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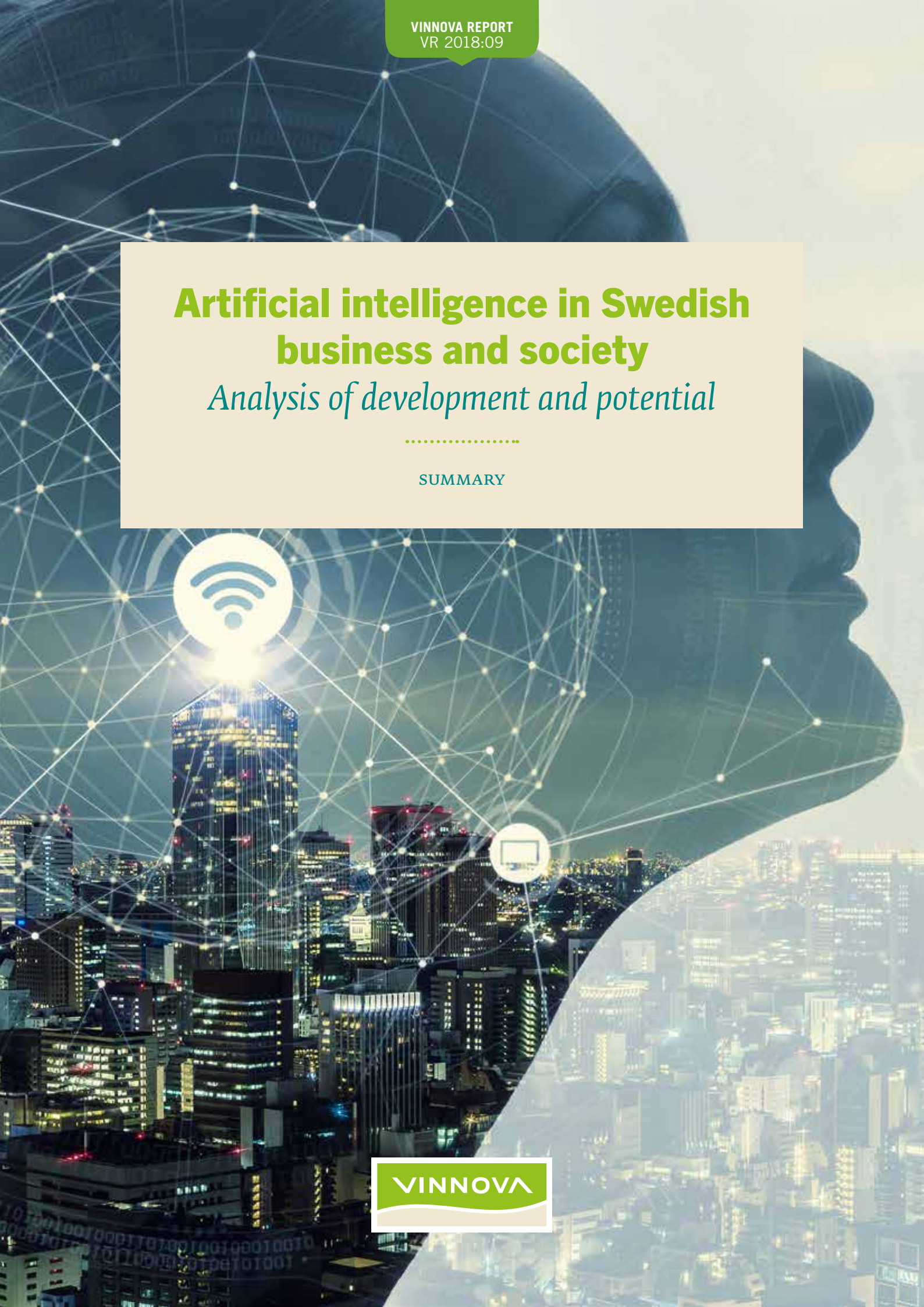

Artificial intelligence in Swedish business and society

Analysis of development and potential

SUMMARY

VINNOVA

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Short about Vinnova

Our vision is to strengthen Sweden as a country of research and innovation.

Vinnova's vision is for Sweden to become a leading global player in research and innovation, and a country that is attractive for investment and entrepreneurship.

Vinnova is Sweden's innovation agency. Our mission is to contribute to sustainable growth by improving the conditions for innovation. We do this mainly by funding innovation projects and the research needed to develop new solutions. We also invest long term in strong research and innovation environments.

We stimulate collaborations between companies, universities and other higher education institutions, public services, civil society and other actors. Our activities also focus on strengthening international cooperation.

Each year, Vinnova invests around SEK 3 billion in fostering innovation. Most of these funds are allocated via calls for proposals in which companies, public sector actors and other organisations apply for funding. All investments are continuously monitored and evaluated and we regularly analyse the impacts of our investments.

Vinnova is a government agency under the Ministry of Enterprise and Innovation, and the national contact authority for the EU Framework Programme for Research and Innovation. We are also the Swedish Government's expert authority in the area of innovation policy. Vinnova employs just over 200 people and has offices in Stockholm and Brussels. Acting director general is Leif Callenholm.

The **Vinnova Report** series includes evaluations, analyzes and reports about our programmes, funded projects or assignments we've given others.

