The State of Artificial Intelligence in the Nordic Countries

Produced by Oxford Research

Key conclusions

Artificial intelligence in the Nordic countries

- The Nordic countries all have good prerequisites for artificial intelligence (AI) development, with strong interest from governments, established research centers and a digitally mature population with high trust in the public sector.
- Whilst the Nordic countries are still lagging behind major actors on AI, like the United States and China, all Nordic countries are expected to see much development in AI in coming years. Finland in particular has become a rising star, ranking #11 in the Global AI Index complied by Tortoise, but the other Nordic countries are not far behind.
- There are some sectoral differences in AI research and implementation between countries, mirroring broader trends. For example, Sweden is traditionally strong in manufacturing and process industry and these are also sectors where it has come relatively far in AI development. Denmark is instead very advanced in life science, which has translated into strong AI development in this sector.

Artificial intelligence in the Nordic countries

- Some sectors are taking the lead on AI development. The Nordic countries, led by Finland and Sweden, are already strong in the FinTech and telecommunications sectors. Artificial intelligence, together with IoT and 5G-roll out, is promoted by several larger companies.
- Other sectors are now seeing emerging use of AI technologies and are likely to see much development in the next couple of years. This includes healthcare & life science as well as government and public administration. Making the public sector more efficient and accessible is a key motivation for all Nordic countries. Much research is ongoing on the use of AI in these sectors and large-scale implementation will likely follow relatively soon.
- Transport & logistics, energy & utilities, and wholesale & retail are sectors that are only beginning to see the benefits of AI. There are some interesting case studies that show that AI development is starting to materialize, but much potential is currently unused. However, this is also likely to change in the next ten years, especially if Nordic companies wish to follow examples from elsewhere.
- The first two sectors are also seen as a crucial part of many Nordic climate strategies and there is currently much excitement around the potential of AI to reduce emissions of carbon dioxide and make energy use more efficient.

Artificial intelligence in the Nordic countries

- A key barrier to more wide-spread implementation of AI solutions across all sectors and all Nordic countries is a lack of knowledge amongst executives, with a significant need for competency development on the benefits and use of AI.
- Access to data can be tricky for some sectors, but the Nordic countries have a comparative advantage compared to many other countries in a strong public sector with much data already collected. There are also various national initiatives to promote access to open data for AI applications.
- The recent proposal of new AI legislation from the European Commission has reduced uncertainty caused by a lack of regulations. This allows companies to invest in and launch AI solutions in the European Union with more clarity around the future course for AI legislations.
- The ethical use of AI, together with data privacy and integrity, will continue to be areas of importance to all Nordic countries.

The case of Iceland

The case of Iceland

- Iceland is a special case amongst the Nordic countries because of its smaller population. That means that the number of companies using artificial intelligence is more limited.
- Some examples of companies already using AI in Iceland include CCP Games and ÖSSUR, a world-leading prosthetics company that offers an artificially intelligent prosthesis. However, estimates suggest that no more than 10 Icelandic companies are truly using AI to its full potential, often focusing on gaming and natural language processing (NLP).
- The next couple of years will likely see much action on AI from the Icelandic government, with an official strategy based on this AI policy coming out relatively soon.
- Due to the relatively small size of the country's population and lack of AI specific expertise in many sectors, Icelandic companies often lack staff with the right competency and awareness.
- Additionally, Iceland was identified as the safest place in the world to host a data center in 2016 in the Data Center Risk Index report because of readily available sustainable energy, a naturally cool climate and political stability.

Key sectors

Healthcare and life sciences

Healthcare and life sciences

- Healthcare and life science is a well-established sector in the Nordics, where the interest in artificial intelligence is growing. Digitalisation could revolutionise healthcare by making it more accessible, reducing costs and improving quality.
- The Nordic countries all list healthcare as an important sector for AI development in their national AI strategies. Sweden and Denmark are particularly strong in life science, whilst Finland instead has focused more on operative IT in hospitals. But all countries see large benefits with the technology.
- Research and development on AI in the healthcare and life science sector has been active for decades and there is currently much happening in this field. It is also becoming more mainstream, but implementation of AI technologies in hospitals and care is still in early stages.
- Pressure to reduce the cost of healthcare in Nordic countries, as well as more available healthcare data and advanced hardware and software, means that AI initiatives are increasingly of interest to healthcare providers.

