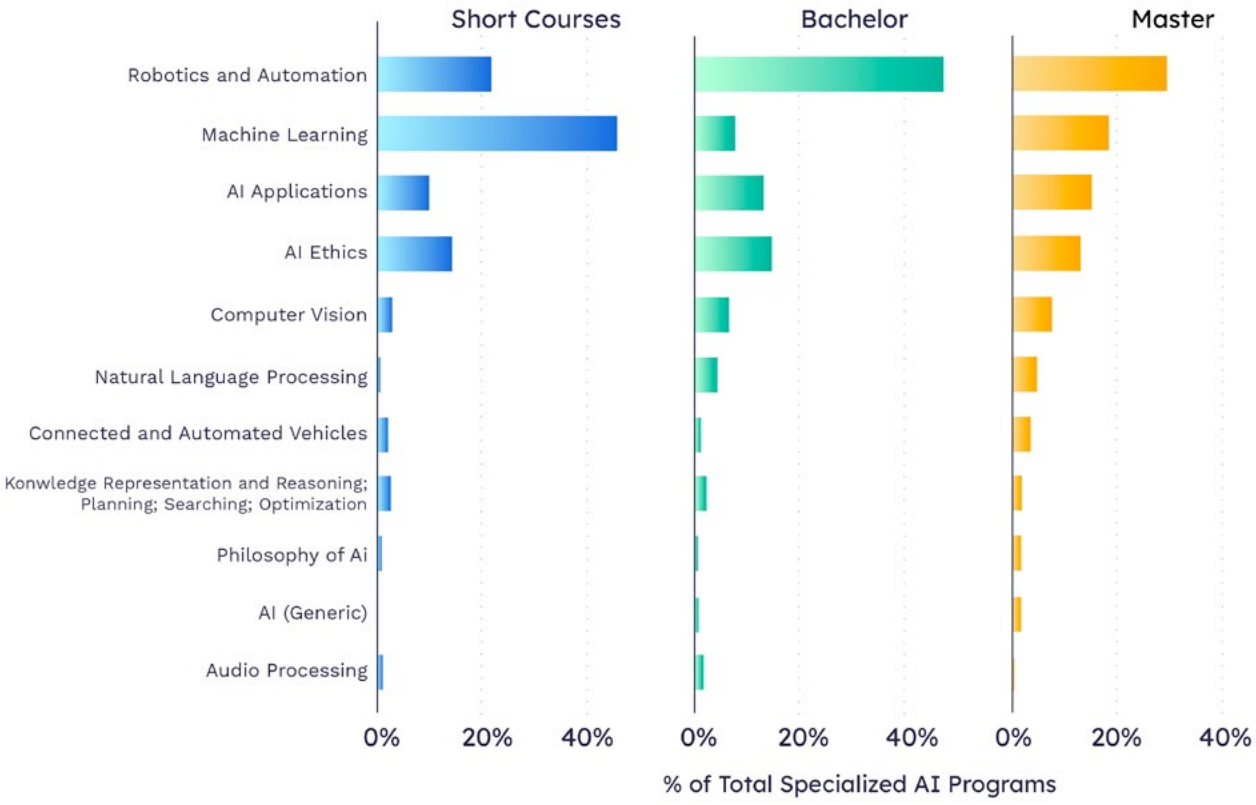
Figure 9. Number of Specialized AI Programs in the Nordics, 2019-22



Source: Stanford University 2021; NORA.ai 2022

According to the Artificial Intelligence Index Report 2021 (Stanford University 2021), the three most common master's level programs in EU27 focus on Robotics & Automation, Machine learning, and AI Applications (Figure 10). This is also the case in the Nordics. At the bachelor's level, Machine learning is a far less common course than at the master's level but is the most common to appear on the list of short courses. AI Ethics is the second most common program type and AI Applications is the third. Robotics & Automation represents a considerably larger proportion of available courses than at the master's level. AI ethics is quite typical at both the bachelor's as well as master's levels, as well as in the short courses category (Stanford University 2021).

Figure 10. Specialized AI Programs by content area in the EU27



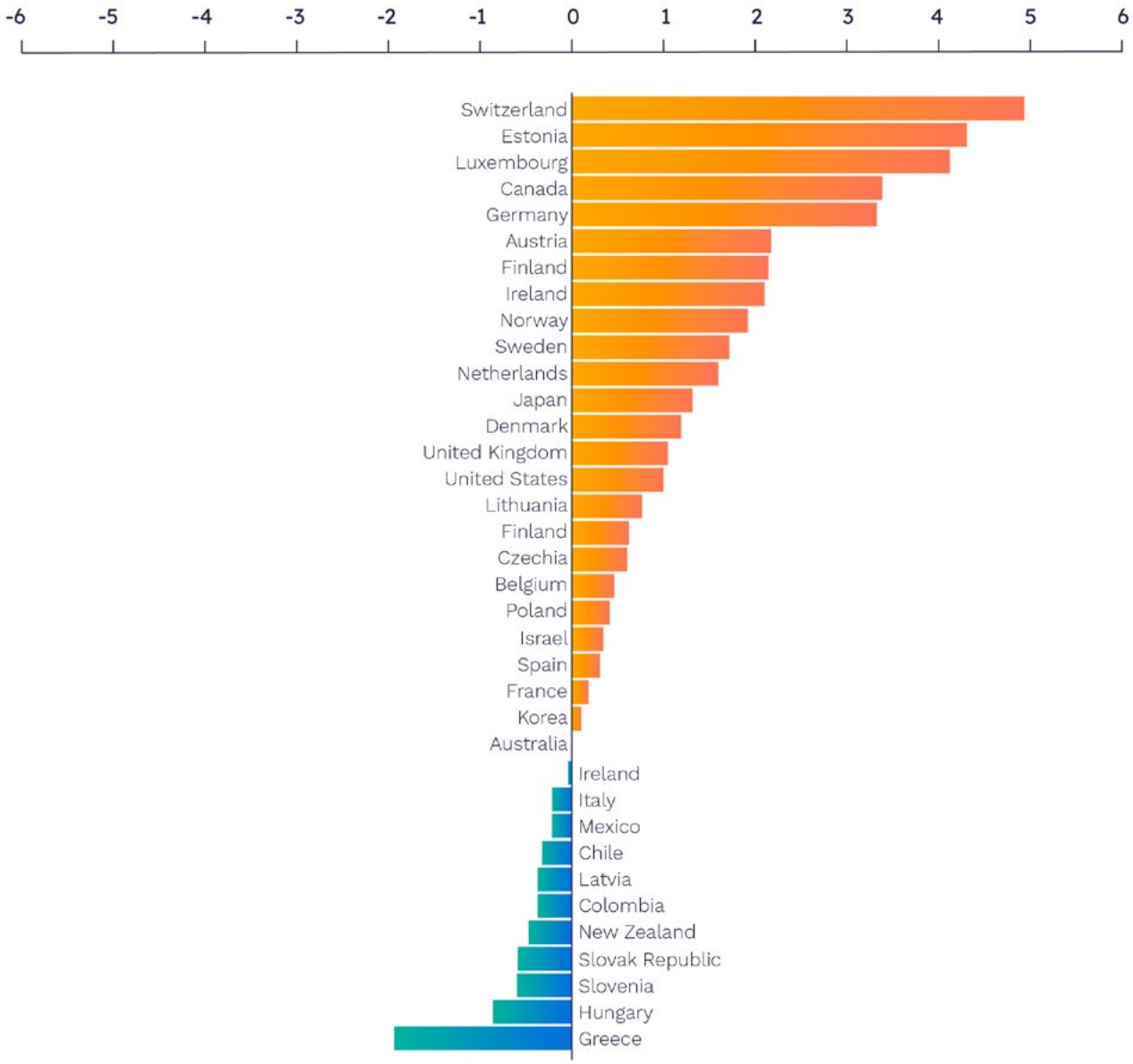
Source: Stanford University 2021.

Most of the available programs are at the master's level, which is also the prevailing trend in the EU27 countries.

TALENT

A lack of talent or expertise is the top reason hindering AI adoption (IBM 2022). Globally, 80% of companies have already reported or are planning to reduce some of their AI-related activities as a direct consequence of an AI talent shortage (PwC 2022 AI Business Survey). Of respondents queried in O'Reilly's AI Adoption in the Enterprise 2022, 45% reported a talent shortage in ML modeling and data science. However, successful AI adopters are thriving despite this challenge due to their holistic approach - they are more likely to rearrange teams for utilizing the available talent and retrain their existing workforce to match new AI scaling needs (PwC 2022). Retraining staff has been raised by IBM (2022) too.

Figure 11. Between-country AI skills migration



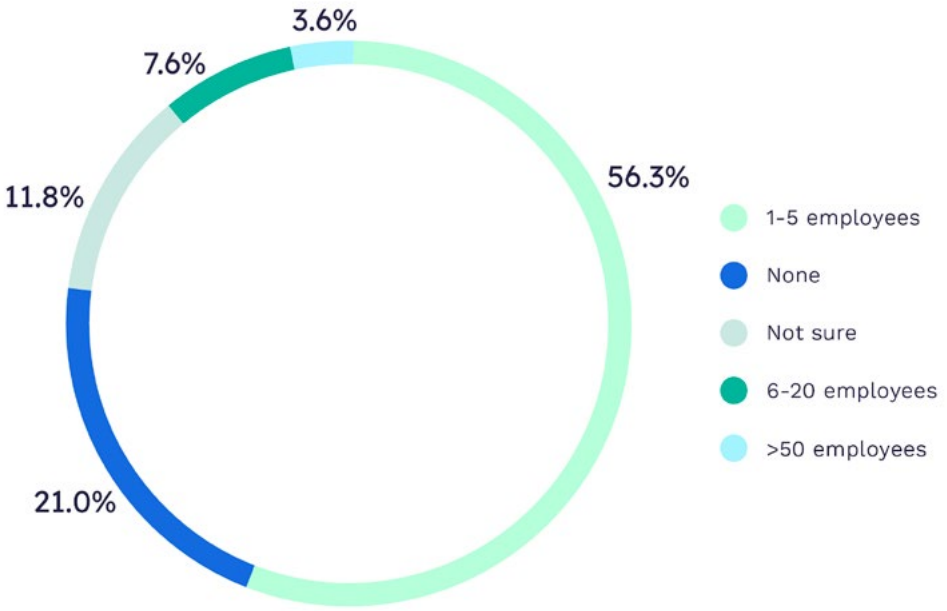
Source: OECD.AI 2022.

The Nordics have managed to have a positive talent migration trend, attracting AI talent from abroad (OECD.AI 2022). The Nordics represent less than 2% of the worldwide AI talent pool (Nordic State of AI 2021), so while the region can't compete in scale, it can focus on quality. Helsinki and Stockholm are among the top 50 global AI talent hubs, despite some heavy competition (Harvard Business Review 2021). In 2021, Finland was the seventh most attractive OECD country for AI talent to migrate to. Norway and Sweden placed close by at 9th and 10th, respectively. Nordic countries are doing relatively well in attracting talent, however, it can be noted that Estonia, a small country neighboring the Nordics, performed better, placing second right after Switzerland (Figure 11, OECD.AI 2022).

According to our survey, at least half of the respondents are intending to hire 1-5 AI-related people within the next six months (Figure 12). Close to 20% of Norwegian companies plan to hire more than five people, which was the highest result from an individual Nordic country (Nordic State of AI Survey 2022).

Many Nordic organizations surveyed rely on internal talent (see Figure 13) for AI development. Organizations prefer to use internal expertise (79.8%) rather than outsource their AI development entirely (13.5%), which puts pressure on hiring. Companies should perhaps consider retraining existing talent as the AI talent market becomes overly competitive, stalling the progress of AI development. From a software perspective, Open source platforms and tools were the most selected resource, as more than 60% of organizations chose that. Furthermore, more than 40% selected Internal platforms and tools as a used resource. However, this does not rule out the use of external and commercial options (Nordic State of AI Survey 2022).

Figure 12. Recruitment of new AI-related talent in the next 6 months



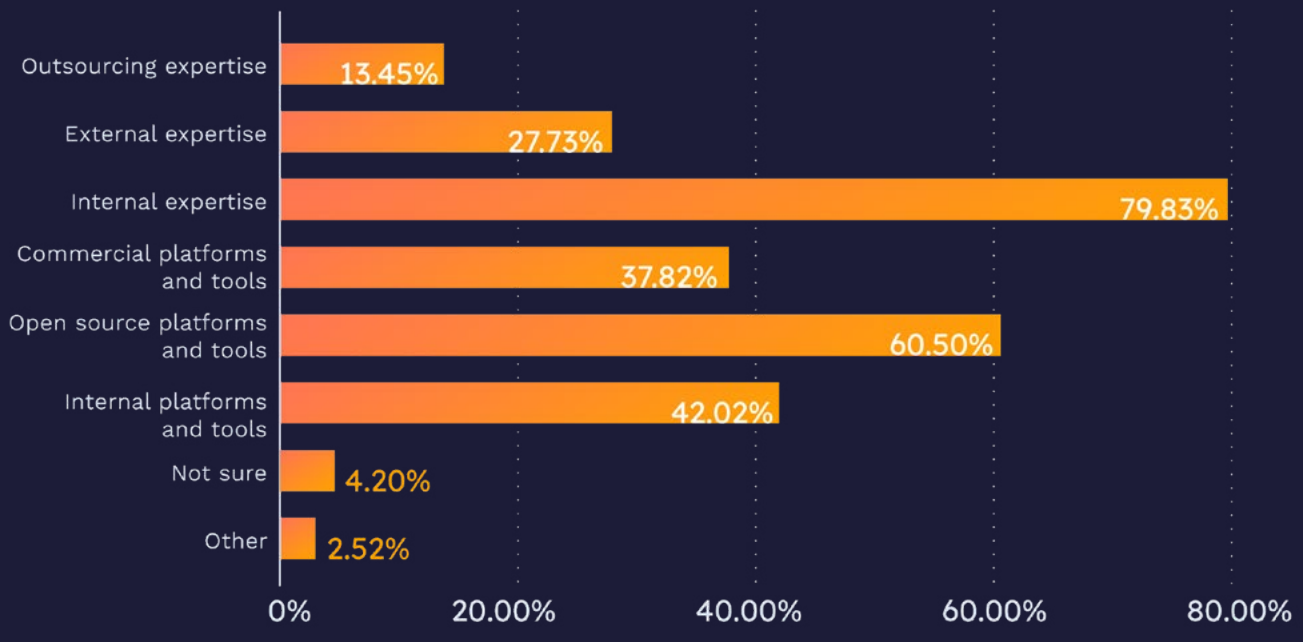
Source: Nordic State of AI Survey 2022.

COMPANIES CLAIMING LACK OF TALENT AS MAIN CHALLENGE IN ADOPTING AI

- 35% in Denmark
- 31% in Norway
- 47% in Finland
- 14% in Sweden

All of the Nordic countries are in the top 20 in European rankings when it comes to skills in Business, Technology, and Data Science (Coursera's Global Skills Report 2022, Figure 14). Denmark leads in the Nordics with the highest percentage of skilled workers in the Business and Technology categories. Finland is the strongest in Data Science, while it was the weakest performing Nordic country in the Business category. Norway has the lowest percentage of skilled talent in the Technology and Data Science sectors and is the lowest performer overall. The Nordics are ranked exceptionally well at the European level. To compare, the UK, which is often mentioned as the top performer in AI-related matters, placed 38th globally (Coursera 2022).

Figure 13. Resources used to develop AI



Source: Nordic State of AI Survey 2022.

Companies should perhaps consider retraining existing talent as the AI talent market becomes overly competitive, stalling the progress of AI development.

Figure 14. Coursera Global Skills Report 2022

Global Position	Position Change	Country	Business	Goverment	Technology
1	0	Switzerland	99%	94%	97%
2	↑ 5	**Denmark**	94%	97%	97%
4	↑ 1	Belgium	98%	89%	90%
7	↑ 8	Netherlands	82%	90%	93%
8	↓ 2	**Sweden**	81%	87%	94%
9	↓ 5	Germany	92%	85%	88%
10	↑ 3	Bulgaria	80%	86%	95%
11	↓ 9	Austria	97%	74%	92%
12	↓ 2	Belarus	26%	99%	96%
13	↓ 1	**Finland**	65%	91%	98%
15	↓ 1	Italy	86%	84%	79%
16	↑ 9	France	68%	88%	87%
17	↓ 8	**Norway**	75%	80%	89%
19	↑ 11	Serbia	73%	79%	83%
20	↑ 7	Poland	41%	93%	80%

Source: Coursera 2022.

Diversity of talent

When it comes to diversity, gender inequality and lack of diversity continues to be an issue in technology, including in the field of AI. As it is well known, hiring more diverse talent would reduce the biases in AI systems, leading to more reliable results, decisions, and outcomes and a better representation of the real users of these technologies.

Products conceived by diverse teams are more likely to perform better, as they can better relate to their user group. In addition, McKinsey & Company (2020, cited in Women in AI 2022) reported that companies with the most gender-diverse executive teams were more likely to be more profitable than their counterparts. When thinking about how to improve diversity, it is important to start somewhere: diverse workplaces are more attractive to the overall talent pool (Women in AI 2022). As re-skilling and training of existing personnel is a viable option to match AI talent demand (PwC 2022), these efforts could focus on people who bring more diversity to the team.

Figure 15. The Global Gender Gap Index 2022 rankings

Rank	Country	Score 0-1	Score change 2021
1	Iceland	0.906	+0.016
2	Finland	0.860	-0.001
3	Norway	0.845	-0.004
4	New Zealand	0.841	+0.001
5	Sweden	0.822	0.000
⋮			
32	Denmark	0.764	-0.004

Source: World Economic Forum 2022

Looking at gender diversity, the Nordics still lead the pack when it comes to gender parity. Finland, Norway, and Sweden all ranked in the top five in The Global Gender Gap Index 2022 (World Economic Forum 2022). Scoring much lower, Denmark came in 32nd out of the 146 countries assessed (World Economic Forum 2022).

The overall trend of women in technology is promising: in Finland, more women applied for technical education than ever before. However, the amount was still small. A mere 2% applied for an ICT program and 5% for a technical program. For men, technical study fields were among the most popular programs (Technology Industries of Finland 2022).

Less than a quarter of all AI specialists are women. McKinsey & Company report (2020, cited in Women in AI 2022) stated that the situation around the gender gap is stagnant. One estimate says it will still take 132 years to reach full parity of the genders at the current rate (Women in AI 2022; World Economic Forum 2022). In 2019, McKinsey & Company named lack of understanding and lack of women as key inhibitors to people not pursuing AI-related education (McKinsey & Company 2019).

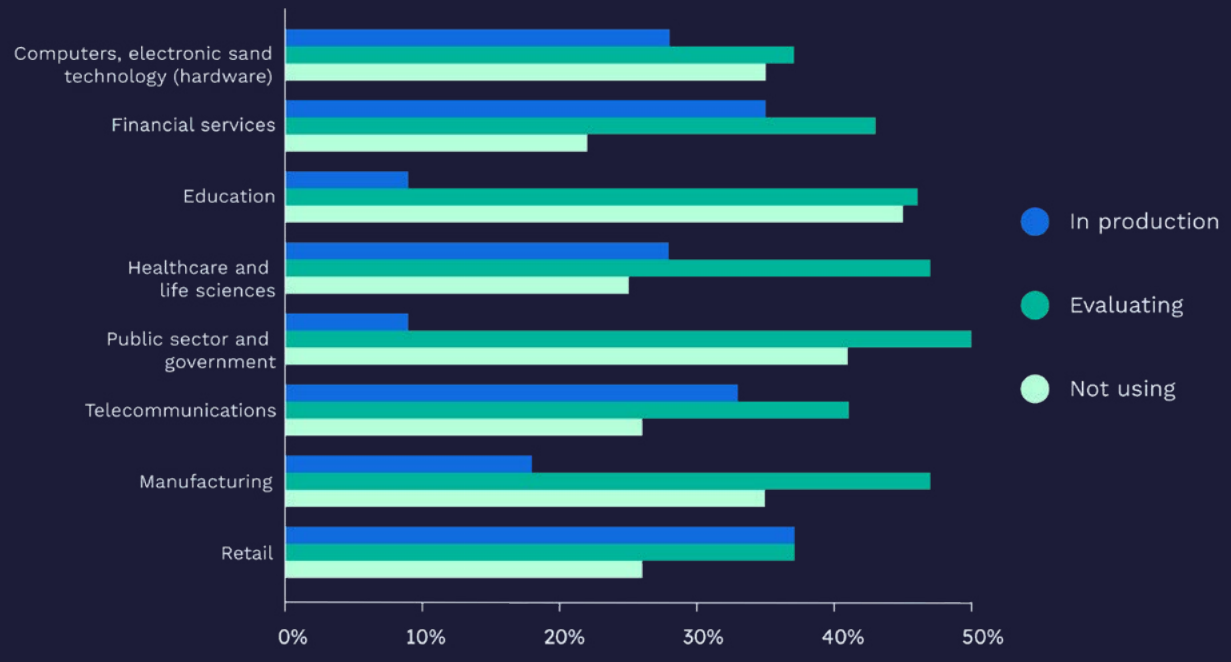
In 2019, McKinsey & Company named lack of understanding and lack of women as key inhibitors to people not pursuing AI-related education.

USE OF AI

The knowledge gap between a company capable in AI and an AI novice is widening, as the amount of new companies implementing AI continues to plummet, while investment in AI flow rises exponentially. More AI-mature companies capitalize on their accumulated knowledge of AI (Stanford University 2022). With a decrease in investments, the AI market will become more difficult to enter and the businesses will be polarized into AI winners and losers. According to IBM (2022), large companies are 100% more likely to adopt AI compared to smaller ones, and larger firms report a faster rate of AI deployment too (IBM 2022).

The hype around AI seems to have passed, and the number of new AI patents filed is diminishing. It looks like we are entering the stage of maturation (Marcs & Clerk 2022). However, investments in AI are still growing (CBInsights 2022). Taking a closer look at different AI technologies, Computer vision has risen in popularity during the past years. In contrast, speech processing has lost ground and likely stabilized its position in the markets by reaching its current full potential (Marcs & Clerk 2022).

Figure 16. AI adoption by industry



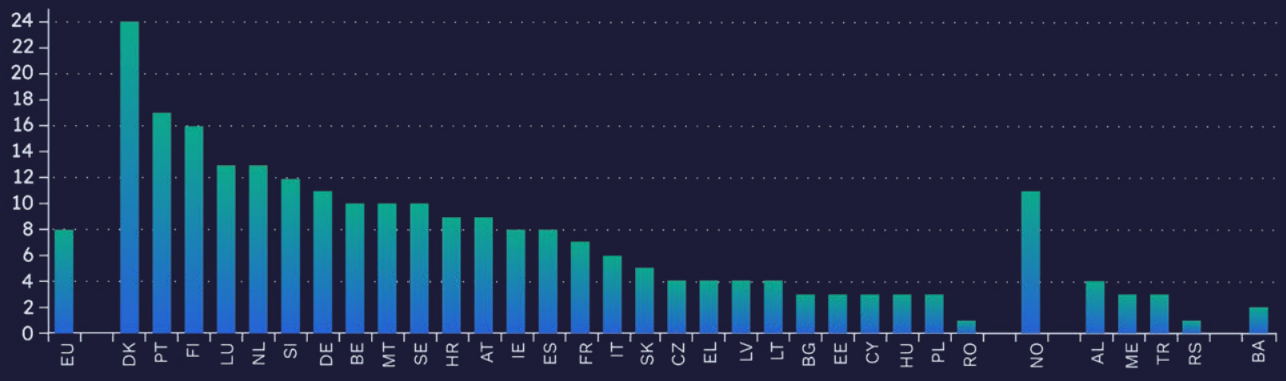
Source: O'Reilly 2022.

The Retail and Financial sectors had the highest percentages of AI technologies in production (Figure 16, O'Reilly's 2022). Both industries rely on data and are relatively well digitized. The least likely sectors to have AI in production or use AI were Education and Government. In both of these sectors, the consent for using data for AI might not be as straightforward as in the Retail and Financial sectors. Both the Education and Government sectors report being in the evaluation stages (O'Reilly 2022).

When it comes to enterprises using AI technologies, the Nordics score above the EU average of 8%. Denmark is the leader in the Nordics and the EU, with 24% of its enterprises using AI (Figure 17). Finland comes second with 16% of enterprises using AI, while 11% of enterprises in Norway report they use AI. Sweden comes in last among the Nordics at 10% (Eurostat 2022). The information is somewhat contradicting as according to our data partner Vainu's data set, Sweden has the most companies mentioning an AI term on their website (Figure 18, Vainu.io 2022).

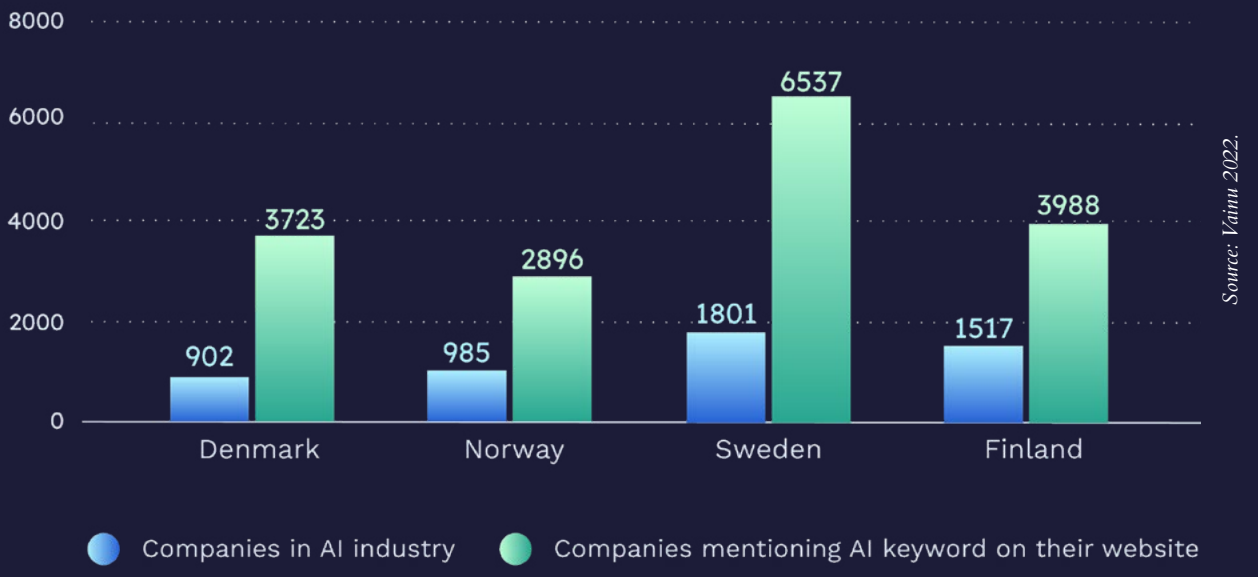
The probability of a Danish enterprise using AI was approximately 18%, while in Sweden the corresponding number was just 11%, according to our calculations.

Figure 17. Enterprises using AI technologies 2021



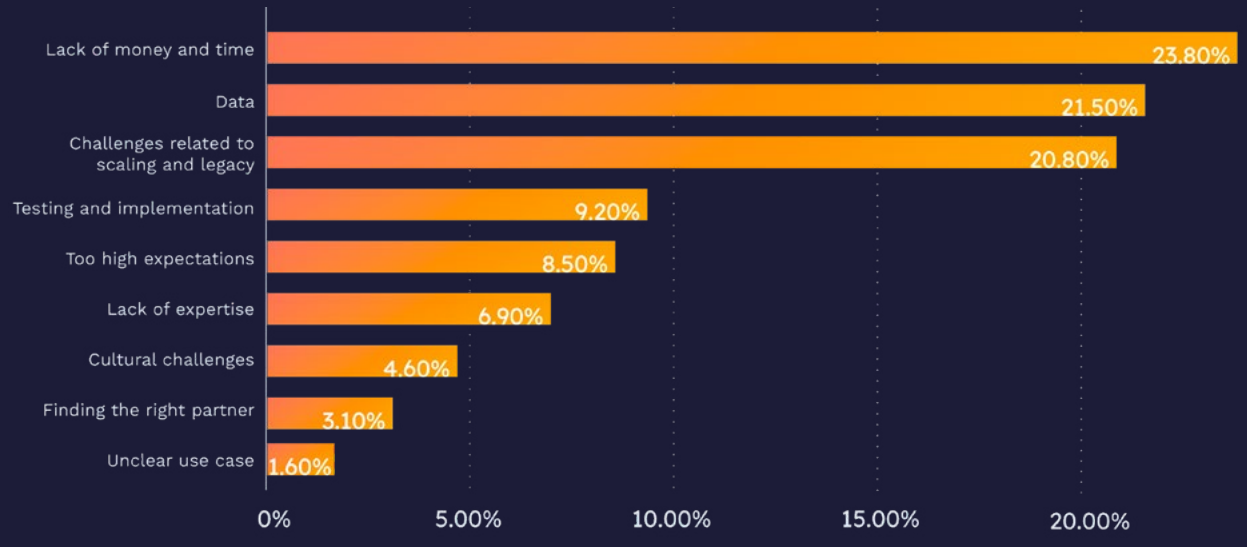
Source: Eurostat 2022.