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Preface

On 22 December 2017, Vinnova was commissioned by the Government (N2017/07836/FÖF) to carry out a mapping study and analysis of how well artificial intelligence (AI) and machine learning are used in Swedish industry, the Swedish public sector and society, and the potential that could be realised by boosting the use thereof. The assignment includes:

- identifying and analysing opportunities inherent in the use of AI and adjacent technologies in Swedish industry and in Swedish business and the public sector generally,
- identifying and describing Sweden's current position within the AI area, in particular in relation to available demand for and supply of skills through education and training, but also in relation to research and public initiatives to apply AI in various industries and sectors of society,
- analysing where Sweden stands in terms of taking opportunities inherent in AI and highlighting bottlenecks that may be limiting factors in relation to utilisation.

The final report must be delivered to the Government Offices of Sweden (Ministry of Enterprise and Innovation) by 30 April 2018. Vinnova submitted an interim report to the Government Offices of Sweden (Ministry of Enterprise and Innovation) on 12 February 2018.

This report is a summary of Vinnova's final report.

Vinnova in May 2018

Göran Marklund
Deputy Director General
Head of Operational Development

Introduction

There is no clear-cut definition or generally accepted demarcation of artificial intelligence (AI). In this analysis, artificial intelligence is defined as the ability of a machine to imitate intelligent human behaviour. Artificial intelligence also denotes the area of science and technology that aims to study, understand and develop computers and software with intelligent behaviour.

The purpose of this analysis is to identify and analyse:

- Opportunities in the use of AI within business and public services in Sweden.
- Development to date of Sweden's use of AI.
- AI skills for business and public services.

A central part of the analysis is to create an understanding of driving forces, opportunities, obstacles and links between significant factors for AI-based value creation in business and the public sector.

The issues dealt with by the assignment are wide-ranging, and many different aspects of the development of business and society are significant in relation to these issues. Accordingly, this analysis cannot claim to be comprehensive. This summary describes Vinnova's assessments and conclusions of the studies, data and expert opinions on which the analysis is based.

Sweden's AI capability

Applications of AI have already been of great importance for the development of internet platforms, information retrieval, image recognition and automated translation, but the practical impact of AI has been limited in large parts of business and in public activities in Sweden. However, during the last decade, access to data in electronic form and computing power has increased very quickly, which has considerably improved the conditions for AI applications in various activities.

Opportunities and challenges

In order to assess the AI potential for value-creation and to use this potential, it is important to understand the possible areas of application in various industries, since it is in these that the value-creating potential lies. Possible applications also provide the driving force for AI development in companies and public activities.

The potential lies in:

- Automating functions in established value chains, operations and functions.
- Developing new business models, products, services and system solutions.
- Transforming value chains and sectors for brand new development tracks.

Sweden's value creation potential in the use of AI within business and public services is great. Most assessments identify a growth potential that is twice as fast with large AI utilisation in the economy compared with a low AI utilisation.

The potential for improved quality and efficiency in the public sector is great. Additionally, there is very considerable potential in developing and implementing AI solutions for environmental and social challenges in society. Accordingly, artificial intelligence can contribute to Sweden's possibilities of achieving the goals in the 2030 Agenda for Sustainable Development.

A considerable increase of AI applications in business, the public sector and society has not only a potential to improve the quality and efficiency in various operations, as well as increased growth and improved welfare; AI developments will also generate new challenges through the development and adjustment processes that will become necessary. The following challenges will become important as a consequence of increased AI utilisation:

- **Leadership and adaptability** in companies, public operations and policy systems
- **Labour dynamics and unemployment** due to rapidly changing job descriptions
- **Data ownership** and challenges in relation to privacy, ethics and trust
- **Data and business monopolies** for a small number of technology-based companies
- **Risk of application of immature AI solutions** based on incorrect data and algorithms
- **Security risks** through conscious harmful data usage and data manipulation

Innovation leadership in all sectors and at all levels will become very significant for the AI development in Sweden. The dynamics in the labour market will increase considerably as the AI applications in business and public operations become more frequent. **Adaptability** of individuals and operations will become increasingly important. This will place very high demands on leadership skills for business development and the ability to support individuals in readjustment and upgrading of skills. Therefore, the momentum, skills and other requirements for such adaptability must be significantly strengthened.

The net effects of labour dynamics for the economy are largely very uncertain. Based on historical development and new scenarios, there is no reason to assume, however, that the creation of new jobs will be slower overall than the pace of the jobs that will disappear.

Regulatory developments and the rules regarding data and **data access** will be crucial for the development of AI. Such rules must strike a balance between the fundamental needs for **privacy, ethics, trust and social protection** and data access necessary for the development of value-creating AI applications. This requires that drivers and competences to participate in innovation processes are significantly strengthened among public authorities and experts in charge of regulatory and regulatory monitoring. One important aspect is that such public authorities and experts should cooperate directly with other stakeholders in the R&D and innovation processes where new AI applications are developed.