Healthcare and life sciences

- AI in healthcare and life science range from more basic automation of back-end processes (for examples, AI routing referrals from primary care or NLP technologies) to AI-driven admin logical processes to more complex medical applications.
- For AI-driven admin logical processes, such as assistance with doctor's notes and patient records, AI solutions are already readily available at the market. For the latter applications, existing market solutions are often not good enough or not appropriate for the data available. Here R&D projects between hospitals, industry and AI developers are crucial to develop custom solutions together with clinical researchers.
- Already, many of these technologies are being tested and researched, particularly in situations where a lot of data exists – such as image recognition technologies. Other domains will take longer, since there is currently a lack of widely representative and accurate data.
- The biggest delay comes from strict regulations around clinical validation and trials, which means that AI products must be extensively tested before they can be implemented on a larger scale.

Case study: Life sciences in Denmark

Case study: Life sciences in Denmark

- Through neural networks, predictive modelling, machine learning and reasoning, AI technologies can develop new drugs much quicker than normal, possibly finding new cures for diseases and recommend individualised treatment plans for patients.
- The life science and pharmaceutical industry is particularly well-developed in Denmark with bigger companies like Novo Nordisk. Novo Nordisk Foundation recently awarded DKK 138 million (CAD $27 million) to 12 projects under its new data science and artificial intelligence initiative.
- R&D using AI in life sciences is growing in importance in Denmark. Additionally, in the Danish National Strategy for Artificial Intelligence, healthcare was one of the sectors selected for the launch of a signature project funded by the government. This signature project will be followed up and new signature projects will be launched in the strategy period for 2019-2022.
- The potential benefits to health, recognised by the Danish government, as well as extensive datasets, makes this sector a good testing ground for launching AI initiatives. It is also a sector that is seeing and will continue to see strong interest and development in the next couple of years.

Government and public administration

Government and public administration

- The public administration in the Nordic countries is already highly digitalised with services such as NemID in Denmark, BankID in Sweden, and the platform Altinn in Norway. There is also much interest in AI from governments and municipalities, Norway and Denmark in particular.
- The public sector is prioritised in all national AI strategies where AI usage is seen as a way to make governments more transparent, efficient and accountable. One report by the Swedish Agency for Digital Government suggests that increased use of artificial intelligence could lead to savings of around 140 billion SEK ($20 billion CAD) in public administration by automating routine tasks.
- A recent report by the Nordic Council of Ministers suggests that actual uptake of AI solutions has not yet reached its full potential and remains in experimental stages in all Nordic countries.
- But despite slow roll-out, the report also found that AI usage is likely to accelerate soon. There are examples of many government Ministries implementing AI initiatives on a smaller-scale, such as the Danish Ministry of Taxation.
- Key AI technologies for government and public administration are related to automation of routine tasks and better communication with citizens through conversational AI and augmented citizen experiences. Predictive and prescriptive analytics can help government workers make better decisions.

Government and public administration

- Trust is a crucial issue for the use of AI in the public sector. The need for transparency is particularly important for decision-making and case processing technologies.
- Because the sector is already highly digitised, a lot of data exists. However, the use of AI requires citizens' trust to disclose and share this data. GDPR and protection of data privacy are issues that will become important in this context. Cyber security is another area of concern: municipalities must be able to show that disclosed data can be kept safe.
- However, open data initiatives in the public sector are becoming more common – for example, the Swedish government has proposed in its 2021 budget to develop a strategic direction for open data so that municipalities and regions can better make use of AI technologies going forward
- Challenges for municipalities are primarily organisational and technical, ranging from using quality data to train AI to a lack of AI competency, limited financial resources, and organizational inertia.

Financial services

Financial services

- FinTech is an area where the Nordic countries are pioneers. Often, financial businesses are already leaders in AI development and use. Yet there is still room for expansion. The Nordic FinTech Manifesto from 2019 estimated that the deployment of AI technologies in the sector would grow by 23%.
- Apart from national FinTech initiatives and strong established AI usage, there is also much support for AI within the financial sector from the public, which is seen as an area where AI can perform tasks more efficiently than humans.
- Key AI usage for the FinTech sector include automated customer support and chatbots, more accurate risk-related decision-making, mortgage and loans processing as well as fraud detection.
- Established players are collaborating with AI providers to improve their services. For example, the Swedish bank Swedbank is using AI to shorten its waiting times for customer support and mortgage processing.
- FinTech companies already have much of the data that is required for successfully launching AI in its operations. They have a higher tech know-how than most sectors, which means that they are more open to experimenting with new technologies.

