

Nordic-China AI Synergies

A Case Study of Business and Collaboration Opportunities
Between the Stockholm Region and China



北欧中国初创论坛
Nordic-China Startup Forum



KTH AI SOCIETY

This report has been made in collaboration between [Nordic-China Startup Forum](#) and [KTH AI Society](#).



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KTH AI Society is a student organization which works to connect KTH (Royal Institute of Technology) students of all majors with the fast evolving field of Artificial Intelligence.

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Introduction



Preface

This is a knowledge report which surveys the progress of AI implementation in China and explores how the Nordics - exemplified by Sweden and the Greater Stockholm Region - could position themselves in the light of China's development on the AI scene: What are the Nordic regions' points of strength relative to China when it comes to AI implementation, and how may those be leveraged to create sustainable growth?

Over the last few years, AI has returned to the headlines and to everyone's whiteboards and lunch chats. After spending some hazy decades as a vague, futuristic-sounding term, it has sprung to life again, now as a readily applicable real-world technology. The ongoing unfolding of the potential of this technology has even made it a key factor in a number of forecasts about the global economy and a requisite element in the economic strategies of major governments.

Most of this report was written before the pandemic, in the beginning of 2020. In some cases, circumstances may have changed since the time of writing. However, the advent of AI technology is not likely to be halted by the pandemic, even if some investments will be delayed. AI is a technology that cuts costs by simplifying processes. It's a technology that gives us more for less. If anything, that will be needed in the years following the pandemic.

AI is shaping up to be the most economically important technological advancement since electricity. It's arguably the most impactful component of a sweeping trend of digitization which also involves technologies such as cloud computing, blockchain and Internet of Things.

Even so, a lot of the perceived importance of AI technology seems to depend on future successes. While AI is already widely in use, the attention devoted to it rests on a belief that it's going to change over the coming decades from being an emerging technology to causing a major technological transformation. This is leading some to contend that AI may mostly be a hype phenomenon which will fade from view in just a few years.

There's no question that the hype is there. The term features on several lists of the most ubiquitous tech buzzwords of the year, and there are even multiple stories of fake AI startups pretending to be using AI just to get more funding. So the first question to ask is of course: Why is AI important enough that you should read this report? Is it really more than another buzzword that will be forgotten in a couple of years? Only time will provide the true answer. Until then, the best one can do is look at the analyses that have been made on the subject.

The report *Swedish IndTech: [How Artificial Intelligence & Digital Platforms Are Changing Industry](#)*, by [PiiA](#) and [Blue Institute](#), cites analyses from PwC, Accenture, McKinsey and Wall Street Journal, which all conclude that AI will come to contribute somewhere in the order of \$15 trillion to the world economy by 2030, or, in other words, that global GDP will be 14% higher by then than it would have been without AI¹.

Looking at the industrial sector², consultants estimate an annual productivity improvement of 1.2% caused by AI. This is higher than the productivity improvements caused by other technological breakthroughs such as the steam engine and electricity.

¹ [Swedish IndTech: *How Artificial Intelligence & Digital Platforms Are Changing Industry*](#) (PiiA and Blue Institute 2019)

² Here specifically the resources, process and manufacturing industry.

The report's verdict is clear:

“The movement that has now been set in motion has few parallels in history in terms of change potential. For companies and businesses, it means that there will be few, if any, players who can afford to pass up the competitive improvements that AI will eventually deliver.”³

Although this prediction could still turn out wrong, it seems to be shared by some major players, including the governments of the world's two largest economies, USA and China, both of whom have been heavily increasing their investments in AI during the last few years.^{4 5}

The Swedish Innovation Agency, Vinnova, in its 2018 report on the potentials for AI implementation in Sweden, also finds that AI is likely to be an extremely economically impactful technology in the near future⁶.

This supports the hypothesis that the hype about AI is built on a strong foundation of true technological and economical significance. And if this is the case, it's also essential for Sweden and the Greater Stockholm Region to pay close attention to the development and implementation of AI technology and work to leverage advantages and close eventual gaps. There are already several great Swedish AI initiatives working on this on a general level: [AI Innovation of Sweden](#) is building a general platform for Swedish AI transformation, and [Vinnova](#) has already published [an extensive report](#) on Sweden's AI potential. But the subject also merits a range of more narrow, focused efforts such as the one presented here. This report focuses specifically on developments seen in China and in Sweden's Greater Stockholm Region. As such, it's an experiment in drafting a report that is both sector-specific and bilateral.

Motivations and outline

Crude figures seem to suggest that China is 2nd in the world in AI overall. According to a 2019 report by Center For Data Innovation⁷, China is behind the US but ahead of Europe when aggregating a range of parameters including talent, research, development, adoption, data and hardware.

Category	China	European Union	United States
Talent	3	2	1
Research	3	2	1
Development	3	2	1
Adoption	1	2	3
Data	1	3	2
Hardware	2	3	1

That in itself makes China an important player on the AI world stage. But aside from this, there are three different and much more specific reasons why China is important to take into consideration right now.

³ [Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry](#) (PiiA and Blue Institute 2019)

⁴ Finding Artificial Intelligence Money in the 2020 Fiscal Budget (Bloomberg Government)

⁵ [State Council Issuing New Generation Artificial Intelligence Plan \(FLIA\)](#)

⁶ [Artificial Intelligence in Swedish Business and Society](#), Vinnova 2018

⁷ [Who Is Winning The AI Race: China, The EU or The United States?](#), Daniel Castro, Michael McLaughlin, and Eline Chivot, Center For Data Innovation 2019

They are as follows:

1. China is officially **in the middle of a transition** from an exports based economy to a consumer economy, in which AI implementation plays a central role.⁸
2. China's extremely fast technological and economic development means that they are **attempting to leapfrog** some intermediate technological steps, such as non-AI computerization in manufacturing and credit cards in payment. This has both positive and negative effects, which will be explored below.
3. China is **investing significant amounts** of funds specifically into AI. In 2017, the Chinese government released its "New Generation of Artificial Intelligence Development Plan"⁹, aiming to produce an AI sector worth \$150 billion by 2030. This has entailed strong incentives and very good funding opportunities for AI related businesses.