Leadership and governance for a safe and value-creating transformation of society as a whole must be strengthened considerably. Knowledge about how increasing AI usage may affect the development of society and what measures may contribute to minimizing the risks of adverse effects of AI are deemed highly undeveloped. Competence development in relation to social aspects of AI therefore needs to be strengthened. The ability to prepare **system analyses** that create understanding of how different drivers, factors and processes affect each other are very significant in this context. However, analyses that form the bases for various policy areas are often conducted with a systems perspective that is too narrow, linked to specific areas of policy and based on narrow questions. Often, they are also based on a method repertoire for necessary systems analyses that is too narrow. While initiatives are taken to promote the utilization of AI, research, analytical capacity and processes for system analyses need to be developed significantly.

Important areas

Artificial intelligence will be important for Sweden's future competitiveness and innovative strength in all sectors and industry branches, that will all be affected by the development of AI. Therefore, it is difficult to identify areas of application for AI where Sweden is particularly well-placed. However, the following broad and mutually dependent areas of application for AI are expected to be particularly important for the development of both Swedish business and society.

- **Industrial development** - development of products and services and manufacturing and service processes
- **Travel and transports** - autonomous vehicles, logistics and transport infrastructure

- **Sustainable and smart cities** - transport systems, energy and waste, education and healthcare systems
- **Health** - products, services and processes for diagnostics, drugs, and healthcare
- **Financial services** - service development in finance, insurance and payment systems
- **Security** - defence, civil contingency, police and customs

The opportunities for AI applications are different in different areas. Many different factors will be important in the development and these will be strongly mutually dependent on each other. The following factors and the interaction between these will be important in all activities:

- **Business and operational models** - for some companies and public operations the value creation potential of AI is apparent, while others cannot yet perceive a benefit as clearly.
- **Drivers** - for some companies AI is already a significant competitive factor, while others still lack clear drivers, and the drivers are generally weak in the public sector.
- **Data access** - in most areas, lack of data access is a crucial limit on the development of business and operational models are based on AI applications.
- **Competence** - limited AI skills in companies and public activities, among both managers and employees, hampers the development of AI in most operations.

Business and operational models, data access and competence are mutually dependent and therefore heavily affected by each other in companies and public operations. Without clear prospects of business benefits, the drivers of AI-based investments are inhibited. If the business benefit is not clear, AI competence is also not viewed as an important factor for value creation and efficiency, affecting recruitment patterns and competence development. Limited AI competence, at managerial level and among employees, makes it difficult, in turn, to develop AI based business and operational models. Data access and possibilities of combining different data will be fundamentally significant for purposes of identifying the applications that can be developed. Data restrictions that inhibit or eliminate the development of AI-based products and processes weaken the drivers for AI investments, Figure 1.

Figure 1 Mutual dependencies among important factors for the development of AI applications

Important prerequisites for a positive development of the interaction between the above factors will include:

- **Innovation leadership** for the development of AI applications and the ability to lead business restructuring and to support individuals in readjustment and upgrading of skills.
- **Labour market models** that give individuals drivers and favourable terms for labour dynamics and life-long learning lay the foundation for continuous adjustment in the labour market.
- **Data regulations** for many AI applications restrict the development considerably. Such regulations often have strong links to privacy, ethics, trust and ownership rights.
- **Social solutions** for digital security, integrity, ethics, trust and safety, striking a balance between the fundamental needs for data access for AI development and social development needs.
- **Critical mass** and international attractiveness in environments for research, education and innovation that are characterized by efficient cooperation among different functions and market participants.
- **Collaboration** among companies, public operations, research institutes, universities and university colleges will be crucial in realizing Sweden's AI potential.

Leadership in relation to innovation and operational development will be of crucial significance, and there are many indications that requirements in relation to this ability in companies, public operations, universities and university colleges as well as in political bodies will increase significantly as the use of AI becomes more frequent. Increased AI applications will have a strong impact on job descriptions, labour organisation and the labour market. This will involve significant challenges in leading restructuring or AI-based operational development and innovation in companies, public operations and in universities and university colleges.

Increased AI usage will also place significantly higher demands on individuals to continuously change tasks and continuously renew their competence. This in turn will require development and adaptation of drivers and social security systems for transitions in working life, presenting new challenges in terms of labour market policies and for the participants in the labour market. Successful AI development in different areas will depend on both specialist and broad competence within AI and domain and organizational competence for different AI applications.

Access to data is closely linked with regulatory conditions relating to data and data management. Data regarding individuals and individual behaviour is of crucial significance for many AI applications. Data access is determined by how companies and public operations develop and safeguard data in their operations and collaboration, and by the development of regulatory conditions for data generation and data access. Therefore, society's regulatory and ethical management of privacy issues, data security and title to data will be very important in the context of AI development.

Internationally strong environments for research, education, and innovation will therefore be important for Sweden's innovative strength and international attractiveness for leading AI competence and corporate AI development. Cooperation to achieve a critical mass in such environments will be crucial. Cooperation will also be important to link regulatory development and labour market development with innovation processes for AI applications. It is difficult to identify any area that is as dependent on cooperation between different stakeholders and across sectoral borders as AI. A positive AI development in Sweden thus demands efficient cooperation among many different actors and functions in society.

Sweden's AI capability

There are many different factors that are significant in relation to Sweden's ability to develop and use AI. Different factors also play roles of different magnitude within different sectors and different branches of industry. Table 1 is an overall analysis of Sweden's Strengths, Weaknesses, Opportunities and Threats (SWOT).