Telecommunications

Telecommunications

- Finland and Sweden have a long history of global leadership in the telecommunications (telecoms) sector. The potential of AI in this sector is expected to be very high. AI has also been supercharged during the covid-19 pandemic, when online meetings and virtual communication has been crucial.
- It can be used for personalised trends and forecasting network supply; smart manufacturing, IoT and 5G roll-out; network operations and customer service; and business operations.
- Telecoms is also another sector where AI has already been implemented in various areas. Key players in the telecoms sector are globally established companies Nokia from Finland and Ericsson from Sweden.
- AI is used both in customer-facing interactions and in internal operations. Customer complaints are commonly handled through an AI and chatbots. The most common internal use of AI is controlling and managing networks to ensure consistent quality. Future applications are expected to include more personalised and individualised offers to customers, but this has not yet been wholly implemented.

Manufacturing

Manufacturing

- Manufacturing is a prominent sector in several Nordic countries with much potential to benefit from AI. Current trends in manufacturing talk about ‘industry 4.0’ or the ‘fourth industrial revolution’ where manufacturing is supported by real-time decision-making and automated processes.
- Both Finland and Sweden benefit from strong ICT and telecoms research and development, including 5G and IoT technologies, that enables the collection of data in manufacturing and more sophisticated AI technologies.
- However, whilst many industrial companies are highly interested in AI solutions, fewer companies have gone beyond pilot projects or R&D to implement AI solutions in their operations.
- A report on Swedish IndTech (industrial technologies) suggests that companies are about to move from small-scale pilots to a search for best practices in implementation that will lead to large-scale uptake of new technologies in a few years’ time.
- Predictive quality and yield, predictive maintenance and human-robot collaboration have seen much research in recent years and are starting to move onto the factory floor. These technologies are powered by machine learning – supervised, unsupervised and reinforced learning – as well as imagining diagnostics.

Manufacturing

- Many initiatives and research centres have been started in the Nordic countries, especially in Finland and Sweden. In Sweden, the well-established WASP (Wallenberg AI, Autonomous Systems and Software Program) project is a major national initiative for strategically motivated basic research, education and faculty recruitment.
- Industrial companies often lack the in-house AI skills needed to implement artificial intelligence, particularly since AI solutions often need to be customised for specific manufacturers.
- A global report from Forbes analytics identified central challenges as trust in AI-based outputs; lack of AI expertise; as well as organisational culture and resistance from employees because of concerns for job security. These challenges are very much relevant for the Nordic manufacturing sector.
- Additionally, some parts of manufacturing suffer from legacy systems that prevent them from quickly upgrading or switching out their systems when new technologies are developed. Lack of system interoperability also hinders progress.

Process industry

Process industry

- The AI technologies of interest in the process industry are very similar to those used in the broader manufacturing sector. Optimisation and predictive maintenance are key, using unsupervised, supervised and reinforcement learning.
- Much like in manufacturing, companies are interested in AI applications but are currently lagging behind globally in terms of actual implementation.
- The use of AI in the Nordic process industry is still project- and pilot-based rather than sector-wide. But the process industry has certainly started to realise the great potential that AI solutions can have for productivity and safety in the sector. Many bigger established actors, particularly in Sweden, have committed funds to pilot projects and R&D programmes. Actors are also attempting to scale up and run larger experiments.
- Some Nordic governments are also prioritising investments in this sector, especially Sweden since the process industry accounts for nearly 50 percent of Swedish net exports. The Swedish government is investing heavily in AI in the process industry through a nationally funded strategic innovation programme (PiiA).
- Key players are often established industrial companies like LKAB, SSAB and ABB. Boliden is a leader in the use of 5G and other applications.