These factors suggest that China will continue to invest in AI over the coming years. Furthermore, given that China aspires to develop a high-tech sector on par with developed economies, it is also likely that a considerable amount of their investments will be into foreign assets for the purpose of technology transfer. The onset of the US-China trade dispute in 2018 has accelerated China's need for technological self-reliance and also spurred China to look for technology-advancing investments in other developed countries than the US. For this purpose, a country like Sweden is highly relevant.

The report may be viewed as a case study with Sweden as case country and Sweden's Greater Stockholm Region as case region, exploring the ways in which Nordic countries and regions can approach business and collaboration with China in the field of AI. The regional focus is useful because a lot of the framework for investment is created - and a lot of decisions about investments made - on regional and local levels rather than the national level. The ultimate purpose of this report is then to help identify what opportunities the comparative state of AI development in Sweden and China presents for the Greater Stockholm Region. This of course necessitates the supplementary objectives of surveying the current state of AI implementation in China and the current state of - and conditions for - AI implementation in Sweden and the Greater Stockholm Region.

The question is not so much which country is doing best at implementing AI. The main question is: Which competences does Sweden and the Greater Stockholm Region possess that play into the demands spawned from China's quest to become a leading AI nation? And how can the Greater Stockholm Region leverage these competences for sustainable growth?

The report is directed at Chinese and other businesspeople considering investing in Sweden, businesspeople and public officials from the Greater Stockholm Region looking to understand the region's potential and how it can leverage its AI strengths in links with international markets, and anyone else who's interested in learning more about the status of AI implementation in China or in Sweden or how they potentially relate to each other.

The first part of the report takes a look at China's AI landscape: What are their strengths? What are their weaknesses? Why is China strong in some aspects and weak in others? What are their challenges? What are they in need of? What does the future hold in store for Chinese AI?

To understand what the Greater Stockholm Region has to offer which may match China's demand, the relevant advantages held by Sweden will then be analyzed, followed by the specific advantages held by the Greater Stockholm Region. A discussion then follows of how Sweden and the Greater Stockholm Region can leverage these advantages for sustainable growth. Finally, a case study of an AI implementation from the Greater Stockholm Region will be presented which demonstrates some of the various competencies of the region that may be relevant for creating sustainable growth through doing business with China.

8 China unveils economic blueprint for 2016 (Permanent Mission of the People's Republic of China To The United Nations and Other International Organizations In Vienna)

9 State Council Issuing New Generation Artificial Intelligence Plan (FIJA)

Scope and limitations

The report is meant to inspire readers, point out opportunities, and encourage you to seek further information. All data, quotes and statements in this document are backed up with references. However, note that this is not an academic report and does not adhere to academic standards. It is also not a consulting report. The information presented should not be seen as advice but rather as suggestions for further consideration and research.

Everything said about China should be taken with some reservations in light of China's size and complexity. Conclusions are based on books, reports and articles listed in the footnotes, as well as a research trip to Beijing, Guangzhou, Shenzhen and Shanghai in November 2019 including interviews with a dozen Chinese field experts and AI professionals. It's inevitable that there are many things happening in China which would be relevant to this report but of which the authors are not aware. Findings about Sweden are based on reports and articles listed in the footnotes, and interviews with professors, ecosystem actors, startups and AI professionals.

The footnotes of this report contain links to a large amount of articles, research papers and other reports which can provide further reading for anyone interested in AI.

In the sections about the conditions for AI implementation in Sweden, the emphasis is on Sweden's advantages – especially where Sweden has an advantage compared to China. Any potential Swedish weaknesses have not been the focus of investigation. Descriptions of Sweden's AI development and the AI ecosystem in the Greater Stockholm Region are not exhaustive.

This report is about the business perspectives of AI implementation. It does not concern itself with the societal or ethical aspects of AI. If you're interested in these topics, the work of the [AI Sustainability Center](#) is recommended for further reading on how AI can be integrated into society in a secure and responsible way.

Definitions

AI: Artificial Intelligence (AI) is a discipline within Computer Science founded in 1956. Very early on, three sub-disciplines were established:

- Knowledge Representation (KR), established in 1959
- Automated Reasoning (AR), established in 1957
- Machine Learning (ML), established in 1959.

Since the early days, work in Artificial Intelligence has been divided into symbolic approaches (with logic as the major paradigm) and sub-symbolic approaches (with artificial neural networks as the major paradigm).

Furthermore, over the years, a growing set of application areas have been defined:

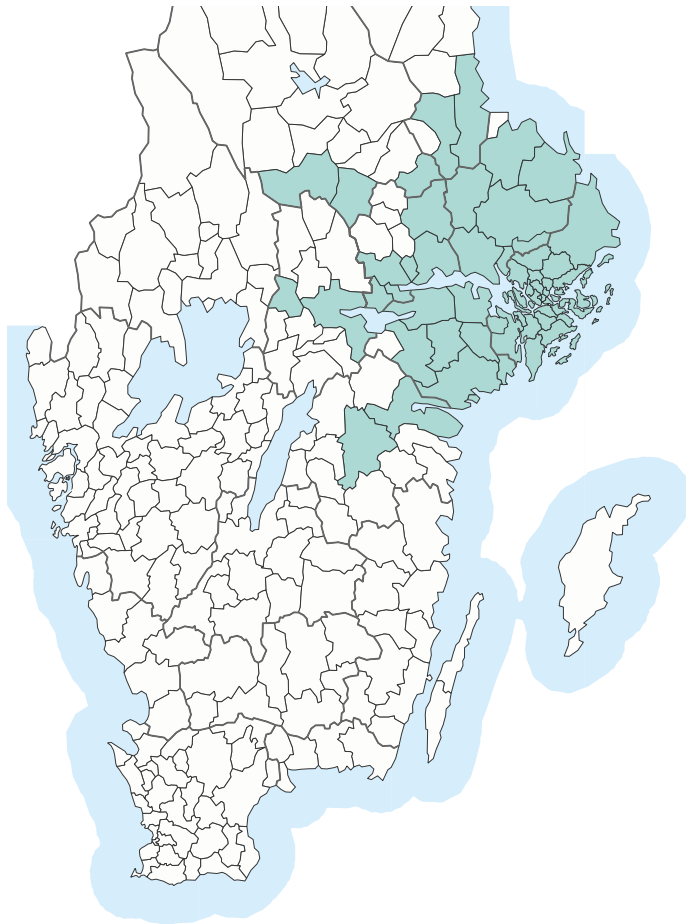
- Expert Systems – Decision support and advice giving systems
 - Adaptive control of technical systems
 - Data mining or Data Analytics
 - Text mining or Text Analytics
 - Speech Recognition
 - Image Recognition – Computer Vision
 - Video analysis.
 - Robotics
-