Table 1 Overall SWOT-analysis of Sweden's AI capability

STRENGTHS	WEAKNESSES
Technology-friendly population High level of technological skills Qualified researchers and engineers Good domain competence regarding processes Good data access Excellent IT networks Infrastructure for data traffic Many digitalised processes High level of automation Major international technology-driving companies Efficient public operations Good innovation ability Ability to solve complex problems Long experience in security-critical solutions Culture of cooperation Developed innovation system Efficient value chains and ecosystems Ability to build consortia	AI competence hard to recruit Lack of competence for digital business models Universities and university colleges have weak drivers for flexible professional training Many SME have limited resources and competence Slimmed-down organisations hamper competence development IT infrastructure not always accessible and stable IT maturity varies within value chains Lack of coordinated security initiatives Automation systems are often based on old technology Unclear ownership and data rules Uncertainty concerning future data access regulation Lack of AI standards Difficult to cross-check data Failures in data quality and structure Fragmented municipal sector Poor cooperation among county councils Lack of state control Few and unfocused R&D initiatives in AI
OPPORTUNITIES	**THREATS**
Increased innovation pace with AI Use access to large volumes of data Use our quality register for AI analysis New technical opportunities via system connections New functions and improved quality of products and services Increased efficiency in production and processes System potential in new value chain connections New work methods and new organisation methods New interesting and attractive jobs Improved work environment Sweden could be a test bed for AI development Sweden has a high attractiveness level internationally Develop cooperation around AI-development Develop cooperation around AI-implementation Use the cooperation capacity of the research institutes Train existing AI competence Develop regulations promoting data access Develop policies promoting system development	Regulatory development does not interact with the AI requirements Privacy issues are dealt with differently in Sweden Intellectual property rights could be threatened Poor AI competence at management level Poor AI competence weakens development momentum Regional differences in AI competence AI competence leaving Sweden Fears and unrealistic expectations Long implementation timelines inhibit investment Lack of AI investments inhibits competitiveness The rest of the world invests more and faster than Sweden Sweden will not become a test bed for new AI solutions Large dependence on systems suppliers Increasing vulnerability in systems Poor IT security increases social risks Simple jobs are disappearing and unemployment is rising Trust and confidence in the future is inhibited by the development of AI Distrust as AI failed in the 80s and 90s

Swedish society is characterized by a high degree of digitalisation compared to most other countries. IT infrastructure is well developed and has a high capacity in large parts of the country. Digitisation in working life has come a long way in many sectors, while a majority of the population is connected to the internet and has a high level of IT experiences. This provides an important basis for Sweden's AI capability and for a strong development of AI competence and AI applications.

AI competence will be of crucial significance in order to realize Sweden's AI capability. While computer science skills are important, access to software engineers will be crucial, since successful AI development often requires extensive software development. Access to AI competence will be a significant challenge, since there is a global lack of such expertise. AI applications are expected to increase drastically in the next few decades. Global demand for AI competence will therefore increase sharply, which means that an already significant lack of AI competence is expected to grow further.

How digitisation competence in general and AI competence in particular should be compared between countries is not obvious. In relation to technology and IT competence, Sweden has a relatively good starting position, both for newly graduated and for IT-educated in the labour market. This should mean that there are good opportunities for strengthening AI competence in Sweden through competence development of already well-educated technological competence. However, digital transformation and AI development will change the requirements and conditions for both research and competence development. Technology development increasingly takes place through interdisciplinary science, i.e. through new connections between different areas of technology and competence. In this context, established processes and institutional solutions in research and education are becoming less suitable for this development.

The ability of universities and university colleges in Sweden to adapt the focus of their research and education to the rapid and multidisciplinary changes that AI generates is poor. There are many indications that further education must account for most of the education system's adaptation in catering to the AI requirements of business and society. However, universities and university colleges find it difficult to develop and operate brief independent courses in close interaction with and directly adapted to working life, i.e. for life-long learning in general and AI in particular. The forms of cooperation between universities and university colleges with business and society need to be developed, especially to achieve a faster and improved adaptation of the educational offer to existing needs.

The digitisation of the educational institutions needs to be developed, both at a basic level and in universities and university colleges. This applies both to the use of digital technology and AI in courses as well as the utilization of digitalisation opportunities for management and administration. It is likely that successful education and research institutions will, in the future, have high digitisation rates in both core and support activities. AI will be significant in this context.

Bibliometric data indicate that Swedish AI research has, overall, limited international competitiveness. It is a generally accepted view that development within AI, both in research and commercially, is dominated by the USA, with China being the main contender, while Europe has tended to lose ground, relatively speaking. An analysis of the contributions to the 19 highest ranked AI conferences since 2010 strongly supports 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 and a downward trend compared to previous years. 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.

The situation changes considerably if these comparisons are widened to include all the articles published in journals classified as belonging to AI as a subdivision of computer science - mainly by strengthening China's position. The average citation rate for articles with authors from China was indeed just a third of the citation rate for articles with authors from the United States a few years ago. Nevertheless, there were almost as many articles with Chinese writers among the 10 percent most cited as with American writers. For Sweden the wider picture is somewhat more favourable than that for highly ranked conferences. This applies in particular to the average citation rate that gives a positive picture of the quality level of AI research in Sweden. However, when comparing the number of publications among the 10 percent most cited, the distance to Singapore and Switzerland is great.