Figure 18. Companies in the Vainu Custom Industry for AI and those mentioning AI keywords on websites by country



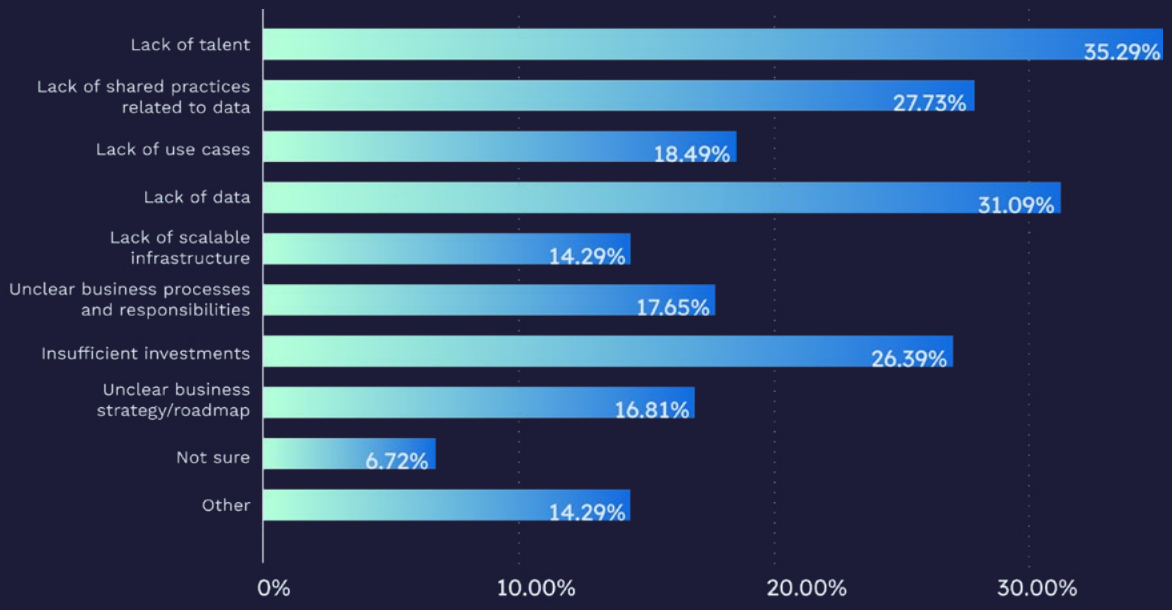
When looking at obstacles when using AI as well as scaling AI (Figures 19a & 19b), issues with data and data management still need to be addressed. In scaling already existing AI operations, the lack of talent represents the biggest challenge.

Figure 19a. Obstacles when using AI (Nordic State of AI Survey 2021) vs. Challenges in scaling AI (Nordic State of AI Survey 2022)



Source: Nordic State of AI Survey 2021.

Figure 19b. Challenges in scaling AI (Nordic State of AI Survey 2022)

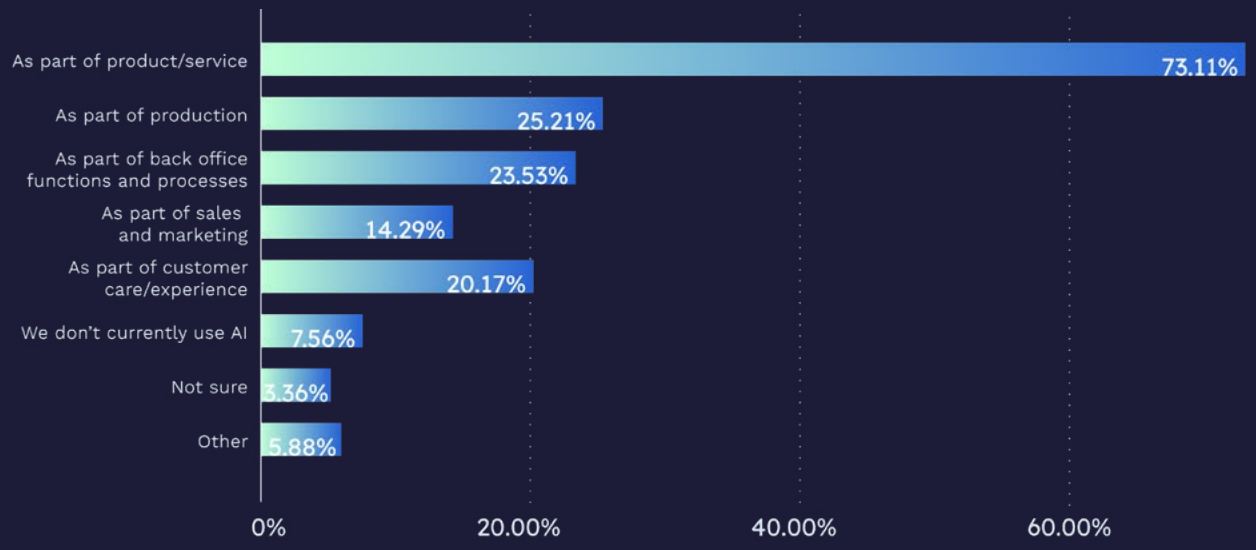


Source: Nordic State of AI Survey 2022.

The Nordics have been applying AI for the same purposes as last year. Most surveyed companies report that they use AI as a part of a product/service (73.1%) as well as for production stages. Using AI in one's core business usually results in the most direct value and financial gain for companies. Using AI in supporting functions is still common, but as a secondary priority (Nordic State of AI Survey 2022). According to IBM (2022), sales and marketing should have a much higher representation. This year we did not inquire if R&D was a use case nor apply future aspects to the options - we merely asked them to select where they use AI in their organizations (Nordic State of AI Survey 2022).

Using AI in one's core business usually results in the most direct value and financial gain for companies.

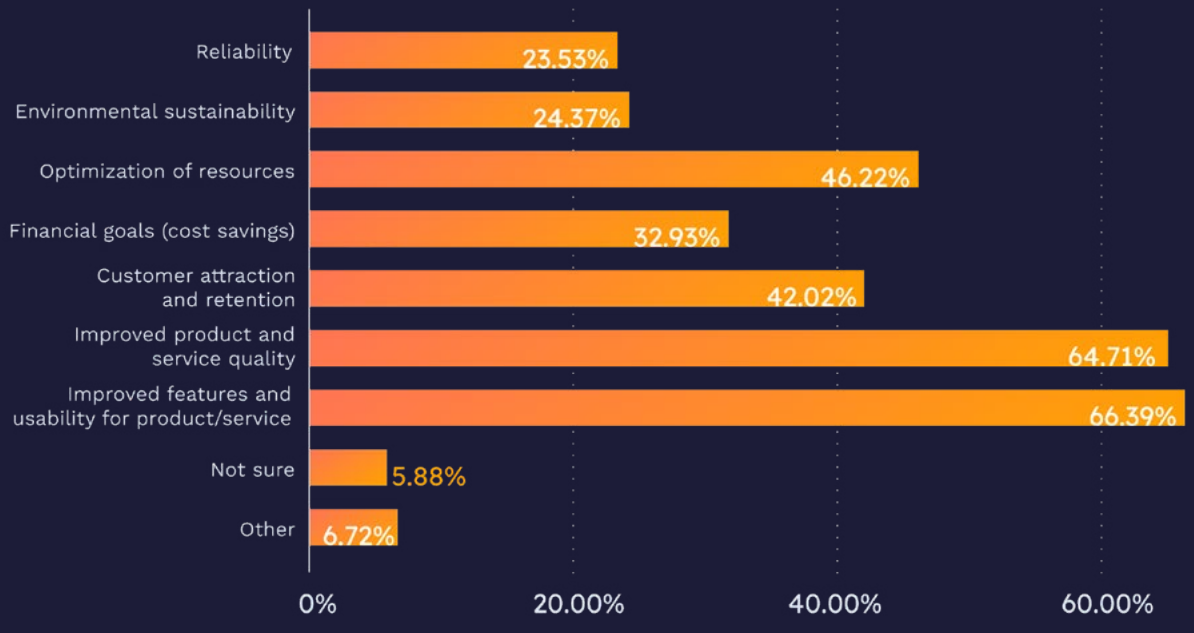
Figure 20. Use of AI technologies



Source: Nordic State of AI Survey 2022.

In the Nordics, businesses mostly use AI to improve the quality of their products and services as well as to improve their features and usability. Notably, a fourth of those surveyed responded that they perceive the value of AI for environmental sustainability (Figure 21). IBM's (2022) research has shown that 66% of respondents use or plan to use AI to address sustainability issues (IBM 2022).

Figure 21. Value brought by artificial intelligence

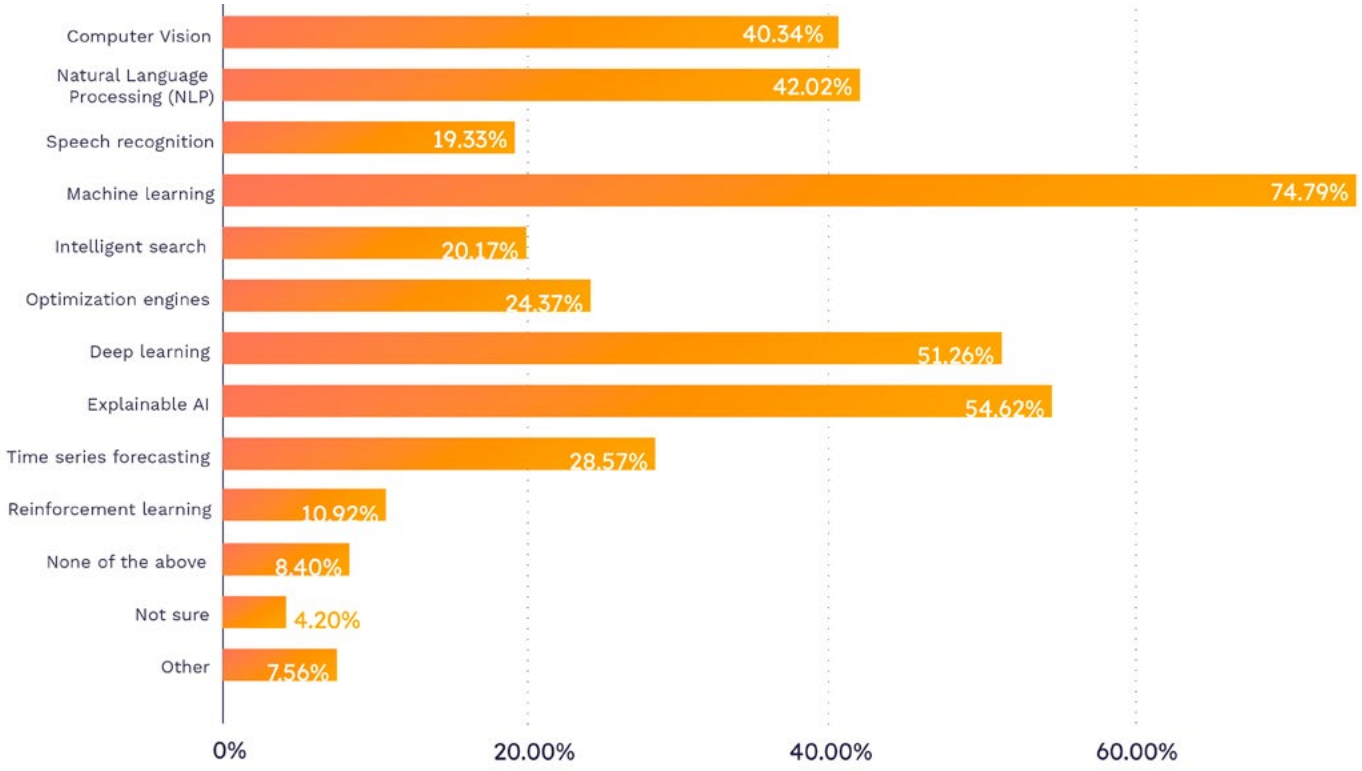


Source: Nordic State of AI Survey 2022.

TECHNOLOGY

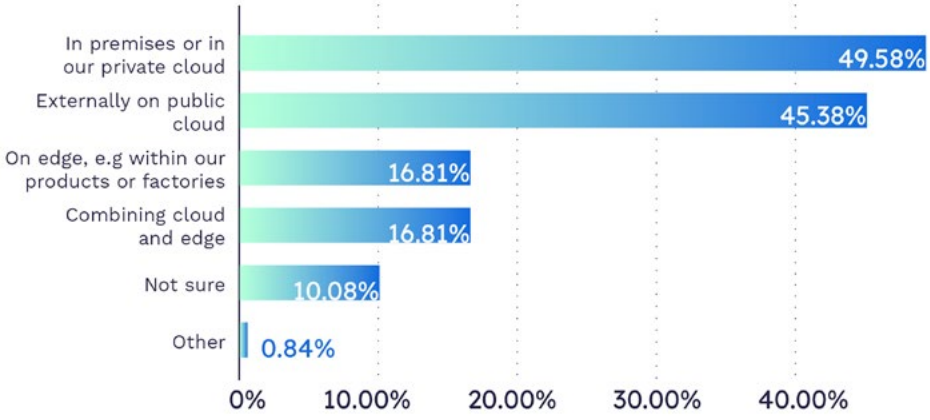
Almost all surveyed organizations plan to continue investing in AI, and more than half expect to see new technologies within the next six months (Nordic State of AI Survey 2022). When it comes to the computation of AI models, 17% of surveyed Nordic companies reported that they use Edge AI together with cloud computing (Figure 23).

Figure 22. Which technologies do you use in your organization?



Source: Nordic State of AI Survey 2022.

Figure 23. Computation of AI models



Source: Nordic State of AI Survey 2022.

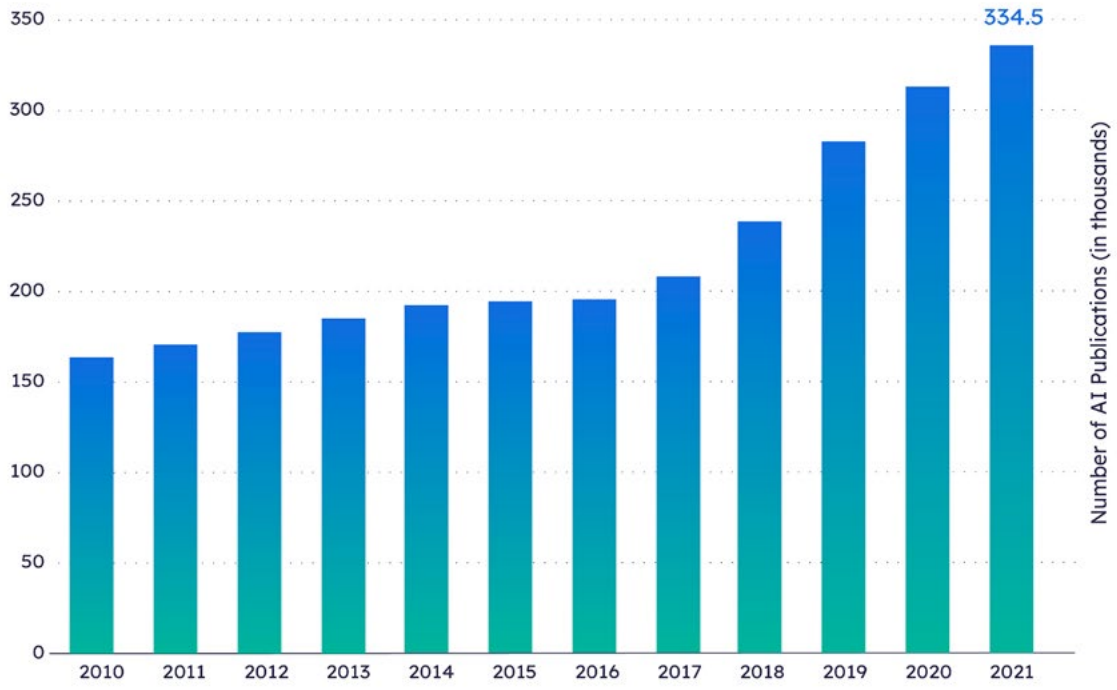
RESEARCH

Roughly two percent of professional AI researchers worldwide reside in the Nordics (Nordic State of AI 2021). The existence of national datasets is one common stronghold for the Nordics (Nordic Innovation 2022). These datasets require better data management but when properly leveraged, they could provide a considerable boost to Nordic business ecosystems and potentially for research (Nordic Innovation 2022). The Nordics, being technology-savvy and data-driven, could be used as a test bed for privacy-preserving societal AI.

If the Nordics could band together to provide reliable, trackable, up-to-date, and accessible data streams, it would lend the region a competitive edge in both business and research.

The United States and China are still producing the highest number of bilateral collaborations on AI research, by a considerable margin (Stanford University 2022). While China holds first place in AI journal publications, accounting for more than a third of all articles, Europe and Great Britain produce 19.05% of the worldwide total (Figure 24).

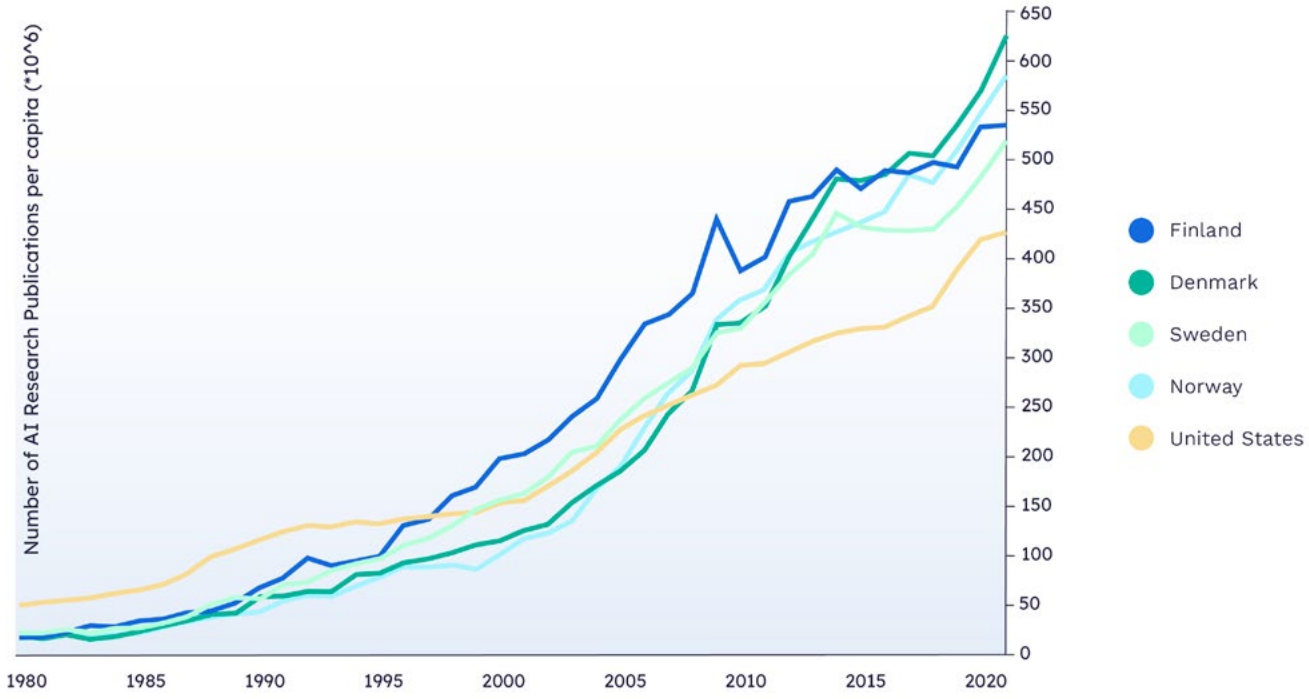
Figure 24. The number of AI publications worldwide, 2010-21



Source: Stanford University 2022.

In the Nordics, Denmark is currently publishing the most AI research papers per capita, while for a long time Finland was in the lead – until 2015. All of the Nordic countries except Finland saw considerable growth per capita in AI research publications from 2020 to 2021. When looking at AI research papers published per capita, we can see that all Nordic countries publish more than the US (Figure 25).

Figure 25. AI publication time series by country (per capita)



Source: OECD.AI 2022.

When looking at AI research papers published per capita, we can see that all Nordic countries publish more than the US.

ETHICS

While the ethics around using AI technologies should be predicated on the ethics of using any other technology the fact remains that with such powerful modern technologies it is important to increase the awareness and understanding of how the AI models have been trained, how the data has been collected and used, as well as to create explainable, transparent AI solutions to support processes and decision-making.

AI-powered tools help humans to automate tasks and make suggestions, but the overall responsibility should still belong to a real person. However, this is not always so easy to do. Governments the world over have awakened to the emergence of AI technologies and the desperate need for renewed regulation and legislation. Despite that, researchers have found that AI is actually magnifying human biases and even discriminates against people based on their socioeconomic status, gender, and race (Stanford University 2022).

As AI technologies become more widely adopted and used in everyday business, the need for explainable AI systems increases. Recent reports have shared concerns over the potential risks in the trustworthiness of AI (IBM 2022; O'Reilly 2022). AI systems need governance, especially when they are used for automating certain decisions. Companies at the exploratory stage in their AI journey don't often have these processes in place (O'Reilly 2022). Companies claim they prioritize trust in AI but struggle to make this vision a reality (IBM 2022). When taking AI into production, it is crucial to ensure that both data, as well as models, are constantly monitored by employees. No AI system should work in a vacuum. Leading performers with AI are more likely to engage in activities of AI explainability, robustness, bias, fairness, and transparency (PwC 2022).

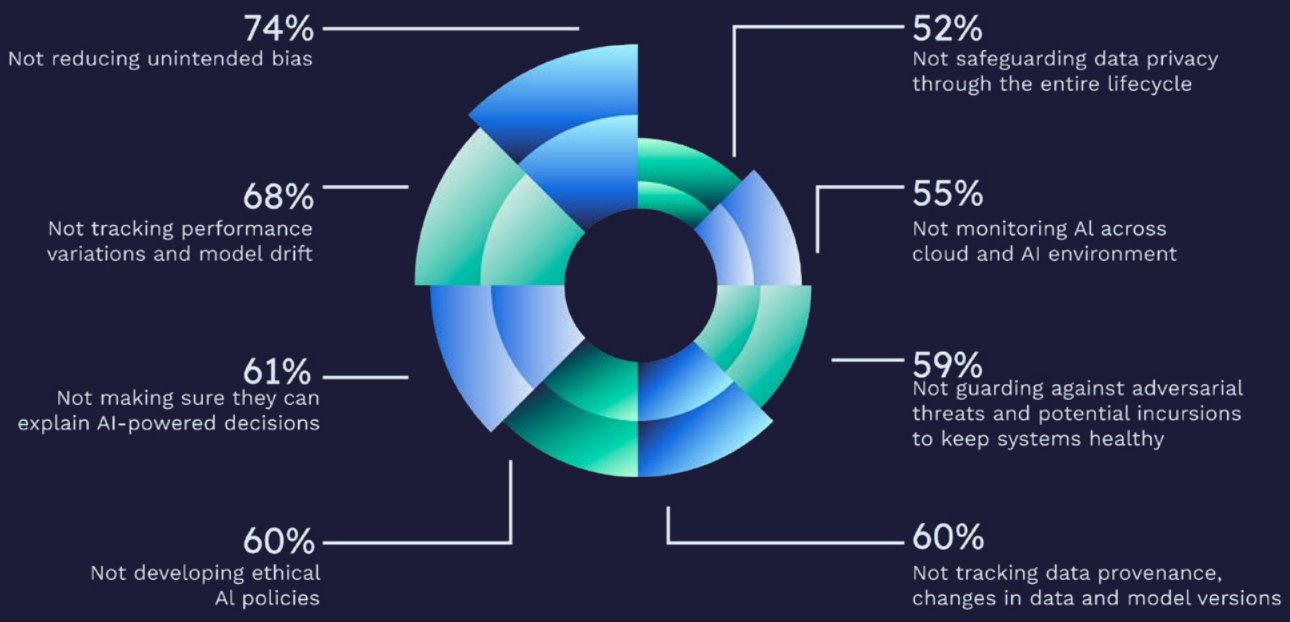
PRINCIPLES OF GOOD AI GOVERNANCE

- Reduce unintended bias
- Track performance variations and model drift
- Only make explainable AI-powered decisions
- Secure data privacy and data consent for training and use of data across the entire pipeline
- Monitor AI systems across cloud and other AI environments
- Cyber security in place
- Track data provenance, changes in data and model versions

IBM (2022) in its report underlines how immature prevailing AI governance can be. As seen in Figure 32 from IBM (2022), more than two-thirds of companies are not able to explain how their AI has reached a certain decision. Also, a lack of both ethical policies and data privacy are issues that continue to overshadow the speedy adoption of AI. These issues will take time to resolve if companies overlook them at the early stages of their AI implementation initiatives.

A lack of skills for training trustworthy AI was listed as the most common reason for issues in this department (IBM 2022). As we mentioned earlier, hiring diverse teams could help overcome unintended biases. Coincidentally, it has been found that nearly three-quarters of companies are not working to reduce unintended bias, along with many other indicators of trustworthiness listed in Figure 26.

Figure 26. IBM collected Ethics and Trustworthiness indicators



Source: IBM 2022.

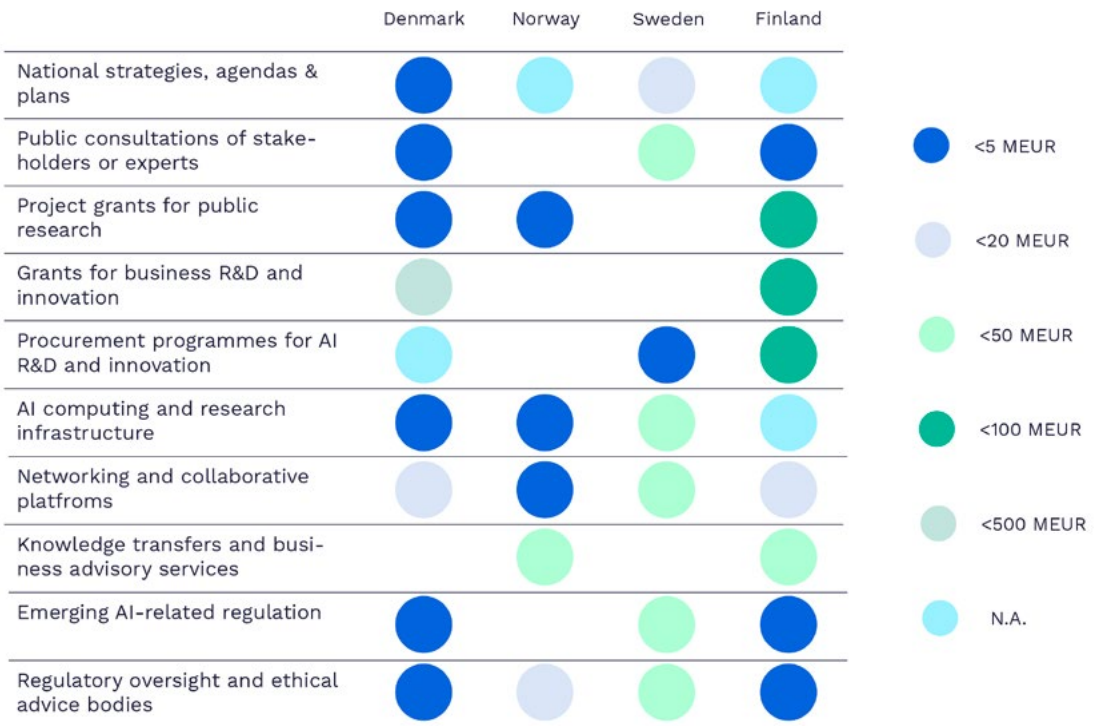
"Leading performers with AI are more likely to engage in activities of AI explainability, robustness, bias, fairness, and transparency." (PwC 2022)

REGULATION & POLICY INSTRUMENTS

In April 2021, the European Commission set in motion a legal framework for Artificial Intelligence called the Artificial Intelligence Act. This framework addresses the risks associated with AI and categorizes them as follows: unacceptable risk, high risk, limited risk, and minimal risk. In June 2022, a regulatory sandbox was introduced, with the aim to improve the dialogue between innovators, such as businesses developing AI, and corresponding regulatory parties, in order to guide the implementation of the act. Such close cooperation should in theory ensure that new AI innovations are compliant with the new regulatory system. Not only that, it should serve as a foundation for best practices and guidelines to follow and provide documentation on obligations and their usage. The first results of the regulatory sandbox are expected sometime in late 2023 (European Commission 2022).

From a global perspective, 25 countries have mentioned artificial intelligence in newly enacted laws. The United States, Spain, and the United Kingdom passed multiple laws in 2021 alone. In the Nordics, Norway is currently leading the push to legislate the use of AI, however, through the years, Finland has actually seen a higher number of mentions of AI in legal proceedings when looking at a longer time period (Standford University 2022). In the following country reports in the second part of this report, we will take a closer look at the regulatory and legal environments in each Nordic country.