To classify systems that claim to be using Artificial Intelligence, the three dimensions above is still the most appropriate model. As an example, a particular system may be characterized as doing **image recognition** using a **sub-symbolic machine learning approach**.¹⁰

AI's recent return to the spotlight is, to a high degree, a result of vastly increased data availability, helped along by a scientific breakthrough in machine learning algorithms in 2012¹¹, and continually increasing processing power.

AI implementation: "AI implementation" is used interchangeably with "AI application". It means the productive use of AI technology for practical purposes. The focus of this report is on AI implementation, which means that attention is only focused on research and development of AI technology to the extent that it determines implementation.

The Greater Stockholm Region: The Greater Stockholm Region is a partnership of 56 municipalities across eight counties in East Middle Sweden. The focus of the partnership is to attract foreign direct investments and international talents to the region.



¹⁰ This definition has been given by Carl-Gustaf Jansson, Professor emeritus of Artificial Intelligence at KTH.

¹¹ [AlexNet](#) (Wikipedia)

Executive summary

The report consists of three main chapters. The first part surveys AI implementation in China. The second part surveys AI implementation in Sweden as a whole and in the Greater Stockholm Region in particular. The third part discusses how AI implementation in China, Sweden and the Greater Stockholm Region may be utilized to create sustainable growth.

These are the findings from each of the three chapters:

1. China

China holds a general lead in AI adoption. It has by far the highest amount of workers employed in an enterprise that uses AI. China's lead in AI is partly a result of a 2017 government plan pledging up to 1 trillion RMB to the goal of becoming world leading in AI by 2030. China's drive to transform with AI is partially a consequence of the fact that China needs to raise worker productivity in order to transition from an exports economy to a consumer economy. A more digitalized society can also mean that Chinese companies enjoy easier access to person-related data.

China is competitive mainly in AI implementations that rely on user data and digitally native implementations that may be scaled with little effort. On metrics of impact of AI research, the available figures show China to be lagging behind the US. China is also facing challenges attempting to achieve transformation in areas that require profound levels of domain expertise, such as healthcare and most heavy industry sectors. China has put policies in place in order to make up for a deficit in ground research and in AI talent availability.

China's software hub in Beijing and its hardware hub in Shenzhen are major sources of innovation within AI implementation.

2. The Nordic regions

At first glance, Sweden does not match the AI adoption levels of countries like China and the USA. However, awareness of the importance of AI has been raised through several initiatives put in place to promote its development and adoption, including the collaborative government/industry/university initiative AI Innovation of Sweden. The WASP foundation has donated \$550 million to the purpose of educating talents in AI and related fields.

Whereas Sweden is behind in AI adoption as of yet, it is in a superior position to implement AI in certain sectors. Sweden's state-of-the-art industrial sector and accumulated domain knowledge in a wide range of industrial areas over a hundred years put Sweden at an advantage compared to China whose economic rise has happened so recently that a lot of its industrial facilities have not been able to keep up and are therefore still unfit for AI transformation.

In addition to this, Sweden boasts a highly educated workforce with a concentration of workers in fields relevant to AI implementation. There is also a well-developed system of organizations that makes professional networks more integrated, which is important because successful AI implementation has been shown to be especially dependent on interdisciplinary cooperation in teams.

While China has a strong personal data advantage, Sweden is doing well at providing access to public, non-personal data.

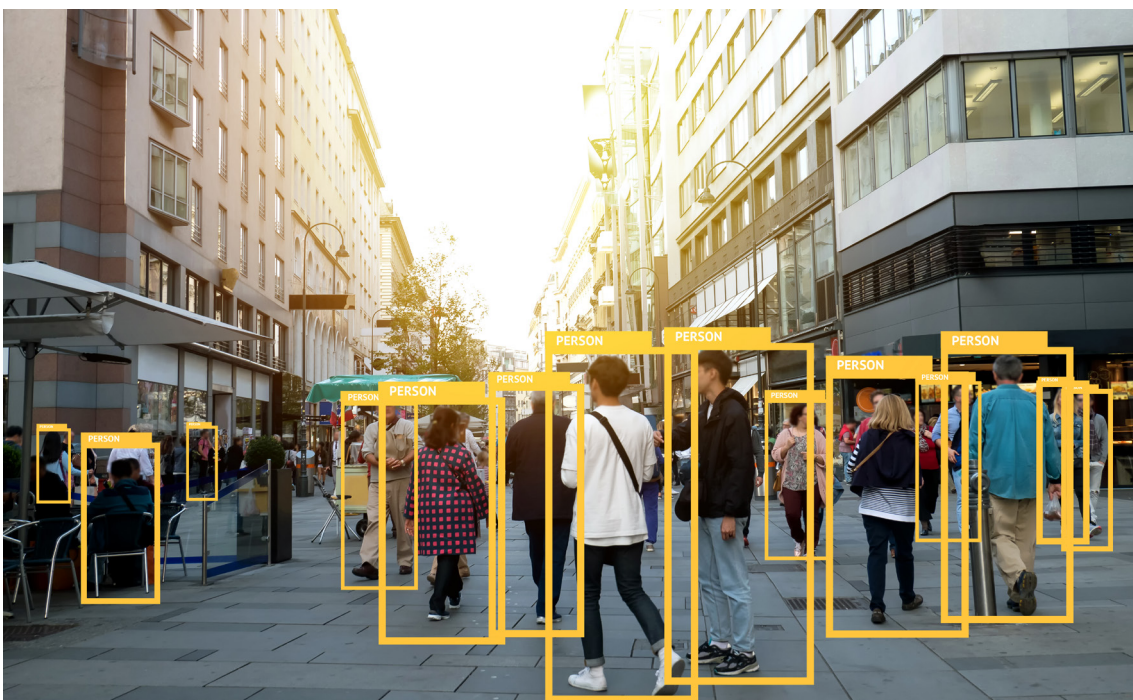
Stockholm is one of Sweden's leading ICT hubs and has one of the most vibrant innovation ecosystems in Europe. The Greater Stockholm Area is home to a great deal of advanced manufacturing plants and other industrial facilities. The greater part of Sweden's best research institutions are also located here. The Greater Stockholm Region has a range of clusters in healthtech, fintech, gaming, telecommunication, manufacturing, smart mobility and clean energy which are all implementing AI.