The great attention that has surrounded artificial intelligence globally in recent years has its background in an increased use of machine learning in various applications. So-called deep learning has yielded particularly striking results. The increased use of AI is reflected only to a small extent in conferences and journals with AI specialists as primary target audience. An analysis based on key words with a close connection to deep learning gives the impression that Sweden, from a relatively favourable starting point at the turn of the century when technology was still in its infancy, failed to join in the growing experimentation with deep learning that has taken place in some other countries and successively lost ground. Fortunately, there is evidence that a positive shift in this trend occurred in 2017.

Patent data is another indicator of Swedish development capability. Since around 2010, AI is a rapidly growing patent area, and today it is one of the largest patent areas globally. AI-related patenting is strongly dominated by major IT companies such as Samsung, Microsoft, IBM and Google, but as the use of AI is widened to new areas, the group of companies applying for AI-related patents is also widening.

Based on data on patent applications to the patent authorities in the USA, Europe and Japan, Sweden's development capability in AI appears neither particularly weak, nor particularly strong. Sweden is ranked 13th internationally in AI patenting and just under 1 percent of all the world's AI patents in recent years have involved inventors from Sweden. In a closer comparison with five other smaller countries, Sweden's AI patenting per capita is a little ahead of Canada, equal with Switzerland and Denmark, a little behind Finland and significantly behind Israel.

In Sweden, as in the other five countries above, the number of AI patented companies has increased significantly in recent years. However, Ericsson strongly dominates Swedish AI patenting with computer networks and the operation of mobile communications networks as special strengths, which also resulted in these areas being the strengths of Sweden, a position that has also been strengthened. Smart transports and vehicles is one of the fastest growing sub-areas for patenting within AI and of particular importance for Sweden with several major vehicle companies in the country. However, in this area of patenting Sweden has been unable to keep up with the development in the rest of the world and seen its share of patenting halved.

Artificial intelligence is still a relatively unestablished research area in the Swedish research system. Within undeveloped research areas, there is often a need to invest with special initiatives in building research expertise and research environments before a strong demand for such skills emerges from business or society. In Sweden, it is difficult for academic institutions to develop internationally strong research environments within AI through their own strategic initiatives.

Concerted effort to boost Sweden's AI development

A successful realisation of Sweden's AI potential requires a targeted and powerful national strategy for AI development and AI utilisation. Several other countries currently have national AI strategies.

The goal of a Swedish AI strategy should be to turn Sweden into a leading country for the development and application of AI for sustainable growth and social development.

Since the correlations and dependencies are strong between different factors that are significant for AI development, it is important that a national policy stimulates cooperation between all significant stakeholders, so that a mutually reinforcing development momentum is generated.

Sweden's greatest opportunities for competitiveness within AI lies within a mutual interaction between innovative AI application in business and innovative organization of society.

This requires a well-developed strategic cooperation among participants in business, the public sector, research and education. Accordingly, not only strategy as such is important, but through the strategy process itself, the necessary knowledge, competencies, leadership and collaborative relationships can be strengthened among the various actors involved in the process.

A national strategy based on a broad and inclusive process should be designed and include most areas of policy and public authorities.

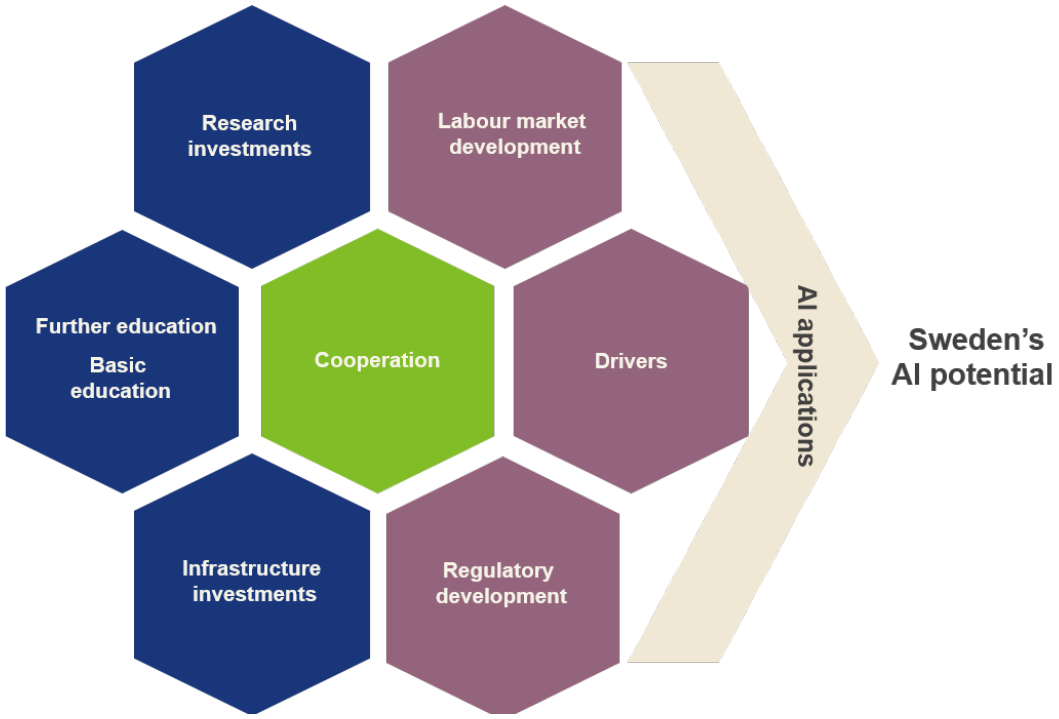
Strategic areas

In a national concerted effort to achieve Sweden's AI potential, it is important to purposefully prioritize the development of each of the following areas so that a mutually reinforcing interaction between them is generated:

