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AI in 4 Nordic countries



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Foreword

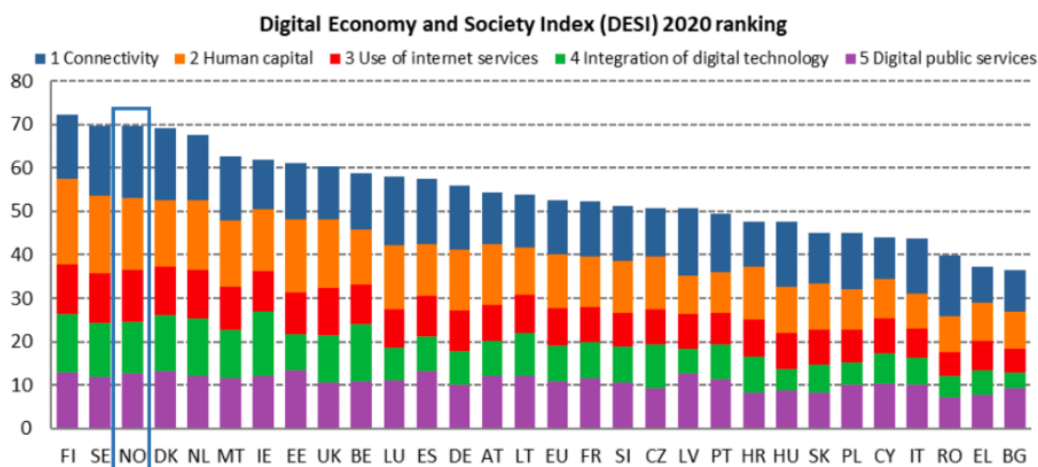
The current brief is a response to a call from Human-centered Artificial Intelligence research center at Stanford to Center for Digital Innovation for sustainable Growth (DIG) at NHH Norwegian School of Economics for a summary insight into AI in the Nordic countries. We reached out to our research partners involved with national innovation index in the Nordics.

According to Statista, there were 183 Artificial Intelligence (AI) startups in Sweden as of April 2020. The corresponding figures for other Nordic countries Finland and Denmark were 152 and 108 respectively. As of 2019, 57 percent of Swedes reported to be concerned about artificial intelligence (AI) misusing their data. The corresponding figures for Norwegians and Finns were 47 percent and 58 percent. Another main concern regarding handling personal data was interpreting the data wrong.

According to McKinsey Global Institute, AI can unlock USD 60-95 billion in value for Nordic businesses, equivalent to a 2 to 3 percentage point profit margin uplift. Importantly, this value potential only constitutes the direct impact from currently proven deep learning techniques and applications, hence future AI applications are not taken into account. Among specific industries, transport and logistics offers the highest potential (USD 11-14 billion), followed by retail (USD 6-10 billion). Source:

<https://www.mckinsey.com/~media/mckinsey/featured%20insights/artificial%20intelligence/how%20artificial%20intelligence%20will%20transform%20nordic%20businesses/how-artificial-intelligence-will-transform-nordic-businesses.pdf>

The Nordics (see figure below) are topping the 2020 DESI-ranking (Finland first followed by Sweden, Norway, and Denmark). From an AI perspective (for example edge computing, Voice AI, and Vision AI), the Nordic countries have an excellent starting point concerning adopting wearables, smart-homes, smart cities, and smart industry. The 5G download speeds (which is important for connectivity and latency when AI meets IoT) measured in Mbps for Norway, Denmark, Finland, and Sweden are 47.5, 33.5, 29.8, and 29.7 respectively. AIoT, (AI + IoT) = superpowers of innovation, is increasingly becoming more mainstream, as it continues to push the boundaries of data processing and intelligent learning for years to come.



The current report reflects four voices emphasizing different aspects in each country but with a common structure. We tie our country comments to three different units of analyses: Macro, Meso, and Micro.

Norway

By Professor Tor W Andreassen, NHH Norwegian School of Economics

Background

Norway with its 5,3M inhabitants has the fourth-highest per-capita income in the world on the World Bank and IMF lists^[18] is heavily oil-dependent with an industry structure biased toward B2B. Norway is also recognized for its highly digitized Government sector where the platform Altinn plays a significant role. Most notably, Norway has the world's largest sovereign wealth fund, with a value of US\$1 trillion+.^[20]

Macro-level

Norway will focus on artificial intelligence in areas where we have competitive advantages, such as health, seas and oceans, public administration, energy, and mobility. Policy instruments that stimulate investment in strong research communities, such as the research-center schemes, will be important elements. The Government wants Norwegian research communities to be attractive partners for leading AI enterprises and research communities through continued investment in basic and applied ICT research, good study programs, and competence building in AI through courses and further education programs at all levels.