3. Leveraging Nordic advantages for sustainable growth

In order to leverage its advantages, Nordic regions could focus on their strengths and China's points of need. Here are three examples of how this could be done in the Greater Stockholm Region:

- Swedish companies with competitive AI applications could try to enter the Chinese market. Competition on narrow AI applications is tough and the Chinese market is difficult to access, so in order for this to work, one could focus on those applications that build on very specific domain knowledge that is well developed in Sweden. Examples could be things like AI for cross-country skiing, human-robot interaction in industrial settings, or AI-driven power distribution networks for solar panels. When entering the Chinese market, it's essential to build personal contacts first. The startup scene in Stockholm is in a good position to produce start-ups with a chance of success in China.
- The Greater Stockholm Region could attract investments from Chinese enterprises wanting to gain access to important technology, human capital or data in order to prepare their industry for AI transformation. Using takeovers to catch up technologically is an officially declared Chinese strategy. Foreign investments or takeovers – such as the case of Geely's takeover of Volvo Cars – have so far proven to be beneficial for the host region, and they might provide the affected enterprises with better access to the Chinese market. However, research shows that depending on circumstances, foreign takeovers are not always beneficial for the host region, so careful analysis will be necessary.
- The Greater Stockholm Region could attract Chinese enterprises to set up R&D centres for R&D collaboration with local enterprises. This could create high-skill jobs in the region and attract talents, as witnessed in Gothenburg when Geely set up R&D there after acquiring Volvo Cars. This could be a good opportunity because it plays into several of Sweden's strengths: domain knowledge, availability of AI relevant talents, as well as systems and organizational competence. Offshore R&D locations are usually chosen for quality of R&D personnel, quality of IP protection, and possibility of collaborating with high-quality universities. The Greater Stockholm Region is considered competitive on all of these parameters.

Some areas of relevance for such collaboration are sectors such as clean energy, pharmaceuticals, construction or manufacturing, as these are areas where China may need to look abroad. While exploring business opportunities, it's important to ensure that there is a fundament of mutual trust in place between Swedish and Chinese business actors. In order to secure such an environment, a solid legal framework regarding IP protection for collaboration between Swedish and Chinese enterprises is recommended.



**China's AI
developments**



In this section, a brief account of AI implementation in China is presented: The achievements, the challenges, the future prospects, and some of the underlying factors that govern the development.

China's AI achievements

The first thing one notices about AI in China is that everybody is talking about it. In Europe, AI is still a strange, futuristic-sounding concept to everyone except the biggest corporations and those who happen to be engaged in data science. In China, big corporations as well as a large quantity of SMEs are all very aware of the importance of AI and in the process of implementing it. This is reflected in the figures below, which show that China has a larger proportion of workers working in firms using AI than Europe or the US:

Workers in firms implementing AI ¹²

Year	Metric	Weight	Metrics			Scores		
			CN	EU	US	CN	EU	US
2018	Number of Workers in Firms Adopting AI (Rank)	5	1	2	3	3.8	0.7	0.5
2018	Number of Workers in Firms Piloting AI (Rank)	5	1	2	3	3.9	0.6	0.5
	Total Scores	10				7.7	1.3	1.0

But it's not just the business world that's acutely aware of the importance of implementing new technology. In October 2019, president Xi Jinping talked about the importance of blockchain technology in an official speech. Although AI and blockchain are different things, this still shows a level of interest in new technology that has yet to be seen in Europe. It would be hard to imagine the Swedish prime minister mentioning blockchain in an official speech.

“AI is a very hot topic in China. No CIO is uninterested in AI. So every company has some sort of AI plan. It may be for right now or 12 months or 3 years later but every CIO has a plan. Chinese companies are also more aggressive in exploring AI for more than just one use case. When I talk to enterprises in other parts of the world, they're still trying to understand what AI is and what it can benefit them. The question in China is: Where should I implement AI? They already know it's important.”

CK Lu, Senior Director Analyst at Gartner

Interviews with big tech companies in China reveal that most of them have a dedicated AI innovation team ¹³.

With all this in mind, it should come as no surprise that China is ranked 1st in the world in AI adoption. But how did this happen?

¹² *Who Is Winning The AI Race: China, The EU or The United States?*, Daniel Castro, Michael McLaughlin, and Eline Chivot, Center For Data Innovation 2019

¹³ Source: interviews with AI innovation professionals at several of the dominant Chinese tech companies. Some companies even have more than one team, employing the method of “horse racing”, where several teams are put to work separately on reaching a certain milestone and the first one to reach it is kept while the others are discontinued.

Why is China number one in the world at adopting AI?