- **Drivers** for companies and public operations to streamline and develop new value-creating solutions based on artificial intelligence.
- **Cooperation** in research, development, data access and competence development for AI innovation, linking requirements within different value chains and sectors for a combined development momentum.
- **Further education** and **basic education** for continuous supply of AI skills in the labour force, which requires a renewal of the education system.
- **Research investments** in AI for excellence and internationally leading research and innovation environments for advanced AI research and R & D collaboration.
- **Regulatory development** for data access, data integration and data ownership promoting AI innovation and safeguarding integrity, ethics and data security.

- **Infrastructure development** promoting research, development and testing of AI applications and AI security, integrity and rules in connections between various data, value chains and societal areas.
- **Labour market development** promoting the labour force mobility required by AI, which places significant demands on transition leadership in companies, the public sector and politics.

Figure 2 Policy areas and mutual dependencies in a concerted effort for Sweden's AI-potential



Prioritised initiatives

In the context of a national concerted effort, some government initiatives are particularly important for positive development. These should be initiated before a national strategy is available, while they should also be central parts in such a strategy.

Further education in AI, which is well adapted to the labour market, should be stimulated with special initiatives for a rapid development of such education and processes for these.

Without special policy initiatives, this development will not take place at the pace required to realise Sweden's AI potential. The development of further education in AI and dimensioning of these courses needs to take place in a close dialogue between academic institutions, companies and the public sector.

Internationally leading collaborative environments with a critical mass in research, education and innovation, with advanced data and technology infrastructures, need to be developed.

Without special policy initiatives for this purpose, the necessary concerted effort will not take place. This in turn inhibits the innovation processes for AI-based value creation. As of 2012, the

Swedish Foundation for Strategic Research (*Stiftelsen för Strategisk Forskning*) (SFF) has made major investments in cutting edge research within AI. The Swedish Knowledge Foundation (*Stiftelsen för kunskaps- och kompetensutveckling*) (KK Foundation) has also made several significant investments in research and education within AI at Swedish academic institutions and new universities. Wallenberg AI, Autonomous Systems and Software Program (WASP), started in 2015, is a concerted effort for research and education. From and including 2017 a strongly reinforced 10-year investment in AI in the context of this venture will be made. In the cooperative programs financed by Vinnova in collaboration with the Swedish Energy Agency and the Swedish Research Council Formas, there has been a drastic increase of AI projects in recent years. AI has also increased drastically in the innovation projects for small and medium size enterprises (SME) financed by Vinnova. This development is significant because a major part of the challenges in both research and education concern the use of AI methods in real applications.

A state-wide concerted effort for internationally leading collaboration environments for research, education and innovation should be designed to complement the initiatives of WASP, SSF and the KK Foundation. At the same time, it should be designed to complement and efficiently interact with investments in the major government initiatives in 17 Strategic Innovation Programmes (SIP), the Programme for Vehicle-Strategic Research and Innovation (FFI) and the Programme for Challenge-driven Innovation (UDI). In addition, it should relate to the EU investments in AI which are currently planned and which will probably form an important part of the next framework programme for research and innovation in the EU.

Other important initiatives

Apart from the above initiatives, which should be initiated with a high priority, a number of other initiatives should be central parts of a national concerted effort. These will require targeted development efforts, linking different actors' development processes with regulatory development and with the development of infrastructures and test environments.

Access to data for both education and research as well as application-focused development projects in AI should be an important priority in a national concerted effort.

Society's regulatory and ethical management of privacy issues, data security and data ownership will be very important in the context of AI development. To enable several parties to access the same data, in many cases special agreements governing the use of such data will be required.

Test beds for AI development based on access to important data should be an important focus for a critical mass and efficient cooperation in research and innovation environments.

The role of public organizations in making data available is important for AI applications in the public sector, business and societal development at large. Companies should also be encouraged to open their data to promote cooperation and attractive research and innovation environments in Sweden.

The development of basic education and research-level education in AI for width, excellence and cooperation with industry and the public sector should be prioritized.

In addition to further education, the following parts should be included in the development of higher education for stronger AI competence:

- Investment in industrial doctoral students and industrial postdoctoral students for testing AI solutions.
- Appointment of new combined teaching and research positions:
  - with recruitment in Sweden and internationally,
  - of which part with shared positions between institutions, academic institutions and companies.
- Commitment to education by companies, institutions and the public sector, with practical AI experience.
- The educational system should provide basic computer science for students in many areas.

Drivers and conditions for academic institutions to digitize courses, research training and support operations need to be reinforced.