Figure 27. Policy Instruments by Number of Instruments and Budget Category by Country.



Source: Nordic State of AI Survey 2021.

2 - Country Reports

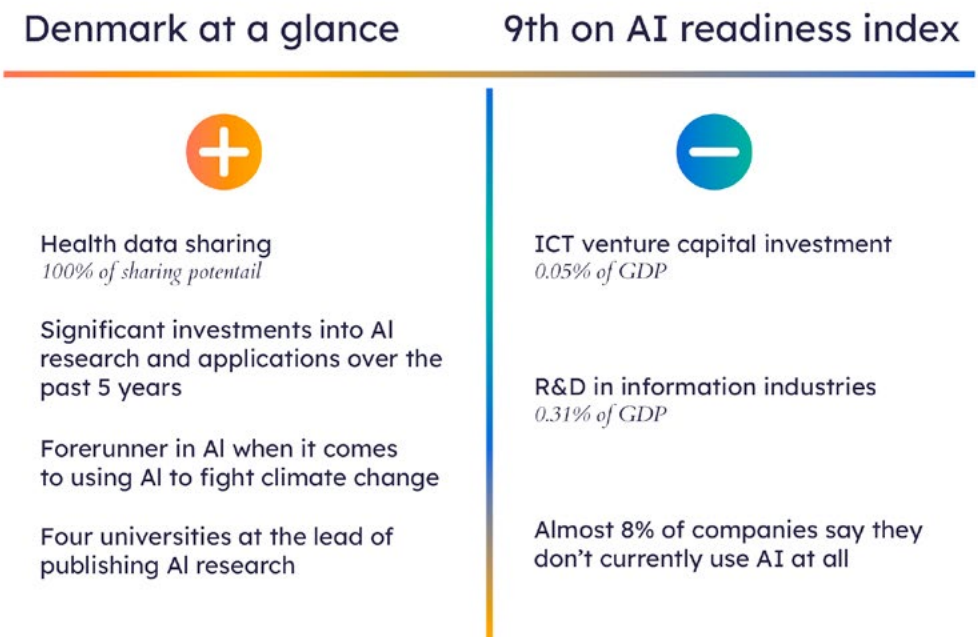
Denmark, Norway, Sweden, Finland

DENMARK

Denmark was 34th largest economy in the world in 2020. Its exports amounted to $102 billion with Packaged Medicaments ($14.5B), Pig meat ($3.21B), and Vaccines, blood, antisera, toxins, and cultures ($1.73B) in the top three. The most important services exported were Sea transport ($36.3B) (OEC.WORLD 2022).

Oxford Insights ranked Denmark 9th in its global AI Index score. The organizational adoption of AI grew from 11% in 2020 to 24% in 2021, which made Denmark an EU leader in terms of AI adoption. Bigger economies such as Germany and France are left behind in the rankings (Eurostat 2022). The European Commission (2022) has also reported that Denmark has the highest AI adoption rate in Europe.

Figure 28. Denmark at a glance



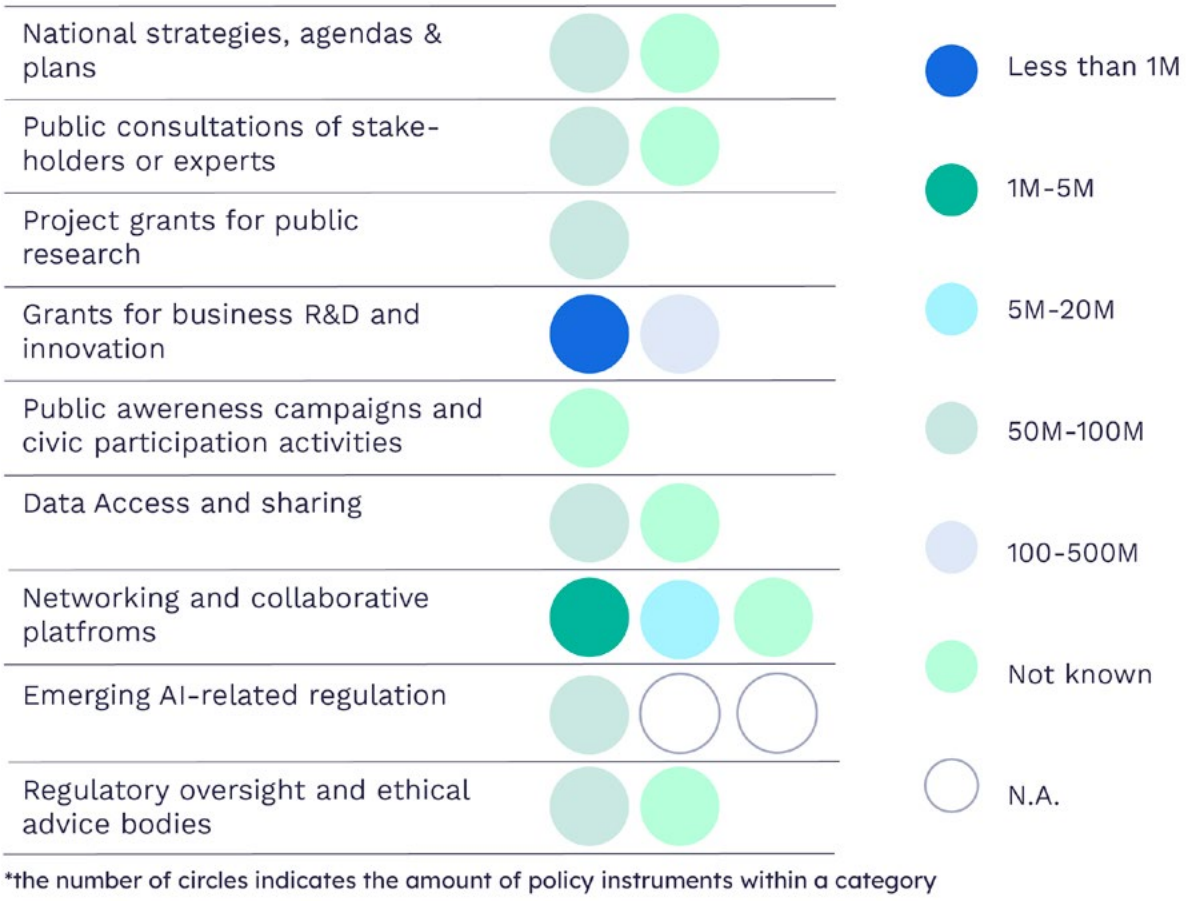
Sources: OECD Going Digital Toolkit 2022; Nordic State of AI Survey, Oxford Insights 2021, Eurostat 2022.

Denmark's main challenges concerning AI are the low AI adoption rate among small and medium-sized enterprises and the general shortage of AI skills. Over the past few years, private investments in AI have increased, and the AI ecosystem has improved in many ways. Denmark's national AI strategy has revolved around AI ethics, empowering the research environment, growing AI, growing Danish enterprises, and offering great public services (Nordic Innovation 2022). This program will come to an end in 2022, but the work will be continued by the Pioneer Centre for AI, which has received €54 million in funding for the next decade (OECD.AI 2022; Nordic Innovation 2022; Pioneer Centre for AI 2022).

The European Parliament's (2021) study on the role of AI in the European Green Deal portrayed Denmark as an AI forerunner when it comes to using AI to fight climate change. The Danish government for its part plans to publish five datasets containing climate and environmental data from the transportation sector (European Parliament 2021).

Since the publication of The Nordic State of AI Report 2021, Denmark has made significant progress in terms of investing in AI (see Figures 5 and 8). The country was the third highest investor in AI within the EU if measured per capita – investing €38 per capita in 2019, a 29% spike since 2018. In addition, venture capital investments in AI grew by 200% last year. Denmark has therefore started to live up to its longstanding reputation as a digitized and data-oriented country (Nordic Innovation 2022). Policy instruments and government initiatives in Denmark are taking a holistic approach to AI and the country has increased funding in many fields. Indications of increased AI maturity can be spotted with an increased emphasis on AI regulatory issues (Figure 29, OECD.AI 2022).

Figure 29. Policy instruments by number & budget in Denmark



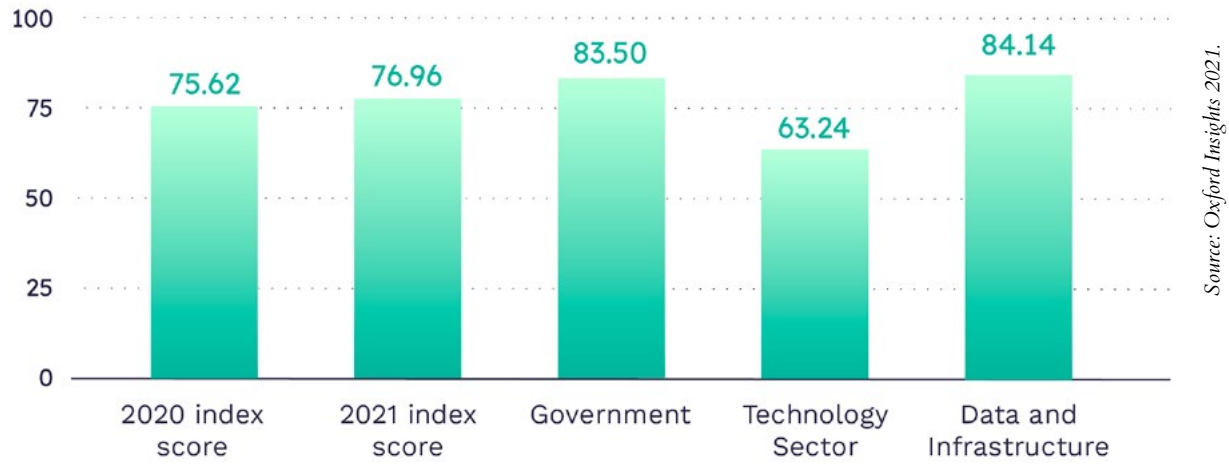
*the number of circles indicates the amount of policy instruments within a category

Source: OECD.AI 2022.

AI MATURITY

Denmark attained 9th position in Oxford Insights' global AI Index score, dropping one position since last year. Compared to other Nordics, Denmark is third. Overall the country performed better than last year and, similarly to the other Nordic countries, Denmark scored high in Government as well as in Data and Infrastructure. Denmark sits 24% higher than the European Index average and just 2.27 points behind the Nordic leader Finland. With heavy investments on multiple fronts, we would not be surprised to see Denmark leading the Nordic index rankings soon (Figure 30, Oxford Insights 2021).

Figure 30. Denmark's AI Adoption Index scoring breakdown



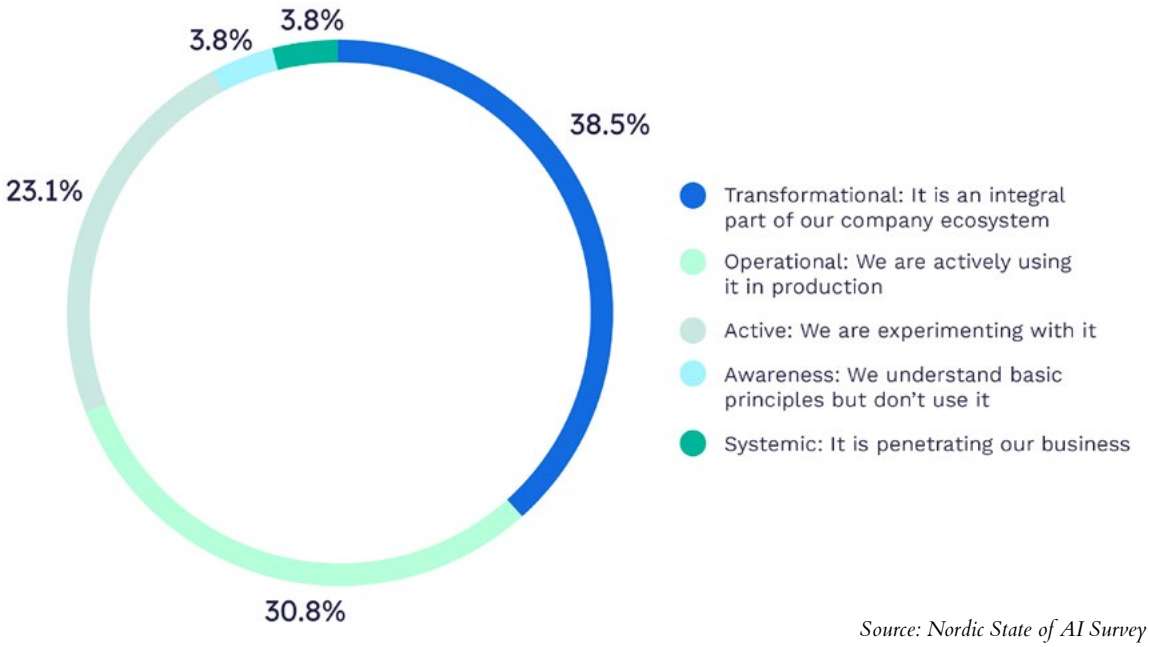
Source: Oxford Insights 2021.

"In Denmark, things have changed dramatically over the last 5 years. Funding programs have increased."

– Lars Kai Hansen, Professor, Head of section, Department of Applied Mathematics and Computer Science at Technical University of Denmark (DTU)

In our survey, 39% of Danish companies said they are at the highest, transformational level of AI maturity. This was the second-highest percentage in the Nordics. Only 3.8% of our Danish respondents reported not using AI at all. Half of the companies responded they are either in active or operational level (Figure 31, Nordic State of AI Survey 2022).

Figure 31. Organizational maturity level concerning AI



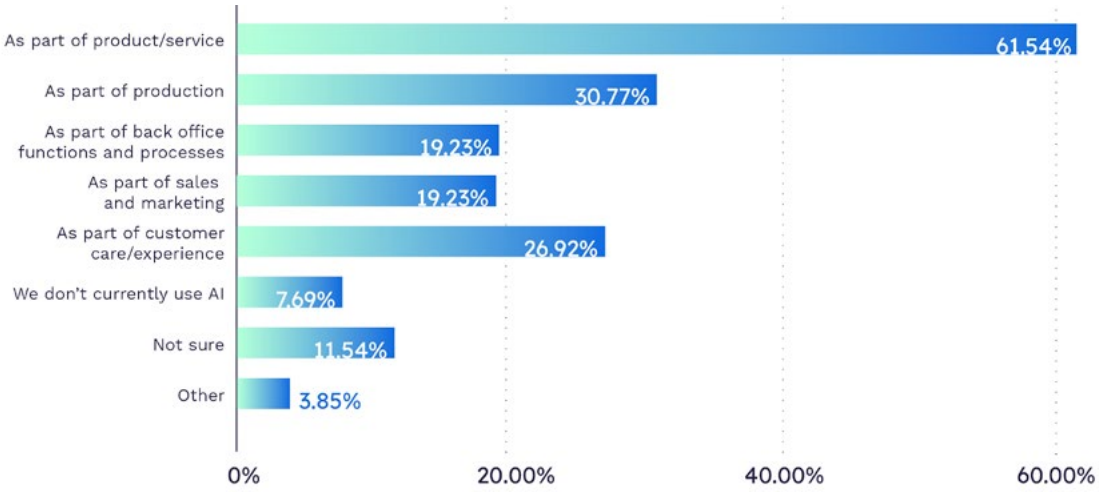
Source: Nordic State of AI Survey 2022.

With heavy investments on multiple fronts, we would not be surprised to see Denmark leading the Nordic index rankings soon.

IMPLEMENTATION

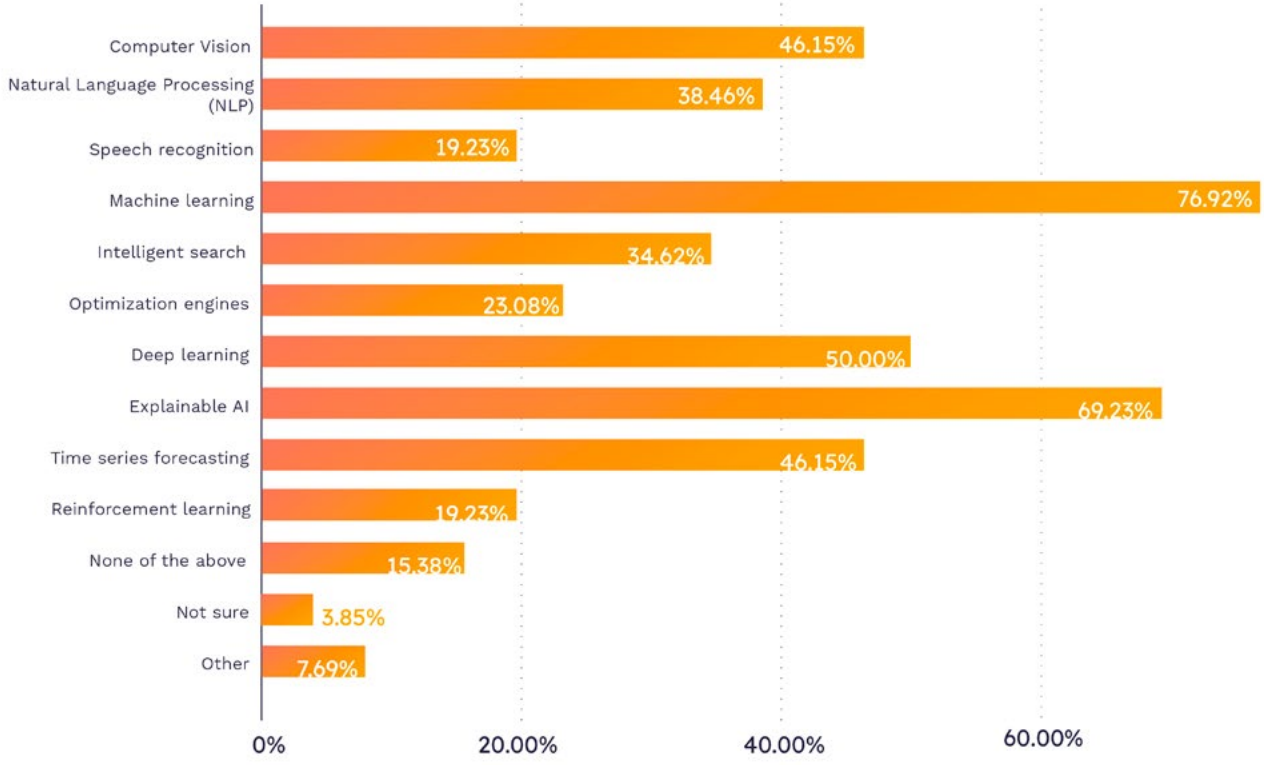
The three most popular use cases for AI in Denmark are: automating workflows, data analysis, and text analysis (Statistics Denmark 2022). Our survey findings indicate that a vast majority of Danish companies implement AI in their products, services, or production. Almost 8% of companies say they don't currently use AI at all (Figure 32).

Figure 32. Purposes of use for AI technologies in Denmark



Source: Nordic State of AI Survey 2022.

Figure 33. AI technologies used in Denmark

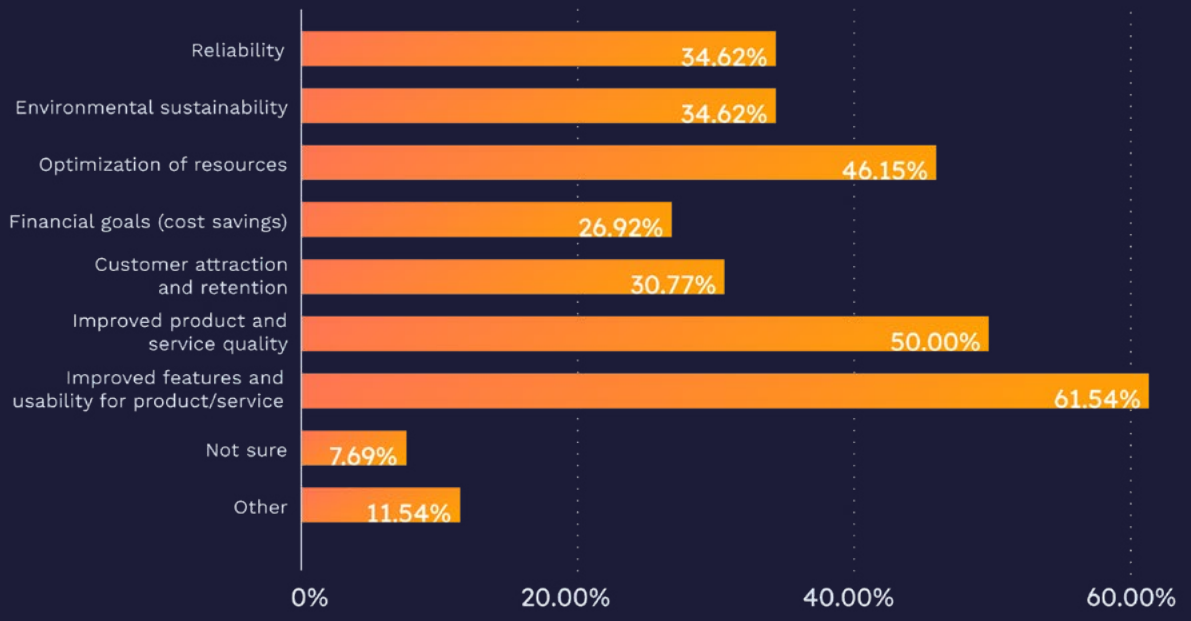


Source: Nordic State of AI Survey 2022.

The use of AI technologies follows similar patterns as in other Nordics: with the umbrella term Machine learning on the lead, followed by Explainable AI (Figure 33).

The Danish companies surveyed said they see value in AI within products and services. AI offers them a chance to improve features, usability, and the quality of their products and services. Also, Optimization of resources is seen as an essential value. Danish companies gave Environmental sustainability the most value compared to their Nordic peers: 35% in Denmark vs. the 20% Nordic average (Figure 34).

Figure 34. Value brought by AI

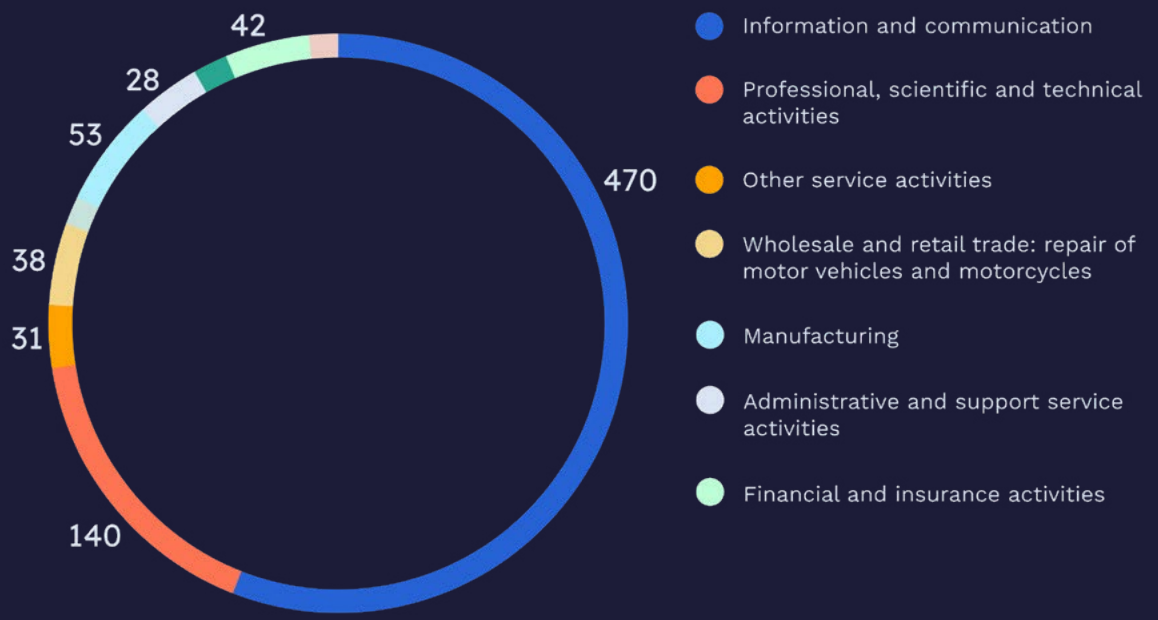


Source: Nordic State of AI Survey 2022.

A query of our data partner Vainu's company database with the Vainu Custom Industry classification tags Artificial Intelligence, Machine learning, Speech recognition, Natural language processing, and Computer vision returned 886 companies in Denmark. As with the other Nordics, Information and Communication and Professional, scientific and technical activities were overwhelmingly the most represented sub-categories. Beyond these top two options, no standout industries exist in Denmark (Figure 38).

Denmark's country-specific challenges with AI development lie in turning Proof-of-Concept projects into products, and are due to a lack of technical resources. In addition, it has been noted that the gap between companies embracing higher technology and those that are less technically savvy is widening (Nordic Innovation 2022).

Figure 35. Top industries for AI-related companies in Denmark



Source: Vainu 2022.

Danish companies gave Environmental sustainability the most value compared to their Nordic peers: 35% in Denmark vs. the 20% Nordic average.

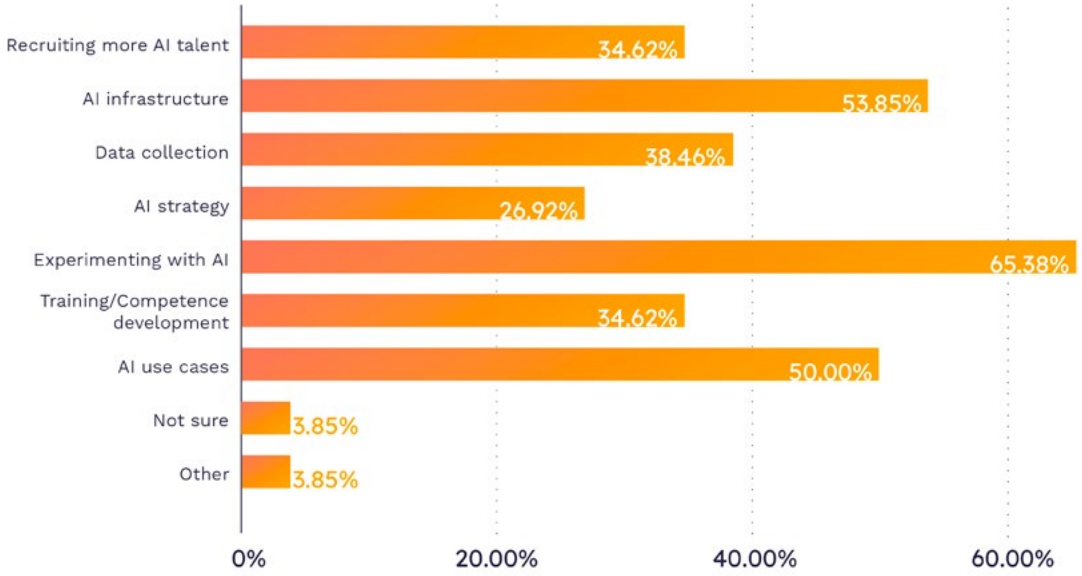
BUSINESS

In Denmark, 66% of all large enterprises have implemented AI (Eurostat 2022). Of those companies that replied to our survey, 46.2% work in the Information Technology & Services sector. The second largest industry was Energy, which represented 15.4% of the entire sample.

Out of the surveyed companies, 84.6% view AI as either Highly important or Important for their organization. Interestingly, Denmark had the only respondents who said that AI had no importance at all (4%).

Close to 70% of Danish companies planned to increase the number of AI technologies in use within the next 12 months. More than a third are investing in AI use cases, which is a category selected by many surveyed companies across the Nordics. In terms of AI maturity, Denmark has more than a fifth of its companies still at the experimental level with AI. In addition, Denmark had the most surveyed companies in the Nordics saying they invest in Experimenting with AI (Figure 36).

Figure 36. Investment areas within AI in the next six months in Denmark



Source: Nordic State of AI Survey 2022.

Close to 70% of Danish companies planned to increase the number of AI technologies in use within the next 12 months. More than a third are investing in AI use cases, which is a category selected by many surveyed companies across the Nordics.