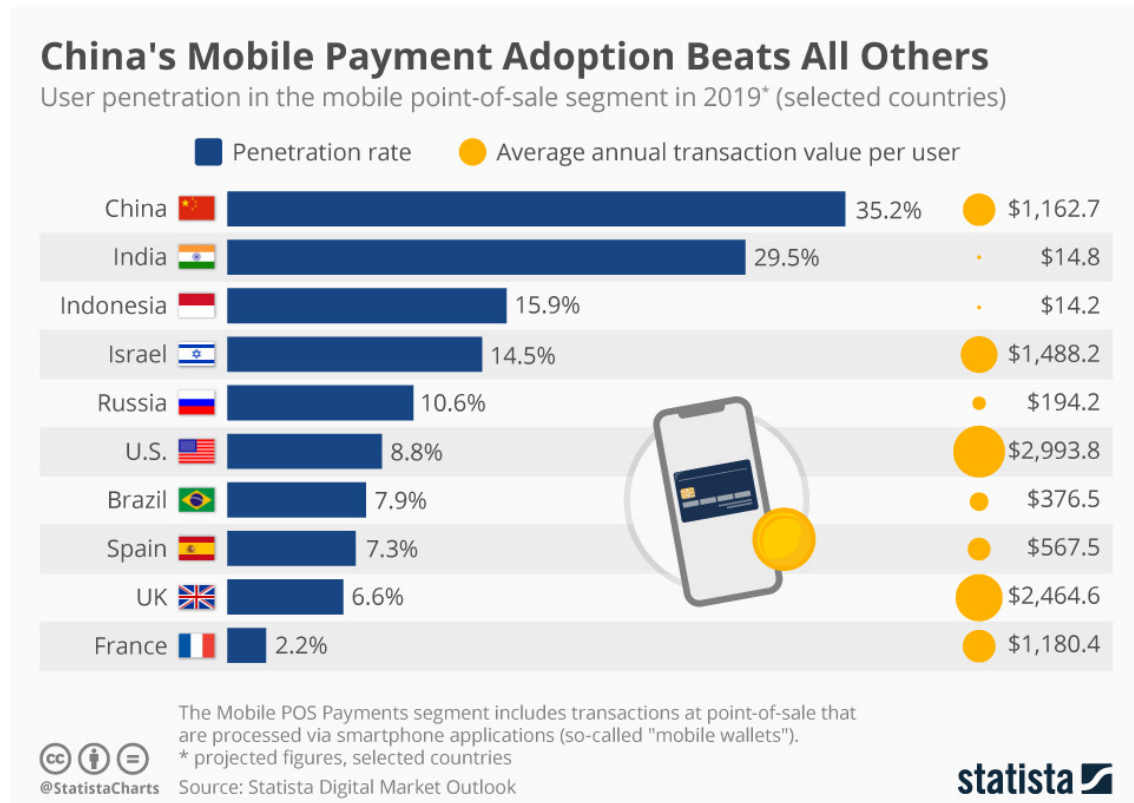
Three main reasons for China's success at AI adoption:

1. China's data advantage
2. The general high speed of China's tech sector
3. The government's commitment to AI

Data

If you've gone to China and gotten into an awkward situation because you thought you could pay with your Visa card like anywhere else in the world but then it turned out you couldn't, you're not the only one. Most payment in China happens through mobile apps. Mobile payment has permeated society much deeper in China than in the West. Even the scrappiest noodle joints in the outskirts of Beijing receive payment through apps, and even beggars sometimes wear a slip around their neck with their WeChat or AliPay QR code which you can scan with your phone to give them alms. This is because China, going through centuries' worth of economic and societal development in a matter of a few decades, has simply leapfrogged credit card technology and gone straight from cash to mobile payment. The same thing is happening in several other areas as well.

The following figure¹⁴ shows how much more widespread mobile payment is in China than in the West. The numbers are from 2018 and they're certainly even higher now:



14 Source: [China's Mobile Payment Adoption Beats All Others](#) (Statista)

Payment happens through WeChat and AliPay; the two Chinese “super apps”, owned by Tencent and Alibaba respectively, on which you can handle anything from chatting with friends to booking plane tickets to streaming music and playing games. Collecting data for training machine learning models is extremely important for Tencent and Alibaba. AliPay even [provides millions of free ebikes](#) in Chinese cities for the purpose of collecting extensive GPS data on citizens’ movements, which they can then either use themselves or sell to third parties.¹⁵ The unprecedented amounts of user data collected by these apps are shared with allies in the tech ecosystem, enabling many players to build advanced ecommerce frameworks, customer recommendation algorithms and many other kinds of consumer-oriented AI algorithms.¹⁶ Even for small companies who don’t get to dig into Tencent or Alibaba’s treasure troves of data, it’s easy to quickly gather a lot of personal data from users because of how well developed mobile infrastructure is (with different apps connected and sharing data and apps serving as platforms for other apps), because of how accustomed the population is to using their phones for everything, and because there has never been a “privacy” awakening in China like there has in Europe and the US.

As a result, the amount of user data available to tech companies, and the speed with which they are able to collect it, allows for very smooth AI adoption in digital and consumer-oriented contexts.

Speed

Besides the data advantage, several experts have pointed out that another important factor is the speed of the Chinese tech sector.

Chinese-American Andrew Ng, who has led teams at both Google and Baidu, notes that “Consumer products seem to have the ability to go from 0 to 100 much faster in China than in the US”¹⁷. This is in line with data collected from interviews with Chinese professionals.

Nina Xiang, author of a 2019 book about the state of Chinese AI, notes that “In China’s hypercompetitive environment, companies race each other to launch products and expand sales. A Chinese autonomous vehicle startup is able to put a demo car on the road for testing in just six months, while elsewhere, it would likely take much longer to achieve this.”¹⁸

“Chinese companies are first and foremost market-driven. Their ultimate goal is to make money, and they’re willing to create any product, adopt any model, or go into any business that will accomplish that objective. ... It doesn’t matter where an idea came from or who came up with it. All that matters is whether you can execute it to make a financial profit.”