Source: <https://www.regjeringen.no/en/dokumenter/nasjonal-strategi-for-kunstig-intelligens/id2685594/?ch=5>

Meso-level

According to Statistica, the most relevant use of AI in Norwegian companies is automation of upstream activities, i.e., driving out inefficiencies in production or administration. As of 2018, nearly half of the Norwegian enterprises expected that Artificial Intelligence (AI) would have a significant impact on their industry in the following five years. None of the investigated businesses expected no impact at all. The most relevant use of AI among Norwegian enterprises was automation, according to over 80 percent, alongside with prediction, according to over 70 percent of the respondents to a survey conducted in 2018. 14 percent of the investigated businesses found AI relevant for prescriptions.

From conversations with CEOs associated with the research center Digital Innovation for Growth at NHH, we learn that more leaders are looking at AI as a way of adding value to customers through their market offering and/or business model. Key in this respect is setting themselves up for collecting transactional data (customers' search, buying behavior, and usage, logistics, and payment) which enables them to train algorithms to provide better and more personalized services which leads to increased use and more data, etc.

Micro-level

In 2018, the number of smartphone users amounted to 4.64 million. In the same year, the smartphone penetration rate was at 86.95 percent. In 2024, the number of monthly active smartphone users is projected to reach 5.19 million individuals. This would be an increase of approximately 550 thousand new users in comparison to the first year recorded. Respectively the smartphone penetration rate is forecasted to reach 92.64 percent as of 2024. With a high

penetration rate in other digital domains, Norwegian households should be prime candidates for adopting AI-based innovations.

	Norway			EU
	DESI 2018	DESI 2019	DESI 2020	DESI 2020
	value	value	value	value
1a1 Overall fixed broadband take-up	90%	89%	93%	78%
% households	2017	2018	2019	2019
1a2 At least 100 Mbps fixed broadband take-up	21%	30%	39%	26%
% households	2017	2018	2019	2019
1b1 Fast broadband (NGA) coverage	86%	83%	89%	86%
% households	2017	2018	2019	2019
1b2 Fixed Very High Capacity Network (VHCN) coverage	52%	59%	71%	44%
% households	2017	2018	2019	2019
1c1 4G coverage	100%	100%	100%	96%
% households (average of operators)	2017	2018	2019	2019
1c2 Mobile broadband take-up	98	99	103	100
Subscriptions per 100 people	2017	2018	2019	2019
1c3 5G readiness	NA	NA	49%	21%
Assigned spectrum as a % of total harmonised 5G spectrum		2019	2020	2020
1d1 Broadband price index	NA	NA	NA	64
Score (0 to 100)			2019	2019

Source. DESI2020 report - Norway

Sweden

By Professor Per Kristensson, Service Research Center (CTF), Karlstad University, Sweden

Background

Sweden has a long history of inventions, the pacemaker, the respirator, dynamite, and the refrigerator are all Swedish inventions, to name but a few. The engineering history and culture of Sweden are profound and along with the situation that Sweden has not been in war since 1814 has led to a prosperous trade and industry for Sweden. Among the well-known are IKEA, H&M, and Volvo but recently companies such as Spotify, Klarna, Swish, and Skype have implied a shift from entrepreneurship in traditional sectors to more digital ones.

Macro-level

The overarching aim for Sweden's AI strategy is to: "be best in the world to use the opportunities that digitalization brings forward". The claim might sound bold but the fact that usage is mentioned means that Sweden does not necessarily view itself to be the inventor of AI-related solutions, but rather taking the lead when it comes to adopting and implementing solutions, products, and services, has proven successful.

The Swedish AI strategy identifies that AI can contribute with considerable value within several areas and mainly through financial growth but also, and this is important for the Swedish government, to tackle environmental and social societal challenges.

The Swedish Government released its AI strategy in May 2018. The strategy document serves as a reference to help the government to outline forthcoming policy initiatives aiming at strengthening Sweden's welfare and competitiveness by fully exploiting the benefits of AI. For example, to increase and facilitate the speed of AI development, moving initiatives from the lab to the market, the Swedish strategy emphasizes the need for stronger basic and applied research environment in AI and stronger relationships with leading international AI research environments. There is also a need for pilot projects, testbeds, and environments for the development of AI applications that can ensure both development and user testing at the same time.