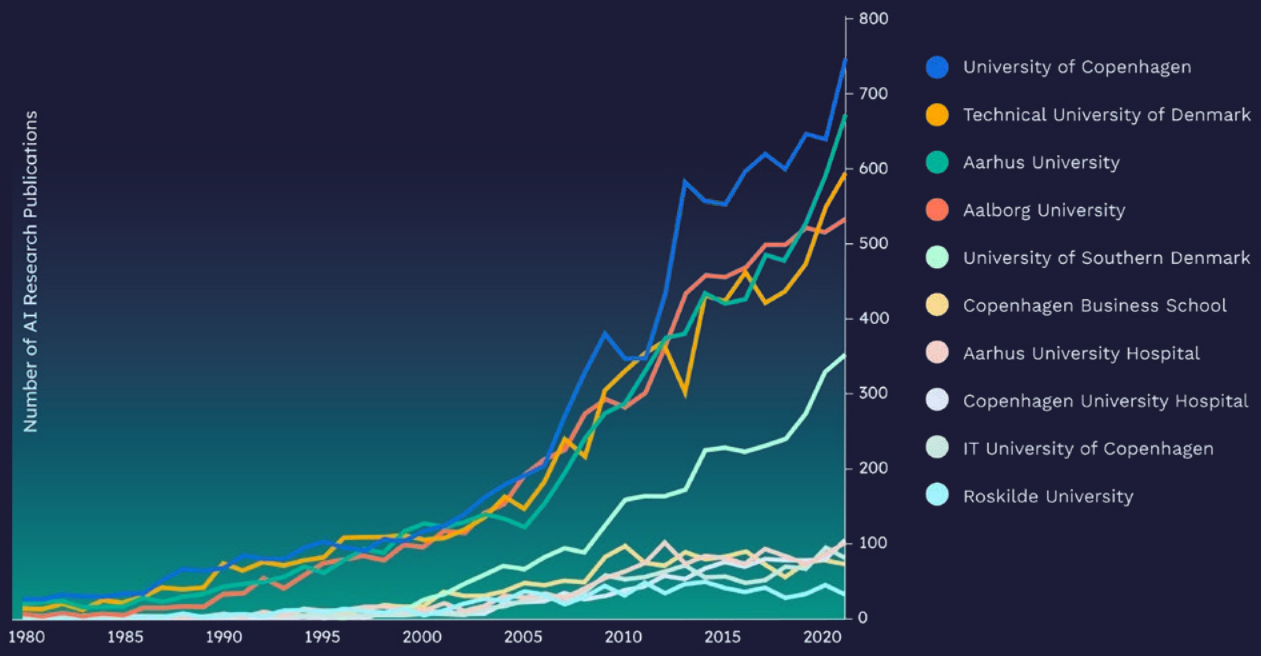
RESEARCH

In Denmark, the recent increase in funding has improved both academic research as well as industry collaborations. The Pioneer Centre of AI is an example of a research center focusing mainly on fundamental AI research with a long time horizon. It's hosted by the University of Copenhagen's Department of Computer Science, in cooperation with Denmark's Technical University, IT University of Copenhagen, Aalborg University, and Aarhus University. Another more application-focused example is the Danish Center for Big-data Analytics-Driven Innovation which presents a research and business-oriented collaboration (McKinsey & Company 2019).

When looking at the number of AI publications in Denmark, the number of research publications grew by nearly 10 percent between 2020 and 2021 (OECD.AI 2022). Denmark had four universities at the lead of publishing AI research: the University of Copenhagen, Denmark's Technical University, Aarhus University, as well as Aalborg University. Having so many universities performing at the highest levels of publication is unique in the Nordics (Figure 37).

A government whitepaper from the Ministry of Foreign Affairs of Denmark (2021) lists Denmark's specialties in AI as NLP, Algorithms and Complexity, Data Mining and ML, and Human Centred AI. Denmark has leading European universities in many of the sub-disciplines listed above. The same whitepaper says that most of the research ecosystem is focused on the application of AI instead of the technology itself.

Figure 37. AI research by institution in Denmark



Source: OECD.AI 2022.

EDUCATION

Denmark had three universities listed among 100 Europe's top AI Universities: the first Danish university mentioned was the Technical University of Denmark, ranked 56th. Despite having many universities on the list, Denmark came in as the third Nordic country. Aalborg University came in 64th and the University of Copenhagen 71st (Edurank 2022). Notably, Aarhus University was missing from the list, even though the second-highest number of AI research papers come from Aarhus. The aforementioned universities also produce the most Danish research papers in AI and there's been a growing number of Danish academic research in AI.

> "Now we must also be possible to explain how artificial intelligence arrives at its predictions, so that it is no longer a mystery which no one fully understands, but one which we can use to base a substantial number of important decisions."
>
> – Serge Belongie, Professor at DIKU and Director of the Pioneer Centre for AI

In Coursera's Global Skills Report 2022, Denmark stands not only at Europe's number two, but is also second in global rankings. The country performed well in all of the scored categories: Business, Technology Sector, and Data Science, receiving high scores across the board (Coursera 2022). From these results, we can conclude that Denmark possesses an extremely capable workforce – an ideal starting point when considering retraining or educating people to fit the needs of the field of AI. Denmark has a versatile field of AI education with 67 programs planned for 2023, ranging from Bachelor's level education to Master's level (McKinsey & Company 2019).

Denmark has excelled in the ability to create training programs for select companies either just about to begin their AI-related operations or early on their AI journey. These programs are a result of a combined effort of several educational institutions to narrow the gap between academia and businesses. The Danish government strives to create a spillover effect where companies outside the program too would benefit from this exchange of information. In the end, the program should help companies speed up the process of AI productization (Nordic Innovation 2022).

LEGISLATION

Denmark has listed its AI priorities in the Danish National Strategy for AI (2019): self-determination, dignity, responsibility, explainability, equality, justice, and development. These serve as general guidelines that AI in Denmark should respect and follow. The Danish government has highlighted that AI should not harm anyone in any sense of the word. Rather, it should be transparent and fair and help society develop without compromising ethics in the process.

The Data Ethics Council established in 2019 should ensure that innovations in AI are aligned with national priorities. The government itself will check regularly if new guidelines are required. A ministerial-level working group will also determine if the current legislative framework needs to be updated to accommodate AI (Ministry of Finance and Ministry of Industry, Business and Financial Affairs 2019). In Denmark, there is a new law for all companies to explain their data ethics (Poul Schmith Kammeradvokaten 2020).

"Something Denmark shares with the Nordics is a societal interest in what we are doing in AI.

The government has taken a strong interest in AI and the Ministry for Research launched its Pioneer program to focus on AI and sustainability through the Danish National Research Foundation. This will lead to the creation of four national centers: two focused on AI and two focused on sustainability."

– Lars Kai Hansen, Professor, Head of section, Department of Applied Mathematics and Computer Science at Technical University of Denmark (DTU)

Danish national AI priorities are self-determination, dignity, responsibility, explainability, equality, justice, and development.

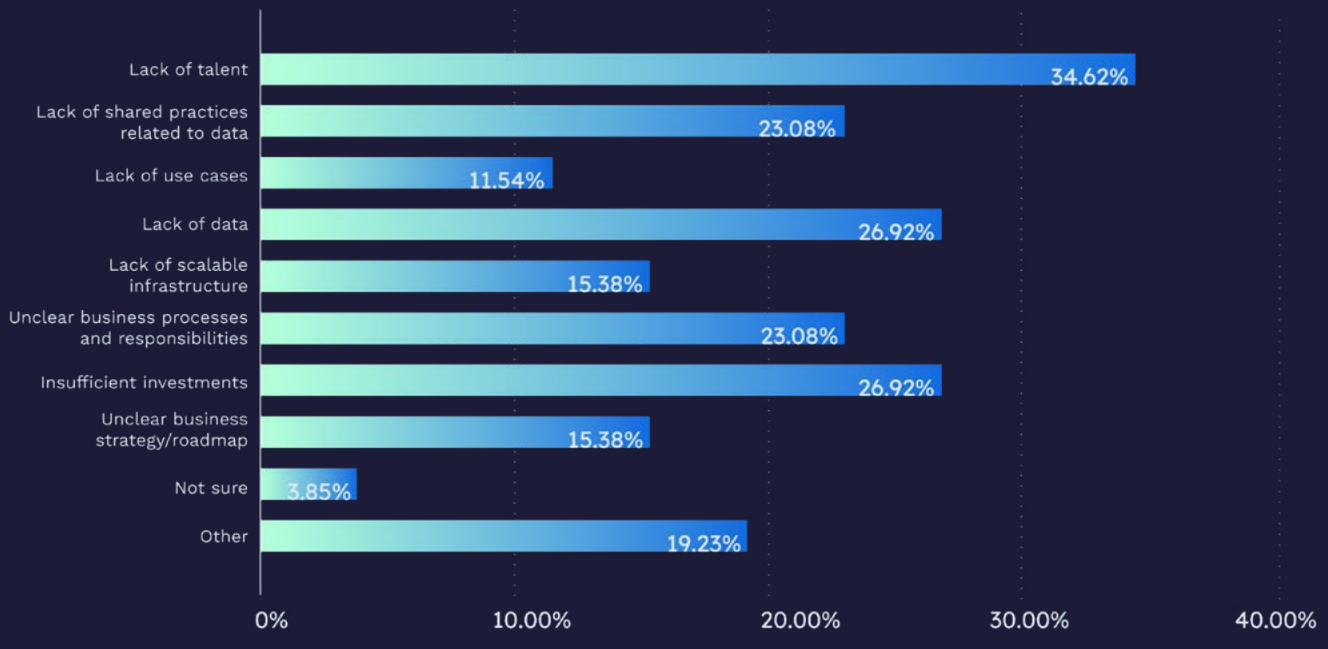
TALENT

In terms of talent requirements, it has been estimated that Denmark's needs for the IT sector could increase by 50% by 2030 (McKinsey & Company 2019). Denmark could eventually need up to 80,000 people with deep analytical skills, which is close to half of the current ICT workforce. Both Danish enterprises and startups say the number one thing hindering development is a lack of talent when it comes to AI (McKinsey & Company 2019; Eurostat 2022).

Denmark has managed to attract plenty of international AI talent, as it has been advised to do (Figure 11), although it is still the least selected Nordic country for the immigration of AI talent (OECD.AI 2022; Eurostat 2021). However, it still has room to improve as it has only mid-tier numbers of ICT specialists as part of the workforce compared to other Nordics.

Nearly 35% of Danish companies surveyed said they face talent shortage problems, making it the top problem in scaling AI across organizations (Figure 38). Lack of talent was a considerable barrier for companies implementing AI (McKinsey & Company 2019).

Figure 38. Biggest challenges in scaling the use of AI across your organization.



Source: Nordic State of AI Survey 2022.

Insights from Denmark

Lars Kai Hansen
Professor, Head of section, Department of Applied Mathematics and Computer Science at Technical University of Denmark (DTU)

In Denmark, things have changed dramatically over the last 5 years. Funding programs have increased. At DTU, we traditionally collaborate closely with industry. I'm involved in two startups myself as are many of my colleagues. One particularly important sector for AI is the hearing systems sector -- Denmark is a leading exporter of hearing aids. The hearing systems sector is a first mover in using advanced technologies such as machine learning, essential for the advanced audio modeling used in hearing devices. Other active sectors are pharma and media. Also the public sector is engaged in promoting and deploying AI.

Something we share with the Nordics is a societal interest in what we are doing in AI. The government has taken a strong interest in AI and the Ministry for Research launched its Pioneer program to focus on AI and sustainability through the Danish National Research Foundation. This will lead to the creation of four national centers: two focused on AI and two focused on sustainability. To accomplish this, the government has also teamed up with large private foundations such as the Novo Nordisk, VILLUM, Lundbeck and the Carlsberg Foundation.The whole wave of new startups that have come out of AI research is also encouraging. This is not just academic, it is going into production.

Computational resources continue to be a challenge. The European High Performance Computing Joint Undertaking has resulted in a series of supercomputers, including LUMI in Finland, that work well for AI and deep-learning algorithms, but we need that at all levels, both locally in universities and at the national levels, plus facilities at the European level. LUMI is partially owned by Denmark and there is generally much cooperation between the Nordics.

Besides computation, another obstacle to the wider use of AI is lack of relevant data. All AI research is data driven, and in particular we could use medical data in a better way than it is now. We need to protect patients' rights, but not make access so restrictive that it is impossible to use medical data for modeling. The same goes for demographic and government data. There is a need to model without compromising privacy. We should use all the mature technologies available that can help to preserve privacy and still gain insights from the data.

Insights from Denmark

Mads Rydahl

Strategy Evangelist in Cactus Communications, former product lead on Apple's Siri, and a seasoned expert in ML and NLP

Looking at Denmark's AI scene from a wider perspective, NLP-based products are seeing more backing now than five years ago, and investment volume is slowly climbing. We're at the dawn of a golden age of language understanding, and AI penetrates all academic domains, not just Computer Science. With most cutting-edge NLP research performed on English content, local languages often become a distant second priority. However, I do also think we are seeing a few promising research initiatives in other languages.

Engineering talent is very globally-connected, and as a consequence, we are competing directly with the tech giants in Silicon Valley. Previously, young talent would choose the adventure of going abroad, and the most successful would often stay gone. But with better opportunities for remote work, young researchers and engineers increasingly choose to remain in Denmark, and local companies often win them back. The job market has become more liquid, but unfortunately, the underlying shortage of engineering talent has not disappeared.

Denmark is relatively strong on B2B solutions. Especially in the areas of security and privacy, we have a focus on robustness and edge computing, instead of monolithic repositories that might become a single point of failure. Usually, these research endeavors are anchored in universities, but we are starting to see private sector movement at a commercial level here. To me, this is also about citizen empowerment. It is not just good business, it's good politics. The rollout of GDPR has disturbed the market environment for American tech giants, and if companies like Google fail to comply with our regulations, that creates a real market opportunity for European companies.

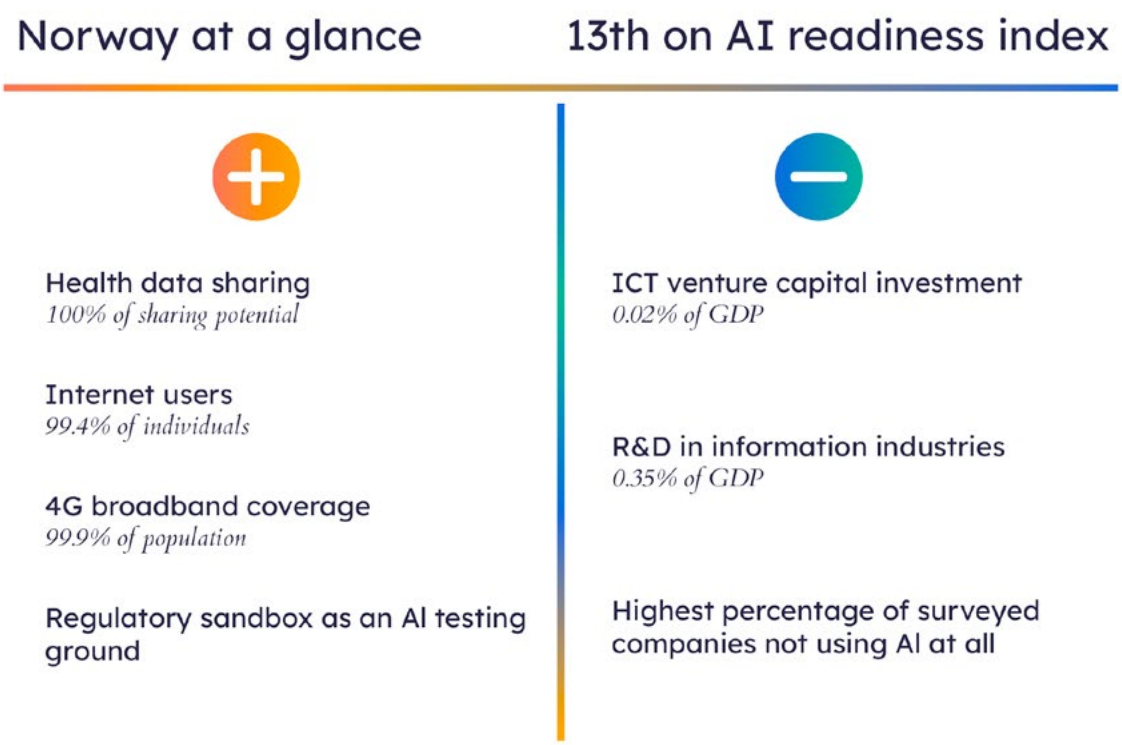
Europe may have entered the AI game a little late, and we are still paying the price for that. We should have invested more aggressively in this field 10 years ago. I do think we are doing a lot better now, but there is still massive room for improvement. Building products with natural language features for smaller language groups is always challenging. Even in an advanced digital economy like Denmark, it is much easier to find training data for most use cases in English. Denmark is a globalized economy with a diverse workforce and Danish startups often choose English first. As a consequence, the best tools rarely work best in Danish, and over time, the status of our own language becomes contested.

NORWAY

Norway was the 31st largest economy in the world in 2020, and its exports amounted to $86.2 billion, with Crude petroleum ($22.6B), Petroleum Gas ($14.4B), and Non-fillet fresh fish ($6.49B) at the top of the list (OEC.WORLD 2022).

In 2021, a total of 11% of Norwegian enterprises were using at least one AI-based technology, making it the third largest adopter in the Nordics, and putting Norway on par with Germany. The EU average adoption rate was 8% (European Commission 2022).

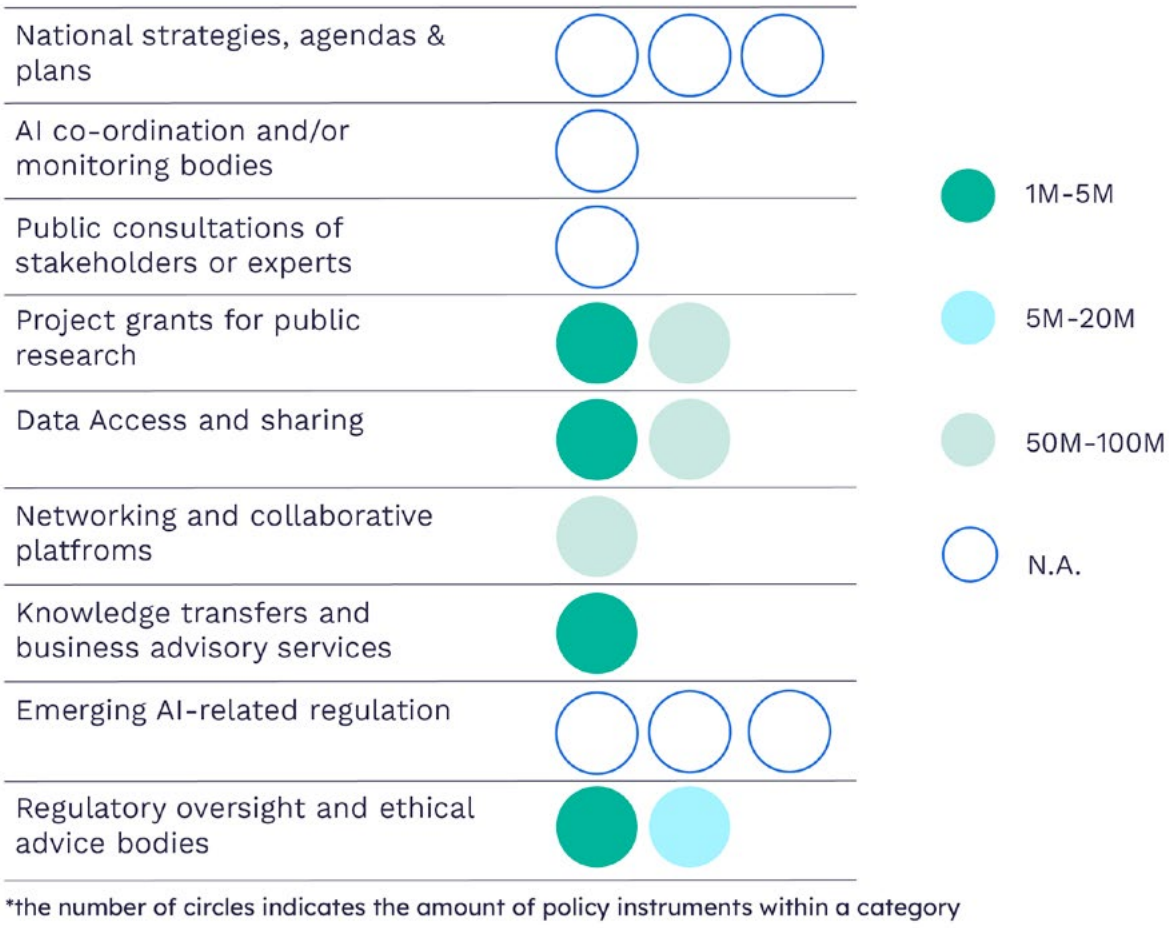
Figure 39. Norway at a glance



Sources: OECD Going Digital Toolkit 2022; Nordic State of AI Survey; Oxford Insights 2021; Eurostat 2022.

In terms of policy, Norway has focused to date on AI ethics and regulation (Nordic Innovation 2022). Norway has policy instruments underway related to emerging AI regulations as well as regulatory oversight and ethical advice bodies (Figure 40). However, Norway still has the least amount of policy instruments compared to the other Nordic countries (OECD.AI 2022).

Figure 40. Policy instruments by number & budget in Norway



*the number of circles indicates the amount of policy instruments within a category

Source: OECD.AI 2022.

"As public authorities, we have a special responsibility to ensure that citizens' data are handled securely, and that decisions that affect individuals are correct and transparent. I believe that this is possible, and that AI will be essential for providing better public services in the future."

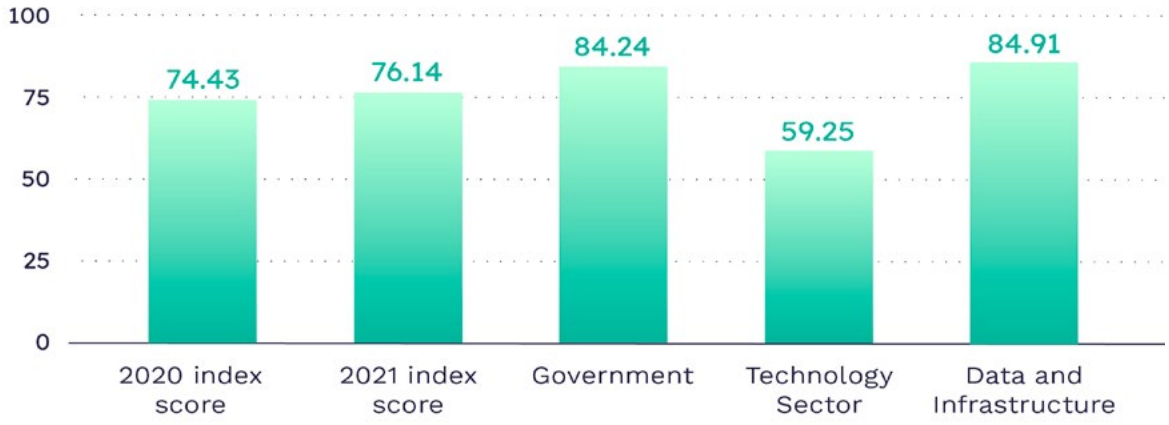
– Christine Hafskjold, Senior ICT Policy Adviser at the Norwegian Ministry of Local Government and Regional Development

AI MATURITY

This year, Norway dropped from 10th to 13th in the global AI readiness index as larger economies such as Canada, France, and Japan advanced in their ranking. Other Nordics suffered from a similar trend. (Figure 41, Oxford Insights 2021)

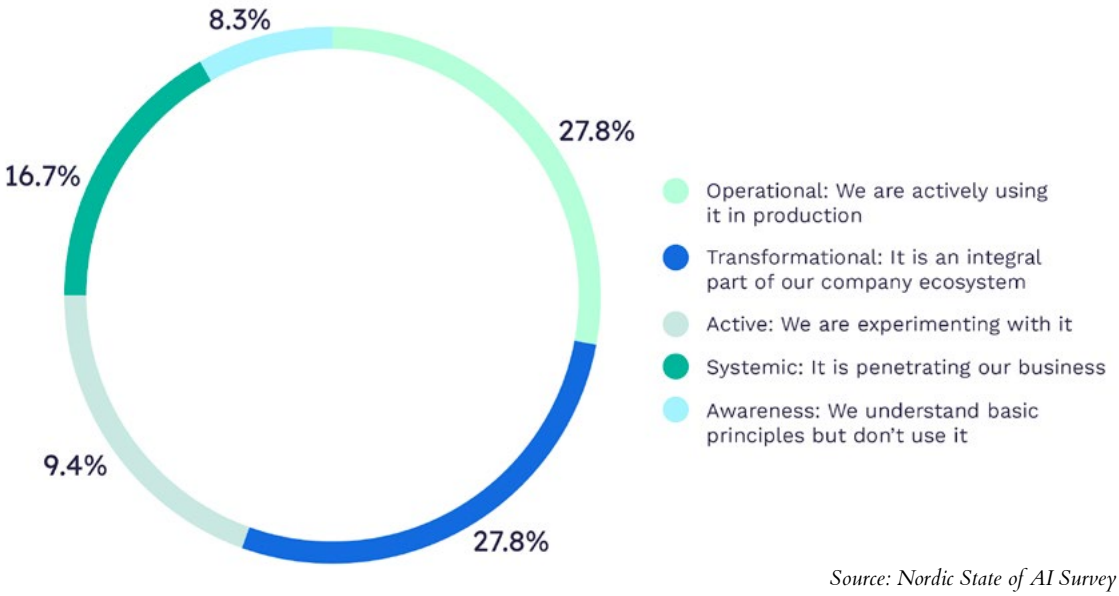
About a quarter of companies surveyed in Norway described themselves as being at the transformational maturity level with AI. The rest of the companies are spread out evenly. Other Nordics had a higher proportion of companies at the highest, transformational level of using AI. Norway also had the highest percentage of respondents who said they are not using AI at all (Figure 42, Nordic State of AI Survey 2022).

Figure 41. Norway's AI Adoption Index scoring breakdown



Source: Oxford Insights 2021.

Figure 42. Organizational maturity level with respect to AI in Norway.

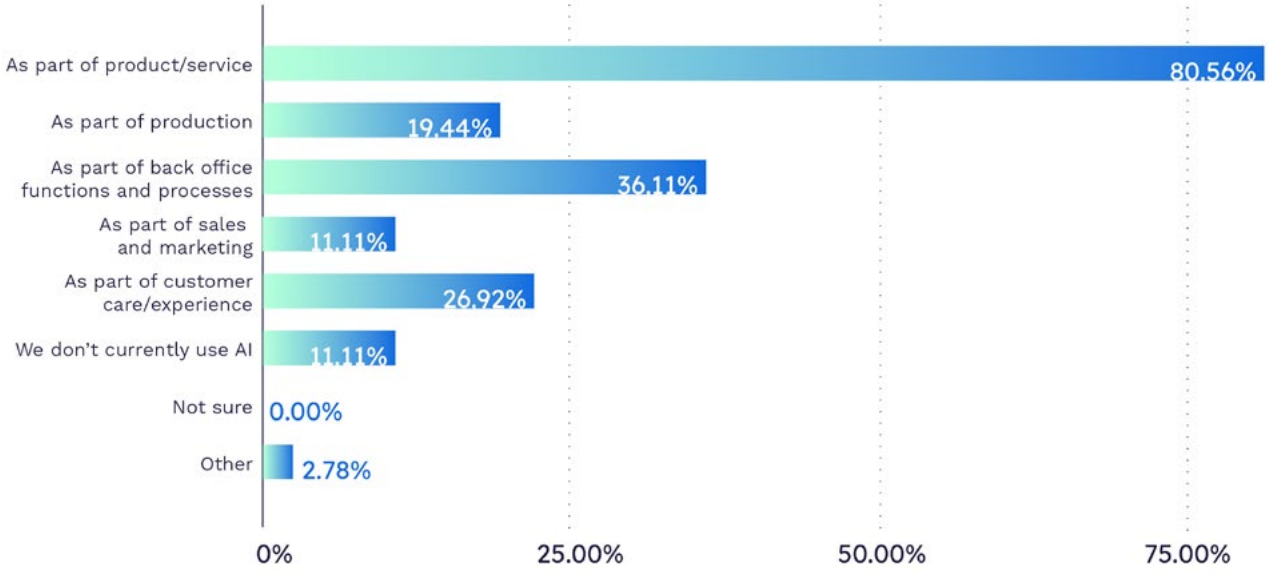


Source: Nordic State of AI Survey 2022.

IMPLEMENTATION

Like other countries, Norway has struggled with the basics of commercially utilizing AI. Local companies have a hard time turning AI pilots into actual products (Nordic Innovation 2022). Perhaps as a direct result of this, Norway has the least amount of companies using AI. However, a recent spike in VC capital might spur AI innovation and help startups thrive. Greater collaboration between academia and industry is still necessary though (OECD.AI 2022; Nordic Innovation 2022). In 2019, Norway invested roughly €40 million in AI, robotics, visualization and digital content. According to the Norwegian National Strategy for Artificial Intelligence, the country should focus its investments on supporting strong research communities in close cooperation with industry (Norwegian Ministry of Local Government and Modernisation 2020).