Kai-Fu Lee, AI Superpowers

The speed factor is also visible when you run the raw numbers on Chinese AI. The Chinese AI industry grew by about 60% year-on-year between 2016 and 2018 and is expected to maintain or even quicken its pace in the next few years.¹⁹ Chinese tech’s quick pace, dynamic market and breakneck competition makes innovation more important, spurring companies to find new ways to use AI to get an edge.

Government

Thirdly, the government’s previously mentioned unsparing commitment to AI has resulted in ample funding opportunities and friendly policies, which is also driving AI adoption. Advantages include low-rent high-tech zones, grant funds without equity, and sophisticated “[guiding funds](#)” with cash incentives. But the government’s commitment to AI also helps businesses beyond just funding. For example, an employee at the EdTech startup Imagimaker in Shenzhen reports that her company turns a profit delivering tools for AI and Robotics classes that the government specifically requires schools to teach.

¹⁵ [Alipay app unlocks 6 bike-sharing services](#) (China Daily)

¹⁶ [JD.com builds a coalition to challenge e-commerce king Alibaba](#) (Nikkei Asian Review)

¹⁷ [China’s AI market to hit 71 bn yuan](#) (Asia Times)

¹⁸ [Red AI: Victories And Warnings From China’s Rise In Artificial Intelligence](#) (Nina Xiang 2019)

¹⁹ [China’s AI market to hit 71 bn yuan](#) (Asia Times)

The government has selected 15 national “AI champions” and tasked each with managing a “National AI Open Innovation Platform” within a certain field of AI development.²⁰ These champions comprise all of the biggest AI players in China, and they are expected to receive large chunks of the 2017 AI plan funds as well as strong support in regulatory and administrative matters:

Baidu:	Autonomous Driving
AliCloud (AliBaba):	Smart Cities
Tencent:	Medical Imaging
iFlyTek:	Voice Recognition
SenseTime:	Computer Vision
Yitu:	Visual Computing
MiningLamp AI Group:	Intelligent Marketing
Huawei:	Basic Software and Hardware
Ping'an Group:	Financial Inclusion
HIK Vision:	Video Perception
JD.com:	Intelligent Supply Chain
Megvii:	Image Perception
360 Qihoo:	Digital security
TAL Education:	Intelligent Education
Xiaomi:	Smart Homes

China's AI challenges

Reading the previous paragraphs, one might get the impression that China is soaring ahead in AI development with no clouds on the horizon. When looking at industry size, expected growth, total venture capital fundraising, and the numbers of Chinese AI startups and AI unicorns, China does come either first or second after the US. However, China is only leading the field when looking at these quite specific parameters. The table below presents a more sobering view:

Development metric and scores²¹

Year	Metric	Weight	Metrics			Scores		
			CN	EU	US	CN	EU	US
2017-18	VC + PE Funding (Billions)	5	\$13.5	\$2.8	\$16.9	2.0	0.4	2.5
2017-18	Number of VC + PE Deals	2	390	660	1,270	0.3	0.6	1.1
2000-19	Number of Acquisitions of AI Firms	2	9	139	526	0.0	0.4	1.6
2017	Number of AI Start-ups	4	383	726	1,393	0.6	1.2	2.2
2019	Number of AI Firms That Have Received More Than \$1 Million in Funding	4	224	762	1,727	0.3	1.1	2.5
1960-2018	Highly Cited AI Patent Families	3	691	2,985	28,031	0.1	0.3	2.7
1960-2018	Patent Cooperation Treaty AI Patents	5	1,085	1,074	1,863	1.3	1.3	2.3
	Total Scores	25				7.7	1.3	1.0

20 “15家国家新一代人工智能开放创新平台” (Baidu)

21 *Who Is Winning The AI Race: China, The EU or The United States?*, Daniel Castro, Michael McLaughlin, and Eline Chivot, Center For Data Innovation 2019

A casual look at the top 10 most funded Chinese AI startups can help give an impression of the nature of China's strengths and weaknesses when it comes to AI implementation:

Company	Funding (mn US\$)	Field
SenseTime	3260	Face recognition
Megvii	1357	Face recognition
UBTech	940	Social Robots
CloudWalk	804	Face recognition
MiningLamp	786	Big data
Horizon Robotics	700	AI Chips, autonomous cars
Pateo	540	Autonomous cars
Terminus	529	Smart cities
Yitu Technology	411	Computer vision
4Paradigm	375	Big data

22

As the list indicates, China is doing well at face recognition and other computer vision technology, as well as FinTech and Smart City solutions. Absent from the list are globally important sectors for AI implementation such as manufacturing, agriculture and health care.

The resulting impression is that China is doing well in areas that are mostly digital but less well in areas where AI implementation relies on advanced technological infrastructure and highly trained personnel to be in place.

The concept of **scale without mass** is key. Unlike physical products, which have high fixed costs plus substantial marginal costs that are reduced per unit should production be scaled up, digital products, for the most part, have near-zero fixed costs and marginal costs. With the internet as a distribution network, it is therefore possible for companies with small fixed assets and a low number of employees to quickly scale up to become international businesses.²³

While the above list can only give hints and does not in itself prove anything about the overall state of Chinese AI, the impression is coherent with overall findings.

It is also important to note that China's previously mentioned data advantage, while tangible and important, is also quite narrow. It is fair to say that China has an advantage in terms of the amount of data about users that is available to businesses.²⁴ But for other forms of data relevant to AI implementation, China does not hold the advantage. Research indicates that there is little availability of public data in China. While some datasets have been made available by the authorities for the purpose of training AI models, these are few and far between. The public sector in China is not yet as digitized as in Western Europe or America. In the heavy industry sector, data collection is also lacklustre compared to Europe and America.