Bibliometric data indicate that Swedish AI research has, overall, limited international competitiveness in terms of AI development. In general, AI innovation is being dominated by the US, with China as the main contender and with Europe losing ground. This is true for both commercial applications and research. Regarding the latter, an analysis of the contributions to the highest-ranked AI conferences since 2010 support this view. American researchers participate in nearly half of all conference contributions. Researchers from China have the strongest increase and their share is nearly one fifth. The presence of Swedish researchers at the same conferences is very modest, with only 0.6 percent of all contributions in 2014-2017. The participation per capita at the conferences is many times greater for Singapore, Switzerland, and Israel than for Sweden and significantly larger also for Australia, Canada, Finland, and Denmark.

For Sweden to take the next step forward, Vinnova concludes that governmental initiatives are needed. In particular, further education in AI, well adapted to the labor market, need to be stimulated with special initiatives for the rapid development of such education. More specifically,

educational institutions need to provide a sufficient number of people with AI education, including continuing education for professionals. Swedish technical universities have started proposing bachelor's and master's programs in AI fields but AI also needs to be integrated into other types of non-technical programs.

Meso-level

As of 2018, half of the Swedish enterprises expected that Artificial Intelligence (AI) would have a high impact on their industry in the following five years. None of the investigated businesses expected no impact at all. It should be noted that the business sector in Sweden has a good awareness, possesses technological skills, and have other types of necessary capabilities in place to be able to adopt and implement AI-solutions.

Vinnova – Sweden's innovation agency – has published an extensive policy report outlining the opportunities and challenges of AI in Sweden, and Sweden's capabilities to embrace the full potential of AI (with concrete examples of ongoing AI projects).

To assess the AI potential for business organizations, it is important to understand the possible areas of application in various industries, since it is in these that the value-creating potential lies. In this regard, Vinnova estimates the potential to lie in:

- Industrial development - development of manufacturing and service processes
- Travel and transports - autonomous vehicles, logistics and transport infrastructure
- Sustainable and smart cities - transport systems, energy and waste, welfare systems
- Health - products, services and processes for diagnostics, drugs, and healthcare
- Financial services - service development in finance, insurance, and payment systems
- Security - defense, civil contingency, police and customs

In a detailed SWOT, Vinnova summarizes the potential of AI for Swedish businesses. In terms of strengths, it is noted that Sweden has a technology-friendly population and a high level of technological skills. In terms of weaknesses, Sweden has difficulties in recruiting competence. An opportunity is that Sweden has implementation and development skills and the threat is that the regulatory development does not interact with AI development. The latter means that although there might be AI solutions that are of great use for companies, laws and other types of bureaucracy might hinder its implementation.

Micro-level

On the micro-level, it should be noted that Sweden is a digital leader, ranking 2nd out of the 28 EU Member States with a score of 69.7 in the Digital Economy and Society Index (DESI) 2020, based on data before the pandemic. This means that citizens in Sweden is the front-runner when it comes to connectivity and the human capital is one of the nation's strongest competitive advantages. 72% of the population has at least basic digital skills and 46% above basic digital skills. Sweden also ranks second in Europe when it comes to internet use. Almost all Swedes use the internet daily. Swedish companies are integrating digital technology relatively well (ranking 6th), although progress is slowing and other countries are catching up. Overall, this data conclude that it underlies that Swedish citizens are well equipped in terms of capabilities to adopt and use new AI-solutions.

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Denmark

By Dr. Darius-Aurel Frank, Aarhus BSS – School of Business and Social Sciences, Aarhus University, Denmark.

Denmark is the most southern Scandinavian country – and its population of 5.8 Mil (Source: [Population in Denmark - Statistics Denmark](#)) the second most happy in the world (Source: [World Happiness Report 2020](#)). The country has nurtured a tradition of positioning itself as one of the world's most peaceful societies that is taking a lead role in promoting healthy and sustainable living. Experts predict AI in Denmark to impact all levels of society, transforming Danish organizations, firms, and lives over the coming years and decades.