Figure 43. Purposes of use for AI technologies



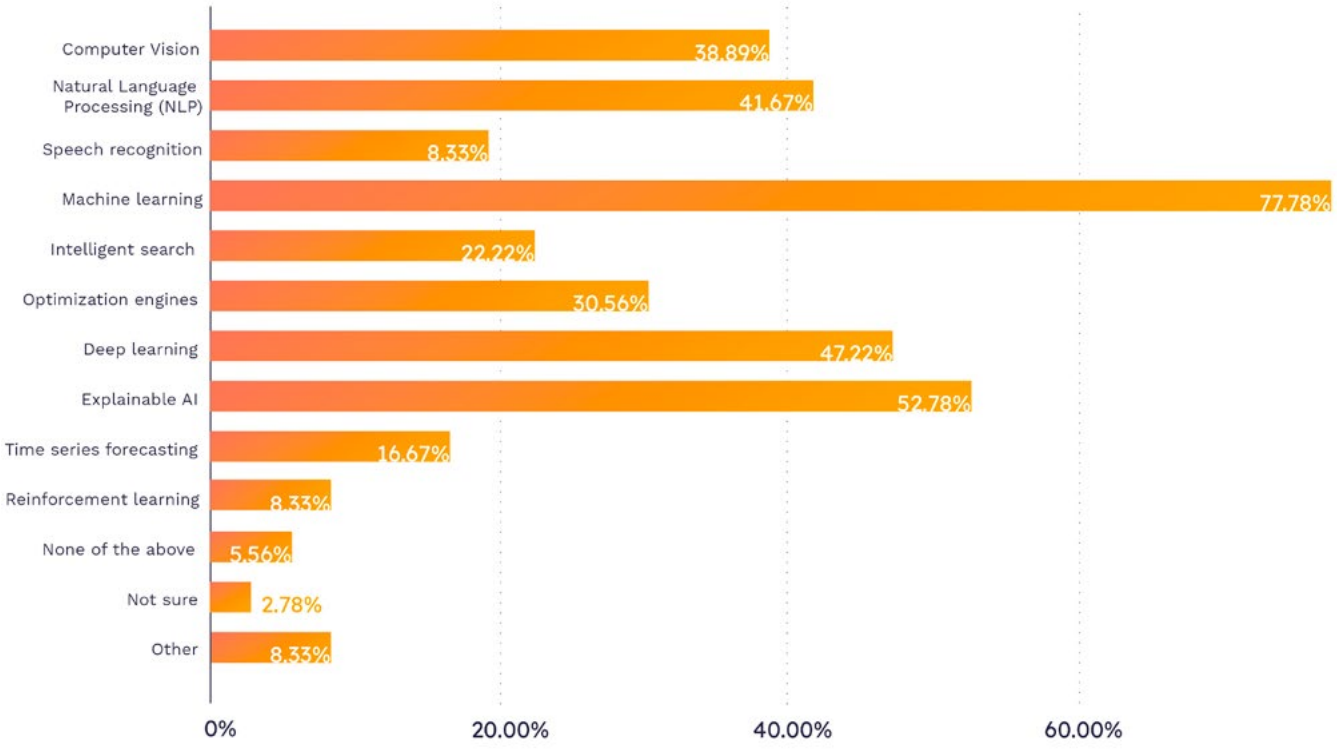
Source: Nordic State of AI Survey 2022.

Statistics Norway states the top three purposes of use for AI in Norway are: Organization of business administration purposes, Production processes, and ICT security. Our survey concluded that a vast majority uses AI as a part of a product or service (Statistics Norway 2022; Figure 43, Nordic State of AI Survey 2022).

Our survey suggests that Norway's most favored AI technologies are similar to the Nordics overall, with the umbrella term Machine learning dominating. Other technologies highlighted in Norway were Explainable AI, Deep learning, and Natural language processing. According to Norwegian government statistics, Robotic process automation was the most popular choice, closely followed by Deep learning and Text mining (Nordic State of AI Survey 2022; Statistics Norway 2022). RPA was also the top choice in Sweden (Statistics Sweden 2022).

As is the case in the other Nordics, nearly half of Norwegian companies surveyed say that AI has allowed them to improve the features, usability, and quality of their products and services (Nordic State of AI Survey 2022). The results indicate a broad focus on improving core products and services, efforts that will result in revenue growth. Interestingly, Norway and other Nordics are still underutilizing AI in new business creation activities like sales and marketing. By integrating AI into customer care though, it would be easier to attract new business.

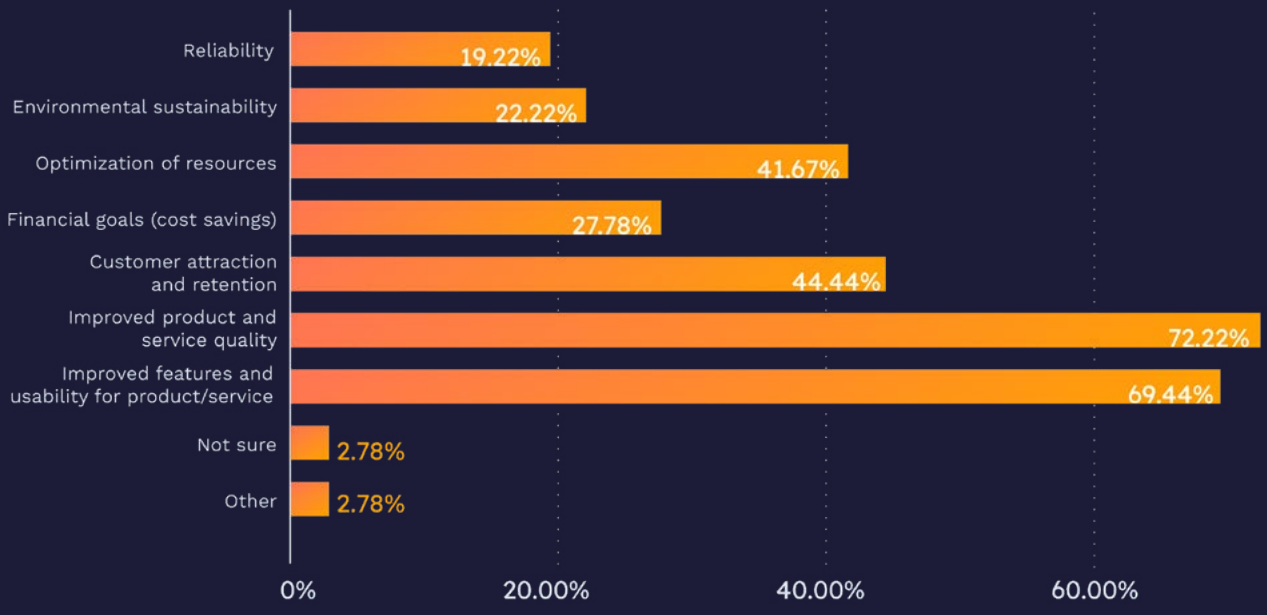
Figure 44. AI technologies used in Norway



Source: Nordic State of AI Survey 2022.

Norway and other Nordics are still underutilizing AI in new business creation activities like sales and marketing.

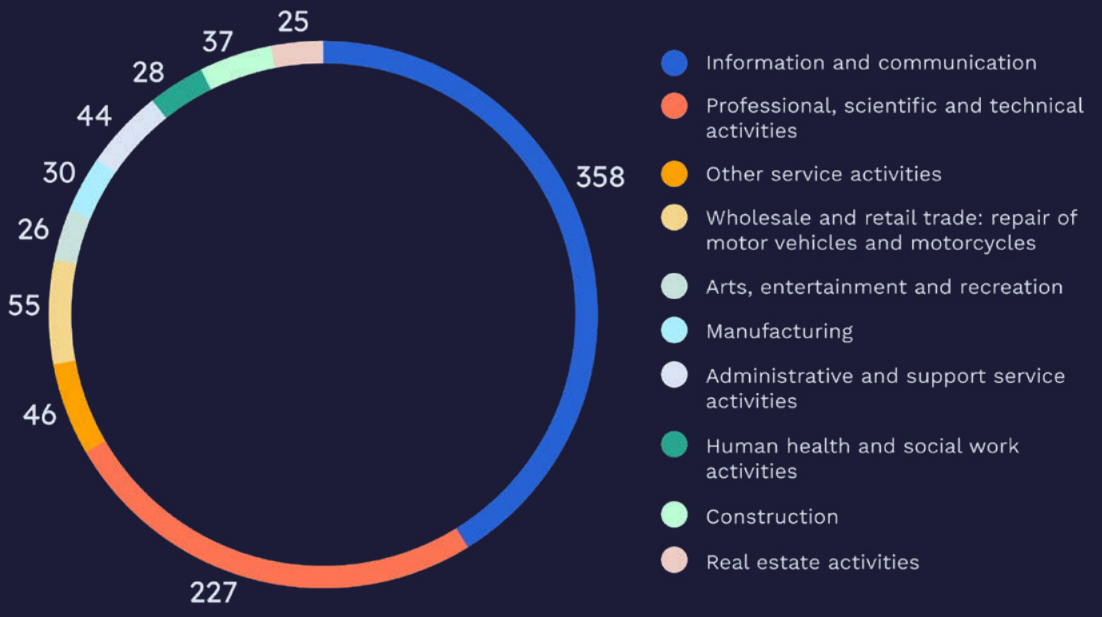
Figure 45. Value brought by AI



Source: Nordic State of AI Survey 2022.

Currently, 975 companies in Norway can be found in the Vainu company database when searching for the Vainu Custom Industry tags Artificial Intelligence, Machine learning, Speech recognition, Natural language processing, and Computer vision (Figure 46). As expected, Information and communication is the top industry, representing one third of the firms identified. The second biggest industry is Professional, scientific and technical activities, amounting to one quarter of listed companies. No other specific industry stands out (Vainu 2022).

Figure 46. Top 10 industries for AI-related companies in Norway



Source: Vainu 2022.

BUSINESS

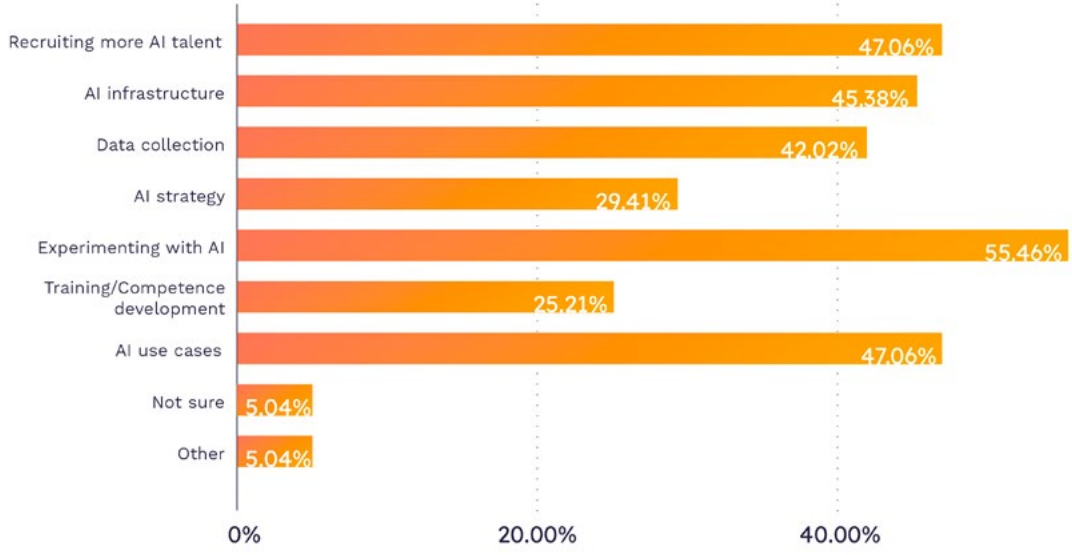
In 2021, 9% of small enterprises in Norway used at least one AI technology. For MSEs, the adoption rate was about twice as much. In Norway, 43% of companies with 250 or more employees use AI (Eurostat 2022).

The Norwegian economy leans heavily toward large companies, as they constitute up to 66% of total economic value (OECD 2022). Only 11% of all Norwegian companies have adopted AI (OECD 2022). Norway might consider working on achieving mainstream adoption and diverting more attention to smaller companies that are at the risk of remaining underdogs in the AI adoption race.

Slightly more than half of our Norwegian respondents were working in the Information Technology and Services industry. A total of 66.7% of them said that AI was Highly important for their organization, which was about 17 points higher than the Nordic average. About two-thirds of respondents expect to see more AI technologies adopted within their organization during the next six months.

Roughly 56% of organizations said they intend to hire 1-5 new AI professionals in the next 6 months and almost 20% plan to hire more than that. Hiring more AI talent was the most popular investment target in Norway. Much like the other Nordics, there was no clear distinction between these categories, except for scoring low percentages in Training/Competence development and AI Strategy, both of which had a considerably lower investment share (Figure 47, Nordic State of AI Survey 2022).

Figure 47. Biggest challenges in scaling the use of AI across your organization



Source: Nordic State of AI Survey 2022.

RESEARCH

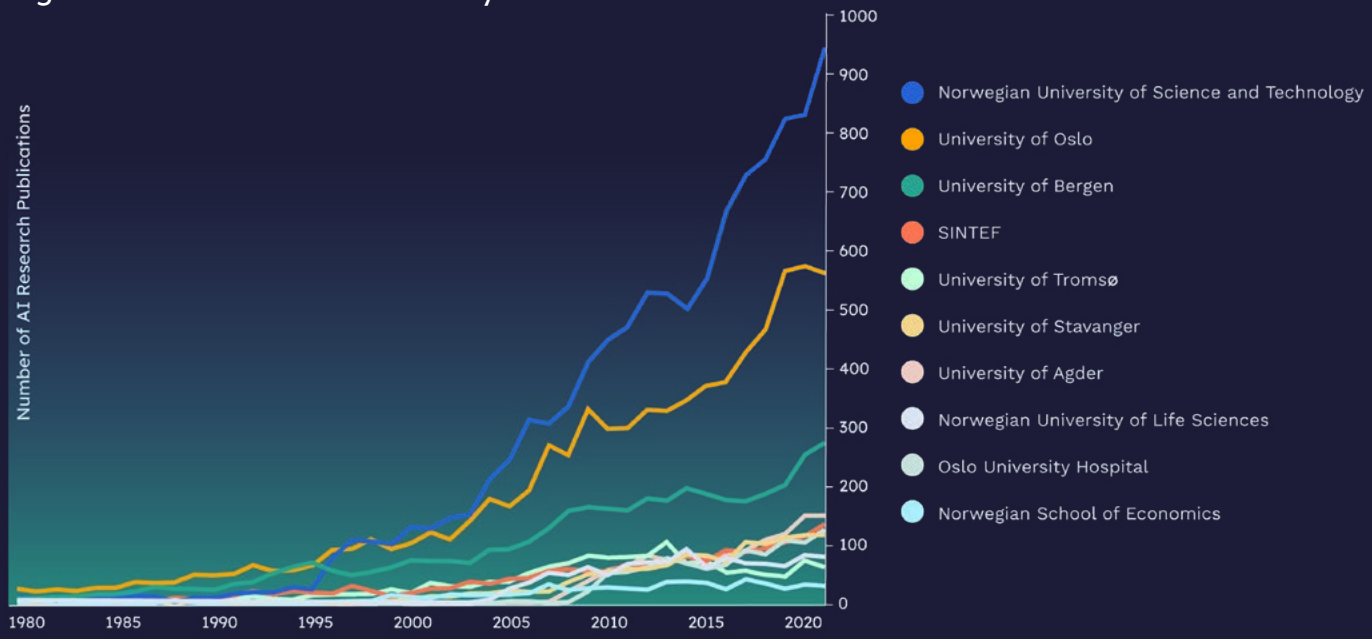
The top three universities – NTNU, the University of Oslo, and the University of Bergen – contribute most to AI research in Norway. The Norwegian Artificial Intelligence Research Consortium (NORA) has partnered with 8 universities, 4 university colleges, and multiple research institutions to keep developing and strengthening these fields as part of the push to establish an AI society in Norway (NORA 2022).

Norway also has a national eHealth platform, which allows for rapid sharing and monitoring of health-related data. For instance, multiple data sources can be connected, ensuring speedy and efficient research into various conditions. It can even give individuals the power to withhold the release of such information if they choose not to share it (Nordic Innovation 2022).

Similar to Denmark, Norway has seen rapid growth in the number of AI research papers, with the absolute number of publications increasing almost every year over the past two decades (Figure 48).

The Research Council of Norway has more than 1,500 ICT and digital transformation-related projects in 2022 underway which have received nearly €350 million in associated funding (The Research Council of Norway 2022).

Figure 48. AI research research by institution



Source: OECD.AI 2022.

EDUCATION

The Norwegian University of Science and Technology (NTNU) was the first and so far only institution from Norway to make it into the Edurank listing of top European Artificial Intelligence educational institutions, placing 79th out of 100. Norway was the last Nordic country, but the growing number of Norwegian AI publications (see Figure 57) could soon start to move Edurank's rankings more in its favor. NTNU has been the leading producer of AI research papers since the mid-1990s in Norway. In addition, the University of Oslo has seen a huge increase in publications from the early 2000s onward (Edurank 2022; OECD.AI 2022).

Norway dropped 8 positions from 9th to 17th place in Coursera's global skills report, thus making it the lowest ranking Nordic country. Norway scored relatively high in the Technology and Data Science categories but surprisingly low in the Business category (Coursera 2022).

For business, however, there are multiple organizations that serve the purpose of competence and network building in the Norwegian AI business ecosystem, such as the Norwegian AI Startup Landscape or AI-klinikken (Nordic Innovation 2022).

When it comes to AI education, Norway is once again the Nordic underdog with only 11 programs available at the master's level. Other Nordics have almost double that and all offer bachelor's level education (Figure 10, Stanford University 2021). The Norwegian government recognizes its citizens will require more continuous training as AI emergence will continue to reshape the economy (Norwegian Ministry of Local Government and Modernisation 2020).

Norway was the last Nordic country, but the growing number of Norwegian AI publications could soon start to move Edurank's rankings more in its favor.

LEGISLATION

As its National Strategy for Artificial Intelligence stipulates, Norway has a strong position regarding the regulatory aspects and trustworthiness of AI (Norwegian Ministry of Local Government and Modernisation 2020).

Despite being the only non-EU member in the Nordics, Norway has sought to lead AI development by ensuring that individual rights and freedoms are protected under the GDPR (Norwegian Ministry of Local Government and Modernisation 2020). Furthermore, Norway has ensured there is governing authority to make sure these values are being respected. In general, Norway will continue to work with the EU to highlight the use of responsible and trustworthy AI and to align its suggested principles of ethics and development with Norwegian government guidelines. Even though Norway brands itself as a regulatory and ethically conscious country, it does not intend to jeopardize the innovation and development of AI by regulating the technology specifically. On the contrary, Norway wants its regulatory documents to be machine-readable and AI-friendly to speed up decision-making processes (Norwegian Ministry of Local Government and Modernisation 2020).

Norway has also constructed a regulatory sandbox as an AI testing ground. This

Even though Norway brands itself as a regulatory and ethically conscious country, it does not intend to jeopardize the innovation and development of AI by regulating the technology specifically.

sandbox allows companies to safely test if their product or service is compliant with the current laws and regulations. In return, Norway receives valuable information about future AI prospects and the risks that new solutions may create. The model is inspired by the one adopted in the UK. The system should help set examples for companies to follow while navigating the maze of rules that can be both confusing and complex (Nordic Innovation 2022).

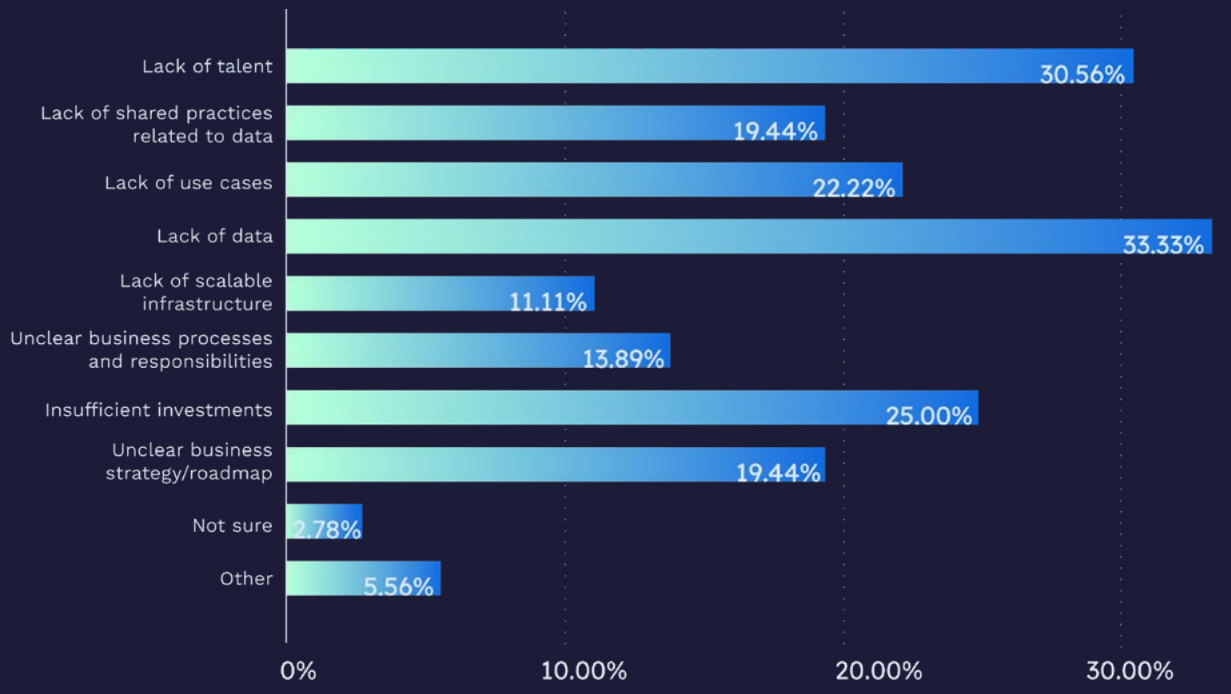
Lovdata is the database for Norwegian laws and regulations. We used this platform to search laws containing the words ‘artificial intelligence’ or ‘machine learning’. These searches revealed that these terms have been mentioned but not directly addressed as laws in Norway (Lovdata 2022). Additionally, we tried searching from the Norwegian government website for the same terms but obtained no results about proposals for bills in motion (Government.NO 2022).

TALENT

Lack of talent was Norway's second biggest challenge in scaling AI within organizations, according to our survey (Figure 49, Nordic State of AI Survey 2022). Norway can easily start harnessing foreign talent, as it was the second favorite Nordic destination for AI talent (OECD.AI 2022).

Norway is active when it comes to hiring new AI professionals. Judging by talent movements recorded by the OECD (Figure 11) and our survey findings, it's clear that Norway has strongly focused its efforts on growing its talent pool (OECD.AI 2022; Nordic State of AI Survey 2022).

Figure 49. Biggest challenges in scaling the use of AI across your organization



Source: Nordic State of AI Survey 2022.

To help with the talent-gap, NORA has started a program to bring AI students and businesses together, so that supply meets demand. DigitalNorway is a similar organization that is focused on helping SMEs digitize by offering free courses and the chance to network. In addition to these options, there are other undertakings in a process that are helping Norway to become a breeding ground for state-of-the-art AI and a digital nation (Nordic Innovation 2022).

Insights from Norway

Klas Pettersen
CEO at NORA.ai

NORA.ai, the Norwegian Artificial Intelligence Research Consortium, started its work just over three years ago. We're a collaboration between eight universities, three university colleges, and five research institutes involving AI, machine learning, and robotics. We have been promoting research, education, and innovation in the field of AI both in Norway and internationally, with a special emphasis on collaboration between Nordic countries.

In Norway, there is a good research community and Norwegian researchers publish a lot of research papers. To keep this trend going, we recently established a national research school at the Ph.D. level, including all of our partner universities in Norway – almost all universities doing AI research. This research school is working in collaboration with industry, for both the public and private sector's benefit.

Norway could improve its activities around innovation, startups, and industry. We need more practical uses for AI. I believe that through having more practical industry collaboration, we could have more of our innovations adopted into actual use. That's why establishing a startup network was seen as a high priority, where the focus lies on research-based companies. The companies that join must be validated as research-based and individual researchers are urged to join this network. There are currently 35 companies in the network.

Norwegian companies also suffer from a lack of talent in AI. We've just recently launched educational programs for AI to tackle this problem. Despite having educational programs for PhD-level people, we should aim at educating people across society. Having more women enter technical jobs is also an issue that's often raised. To help with this goal, we published a list of 100 women in the field of AI to serve as examples.

For all of the Nordic countries, I would like to see more Nordic collaboration. We already share many strengths, such as our common values, trust in public authorities, and a lot of data having been collected over a long period of time. NORA has established a peer-reviewed journal called Nordic Machine learning to promote Nordic research. We also host an annual event for young Nordic researchers.

Insights from Norway

Christine Hafskjold
Senior ICT Policy Adviser at the Norwegian Ministry of Local Government and Regional Development

I worked on the Norwegian AI Strategy that was published in 2020. Since its publication, one of our key accomplishments has been the regulatory sandbox for responsible AI at the Data Protection Authority, which was inspired by the regulatory sandbox at the Information Commissioner's Office in the UK. In the sandbox, both public and private organizations with AI-driven projects may test if their ways of working are compliant with the data protection legislation. All of this is done in a controlled environment where findings and developments are later shared and used for the public good.

I work at the Ministry of Local Government and Regional Development, which is the ministry responsible for ICT policy. When working on the AI strategy, we identified that AI poses many regulatory challenges, mostly to the public sector. One challenge that we have faced is sharing data, especially in healthcare, because of data protection concerns. To meet this challenge, the Directorate of e-Health has established a Health Data program, in order to provide faster and more secure access to health data. Data and data sharing in general has been a priority, and we are also looking into how we can help private companies share more data. Some industries, such as seafood and petroleum, already have data-sharing platforms, but there is still a way to go in data sharing, both from the public sector and across industries.

Some of our larger agencies, such as the Labour and Welfare Administration (NAV) and the Tax Administration, have enough experience and resources to experiment with AI. Other, often smaller organizations, can easily become overwhelmed by what they hear about AI and issues with privacy or bias. Our job in the government is to help them better understand the principles of AI and to overcome these fears, while still using AI responsibly. As public authorities, we have a special responsibility to ensure that citizens' data are handled securely and that decisions that affect individuals are correct and transparent. I believe that this is possible, and that AI will be essential for providing better public services in the future.

As in many other countries, we struggle to find enough people with advanced skills in AI. I would love to see more young people, especially women, studying technology in general, and AI in particular. And I wish more people, irrespective of background, would realize how exciting AI is and want to learn more.

SWEDEN

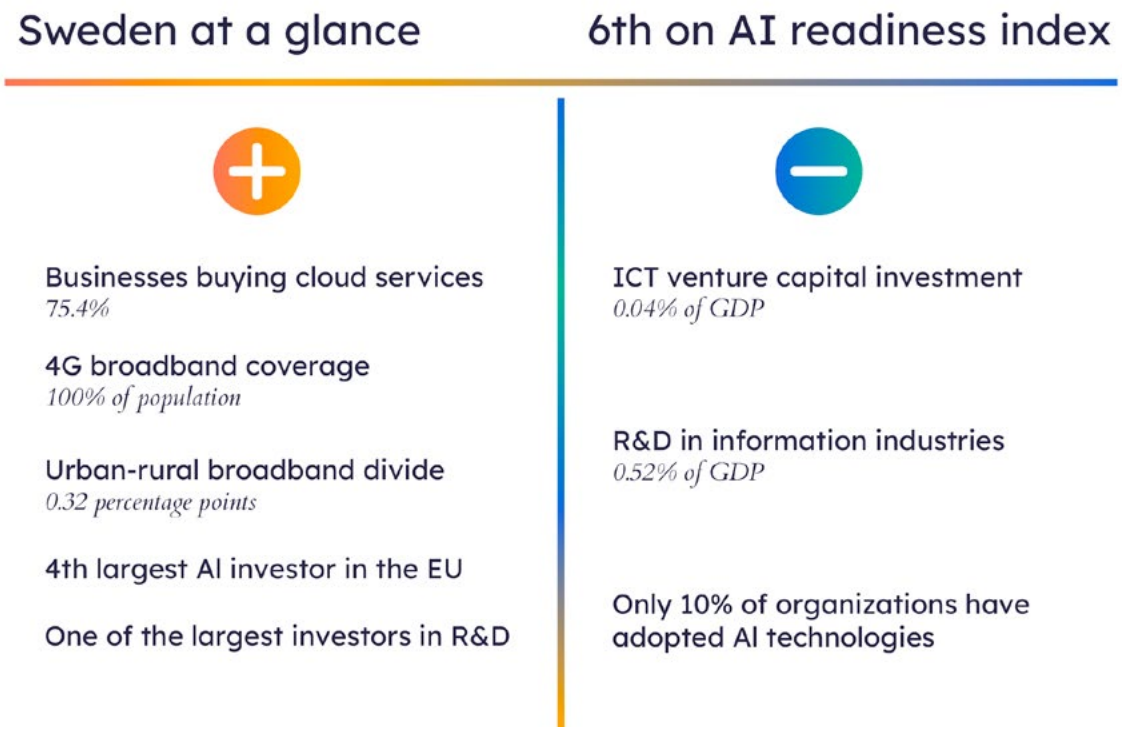
Sweden was the 22nd-largest economy in the world in 2020. Its exports amounted to $152 billion, with Cars ($11.1B), Packaged Medicaments ($9.29B), and Refined petroleum ($5.25B) topping the list. The most important services exported were Miscellaneous business, professional, and technical services ($1.52B) (OEC.WORLD 2022).