Increased digitisation of academic institutions is an important condition for efficient education and research within AI. This is also needed to achieve the flexibility and ability to adapt in education that will be required of academic institutions in the future. Drivers and conditions can be reinforced in a number of ways. This can be achieved with instructions, regulation letters and allocation of funds or through earmarked appropriations linked to specific assignments.

The Governance and Resource Investigation's Committee (Styr- och resursutredningen, Strut) on how governance and resources for universities should be developed will be important for the development of drivers and conditions for academic institutions. The final report of the Investigation will be presented in December 2018.

Drivers and conditions for individuals to take more responsibility for their own competence development needs to be strengthened to encourage active life-long learning and job mobility.

Such drivers and conditions will be important to stimulate and facilitate individuals' capacity for adaptation and lifelong learning, which will become increasingly important for the future's skills supply. This, in turn, will be of major significance for achieving a labour market dynamics and human trust in the rapid technological renewal and social transformation. In this context, network-based courses, such as MOOCs, which are not time- or location-dependent, should be covered by the study funding system. In addition, tax breaks, incentive programs or subsidies should be considered to create opportunities for individuals to take greater responsibility for their own skills development.

Government control and drivers for an innovative public administration will be very important for a value creating AI development that strikes a balance between business innovation and privacy, ethics and digital security.

For many public operations, the drivers to develop and apply AI are weak. These drivers originate in the governance of state and municipal operations. How such governance stimulates and requires innovation management and adaptation ability will be of great importance for AI development in Sweden. Trust-based governance, investigated by *Tillitsdelegationen* (the Swedish Trust Delegation) is an important part of such developed governance.

Developed state governance will be crucial for the utilisation of AI 's transformative potential in the development of systems solutions to address important social challenges and to achieve the targets in the 2030 Agenda for Sustainable Development.

The drivers of the public sector to develop new system solutions that address social challenges, where AI can play a central role, are even weaker than for an AI-based development in the context of individual public operations. Powerful development that addresses social challenges requires developed administrative governance, creating clear drivers for an innovative and collaborative public administration. Such a developed administrative governance needs to generate innovative drivers that cross policy areas, government boundaries, administrative boundaries and geographical boundaries.

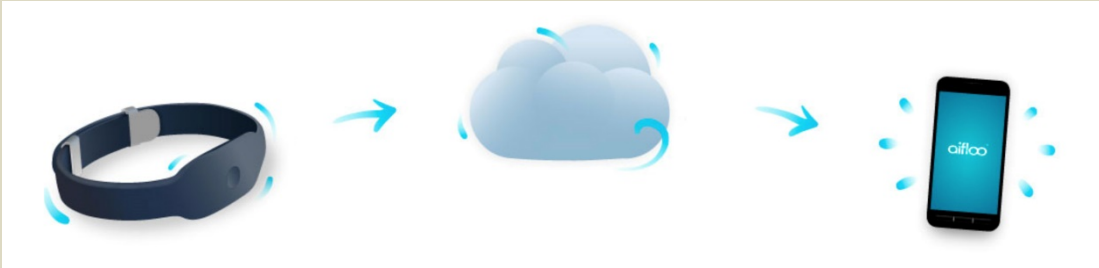
Examples of AI projects

AI improves the life of people in need of care

With a bracelet that alerts if something goes wrong, older people can maintain their independence while carers and relatives do not have to worry.

With a bracelet carried by recipients of home care services, it is possible to see where the bearer is located and how they move. If anything unforeseen happens, such as a fall, the system sends an alarm. The bracelet is combined with a cloud-based AI engine that facilitates smart movement analyses. Other functions include monitoring of whether the bearer has woken up and gotten out of bed, whether the person is eating or taking their medicine.

Aifloo SmartBand – "a self-taught e-health system for home care" was developed by Aifloo in cooperation with Skellefteå Municipality.



Remote controlled vehicles in mines result is safer mining operations

Remote controlled heavy goods vehicles will make mining both safer and more efficient. The project "Wireless and Remote Operation of Mobile Machines, WROOM" contributes to the vision of the independent mine.

The purpose of the WROOM project is to develop concept solutions for remote controlled loading in big wheeled loaders and remote monitoring of such machines. Machine learning is used to develop autonomous functions, such as automatic loading and proactive maintenance.

There are several advantages with remote controlled vehicles below ground. With the help of remote controlled wheeled loaders, loading can start directly after blasting. As a result, there is no need to wait for the mining sites to be ventilated so that staff can work below ground. This results in an improved work environment for employees.

Luleå University of Technology coordinates the project, with the participation of among others Boliden, Volvo CE, ABB, Oryx and RISE SICS Västerås.

Improve healthcare with AI and image analysis

AIDA is a project promoting research and innovation within artificial intelligence and medical image analysis, with the goal of improving healthcare.

There are great opportunities to improve image examinations using AI. For example, analysis of large data volumes can create a higher accuracy in diagnostics.

We know through research that current AI technology is very powerful, but because it is not adapted to healthcare, it has not yet achieved any notable benefit in this field. In AIDA, academics, healthcare and industry meet to create AI innovations. This cooperation results in decision support that creates patient benefit in healthcare. Cooperation between humans and machines is in focus. By using these respective strengths optimally, healthcare will significantly improve.

The project is led by Linköping University and today includes seven hospitals, five academic institutions, one major company and four small companies.