Process industry

- Funding for AI development in the process industry exists both on a European and a national level. Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) has funded many European initiatives to develop AI in process industries with a particular focus on sustainability. For Horizon Europe, SPIRE will continue to finance partnerships in this area.
- Despite significant funding, the process industry still has to overcome some challenges to AI implementation and this process will likely be relatively slow. Because the process industry often deals with hazardous chemicals and processes, legislation and regulations are particularly strict to ensure safety. Concerns exist around data privacy and the sharing of data between companies, both in terms of access and in terms of protecting company secrets.
- AI skills and knowledge must also be developed at the executive level and at the operative level.
- Legacy systems and a slow pace in replacing equipment means that AI solutions have to work with already existing infrastructure. Only in some cases in the batteries and steel industries are new factories being built for this purpose.

Case study: Forestry, pulp and paper in Sweden and Finland

Case study: Forestry, pulp and paper in Sweden and Finland

- Forestry, pulp and paper is an important sub-section of the process industry in both Sweden and Finland. This sector has potential AI applications.
- In forestry, AI can be used to monitor forest inventories and enhance forest data accuracy. In paper and pulp, AI usage mirrors the process industry more broadly and can be used for optimisation as well as predictive yield and maintenance.
- AI pilot projects and testing started less than five years ago but has now garnered some speed. For example, Silo.ai is leveraging machine learning to improve production together with pulp and paper company Kemira.
- Forestry, pulp and paper companies often fund project-based initiatives to become more digital and improve the use of data in the sector. For example, the paper and pulp company SCA is collaborating with Mid Sweden University to implement predictive maintenance in its factories and hopefully reduce accidents and production collapses.
- However, this sector has just started its AI journey and will likely continue to fund R&D initiative in the years to come.

Transport and logistics

Transport and logistics

- AI can assist transport and logistics companies with planning of routes, autonomous transports and more efficient realtime logistics planning. It has major implications for efficiency and cost-saving in the sector. Additionally, leveraging AI in transportation helps the sector increase passenger safety, reduce traffic congestion and accidents, lessen carbon emissions, and also minimize the overall financial expenses. The potential benefit for climate action is particularly important in the Nordic countries.
- The most useful AI technology is machine learning with reinforcement learning for route optimization.
- There are many successful use cases in the Nordic countries. However, AI in transport and logistics is still maturing and the move to a more sector-wide engagement has not yet occurred. Logistics, and particularly transport over land, is lagging behind other sectors in AI use despite much potential.
- Nordic countries are particularly interested in using AI for public transport and for maritime shipping, two prominent sectors in the Nordics. Logistics is another key area, mostly dominated by larger logistics actors like DHL and smaller start-ups.
- The transport and logistics sector often sits on unused data that can be channelled for AI use. Because of the potential for massive savings and other benefits, the transport & logistics branch will certainly increase its use of AI in the future. Among specific industries in the wider industrial sector, transport and logistics offers the highest potential.

Case study: The automotive industry in Sweden

Case study: The automotive industry in Sweden

- The automotive industry has already benefited from much AI development, perhaps the most out of any sector. This sector is mostly relevant for Sweden, where big automotive companies such as Volvo have come far in developing CAV (connected and automated vehicles) technologies together with Zenseact.
- Key AI technologies used in CAV are computer vision software, sensor fusion software, vehicle motion control and localisation. The market is dominated by Volvo its collaborators. Zenseact develops advanced Driver Assistance Systems (ADAS) and next generation Autonomous Drive (AD) features for consumer vehicles.
- There are ethical and legal concerns with AI in the automotive sector, particularly concerning who is responsible for accidents in the case of self-driving cars. This has been a topic of much discussion and controversy. Building trust with the public will be crucial before these vehicles are launched successfully. Many commentators think these vehicles will not be implemented in the nearest future.

Energy and utilities

Energy and utilities

- The AI use in the energy and utilities sector is still in its early stages. Nevertheless, energy and utilities providers are starting to show interest in using AI. Municipalities and other actors are interested both in reducing their carbon emissions, often required by national regulations, and in cutting costs by improving efficiency.
- Denmark is the Nordic country that has come the furthest in this sector. Almost half of its electricity comes from renewable sources, particularly wind. This type of renewable energy fluctuates more than other types more common in other Nordic countries, such as hydropower and nuclear. The need for optimization is thus clearer and explains why AI has taken more of a hold in Denmark. In fact, the energy and utilities sector is listed as a priority area in the Danish AI strategy.
- At the moment, AI is being used to analyse data and identify potential savings. For example, AI can recommend upgrades and maintenance to energy and utilities systems where it would be most beneficial.
- In the future, flexible consumption or demand response will emerge as a crucial use of AI. This would allow AI, using automated algorithms and reinforced learning, to manage the electricity supply so that it matches better with electricity demand in a fluctuating system. This technique has been researched and is viable but has not yet been launched in operations. This will likely happen in a few years' time.