In 2017, Sweden launched its digital strategy with targets to deliver digital literacy, digital security, digital innovation, digital leadership, and digital infrastructure (OECD 2022).

The report highlights the ways AI could be leveraged to fight climate change, as Sweden would like to play a leading role in this global battle (AI Sweden 2022). In 2018, Sweden introduced its strategy initiative related to AI (Ministry of Enterprise and Innovation 2018).

Based on Eurostat (2022), Sweden has the smallest percentage (10%) of organizations adopting AI compared to other Nordics. However, Vainu.io data showed that Sweden is leading the AI industry (Vainu.io 2022; Eurostat 2022).

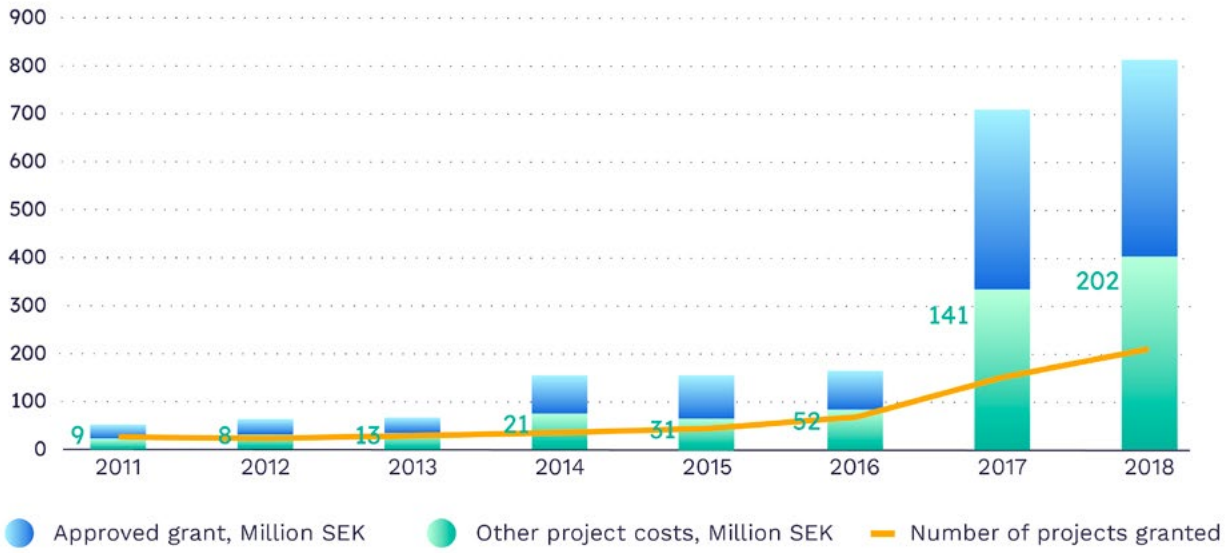
Figure 50. Sweden at a glance



Sources: OECD Going Digital Toolkit 2022; Nordic State of AI Survey; Oxford Insights 2021; Eurostat 2022.

AI Sweden is acting as a government-funded vehicle for proactive AI adoption. One of its newest innovations has been the AI sustainability and growth program, which began in 2021 and will run through 2024, with funding of €5.5 million (Vinnova 2022). The number of projects and overall funding dedicated to AI has been growing rapidly in recent years (Figure 51). To address the shortage of AI specialists, the government has made efforts to accommodate the required level of educational supply of talent. The government also funds research and businesses (Government Offices of Sweden 2022; Stanford University 2021; Vinnova 2022; WASP 2022, AI Sweden 2022). Other Swedish policy instruments can be seen in Figure 52.

Figure 51. AI projects funded by Vinnova 2011–2019. Grants, budgeted project costs, and the number of projects granted

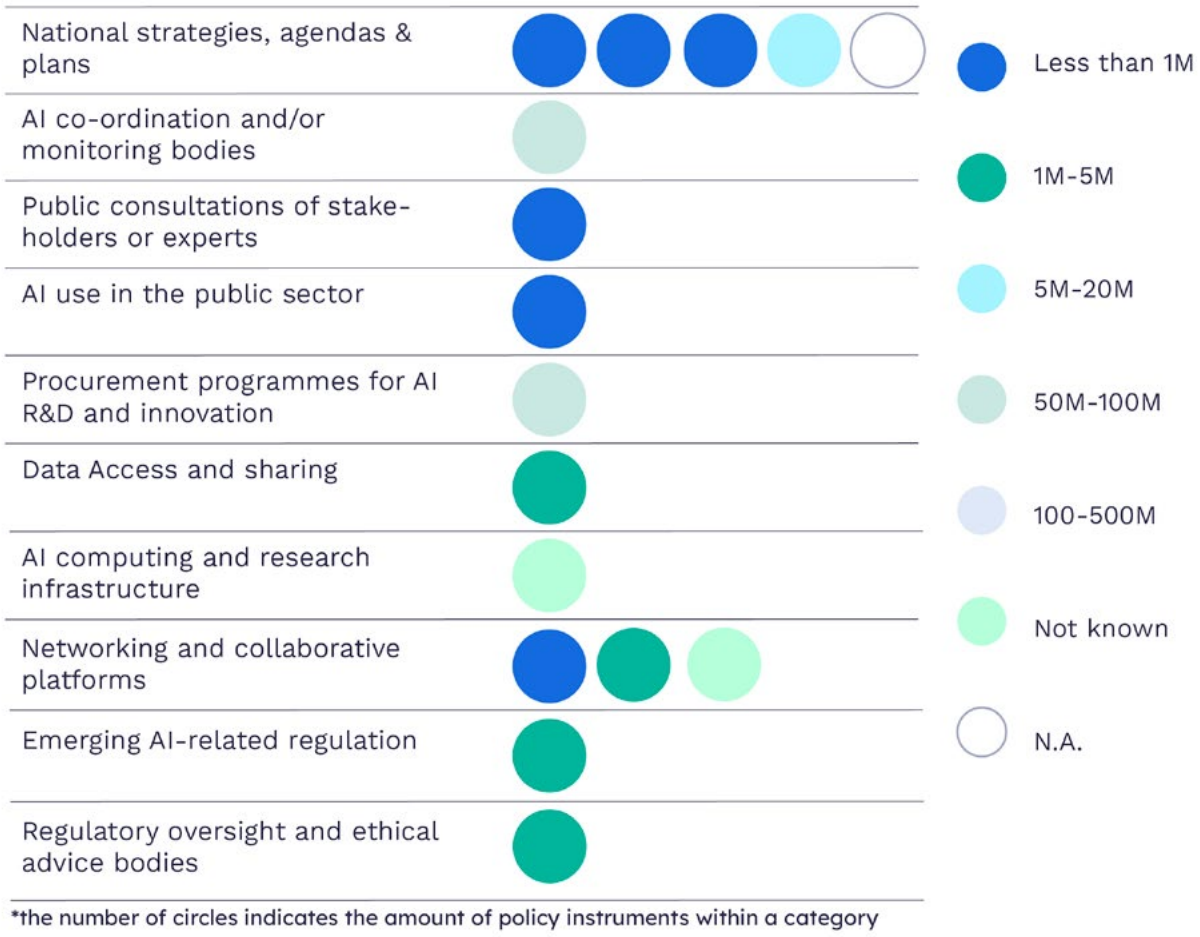


Source: Vinnova 2019.

The number of projects and overall funding dedicated to AI has been growing rapidly in recent years.

Climate change and other related concerns are beginning to impact the field of AI. In Sweden, AI Sweden, the Research Institutes of Sweden (RISE), and the Stockholm Resilience Center took on the theme of environmental sustainability and in 2021 produced a report called AI in the Service of the Climate (AI Sweden 2022).

Figure 52. Policy instruments by number & budget in Sweden

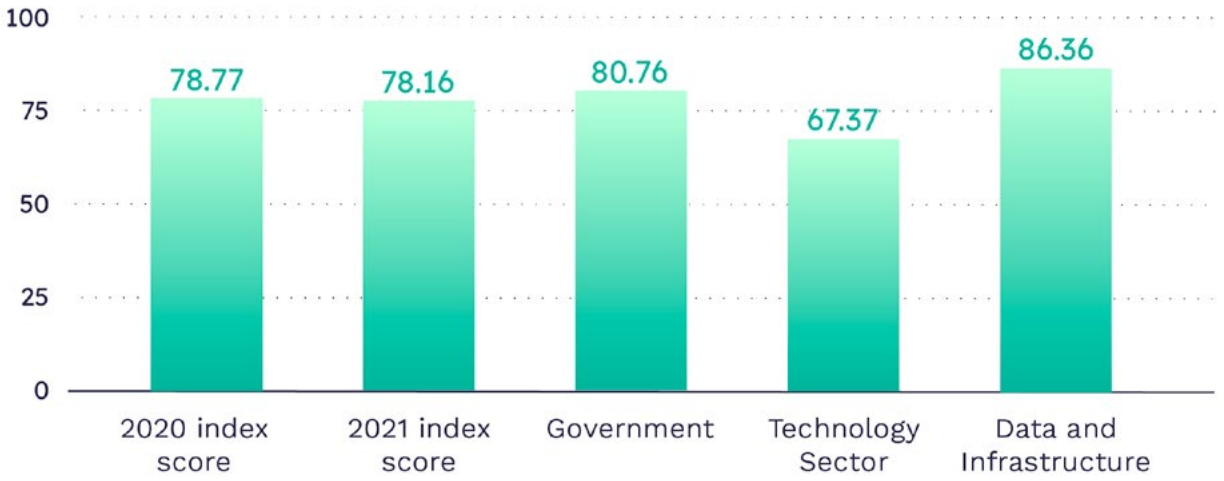


Source: OECD.AI 2022.

AI MATURITY

Sweden placed 6th in the global AI Index score by Oxford Insights, dropping one position since last year. Sweden performed particularly well in Data & infrastructure - higher than Finland, which performed best overall in the Nordics. However, Sweden scored low on Government (Figure 53, Oxford Insights 2021). ETLA's Digibarometer (2022) showed Sweden's government to be one of the least supportive of AI and Machine learning adoption in business (ETLA 2022).

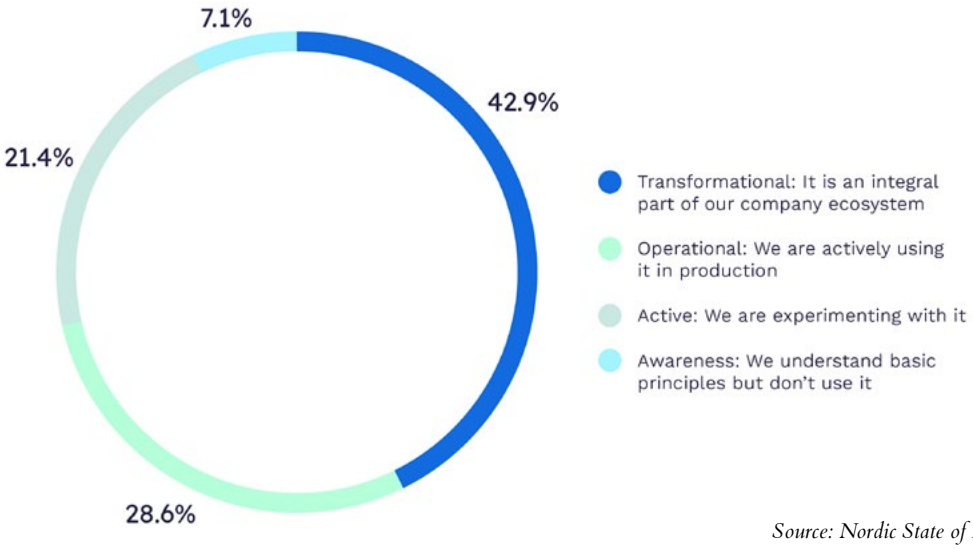
Figure 53. Swedens's AI Adoption Index scoring breakdown



Source: Oxford Insights 2021.

Returning to the AI Index ranking, Sweden was ranked 4th globally in Technology (Oxford Insights 2021). Our survey results from Sweden show a high level of maturity in AI: 42.9% of Swedish companies surveyed put themselves at the highest stage of maturity, at the transformational level (Nordic State of AI Survey 2022).

Figure 54. Organizational maturity level with respect to AI in Sweden



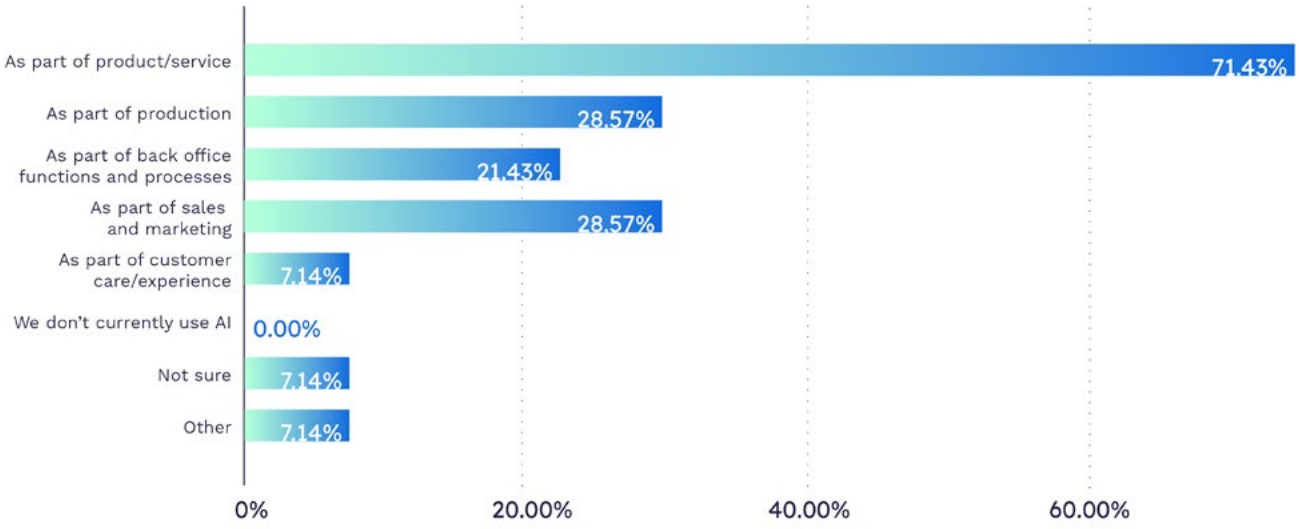
Source: Nordic State of AI Survey 2022.

IMPLEMENTATION

Like the other Nordics, Sweden also has an AI strategy at the governmental level. Sweden's view has been described as vague by local experts, and the relative freedom given to key organizations is resulting in some mixed approaches (Nordic Innovation 2022). We mentioned earlier that government involvement has been small. Looking at AI investments, Sweden remains the fourth largest investor in the EU member states with €31 per capita (European Commission 2022). In addition, Sweden does spend a lot on Research and Development, as its portion of GDP devoted to R&D is 3.53% - one of the highest in the world (World Bank 2022).

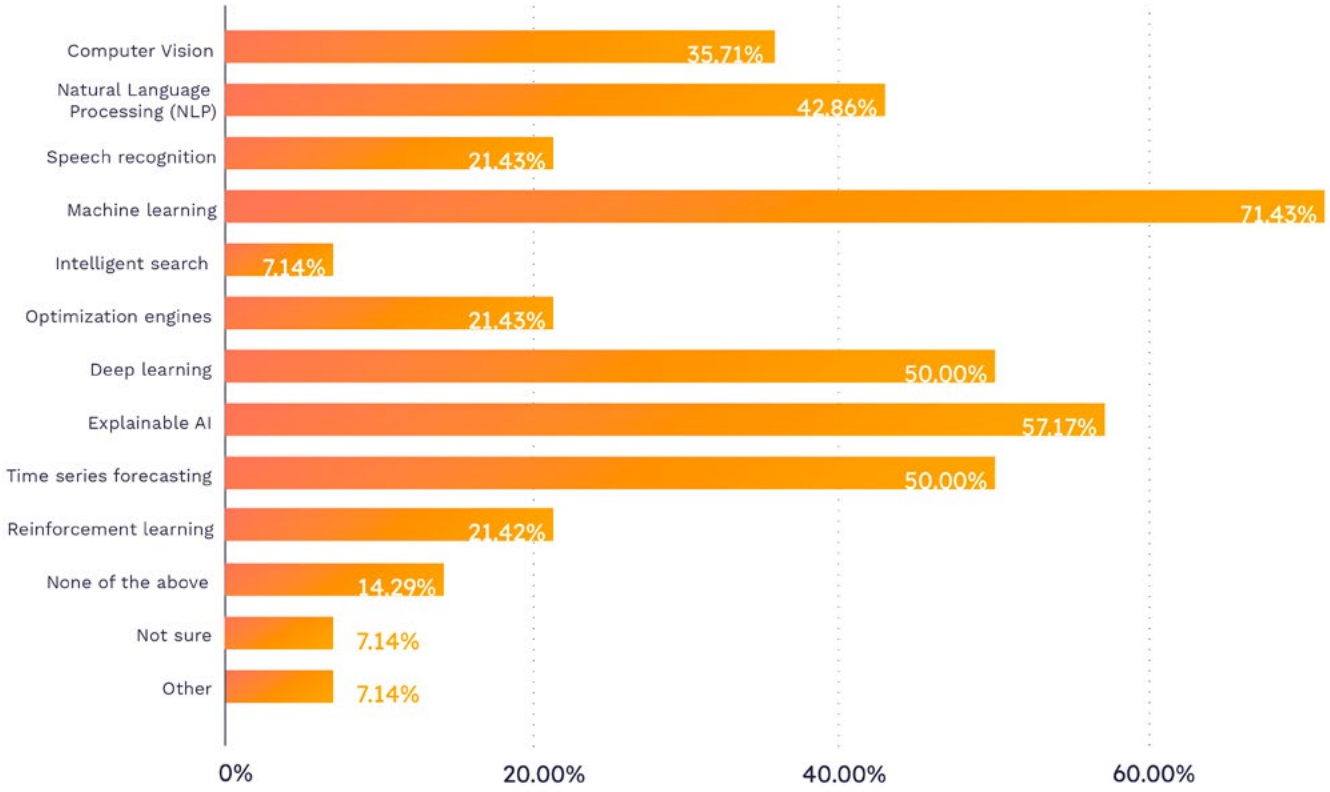
Sweden and Finland have the most digitally advanced manufacturing industries in Europe, with Sweden having taken massive leaps in progress during the last couple of years (ETLA 2022). According to Statistics Sweden, the three most popular use cases for AI in Sweden are marketing or sales, organization of business administrative processes, and ICT security. Our Nordic State of AI survey revealed that most companies use AI as a part of a product or service. Notably, no Swedish company responded that they don't use AI at all (Figure 55).

Figure 55. Purposes of use for AI technologies in Sweden



Source: Nordic State of AI Survey 2022.

Figure 56. AI technologies used in Sweden



Source: Nordic State of AI Survey 2022.

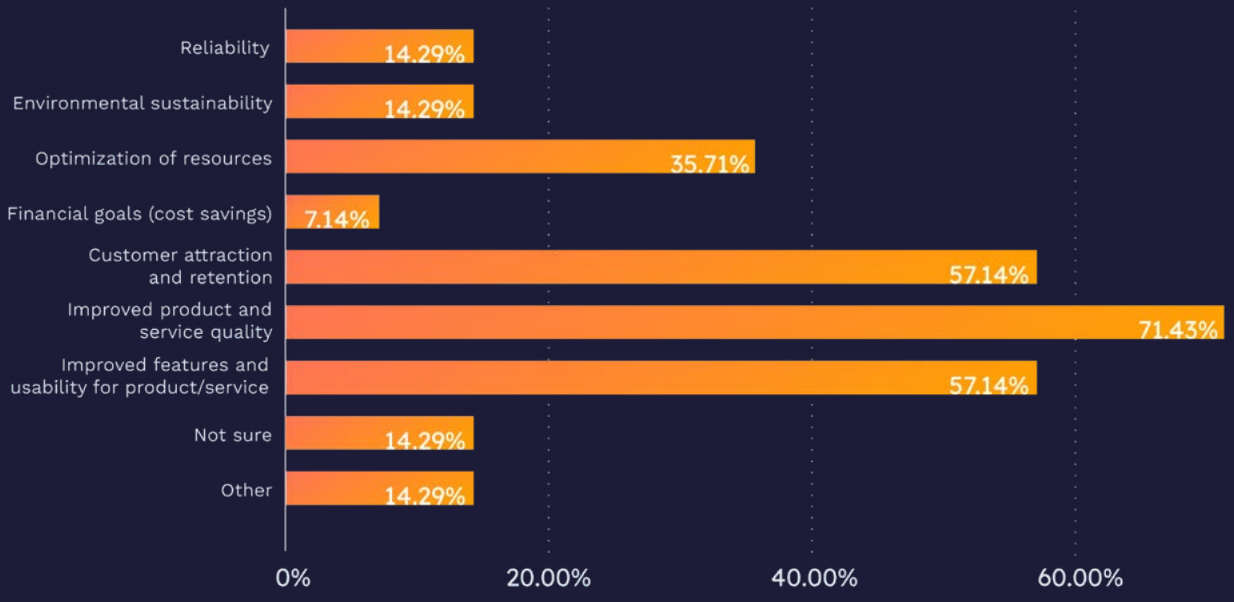
The most used AI technologies in Sweden (see Figure 56) are close to what respondents in other Nordics replied. In Sweden, many companies are using Explainable AI.

Among the Swedish companies surveyed, AI brings the most value when implemented in products and services. However, just as many respondents chose Customer attraction & retention as Improved features and usability for product/service as their option. Financial goals/cost savings were the least selected (7.14%), which was much lower than what companies in Finland responded (46.15%) (Figure 57).

"Sweden have been strong in certain areas, such as automation and communication systems, both in industry and academia. However, there's been a need to implement AI much faster in many other fields."

– Karl Henrik Johansson, Director at Digital Futures and Professor at KTH Royal Institute of Technology

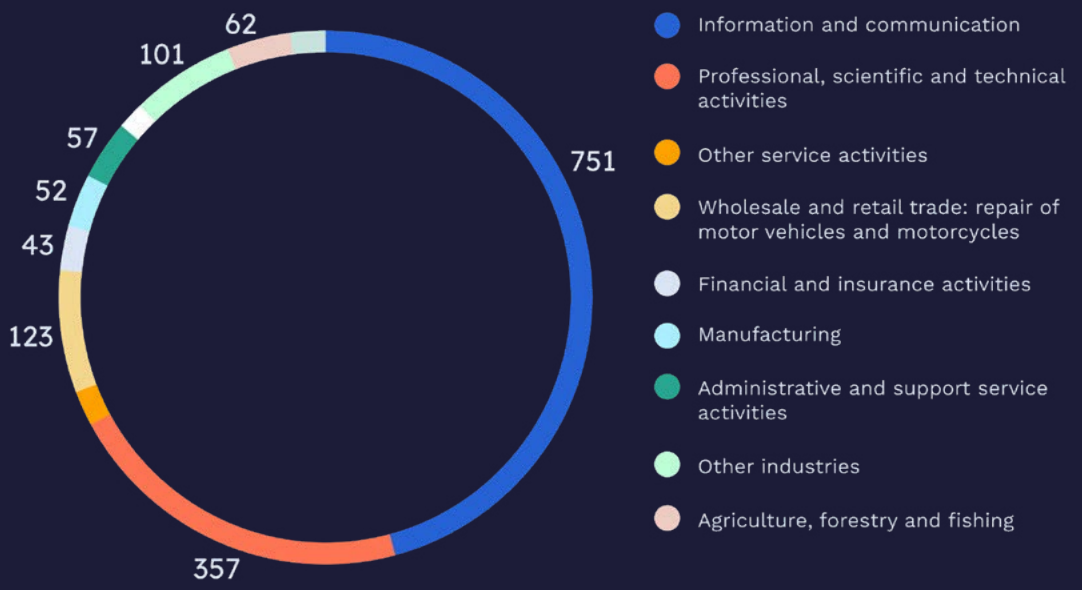
Figure 57. Value brought by AI



Source: Nordic State of AI Survey 2022.

A search with Vainu's Vainu Custom Industry classification using the industry tags Artificial Intelligence, Machine learning, Speech recognition, Natural language processing, and Computer vision returned 1,776 companies in Sweden. As in the other Nordics, Information and communication dominated the field, with Professional, scientific, and technical activities and Wholesale and retail trade following (Figure 58, Vainu 2022).

Figure 58. Top 10 industries for AI-related companies in Sweden.



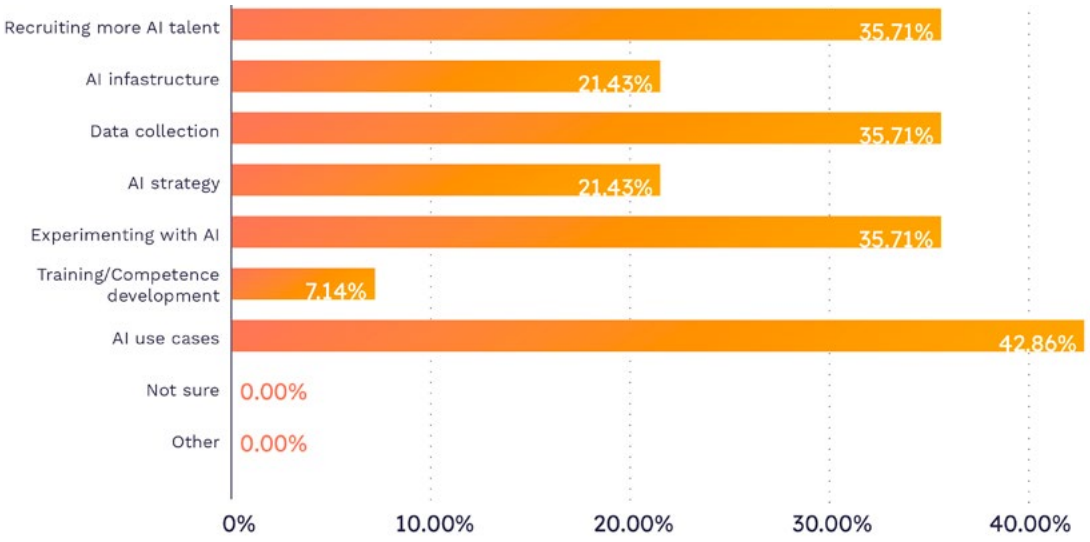
Source: Vainu 2022.

BUSINESS

A total of 8% of Swedish small enterprises used AI in 2021, according to Eurostat. Similar to Norway, 20% of medium-sized enterprises and 40% of large enterprises used AI (Eurostat 2022). Sweden's economic backbone consists of both micro-, small-, and medium-sized enterprises (MSMEs) and large enterprises, as their value to the Swedish economy is equal (OECD 2022). The AI adoption rate of MSMEs is still fairly low and would benefit from more support from the government. None of the categories have reached mainstream adoption (more than 50% of the sample). In comparison, Denmark's large enterprises had AI implemented in 66% of all companies (Eurostat 2022).

Most of the companies surveyed in Sweden operate in Information Technology & Services, like in the other Nordics. A majority of respondents value AI as Highly Important or Important to their organization. Swedish companies were also in the process of scaling their AI, as almost one-third were implementing more AI technologies within the next three months. Logically, hiring more talent was one of the top investment priorities in AI activities. One of the top investment targets for Swedish companies was AI use cases (Figure 59). However, Experimenting with AI was the top investment area in the Nordics (Nordic State of AI Survey 2022).

Figure 59. Investment areas within AI in the next six months in Sweden



Source: Nordic State of AI Survey 2022.