Macro-level

Denmark is unquestionably one of Europe's most digitized countries with one of the most digitally advanced public sectors and unique opportunity through the accessibility of public data (Source: [OECD Digital Government Index \(DGI\): 2019](#)). The country's strategic goal aims to turn this and many others of its core strengths into paving the way for the responsible development of AI technologies. Simon Kollerup, Denmark's Minister of Industry, Business and Financial Affairs, in a joint statement with other leading EU members in October 2020 shared his enthusiasm that "Artificial intelligence offers unimaginable opportunities for Danish and European companies". At the same time, he cautions "Here we must show that responsible use of technology can strengthen both consumer security and confidence and the opportunity to develop new and smart business adventures." (Source: [Europas mest digitale lande vil vise vejen for kunstig intelligens](#)).

Already back in March 2019, the Danish government published its national strategy for artificial intelligence (Source: [National Strategy for Artificial Intelligence](#)). In its 69-pages long strategy paper, The Danish Government sets out its goals and visions for AI development in Denmark, while acknowledging the challenges and identifying specific policy initiatives and priority areas. It aims at putting Denmark at the forefront of responsible development of artificial intelligence and sets out four objectives to achieve this goal: (1) developing a common ethical and human-centered basis for AI; (2) supporting research in AI, (3) encouraging the growth of Danish businesses by developing and using AI and (4) ensuring that the public sector successfully implements AI to offer world-class services for the benefits of citizens and society.

The national strategy on AI already seems to be paying out in that Denmark is ahead of all Nordic countries (and, as a matter of fact, all EU member states) in terms of AI-related publications per capita as of 2019 (Source: [Live data from OECD.AI partners](#)). Within the last ten years, publications have more than doubled for Denmark's leading research institutions – Aarhus University and the University of Copenhagen.

Meso-level

On a meso-level, it can be observed that AI is developing into an increasingly important cornerstone for the Danish industry. Already as of 2018, about half of the Danish enterprises expected that AI would have a high impact on their industry in the following five years. 40 percent of the enterprises expected it to have a significant impact (Statista). The potential economic impact of AI, estimated by Denmark's Innovationsfonden in collaboration with McKinsey Global Institute, will be around DKK 35

billion (EUR 4.7 billion) annually (1.6 percentage points in additional annual GDP growth) if Danish firms and organizations successfully adopt AI at scale by the year 2030 (Source: [AN AI NATION?](#)).

In this global race towards AI leadership, Danish companies draw on the advantage of Denmark's digital competitiveness, which ranks among the best in Europe and the third-best in the world, according to the annual Digital Competitiveness Ranking 2020 (Source: [The IMD World Digital Competitiveness Ranking 2020 results](#)). According to the European Commission's 2020 edition of the Digital Economy and Society Index, Denmark ranks third out of the 28 EU Member States. This is helping Danish SMEs transform their business and transition into the new digital economy (Source: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=66913).

As the first country in the world, Denmark has introduced mandatory company legislation for AI and Data Ethics. This legislation forces companies in the online space to release public information about their data ethics policies. The law requires Danish firms to provide – upon request – information on which algorithms they use in their platforms and demonstrate that these algorithms live up to the standards in terms of transparency. The new legislation came into effect on the 1st of July 2020, meaning that affected companies will have to comply with AI and Data Ethics by 2021. (Source: [Krav om redegørelse for dataetik for de største danske virksomheder indføres i årsregnskabsloven](#)).

Micro-level

Danish consumers anticipate AI to resolve some of the most fundamental problems of their daily lives. According to a representative survey in December 2019, the BEUC, The European Consumer Organisation, finds that these include predicting traffic accidents as well as health and financial problems (Source: [Artificial Intelligence: what consumers say](#)).

At the same time, Danish consumers have reservations related to a significant lack of trust in the emergent technology. When asked whether they trust if their privacy is protected when using AI devices, a large majority of consumers state this to be medium or low. • Respondents are skeptical about AI's ability to perform highly complex human behavior or human properties like emotions. (Source: [Artificial Intelligence: what consumers say](#)).

In a position paper published October 2020, Denmark joined Europe's most digital countries (D9+ consisting of Belgien, Danmark, Estland, Finland, Holland, Ireland, Luxembourg, Polen, Tjekkiet og Sverige) in a push for incentivizing trustworthy AI for the benefit of our society, citizens and economy – proposing a voluntary European labeling scheme which would make it visible for potential users, which applications are based on secure, responsible and ethical AI and data and therefore which applications to trust. (Source: [INNOVATIVE AND TRUSTWORTHY AI: TWO SIDES OF THE SAME COIN Position paper on behalf of Denmark, Belgium, the Czech Republic, Finl](#))