A clunky industrial transition

In 2015, Chinese premier Li Keqiang announced China's **Made In China 2025** plan. This plan outlines China's quest to transition from a manufacturing based economy to a consumer economy. Basically speaking, as Chinese wage levels continue to rise, gradually enabling the growing Chinese middle class to keep the wheels of the economy running through consumption, the average productivity of all workers must be raised in order to finance the higher wages.

22 As of June 2020. Source: *China Internet Report 2020*, South China Morning Post and Abacus News

23 This paragraph taken from the report *Swedish IndTech: How Artificial Intelligence And Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019

24 The Chinese authorities also possess unrivaled amounts of surveillance data from surveillance cameras, which is one of the main reasons for China's superiority at Face Recognition AI, but they are very selective about who this data is made available to.

This is an absolutely necessary transition if China wants to sustain economic growth, and automation is at the heart of it, along with education. China's need for automation is only made clearer by the fact that they have a shrinking working-age population as a consequence of their former one-child policy. This means that concerns about automation causing job losses are not as voiced in China compared to Europe or the US.

The **Made In China 2025** plan received lots of media attention upon its release, but little attention was paid to the description it included of the state of Chinese industry in 2015: "China is still in the process of industrialization, and there is a massive gap compared with advanced countries. Our manufacturing industry is big but not strong, independent innovation capability is weak, the core technologies and high-end equipment are highly dependent on foreign imports, ... the level of digitalization is not high, and the degree of industrial internationalization is not high, and the ability of enterprises to operate globally is insufficient."²⁵

That was in 2015. Industrial automation has been a high priority since then, with considerable government subsidies given out to manufacturers who automate their production. But there is still a long way to go. According to CSIS: "While China has become the largest market for industrial robots, its robotic usage remains low compared to its massive labor force. In 2018, there were 140 robots per 10,000 employees in China's manufacturing industry. This is a large increase from just 25 robots per 10,000 employees in 2013, but China was still 20th globally in 2018."²⁶ According to Nina Xiang, industrial robot penetration in non-automotive sectors was at 1:11 that of developed countries the same year.

The speed of China's development means that many production facilities are already outdated. In Northern Europe, AI and IIoT²⁷ implementation is merely the next step after a computerization and digitalization that happened during the last three decades and which has introduced large scale data collection into the heavy industries and populated factories with workers who possess the necessary skills for learning to operate digital platforms.²⁸ These are crucial prerequisites for AI-based IIoT implementation. In China, in many cases, the industry is attempting to leapfrog the intermediate steps, turning sub-standard factories with less skilled workers into AI-powered, automated factories. Needless to say, this generally requires much more investment and a more thorough transformation. The upside is that the potential economic gain is even bigger.

"A lot of factories in China, are just some of the local people with a few friends, starting a small factory and making some really simple stuff. To become a pro, you don't just need a robotic line. You need to know how to manage the system. When we talk to industrial robotics clients, some of them don't understand how digitalization and automation can help them. They think they're doing okay even though they won't be growing much. But they'll be going out of business in two years. For them to fully embrace the changes, that's an issue we'll face in the next years."

Sean Xiaoyi Yu, manager at JD.com's AI accelerator

AI is easy to implement for some industrial purposes but extremely difficult for others. If a product being manufactured or its production process is very complex, then so is the data collection and the processing of the data. The depth of domain understanding required in order to explain a problem well enough to an AI for the AI to produce the desired effectivization can be a bottleneck for AI implementation in some industrial contexts.²⁹

Another challenge for China is relying on foreign imports for key components across most heavy industry sectors.³⁰ This is especially a problem in the light of the currently ongoing trade dispute between the US and China. Becoming more self-reliant across all industry sectors has turned into a top priority for China in recent years. Within AI specifically, entrepreneurs have expressed concerns that the US might try to cut off access to essential software platforms provided by American companies.

25 *China's Made In China 2025 plan, as quoted in Red AI, Victories And Warnings From China's Rise In Artificial Intelligence* (Nina Xiang 2019)

26 *Is China ready for intelligent automation?* (ChinaPower)

27 "Industrial Internet of Things"

28 See *Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry* (PiiA and Blue Institute 2019)

29 *ChinAI #58: Making Knives Better & Landscape of China's Intelligent Manufacturing* (ChinAI newsletter)

30 *Red AI: Victories And Warning From China's Rise In Artificial Intelligence* (Nina Xiang 2019)

Shortage of talent

According to interviewed experts, China's HealthTech sector is encountering some of the same difficulties as the manufacturing sector: lack of digitalization, lack of organized data collection, and lack of standardized data formats. Aside from that, China's challenges in this sector also highlight another characteristic of China's AI ecosystem: its reliance on low-cost labour.

For data to be useful to a perception-based AI, the data needs to be labelled first. China has relied on low-cost labour for this usually very simple task (for example, looking at a picture and noting whether there is a bird in the picture or not), with data labelling centres popping up in poor areas in Western China, labelling data for tech companies in rich major cities in Eastern China³¹. However, when an AI is used for a task such as recognizing cancerous tumors on X-ray images, which is currently one of the most prevalent uses of AI in healthcare, the task of labelling can only be handled by a trained radiologist, and those are very difficult to come by. In 2017, China had 80,000 radiologists for the task of diagnosing 1.4 billion radiology scans per year³². This is why China urgently needs to use AI for this task but also why amassing the necessary labelled data is arduous and expensive.