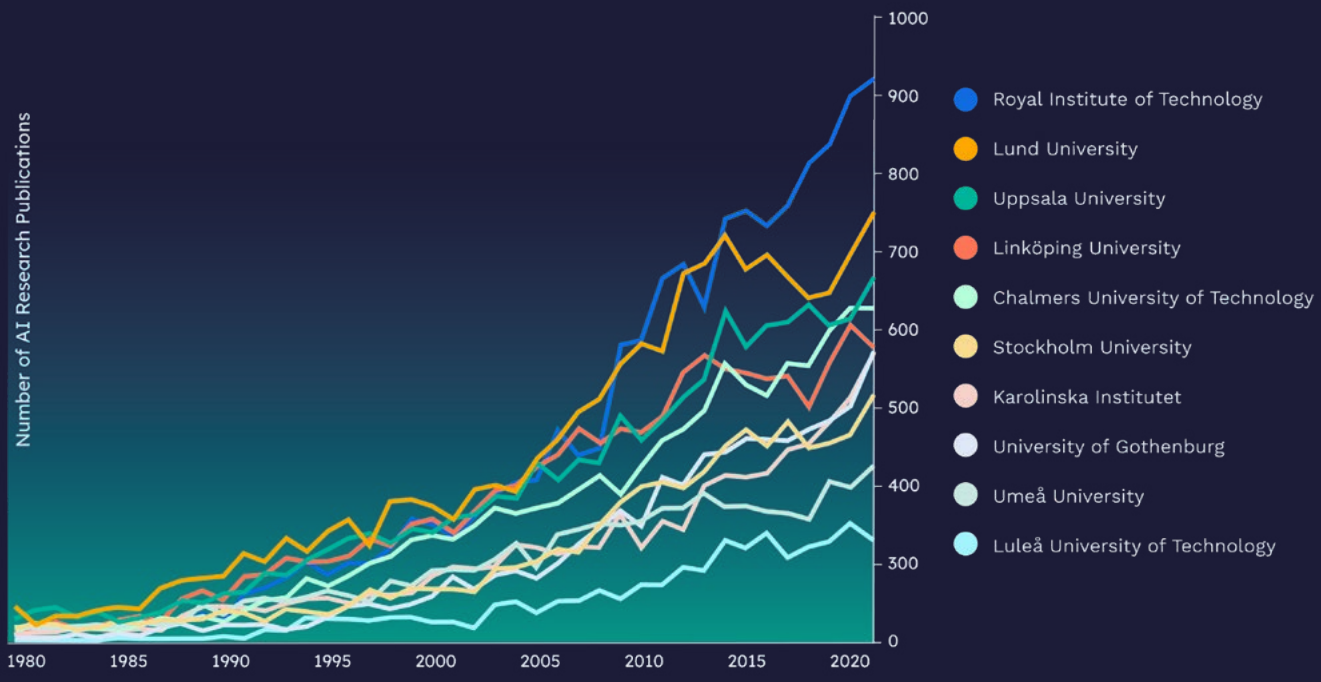
Sweden has worked to help its businesses with the Start Your AI Journey initiative. The initiative provides support to the public and private sectors in instances when limited funding is limiting AI adoption. Sweden has managed to foster an environment where collaboration between academia and business is cherished and even driven by the public sector. Such an environment allows companies or organizations to meet with their peers to learn from each other (Nordic Innovation 2022).

RESEARCH

Sweden has had academic research into artificial intelligence for many decades. The country has been strong in automation and communication systems, both in industry and academia. Only 30% of research in Sweden is publicly funded - in comparison, the same number for Norway was 46% in 2018 (Sweden 2021; Euraxess Norway 2022).

The highest absolute number of AI research papers in the Nordics are being published in Sweden. The total amount could exceed 6,000 publications this year if the current rate continues. Compared outside of the Nordics, there were over 30,000 AI research papers written in the UK last year alone (OECD. AI 2022). KTH Royal Institute of Institute of Technology produces most research papers in AI, followed by Lund University and Uppsala University (Figure 60).

Figure 60. AI research by institution



Source: OECD.AI 2022.

In Sweden, Wallenberg AI, Autonomous Systems and Software Program (WASP) is one considerable private research organization: with €560 million of funding from the Wallenberg Foundation and plans to operate through at least 2031. Its job is to strengthen, expand, and renew national competence while accelerating the research ecosystem in Sweden. It also aims to serve as a graduate school, form partnerships between universities, and entice Swedish companies to join the program (WASP 2022).

EDUCATION

KTH Royal Institute of Institute of Technology is the second Nordic university to appear in Edurank's Best Universities for AI in Europe, placing 25th in the European top 100. KTH also produces the most AI-related research papers in Sweden. Linköping University was the second establishment on the list, ranked at 44th. Lund University placed 78th and Uppsala University was 90th. Sweden has more universities than any other Nordic country on the list (Edurank 2022; OECD.AI 2022).

Sweden came in as the second Nordic country in Coursera's Global Skills Report 2022, although it lost two positions. Sweden was particularly skilled in Data Science, scoring 94% out of 100% (Coursera 2022). The propagation of AI into fields of engineering has been in motion since 2018 - the initiation year of the national AI strategy. To address the constant development of skills, there exists an AI Competence for Sweden initiative to encourage lifelong learning by creating a professional platform to learn AI. It consists of the major subcategories in AI relevant to Swedish industries (Heintz et al. 2020).

Looking at university programs, Sweden has the widest selection of specialized AI programs with seven bachelor's and 13 master's programs as well as four other options (Figure 10, Stanford University 2021). Sweden needs not only technical experts, but also managers and other personnel interacting with technology (Ministry of Enterprise and Innovation 2018; Stanford University 2021). Sweden's national AI strategy stresses the importance of understanding AI across society to maximize adoption in various industries.

Sweden has more universities than any other Nordic country on Edurank's list of Best Universities for AI in Europe.

LEGISLATION

Sweden has a history of mentioning AI in its legal proceedings, according to Stanford University (2022) but lacks any actual laws that are directly devoted to it, according to our research. However, Sweden fully supports the European Commission's Artificial Intelligence Act (Global Legal Insights 2022). Regeringskansliet, the database for Swedish law, produced zero search results when queried with the Swedish equivalents of the words 'artificial intelligence' and 'machine learning' (Regeringskansliet 2022).

Sweden's National Approach to Artificial Intelligence by the Ministry of Enterprise and Innovation calls for rules, norms, and an ethical framework for AI. While doing so, Sweden wants to promote AI use and mitigate its risks in the process. The GDPR is also mentioned as a crucial subset of the AI rulebook. The early existence of standards and regulations is needed to ensure institutions and businesses can cooperate fluently concerning AI. Organizations in Sweden should rely on the standards set by the EU and play an active role in the debate revolving around AI ethics (Ministry of Enterprise and Innovation 2018).

The early existence of standards and regulations is needed to ensure institutions and businesses can cooperate fluently concerning AI.

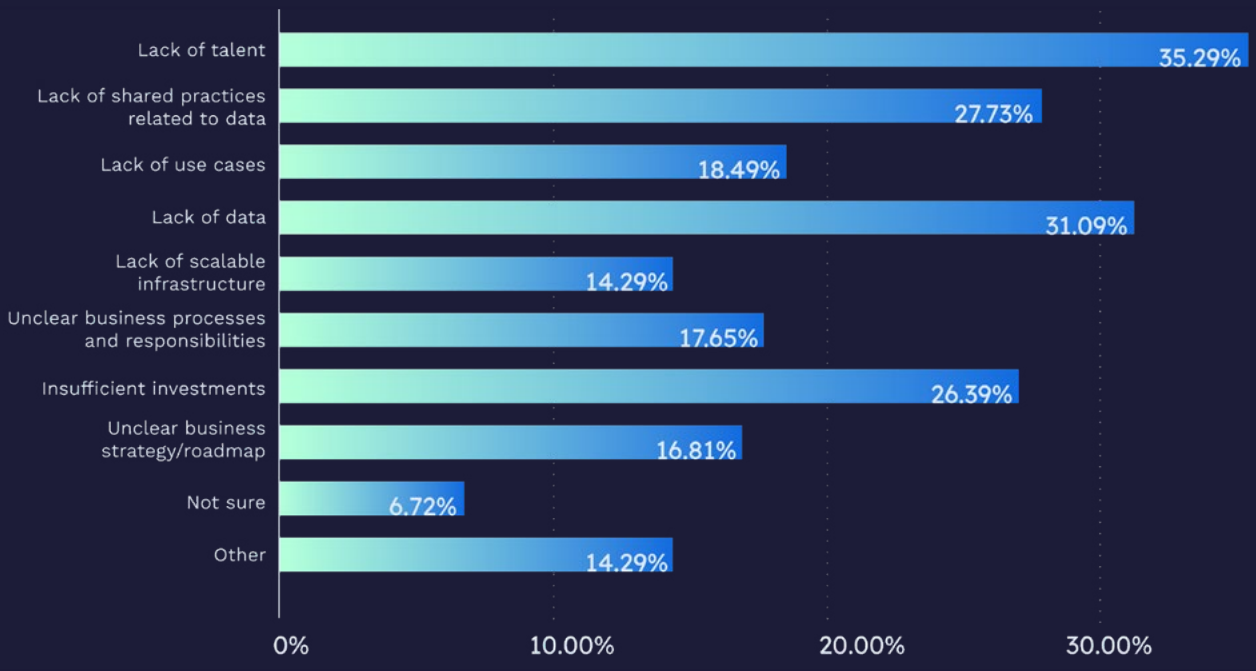
Organizations in Sweden should rely on the standards set by the EU and play an active role in the debate revolving around AI ethics.

TALENT

As of 2021, Sweden leads the EU in terms of the percentage of ICT specialists in its working population, with 8% (407,100 persons) dedicated to the field. Since 2020, there has been an increase of 40,000 people working in ICT (Eurostat 2022). Since 2019 Sweden has changed its course from a talent loser to a talent magnet for workers skilled in AI (OECD 2022).

Enterprises in Sweden are clearly in hiring mode, as our survey findings (Figure 59) and OECD statistics (Figure 11) indicate. The great majority of companies intend to hire between one and five new AI professionals within the next six months. Contrary to the other Nordics, the companies surveyed in Sweden did not score Lack of talent as one of the highest challenges in AI development (Figure 61, Nordic State of AI Survey 2022).

Figure 61. Biggest challenges in scaling the use of AI across your organization



Source: Nordic State of AI Survey 2022.

Insights from Sweden

Karl Henrik Johansson

Director at Digital Futures

There has been academic research into artificial intelligence for many decades, including in Sweden. We have been strong in certain areas, such as automation and communication systems, both in industry and academia. However, there's been a need to implement AI much faster in many other fields. In 2020, we started Digital Futures, a cross-disciplinary research center, to accelerate this development. Digital Futures was jointly established by the KTH Royal Institute of Technology, Stockholm University, and the RISE Research Institutes of Sweden, and based on the long-term support of the Swedish government. There are also other significant initiatives in Sweden, such as the WASP Wallenberg AI, Autonomous Systems, and Software Program, the most extensive individual research program in the country, which was founded in 2015.

Societal needs have recently shaped how we have organized these research efforts in Sweden. Like others, we face complex challenges like climate, energy, and cyber security. There's been hype about AI being able to solve these all through automation. Still, we have also seen concrete advancements. Through our governmental innovation agency Vinnova, industry, the public sector, and academia are collaborating on researching the automation and electrification of our transport system. The automotive industry in Sweden is quite big, particularly in the production of trucks and buses. This field is going through a complete transformation, and we need to be at the forefront of making it happen. Another example of public-private sector collaboration is a project called Advanced and Innovative Digitalization, where companies like Eriksson, Saab, and ABB collaborate.

However, we still have a lot of industries that are not doing enough. One such industry contributing significantly to pollution is the construction- and built-environment industry. We need to innovate across these disciplines. I would also like to emphasize the importance of Nordic-level collaboration. We know from history that research and collaboration in telecommunications helped Nokia and Ericsson in many ways. Although the main industries are quite different from one another in Nordic countries, in academia, collaboration does work. We need to engage the public sector and industry a lot better. One good example is the Nordic Way collaboration, where Nordic countries share data on their road infrastructure.

We need to look beyond the Nordics too. MIT and Stanford have both +1-billion-dollar research centers. Getting collaboration between different sectors to work is key to establishing these research centers that contribute to solving solutions on a societal level.

Insights from Sweden

Vanessa Eriksson
CDO at Zenseact

I'd say the adoption of AI in Sweden is likely to accelerate in most industries and companies. It has a lot to do with businesses struggling to keep up - at which stage AI can arrive to the rescue. I see Swedish companies having the most difficulty in adopting machine learning into their business processes, as businesses need insights on how to recognize potential business cases as well as to be assured that the old and new ways of doing business are not mutually exclusive. Instead of AI replacing us all, I believe new jobs will emerge. I have already seen jobs where people focus on finding business cases where AI could be useful.

Recent developments in AI have happened, in a way, under the radar because there haven't been any major security issues, and evolution in that sense has been rather smooth. However, at Zenseact, an autonomous car company, we've had to consider the risks in development as our product is not out yet. We don't want to market any products we're not fully confident with in terms of security and safety – this is part of our Nordic mindset.

We should see more guidance and rules from the government or the EU that would help us maintain the privacy of the individual. Companies are looking into solutions based on federated learning or other privacy-first solutions. In Sweden, we're very pleased to see our government actively focusing on and supporting the digitalization of industries, including but not limited to AI.

In Sweden and also elsewhere I find the lack of women in the tech industry to be very concerning. I'd like to address this issue by bringing attention to technology at the very early stages of education. I'm the founder of a non-profit organization that encourages young girls to take up technology-related education. One way to inspire children is to show them the fun aspects of technologies such as AI. For the adults of today and tomorrow, we need to create safe environments or channels for discussion, where women can share and discuss their challenges at work and get support from their peers. One area where women need more support is in taking up leadership positions in tech and daring to make career-altering decisions.

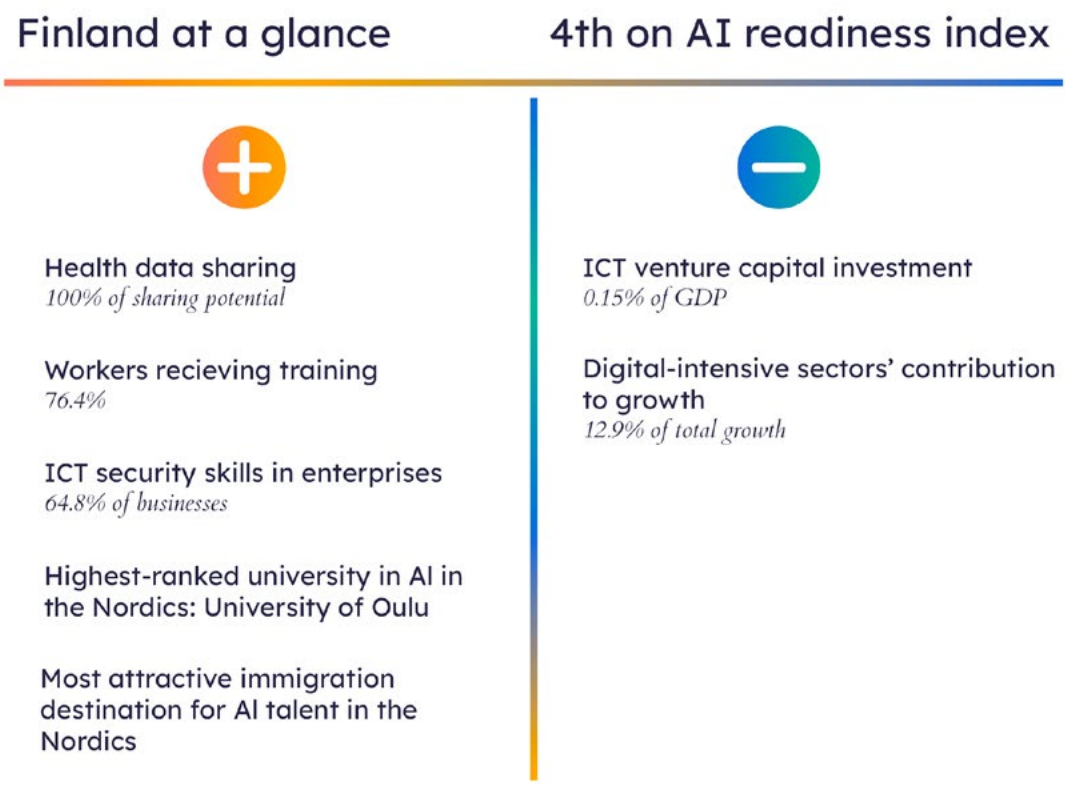
FINLAND

Finland was the 42nd largest economy in the world in 2020. Its exports amounted to $67.5 billion, with the top three being Refined petroleum ($3.95B), Kaolin coated paper ($3.73B), and Cars ($3.05B). The most important services exported were Computer and information services ($7.92B) (OEC. WORLD 2022).

The proportion of Finnish organizations adopting AI grew to 16% in 2021 from 12% in 2020, an increase of more than 30%.

The country has the second-highest AI adoption rate in the Nordics and is third in the EU (European Commission 2022). Finland has great growth prospects with artificial intelligence and was placed third after the US and Singapore (Accenture 2017). However, internal market size, risk avoidance mentality, and a lack of foreign investments were major recognized weaknesses in Finland's national strategy for AI (Ministry of Economic Affairs and Employment 2017).

Figure 62. Finland at a glance

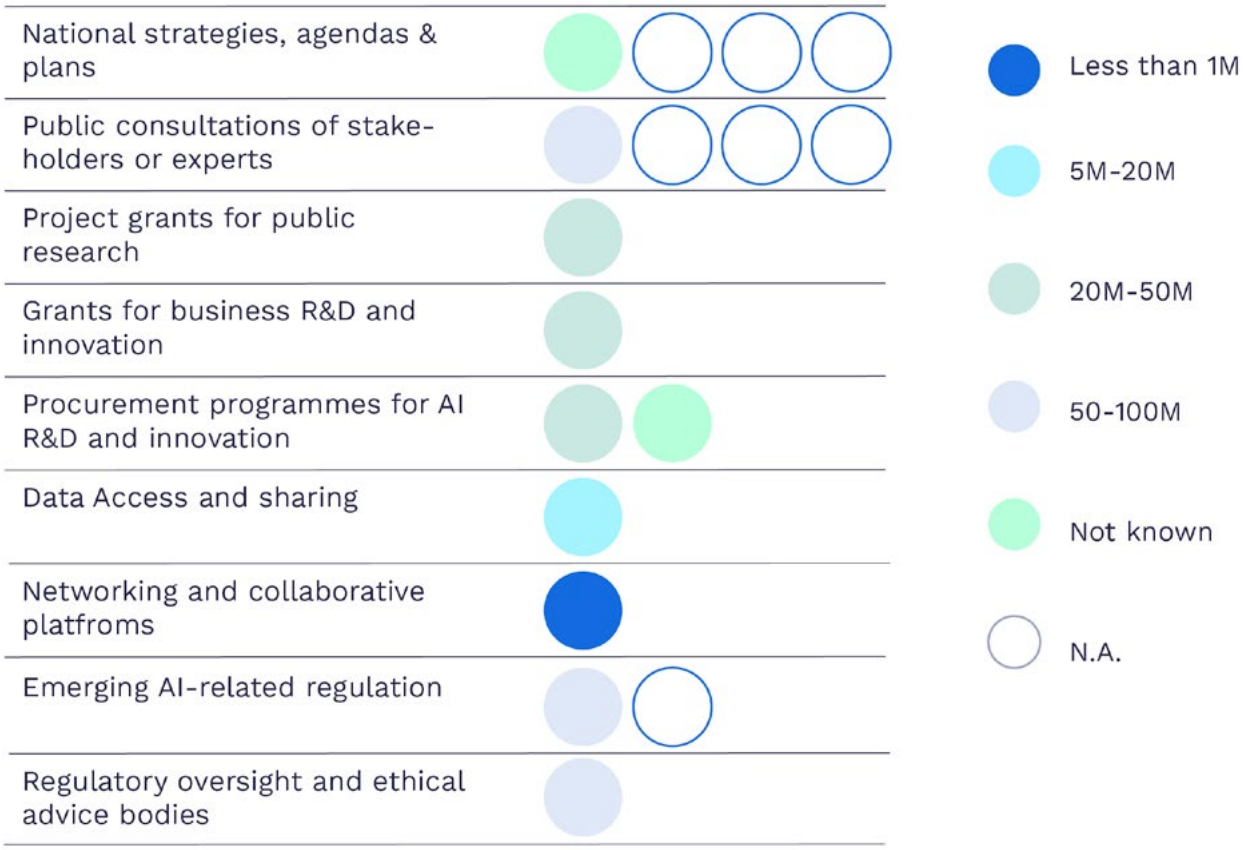


Sources: OECD Going Digital Toolkit 2022; Nordic State of AI Survey; Oxford Insights 2021; Eurostat 2022.

In terms of policy instruments (Figure 63), Finland has had governmental initiatives such as Business Finland's AI program. Currently, the country has an ongoing initiative called Artificial Intelligence Programme 4.0. According to their latest report, companies should not only erase any negative effects on the environment but also make a positive impact on society and the environment as part of their business (Ministry of Economic Affairs and Employment 2022).

From a technological standpoint, Finland is only limited by its talent capacity as Digibarometer 2022 ranks it second based on conditions, use, and the effects of digitalization (ETLA 2022).

Figure 63. Policy instruments by number & budget in Finland



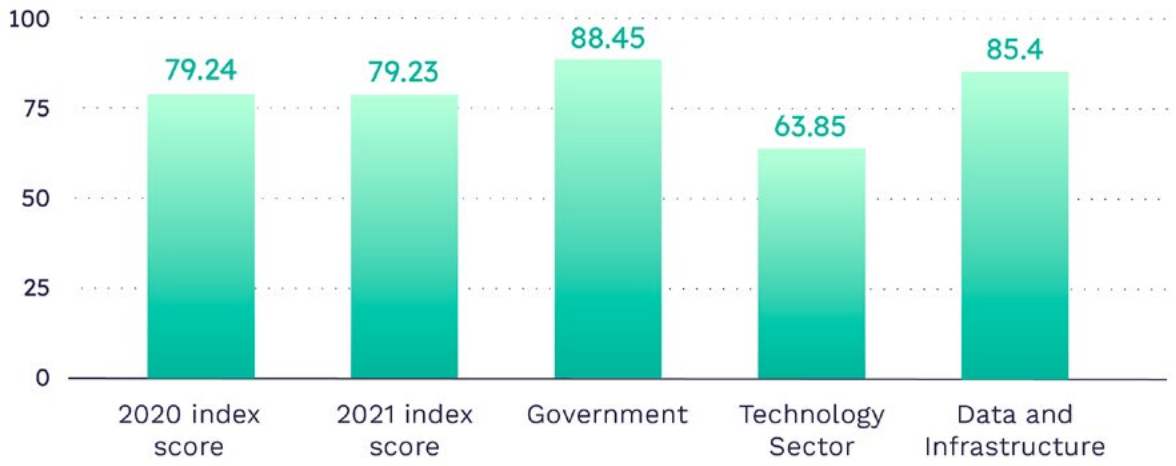
*the number of circles indicates the amount of policy instruments within a category

Source: OECD.AI 2022.

AI MATURITY

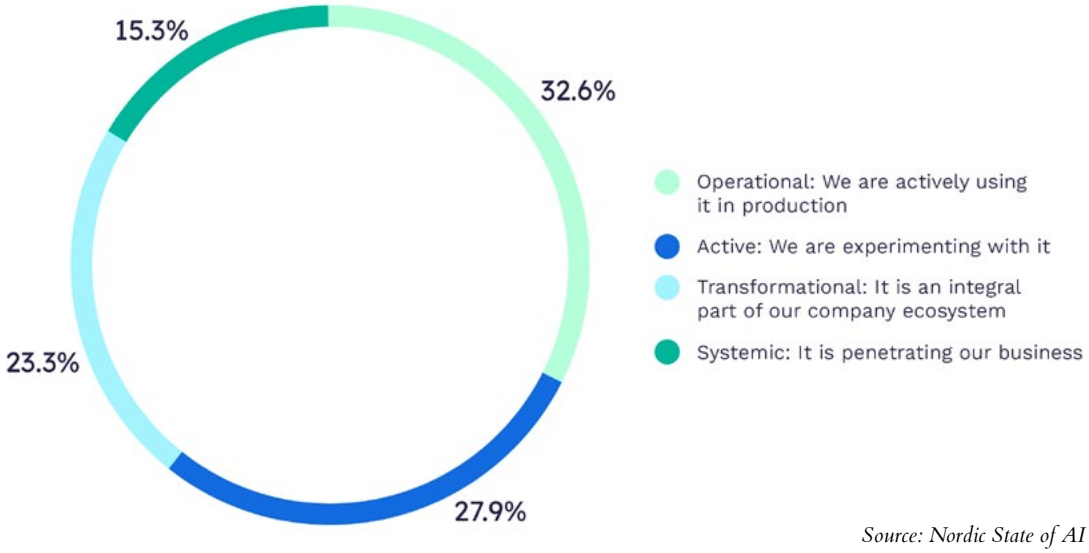
Finland is the top-ranking Nordic country when it comes to government AI readiness. Last year, it was the third in the world but has since dropped to 4th place as Singapore got ahead (Figure 64, Oxford Insights 2021) None of the surveyed Finnish companies are at the lowest level of AI maturity. However, more than a quarter of the companies – the highest percentage of all Nordics – were still at the Active-level and just experimenting with AI Figure 65 (Nordic State of AI Survey 2022).

Figure 64. Finland's AI Adoption Index 2021



Source: Oxford Insights 2021.

Figure 65. Organizational maturity level concerning AI

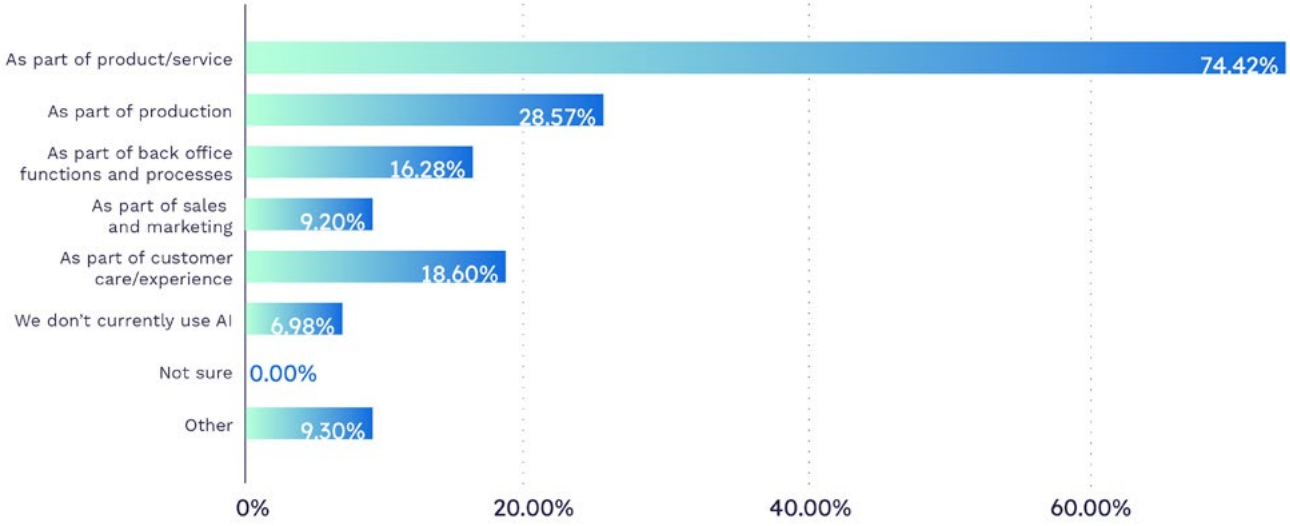


Source: Nordic State of AI Survey 2022.

IMPLEMENTATION

In Digibarometer 2022 report, Finland placed second after Denmark in the usage of digitalization. In particular, the country's manufacturing industry is one of the most digitalized in Europe (ETLA 2022). According to Statistic Finland (2022), the three most popular use cases for AI in Finland are Marketing or sales, Production processes, and ICT security. A third of the companies we surveyed used AI in Marketing or sales (see Figure 66). Additionally, our survey strongly suggests that the most typical use case for AI is as Part of a product/service (Figure 66) (Nordic State of AI Survey 2022).

Figure 66. Purposes of use for AI technologies in Finland



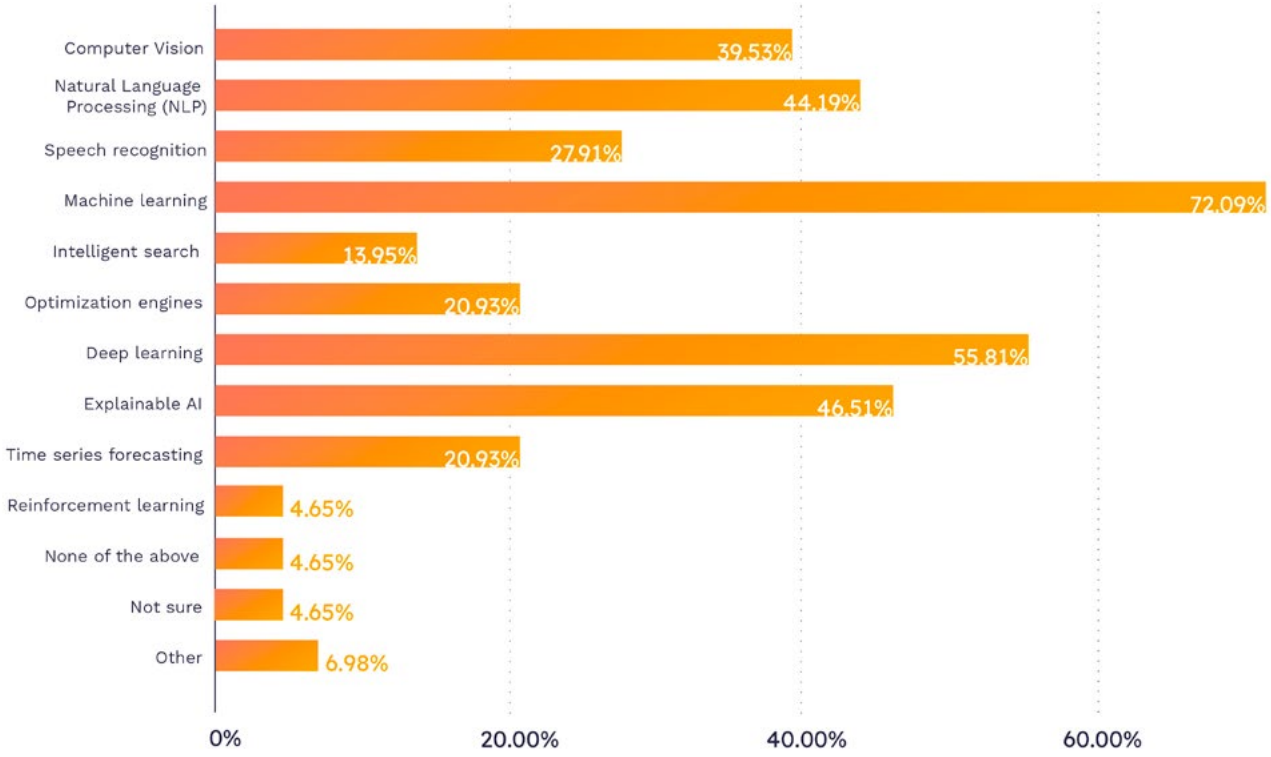
Source: Nordic State of AI Survey 2022.