Finland

By Professor Kristina Heinonen, Hanken School of Economics, Helsinki, Finland

Background

Finland shares land borders with Sweden to the west, Russia to the east, and Norway to the north and is defined to the south by the Baltic Sea. Finland has a population of approximately 5.5 million, making it the 25th-most populous country in Europe. With an area of 338,455 square kilometers (130,678 sq mi), Finland is the eighth-largest country in Europe and the most sparsely populated country in the European Union. Helsinki, the capital of Finland, is the largest city in the country. Finland is a top performer in numerous [metrics of national performance](#), including education, economic competitiveness, civil liberties, quality of life, and human development.^{[17][18][19][20]} In 2015, Finland was ranked first in the World Human Capital^[21] and the [Press Freedom Index](#) and as the most stable country in the world during 2011–2016 in the [Fragile States Index](#),^[22] and second in the [Global Gender Gap Report](#).^[23] It also ranked first on the [World Happiness Report](#) report for 2018, 2019, and 2020.^{[24][25]}

Finland is globally a forerunner in digitalization. Finland is a digital leader, ranking 1st of the 28 EU Member States, with a score of 72.3 in the Digital Economy and Society Index (DESI) 2020. Based on data before the pandemic, its leading performance is due to its excellence in digital public services and the integration of digital technologies, enabled by active cooperation between the public and private sectors and an active start-up scene. According to the annual Digibarometer research in 2019 (sponsored by Business Finland, MINTC, Technology industry, software- and e-business, Confederation of Finnish Industries EK), Finland ranked third after the USA and Denmark in terms of exploiting digitality. The research investigates the antecedents, usage, and implications of digitalization at the levels of companies, state, and citizens. A manifestation of Finland's global position in digitalization is the SLUSH high-tech start-up symposium organized in Finland, the world's largest in its field. The 2020 Global Startup Ecosystem Report (GSER) by Startup Genome identified the Helsinki area as one of the most significant AI ecosystems in Europe along with London and Berlin.

Macro-level

At the macro-level, AI technologies are of strategic importance for Finland. Finland has seven AI policy initiatives. In October 2017, the Finnish Ministry of Economic Affairs and Employment published a national AI strategy entitled [Finland's Age of Artificial Intelligence](#) (Finland, 2017). This report fits under the umbrella of a broader [Artificial Intelligence Programme](#) in Finland (also labeled as AI Finland) intending to establish artificial intelligence and robotics as the cornerstones of success for Finnish companies. A status-check report of the progress titled "Leading the way into the age of artificial intelligence" was published in 2019.

Finland performs well in the following categories (matrix by player and AI area):

1. *Scientific publications* (data analysis; natural language and cognition; digital expertise in work-life; ethics, moral, legislative regulation)
2. *Education in universities* (data analysis; computer vision; natural language and cognition; human-computer interaction; digital expertise in work-life; machine learning; AI computing platforms; robotics and automation)

3. *Companies/public sector* (data-analysis; computer vision; machine learning; AI computing platforms; AI systemic effects (public sector); robotics and automation; ethics, moral, legislative regulation)

The national AI strategy highlights Finland's possibilities in the global market along with its strengths and weaknesses in AI. It describes how artificial intelligence will transform society and provides a range of policy actions and recommendations for Finland to thrive in the age of artificial intelligence. The goal is to position Finland as a leading country in artificial intelligence by adopting an open data policy and creating adequate conditions for a prosperous development of AI. In 2017, Finland was ranked nr 10 in the world on the Oxford Insights Government AI Readiness index that measures the capacity of governments to capitalize on the innovative potential of AI. Overall, the strategy highlighted three areas:

- **Economic growth and business competitiveness:** How can we make sure that the opportunities provided by artificial intelligence are best utilized to safeguard economic growth and the competitiveness of business?
- **Public sector application:** How can we make sure that the public sector will be able to utilize the opportunities provided by artificial intelligence in its operations and thereby efficiently produce good public services?
- **Societal well-being:** How can we make sure that the structures of society will adjust to the changes brought on by artificial intelligence, and that going forward, Finland will be able to provide a well-functioning society and wellbeing to its citizens?