Energy and utilities

- The current key players are the larger energy and utilities companies, such as Energinet, with some emerging start-ups such as Danish Ento, Swedish Rebase or Norwegian eSmart Systems. There are also emerging start-ups in the field of renewable energy provision, such as the Danish AI company Finetune.
- The needed data is often already collected through the roll-out of smart meters, IoT devices and smart buildings. However, it is not being used other than for regulatory purposes.
- Access to data on energy and utilities use is crucial and perhaps the biggest challenge facing companies. In Denmark, the transmission system operator Energinet has created a national system with data on electricity consumption that can be easily accessed by AI providers and AI users. Similar systems are in development but not yet implemented in Sweden and Norway.

Case study: Oil and gas in Norway

Case study: Oil and gas in Norway

- The oil and gas sector is an important sector for AI development in Norway specifically. Many oil and gas companies in Norway are exploring AI opportunities. As a whole, the industry is facing challenges with pervasive cheap oil prices, new reserves and alternate fuel choices. These have put pressure on profit margins, driving the industry to explore AI options.
- For example, in 2018, Norwegian company Equinor launched the first-ever fully automated, unmanned, remotely operated oil platform, Oseberg H.
- Other than automation, top potential AI uses include optimizing subsurface data analysis, precision drilling with machine learning algorithms, and boosting productivity and safety with predictive maintenance.
- A lack of machine learning literacy and competency is one example of a barrier to its adoption. Leaders who lack knowledge and experience of machine learning will first need to be convinced of the compelling business case for its adoption, before committing to the investment needed to advance and scale the technology.
- Another issue to tackle is data siloes. This is particularly so in the oil and gas sector, where local storage of data and long, complex value chains mean individual businesses may lack a holistic view of the data they need to improve their operations.

Wholesale and retail

Wholesale and retail

- The wholesale and retail sector has big potential to benefit from AI. In fact, according to a McKinsey report on AI in the Nordics, the sector has the second-highest potential for businesses after transport & logistics, around USD 6-10 billion. AI can offer a more personalised and effective way of engaging with customers as well as a way to optimise internal processes.
- Nordic wholesale and retail companies are spending relatively little on digital technologies and also lags behind in AI applications. This is particularly true in physical customer-facing interactions. The sector is expected to start using AI to a larger extent in the next couple of years, catching up to international retailers like Zara who have already implemented AI technologies.
- A more recent global report from Capgemini estimates that the use of AI in retail has increased seventh fold between 2016 and 2018. Awareness and use appears to have grown also in the Nordic countries. Operations in warehouses have seen some implementation of AI for automation and cost-cutting measures. Large retailer COOP has opened its first unmanned groceries store in Sweden and start-up Livfs have been opening more than twenty unmanned groceries stores since its launch in 2018. The grocery chain side has also seen investments in apps and scan to pay applications.
- Covid-19 has forced many retail companies to move online. Almost all retail companies with a digital presence are now using AI to some extent in the digital client-meeting. Shopping advisors, chatbots and recommendations are perhaps the fastest growing use of AI in e-commerce. Future applications of AI are expected to also provide personalised offers for customers and predict relevant products based on various types of data from social media and elsewhere, but this technology is not as heavily used amongst Nordic retailers.

Wholesale and retail

- In parallel with the rapid development of artificial intelligence as an assistive tool in retail, it is worth noting that many consumers feel a sense of anxiety about AI's entry into more and more spheres of life. Three out of ten Nordic residents feel anxious about how AI may impact life moving forward. Not least, this means that e-retailers must work carefully with customer data and respect their customers' privacy.
- Key players in the retail sector include both traditional retail companies, such as Ica and H&M, but also so called 'digital natives' that were created with a strong digital tradition. These digital natives include food companies Foodora and mat.se as well as clothing companies NA-KD and Boozt. IKEA is also very interested in AI solutions.
- A report by EY on the future of retail in the Nordics suggest that 'retail is about to enter the most turbulent time in history' with significant digital developments in the next ten years. Most retailers and consumer product companies are aware of this, but very few have the experience and competence needed to harness this.

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