Deep learning improves the process industry

The Swedish process industry produces huge amounts of data and there is an untapped potential in these data, which can be utilized with new tools. *The project "Deep Process Learning" uses data from a board machine at BillerudKorsnäs in Gävle to investigate how analysis of large volumes of data with the help of deep learning algorithms can improve quality and efficiency.*

By analyzing large volumes of data, so-called deep learning, there is potential for increasing the competitiveness of the Swedish process industry through increased productivity, quality and flexibility.

Deep learning has the human brain as a model, and with the aid of algorithms, a system builds knowledge gradually, just as humans do. When the system has built knowledge, it can perceive patterns and better control our processes. In the longer term, the project hopes to inspire other industries to use their large volumes of data for development and process optimization. In 2018, the parties in the project will start a new initiative to develop web-based courses to spread knowledge on how these technologies can be used.

The project is a cooperation between BillerudKorsnäs, PulpEye, Peltarion, FindIT and RISE SICS Västerås, who leads the project.

AI improves breast cancer screening

Today's breast cancer screening has reduced mortality, yet about 1,500 women die annually in Sweden of breast cancer. AI could help reduce the number of deaths due to breast cancer by detecting tumors earlier.

By training deep learning with over one million mammography images combined with clinical data from the Breast Cancer Registry, decision support is produced in the "AI for Breast Cancer Screening" project.

The goal of the decision support is to identify easily assessed mammographs and to identify the women who benefit most from a supplementary study. The digital decision support can easily be distributed across the country and reduce regional differences in the screening system. The hope is that this will provide socioeconomic value with safer diagnosis and improve the efficiency of the mammography process in Swedish healthcare.

Karolinska University Hospital coordinates the project AI for Breast Cancer Screening with the participation of among others Regionalt Cancercentrum Stockholm-Gotland and Sectra AB.

Fredrik Strand Karolinska University Hospital, Photographer: Robert Sundberg

The projects were financed by Vinnova.

Vinnova's publications May 2018

Vinnova Report

VR 2018:

01 Social innovation i Sverige - *Kartläggning av ekosystemet för social innovation*

02 Innovationsplattformar för hållbara och attraktiva städer - *Analys och rekommendationer*

03 Från living labs till transition labs - *En forskningsöversikt och kartläggning av innovationsmiljöer för hållbara städer*

04 Slimmat, snabbt och svenskt - *Samverkan och ledarskap under Sverigeförhandlingen om höghastighetståg*

05 Staden som arena för innovation - *En studie av transformativ kapacitet, kommunens roll och Vinnovas påverkan*

06 Digitalisering - mer än teknik. *Kartläggning av svensk forskning och näringslivets behov*

07 Årsbok 2017 - *Svenskt deltagande i europeiska program för forskning och innovation*

08 Artificiell intelligens i svenskt näringsliv och samhälle - *Analys av utveckling och potential*. Slutrapport *(For English summary see VR 2018:09)*

09 Artificial intelligence in Swedish business and society - *Analysis of development and potential.* Summary *(For full Swedish version see VR 2018:08)*

VR 2017:

01 Att skapa förutsättningar för innovation - *Erfarenheter från "Idéslussar i kommuner - förstudie 2015"*

02 Testbäddar inom hälso- och sjukvård och äldreomsorg - *Portföljutvärdering av Vinnovas program*

03 Samband mellan immateriella tillgångar, innovation och ekonomisk tillväxt - *Två kunskapsöversikter*

04 På jakt bland forskare och managementkonsulter - *Klinisk forskning och praktiknära kunskapsutveckling inom managementområdet*

05 Utvärdering strategiska innovationsprogram – *Första utvärderingen av Innovair, BioInnovation, IoT Sverige, Smartare Elektroniksystem, SIO Grafen och Swelife*

06 Why manufacture in Sweden? *Strengths and best practice - a summary of "Flaggskeppsfabriken" (For full version in Swedish see VR 2016:07)*

VR 2016:

01 Third Evaluation of VINN Excellence Centres - *AFC, BiMaC Innovation, BIOMATCELL, CESC, CHASE, ECO2, Faste, FUNMAT, GHz, HELIX, Hero-m, iPack, Mobile Life, ProNova, SAMOT, SuMo & WINGQUIST*

02 Third Evaluation of Berzelii Centres - *Exselent, UPSC & Uppsala Berzelii*

03 NOVA - Verktyg och metoder för normkreativ innovation *(for English version see VR 2016:06)*

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05 This is about Change - *Ten years as an on-going evaluator of the Triple Steelix initiative (For Swedish version see VR 2015:05)*

06 NOVA – tools and methods for norm-creative innovation *(for Swedish version see VR 2016:03)*

07 Flaggskeppsfabriken - *Styrkor i svensk produktion (For summary in English see VR 2017:06)*

08 Flaggskeppsmetodiken - *En arbetsmetod för industriellt erfarenhetsutbyte*

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04 Öppna data 2014 - *Nulägesanalys*

05 Institute Excellence Centres - IEC -*En utvärdering av programmet*

06 The many Faces of Implementation

07 Slututvärdering Innovationsslussar inom hälso- och sjukvården

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03 Delredovisning av handlingsplan för jämställdhetsintegrering på Vinnova - *2015-2018*

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Vinnova is helping to strengthen Sweden´s innovation capacity

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