These challenges align well with the overall macro-meso-micro i.e. systemic thinking in AI strategy. To tackle the challenges, the following gigantic task areas were identified to be crucial to Finland:

- Key action 1: Enhance business competitiveness through the use of AI
- Key action 2: Effectively utilize data in all sectors
- Key action 3: Ensure AI can be adopted more quickly and easily
- Key action 4: Ensure top-level expertise and attract top experts
- Key action 5: Make bold decisions and investments
- Key action 6: Build the world's best public services
- Key action 7: Establish new models for collaboration
- Key action 8: Make Finland a forerunner in the age of artificial intelligence
- Key action 9: Prepare for artificial intelligence to change the nature of work
- Key action 10: Steer AI development into a trust-based, human-centered
- Key action 11: Prepare for security challenges

The [State of AI in Finland](#) -report published in two sets in September 2020 and November 2020 offers a comprehensive outlook of the Finnish AI market. By showcasing several AI solutions within different sectors it indicates the main strengths of the Finnish AI ecosystem: the ability to come together around a common goal.

Meso-level

According to the DESI 2020 report, Finland ranks 2nd among EU countries, well above the EU average, on the integration of digital technology by businesses into their activities. AI's great promise is to utilize information from numerous sources of information, create better decision-making, manage risks and achieve new skills and skills through the support and

guidance provided by artificial intelligence. Finland has prospered in the wood processing industry (e.g. UPM-Kymmene), telecommunications (TeliaSonera, Nokia), and biotechnology (Neste), and these industries will increasingly use AI more. For example, Nokia is promoting 5G, cloud, and AI through new solutions in application areas such as health care, education, entertainment, smart energy, smart city, and sustainable manufacturing.

The challenge of AI at the meso level is that not all companies may be able to exploit the opportunities offered by AI in their operations, and the use of AI is not part of the strategic support base for future operations. To tackle this, Finland created the Finland's Artificial Intelligence Accelerator program (FAIA) and the Finnish Centre for Artificial Intelligence (FCAI). FAIA is a joint venture by the Ministry of Economic Affairs, Technology Industries of Finland and Silo.AI and FCAI is led by the Academy of Finland. The FAIA brings together the world-class expertise of Aalto University and the University of Helsinki in AI research, strengthened further with VTT Technical Research Centre of Finland to create an ecosystem between AI provider companies and AI users. The ecosystem welcomes also the public sector. An interesting action is also the listing of TOP AI companies ("the best cases") in Finland annually. The list of companies states only those, whose main turnover comes from AI-related operations (e.g. AI product company, AI enabler company, AI consultancy). Therefore, large companies may not end up on the list. The best cases include a variety of AI applications: understanding culture, forecasting sales, the optimal airport, optimizing store space based on data, accelerating Parkinson's disease research with deep learning AI, predicting heat energy consumption, tropical cyclone intensity prediction from satellite images.

Business Finland, Finland's main funding agency for innovation, has actively provided financial support to companies pursuing an AI program to enhance global business development. Initiatives from this agency are complemented with technical support on research and innovation from VTT, the Technical Research Centre of Finland. "The AI Business program (2019) aims to make Finland the best place to research and develop artificial intelligence and platform economy. The program also targets to build global ecosystems and to attract investments in Finland". The AI Business program accelerates the global growth of the Finnish digital service business. The key is that artificial intelligence and platform economy can automatize currently localization-dependent operations and services. This enables Finland to provide significant international services. VTT Technical Research Centre of Finland Ltd (VTT) developed an online tool that organizations can use to test their AI maturity on six dimensions, including strategy and management, competences and cooperation, and technology.

Micro-level

Finland ranks 1st in the EU concerning the use of internet services. Finns score above the EU average in all internet activities, with notable leadership in online banking. 85% of Finnish internet users read news online (72% in the EU as a whole). The development and adoption of AI usage at the microlevel is dualistic. On one hand, Finland is at the forefront of adopting new applications in some areas. A recent example is the rapid adoption of the Covid-19 app Koronavilkku (Corona-blinker) (over 1 million users in Finland). There are also other interesting programs at the micro-level ongoing: Finns try to teach Siri-AI all the different "murteet i.e. dialects" in the Finnish language and over 10 000 speech minutes are needed. On the other hand, the interest and heavy use of the AI applications are not at a high level, e.g. the Finns perform less than average when they give personal information and usage rights to different AI applications. However,

the microlevel usage could be enhanced in the future especially in terms of contextual adaptation (the first two eras were handcrafted knowledge and statistical learning).

Finland is a global frontrunner in the skills development needed for AI. A notable issue of AI on the microlevel in Finland is the efforts for the working-age population providing vocational training and lifelong learning opportunities of AI. According to the DESI report 2020, Finland has a strong and consistent lead in human capital reflecting a highly competent workforce.

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