According to our survey (Figure 67), the three most used AI technologies in Finland are Machine learning, Deep learning, and Explainable AI. Respondents could choose multiple options. Comparing these results to the Nordics overall, the top three are the same but Finland had the highest percentage of companies using Deep learning.

"Older companies are being forced to adapt to new business models in a rapidly changing competitive environment. For example, global technology giants have scaled their expertise and AI capabilities to new industries such as healthcare and consumer retail."

– Inka Mero, Founder & Managing Partner, Voima Ventures

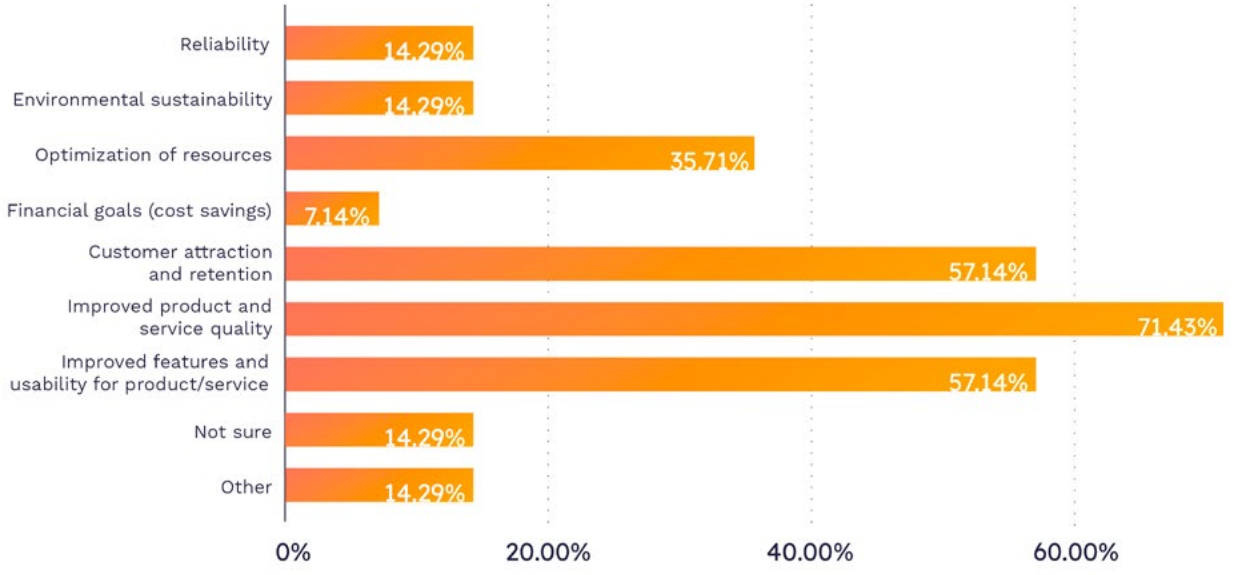
Figure 67. AI technologies used in Finland



Source: Nordic State of AI Survey 2022.

AI in Finland creates value where it is being used; as part of core products (Figure 68, Nordic State of AI Survey 2022).

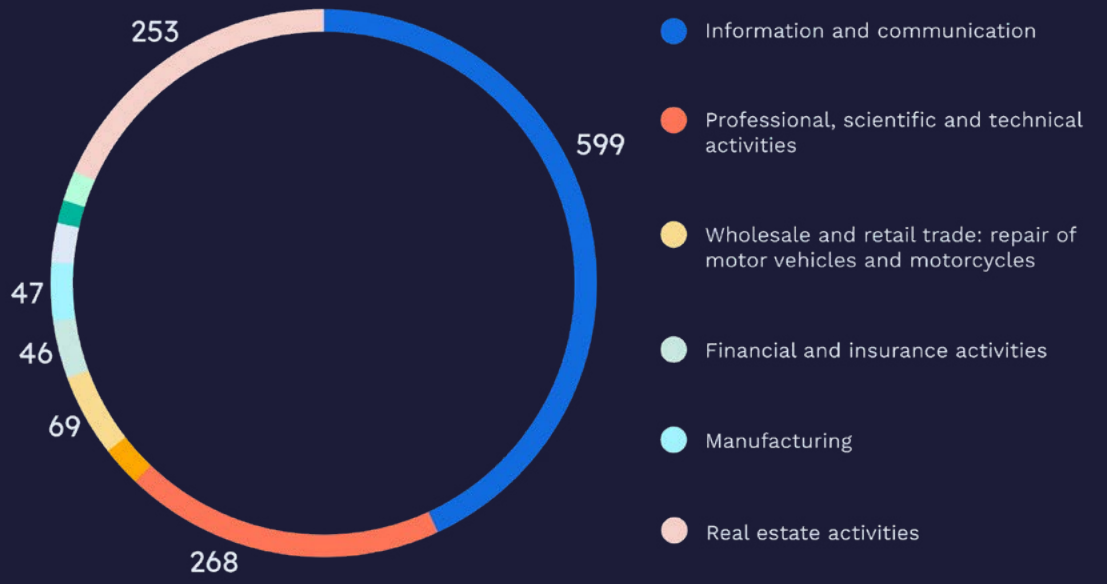
Figure 68. Value brought by AI



Source: Nordic State of AI Survey 2022.

Currently, 1,500 companies in Finland can be found in the Vainu company database when searching for the Vainu Custom Industry tags Artificial Intelligence, Machine learning, Speech recognition, Natural language processing, and Computer vision (Vainu 2022). The top three industries in Finland are Information and Communication, Professional, scientific and technical activities, and Real Estate Activities (Figure 69, Vainu 2022).

Figure 69. Top 10 industries for AI-related companies in Finland



Source: Vainu 2022.

"In an industrial context, AI technologies are currently used for a narrower scope: typically to optimize certain processes or to analyze data in a business-critical context. The business models at larger enterprises are not yet driven by AI technologies."

– Inka Mero, Founder & Managing Partner, Voima Ventures

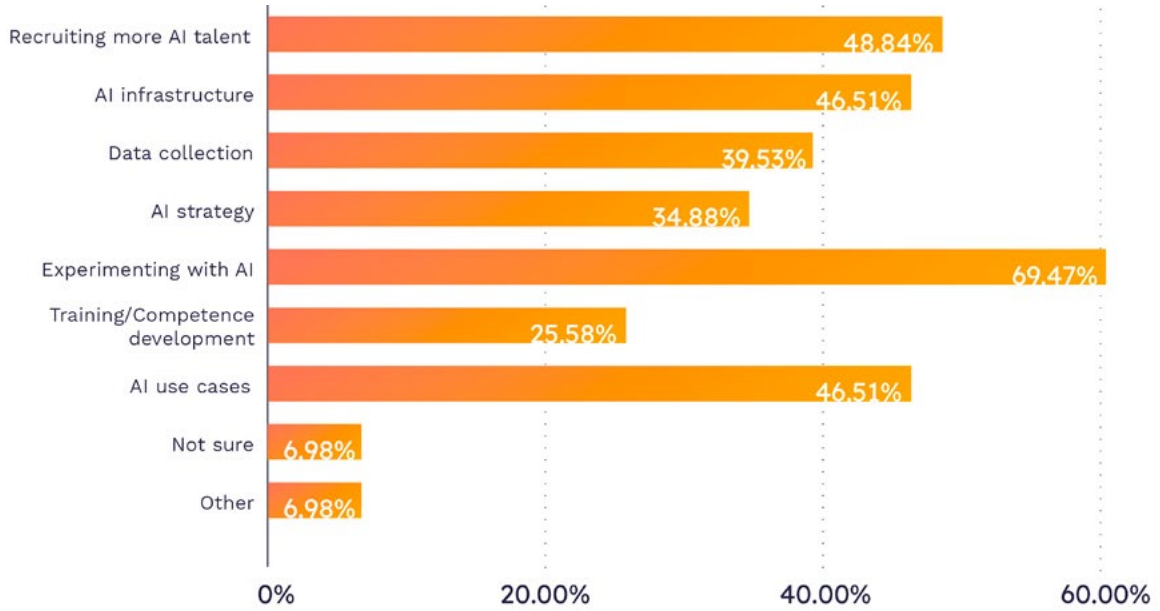
BUSINESS

12% of Finnish small companies currently use AI, whereas the adoption level of AI technologies is at 27% for medium-sized companies, and 51% for large corporations (Eurostat 2022).

Similarly to Denmark, Finland's economy is driven by value added by micro, small and medium-sized enterprises (MSMEs), with 40% of the total economic value coming from large companies (OECD 2022; Business Finland 2022). As such, Finland should direct more attention to helping MSMEs adopt AI. So far, the country has fostered a good startup ecosystem for the capital area (Business Finland 2022).

According to our survey, 92% of Finnish companies view AI as Highly important or Important to their organization – most of the respondents work in Information Technology & Services. Roughly 75% of Finnish companies said they intended to increase the number of AI solutions within the next 12 months. More than a third were already doing so in less than 3 months, indicating that the adoption of AI should be moving forward soon. 60% of companies are still focused on investing in Experimenting with AI (Figure 70, Nordic State of AI Survey 2022).

Figure 70. Investment areas within AI in the next six months in Finland



Source: Nordic State of AI Survey 2022.

Business Finland's Growth Engine program awarded to Silo AI has been a key investment in the Finnish AI ecosystem. Until the end of 2021, a program accelerating businesses with AI was Business Finland's AI Business Program. Companies and research entities could apply for funding that was directly involved in the R&D departments or joint ventures between organizations (Business Finland 2022; Nordic Innovation 2022).

As a small country, similarly to the other Nordics, Finland needs cross-sector collaboration to make the most of the scarce resources. This approach paves the way for the specialization of AI. Large Finnish companies have a chance to be the trendsetters in AI adoption and could set an example for the rest to follow. The SMEs that are the next in line to adopt AI are simultaneously being taught to be more tech-savvy.

The second major challenge Finnish companies face is data management: how can they collect, maintain, and store data in ways that can be leveraged by AI? Finnish companies are struggling more with data than with AI (Nordic Innovation 2022).

"As in other Nordics, in Finland too, we are moving into a more mature phase in AI deployment.

AI is not considered as a standalone solution anymore, but as an inseparable part of products and services.

Many AI startups from only a few years back have disappeared, not because of decreasing AI investments, but rather because of a focus shift in how AI is utilized."

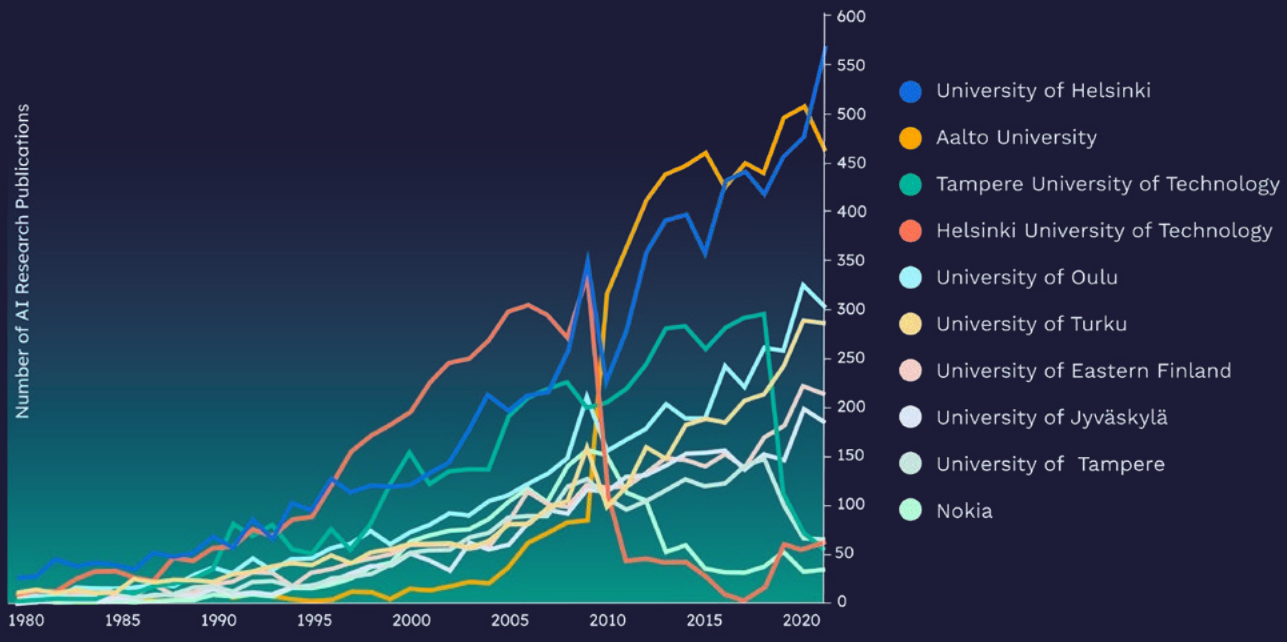
– Peter Sarlin, CEO of Silo AI, Professor at Aalto University

RESEARCH

Finnish Center for Artificial intelligence (FCAI) is the flagship iteration of the Academy of Finland's seven-year program with funding of €250 million through 2026 (Business Finland 2022). Finland is the 5th cited country in the EU (OECD.AI 2022; Nordic Innovation 2022). Finnish research publications have increased from a long-term perspective but between 2015 and 2019, the increase was less than 200 individual studies per year (OECD.AI 2022).

Two universities in the Helsinki capital area, the University of Helsinki and Aalto University, both of which are involved in FCAI, are both active in publishing their AI research (Figure 71). The University of Oulu and Turku, both internationally recognized in their specific fields of AI, publish about 200 papers less (OECD.AI 2022; FCAI 2022).

Figure 71. AI research by institution



Source: OECD.AI 2022.

According to the Finnish Center for AI (FCAI), there has been good progress with Deep Neural Networks performance optimization. The increasing costs of computing can be tackled by applying more advanced technology, hence the popularity of Deep learning (FCAI 2021; Nordic State of AI Survey 2022). Trustworthy AI is another successful initiative that seeks to link ethics and values with AI. Additionally, human-machine interaction-related solutions and seeing their usefulness in real-life situations have been beneficial for the Finnish AI scene (FCAI 2021).

EDUCATION

In Edurank's list of the Best Universities for AI in Europe, the University of Oulu was ranked 24th in Europe and 124th globally, making it the highest-ranking Nordic university. The University of Helsinki was the second Finnish university to enter the listings at 61st place (Edurank 2022).

Finland was 13th in the Coursera Global Skills Report rankings, dropping one position from 2021. Finland scored well in Technology Sector and Data Science but received the lowest score in Nordics for Business Sector (Coursera 2022).

Finnish Center for Artificial Intelligence aims to train new AI specialists and reskill the existing tech workforce. AI should be offered on all levels of education: bachelor's, master's, and doctoral. Furthermore, the general public should be familiar with the basic principles of AI - this agenda concentrates on the quick and low threshold of entry courses (FCAI 2022). In addition, First AI Accelerator (FAIA) by Silo AI has been building grassroots AI capabilities through accelerator programs and market research (FAIA 2022).

The internationally acclaimed 'Elements of AI' course is free to attend and already one percent of the entire Finnish population has taken the course. The purpose of this course was to enable the Finnish EU presidency's goal of lifelong learning and AI skills (Oxford Insights 2021; Elements of AI 2022).

This investment in education has given Finland a competitive edge over other Nordic countries. Finland is offering 250 AI-related courses in its major universities. In addition to these, 40 master's and 19 bachelor's level programs are being offered. Also, three doctoral programs dedicated to AI are available (Business Finland 2022).

LEGISLATION

The main arbiter of AI-related legal matters in Finland is the EU. At the moment, there are only a few laws that mention artificial intelligence or machine learning. Much of the legislation is focused on data (Finlex 2022). For Finland EU Commission guidelines and EU-level legislation will be the overarching level of legislation.

The Ministry of Economic Affairs and Employment and the Prime Minister's Office has been facilitating a public discussion over the ethical issues the emergence of artificial intelligence will raise in the Finnish community. The discussion should happen either at live events or in online forums. These are listed as part of the national AI strategy of Finland (Ministry of Economic Affairs and Employment 2017).

"AI has a key role in improving productivity, boosting the economy and complementing humans, which partially offsets shortages in human talent. It also has the potential to address challenges from the energy crisis to climate change and sustainable development. The key to unlocking this potential is developing and studying AI systems and solutions that assist, rather than by-pass, humans."

– Samuel Kaski, Professor at Aalto University and the University of Manchester and Director of the Finnish Center for Artificial Intelligence FCAI

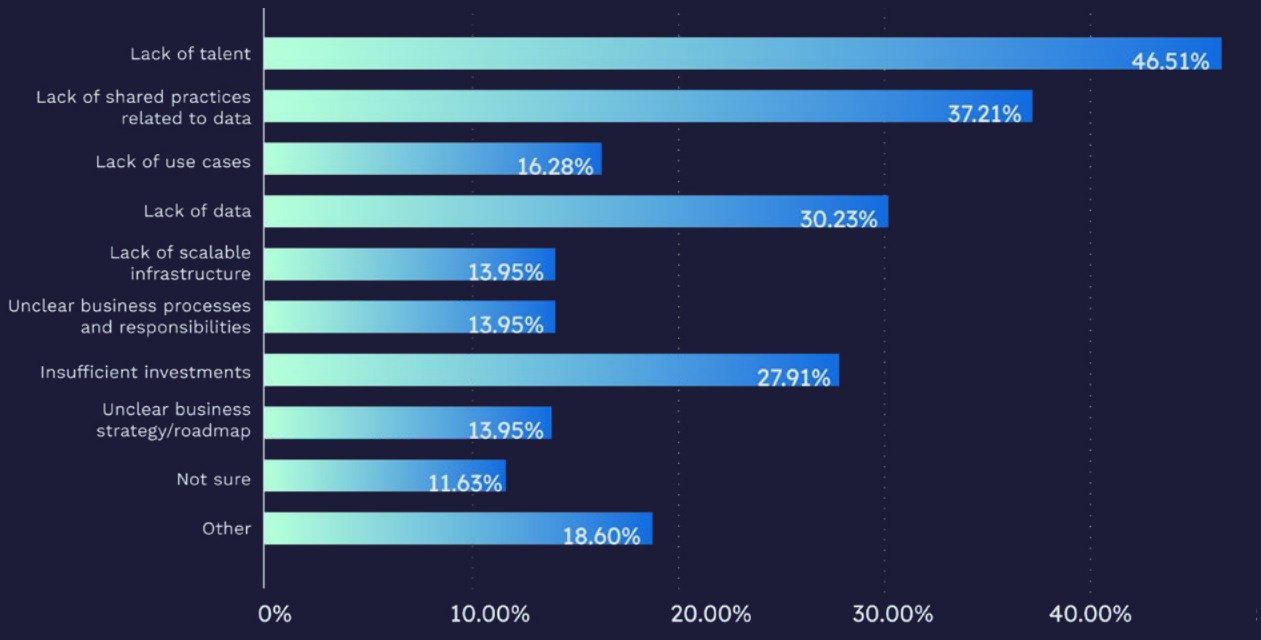
TALENT

Finland has the second-highest percentage of ICT specialists as part of its workforce (7.4%) in the Nordics, with Sweden in the lead (Eurostat 2022). In addition, Finland was listed as the most attractive immigration destination for AI talent among the Nordics (OECD.AI 2022).

Finland has the highest percentage score in Europe when it comes to Data Science skills (Coursera 2022). Like Sweden, Finland has the opportunity to capitalize on this talent pool and retrain existing workforce with AI-related skills. When building a future-proof AI talent pool, we need to consider the educational background, diversity, and gender of hires to build non-biased AI that does not discriminate and understands that people are inherently different. Versatility is necessary for the process of education too. Diversity should not be confined to technical jobs focused on algorithms and data, as people skills are also important (Women in AI Finland 2022).

Similar to the general trend in the other Nordics, the majority of Finnish companies intend to hire AI talent within the next six months (Figure 84). Lack of talent is the top obstacle for Finnish organizations in their effort to scale AI, with Lack of shared practices related to data coming next. One reason may be that large datasets are being managed with different standards (Nordic State of AI Survey 2022).

Figure 72. Biggest challenges in scaling the use of AI across your organization



Source: Nordic State of AI Survey 2022.

Insights from Finland

Samuel Kaski

Professor of Computer Science, Aalto University; Professor of AI, University of Manchester. Director, Finnish Center for Artificial Intelligence FCAI

AI can play an important role in improving productivity, which would be a major boon to our markets as we face a shortage of human talent. Finland is known for innovation and pioneering research and development, but underlying inefficiencies are inhibiting a bullish Finnish economy. Artificial intelligence can tackle many issues at once: the increased use of AI in the service of productivity has a knock-on effect in the fight against climate change, as more efficient manufacturing produces less waste and consumes less energy, for example.

However, AI risks falling short of meeting this promise. Far too often, modern AI applications overlook the human element in automated decision-making. These AI systems do not quite understand human goals, which may be fuzzy or hard to articulate. Users also have trouble understanding AI and find it frustrating to interact with. Ideally, a new kind of AI will offer multiple decision options or paths, leaving the human decision-maker room to make the final judgment call. Artificial intelligence research produces systems and solutions that are not independent of, but ancillary to, humans. AI products that assist rather than direct can become truly useful and successful while also addressing human safety and well-being.

AI can assist in societal decision-making, too. The outcomes of political processes may appear dense and unclear to the average person and even to the lawmakers who create them. Artificial intelligence assistants can anticipate, suggest and steer people in the decision-making process, clarifying goals. Because people sometimes behave in ways that appear irrational from a machine perspective, we have to incorporate human cognitive science and user modeling into the development of AI systems.

In Finland, groundbreaking basic research that puts humans in the loop with machine learning is already happening. We have a strong tradition in probabilistic modeling that serves this purpose. Functional academic-industrial partnerships are part of the reason Finland maintains such a high level of AI research despite its small size. We can become even more competitive if businesses are willing to take risks and consider longer-term objectives. Top talent doesn't come to Finland to work on routine tasks or marginally improve existing products–they want challenges and to create breakthroughs. On the university side, this calls for more resources to accommodate and train these talents and also time and space for industrial collaboration. We anticipate that a prospective ELLIS Institute in Finland will crucially expand the cooperation between research and industry.

Insights from Finland

Inka Mero
Founder & Managing Partner, Voima Ventures

My fund Voima Ventures helps founders accelerate the growth of deep technology ventures to global markets. As technology and data-driven startups, many of our portfolio members use AI as a part of their core business. A great example of a company fundamentally based on data and AI is a company called Kuva Space, which leverages hyperspectral satellite cameras combined with AI technologies for imaging Earth's surface. The applications play a critical role for instance in monitoring carbon emissions and measurement of carbon sequestration.

In an industrial context, AI technologies are currently used for a narrower scope: typically to optimize certain processes or to analyze data in a business-critical context. The business models at larger enterprises are not yet driven by AI technologies – only a few industrial players have begun building their own ecosystems and business models around AI. There's a large gap between data-driven startups and traditional enterprises in terms of data processing and leveraging AI. We don't see the use of data and AI across the entire value chain of larger companies yet.

In the future, AI will enable new business models – this will require a leadership-level commitment to long-term strategic work from industrial companies as well as new kinds of partnership models. To exemplify, our portfolio company Betolar is providing sustainable construction materials with the help of data and AI. Large companies in material business benefit from a collaboration with such a partner focusing solely on turning industrial side streams into value.

Currently, there's a strong pull from the consumer's side for more sustainable products and services as well as data transparency. Older companies are being forced to adapt to new business models in a rapidly changing competitive environment. For example, global technology giants have scaled their expertise and AI capabilities to new industries such as healthcare and consumer retail.

The ongoing crisis around energy and climate change are great facilitators of change. The global economic situation – especially the war in Ukraine – has a direct impact on the number of investments we see in Finland. Despite the changing environment, I would call for more investments: now it's the perfect time to re-evaluate how your business can leverage AI technologies to tackle emerging challenges.

I would also call for more collaboration between startups and enterprises – this model of combining specific expertise, quick iteration cycles and focus from startups to the existing business at large enterprises has proven to work for instance in the US.

Conclusions

This report has shown that artificial intelligence has become an essential tool for businesses in the Nordics. Most of the companies that use AI, use it at the heart of their business, as part of their products and services.

While the region remains at the top of AI adoption globally, it is evident that big corporations are dominating the industry as the AI knowledge gap has been widening. Small and medium-sized companies are behind in AI adoption and risk missing an opportunity. AI is moving from a period of startup hype into a phase of enterprise implementations, although a big part of AI investments are still geared towards experimenting with AI.

The public and private sectors have increased investments to AI significantly during its resurgence. The Nordics continue to rank well in the global AI scene but their lead has become jeopardized by larger economies slower to accelerate with AI. In the Nordics, the lack of talent and data continue to pose a significant challenge for scaling the use of AI, despite the Nordics being an attractive destination for AI expats.

Research institutions in the Nordics are publishing research at an unforeseen pace. Many Nordic universities are recognized as top AI universities in Europe.

Artificial intelligence is merely at its new dawn and it requires more investment money and engagement from governments - they need to ensure businesses are attractive to foreign and domestic investors. All Nordic VC investments in AI are estimated to decrease in 2022, with the exception of Sweden. In addition, the number of AI startups has been decreasing.

Despite facing challenges with AI, the Nordic countries have the right elements of what it takes to leverage AI at large. More collaboration, sharing of best practices and concrete use cases of AI are key in unlocking this potential. Realizing holistic use of AI across Nordic businesses and societies requires moving beyond experimenting and investing into business transformation driven by AI.

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3 - Appendices

METHODOLOGY

Literature review

This report is a result of the combined efforts of numerous collaborations between Nordic institutions, organizations, and experts. We at FAIA relied on a mixed methods approach to complete this Nordic-level research by gathering information from the latest, most reputable articles and research publications. These papers were selected carefully, and laid the core foundation of many of the key research themes and aspects.

Qualitative data

Thanks to our data collaboration with Vainu, we were able to identify 17,144 Nordic organizations that mention an artificial intelligence keyword on their website. Based on the Vainu Custom Industry search, we identified 5,207 companies that likely use AI and work within these categories: artificial intelligence, machine learning, speech recognition, natural language processing, and computer vision. The Vainu Custom Industry companies are most likely product developers, software developers, or AI consultants who deliver these products and services to end users of AI. We manually verified about 1,000 of these companies. OECD data suggests that true numbers are likely considerably higher, but perhaps difficult to assess, as the data we collected is based on publicly available information and AI is often embedded in many common applications (OECD 2021).

Quantitative data

We followed the structure of last year's report, but this year extended the scope of our survey. In total, we approached more than 4,000 Nordic organizations and received 123 replies, of which we had to remove four duplicates or invalid responses. Each Nordic country (Iceland excluded) received hundreds of survey requests. We received a considerable amount of CXO-level replies and could verify each respondent.

Interview methodology

This year we conducted eight expert interviews with Nordic thought leaders and AI experts with various backgrounds. Each session was approximately a half-hour-long, semi-structured interview. We asked interviewees to reflect on their experiences with Nordic and local AI ecosystems, providing insights into key trends and developments in the space. Each interviewee was carefully selected to provide the best overview possible of what is happening in the Nordics.

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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 Brand Pauliina Alanen at pauliina@silo.ai.

Silo AI

Silo AI is one of Europe's largest private AI labs – a trusted AI partner that brings competitive advantage to product R&D. We build AI-driven solutions and products to enable smart devices, autonomous vehicles, industry 4.0, and smart cities. Silo AI provides its customers a unique access to world-class AI expertise, as well as the Silo OS infrastructure to speed up AI development and deployment. Established in 2017, Silo AI is on a mission to build a European flagship AI company, with offices currently in Finland, Sweden, Denmark and Switzerland.