Radiologists are not the only human resource in short supply in China. As shown below, China is also in great need of more AI researchers:

Talent metric and scores³³

Year	Metric	Weight	Metrics			Scores		
			CN	EU	US	CN	EU	US
2017	Number of AI Researchers	5	18,232	43,064	28,536	1.0	2.4	1.6
2017	Number of Top AI Researchers (H-Index)	5	977	5,787	5,158	0.4	2.4	2.2
2018	Number of Top AI Researchers (Academic Conferences)	3	2,525	4,840	10,295	0.4	0.8	1.7
2018	Educating Top AI Researchers	2	11%	21%	44%	0.3	0.6	1.2
	Total Scores	15				2.1	6.2	6.7

... and AI research:

Research metric and scores³⁴

Year	Metric	Weight	Metrics			Scores		
			CN	EU	US	CN	EU	US
2017	Number of AI Papers	5	15,199	14,776	10,287	1.9	1.8	1.3
2017	Field-weighted Citation Impact	4	0.9	1.2	1.8	0.9	1.2	1.8
2018	Top 100 Software and Computer Service Firms for R&D Spending	3	12	13	62	0.4	0.4	2.1
2018	R&D Spending by Software and Computer Service Firms in Top 2,500 (Billions)	3	\$11.8	\$10.1	\$77.4	0.4	0.3	2.3
	Total Scores	15				3.6	3.8	7.6

Even though China is ahead when comparing the sheer number of AI related research papers published, Abacus News contends that the significance of China's AI research output is still relatively lower than the US or EU.³⁵ China is behind in influential, foundational research.³⁶ This is a problem because the next game-changing breakthrough in AI is likely to come from this kind of research, and China is at risk of falling behind when it happens.

31 [China's Success at AI Has Relied On Good Data](#) (The Economist)

32 [AI Technology from China Helps Radiologists Detect Lung Cancer](#) (Inside HPC)

33 [Who Is Winning The AI Race: China, The EU or The United States?](#), Daniel Castro, Michael McLaughlin, and Eline Chivot, Center For Data Innovation 2019

34 [Who Is Winning The AI Race: China, The EU or The United States?](#), Daniel Castro, Michael McLaughlin, and Eline Chivot, Center For Data Innovation 2019

35 [Report shows China publishes the most AI research papers, but they lack impact](#) (South China Morning Post)

36 [Develop, Nurture and Care for Our Own English Scientific Journals](#), 11 (Wang Jingxiu 2015)

New research from Macro Polo³⁷ shows that 56% of Chinese top-tier AI researchers end up studying and working in the USA. If this trend did not exist, China would be on par with the US on the number of top-tier AI researchers. This is one reason why America's current push to decouple from China^{38 39}, which involves making it harder for Chinese students to get and keep student visas, might backfire.

Chinese policies aimed at surmounting their AI challenges

The fact that China is behind in all of these areas is something they are well aware of and working to amend.

Industry subsidies

To boost automation in manufacturing, China is giving out subsidies. Guangdong province – China and the world's primary manufacturing powerhouse – has pledged 943 million yuan (\$138mn) to expand the local robotics industry and encourage companies to automate.⁴⁰ Nonetheless, a study from Dongguan (manufacturing hub in Guangdong province) suggests that government subsidies still play only a small role in causing manufacturers to automate, with competition being the most important factor.⁴¹

Education

Education is an important part of China's big 2030 AI plan. AI is already on the curriculum in schools in some parts of the country, and on the higher education level, China is in the process of setting up "at least 50 artificial intelligence academic and research institutes", and according to the official newspaper China Daily, funding has been provided to train 500 teachers and 5,000 students in AI at top universities over the next five years.⁴² But even if successful, these measures will take many years to come into effect. In the shorter term, China is working on a coordinated effort to bring home AI talents who have gone abroad.⁴³

Research

The Chinese government hopes these education efforts will also propel them towards a better position in AI research. The 2017 document hopefully states: "By 2025, colleges and universities will achieve a number of original results of international significance and some theoretical research, innovation and application of technology to reach a world-leading level."

Chinese premier Li Keqiang also addressed the issue of original research at a speech last year, asking: "Have there been any major scientific discoveries in human history that took place as scheduled?" and going on to say that "For many theoretical, basic areas of research, especially those that can influence the future of human beings, the only thing the government should do is provide scientists with a more tolerant environment."⁴⁴

Statistics suggest that China is moving in the right direction when it comes to AI research. If the current trend continues, they will have overtaken the US by 2030.⁴⁵

37 [The Global AI Talent Tracker](#) (Macro Polo)

38 [More restrictive U.S. policy on Chinese graduate student visas raises alarm](#) (Science Magazine)

39 [Inside Trump's Immigration Order To Restrict Chinese Students](#) (Forbes)

40 [Is China ready for intelligent automation?](#) (ChinaPower)

41 Naubahar Sharif and Yu Huang: "Industrial Automation in China's 'Workshop of the World'", *The China Journal* no. 81, University of Chicago Press on behalf of The Australian National University, 2019

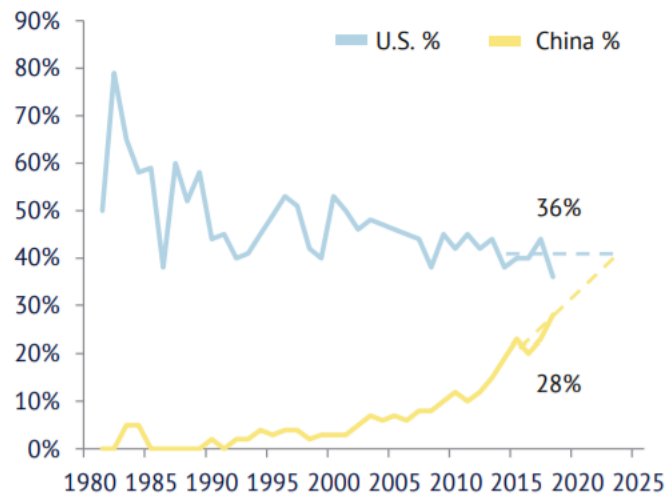
42 [Global ambition behind Beijing's bid to boost AI talent](#) (University World News)

43 [Global ambition behind Beijing's bid to boost AI talent](#) (University World News)

44 [Scientists' creativity should not be restrained: Premier Li](#) (The State Council of The People's Republic of China)

45 [China Internet Report 2019](#), South China Morning Post and Abacus News

U.S. vs China: Share of Top 1% of AI Papers



Startup ecosystems

Finally, China strives to cultivate effective startup ecosystems in order to foster the large scale innovation necessary to attain a leading position in AI and to transition to a high-tech consumer economy. Premier Li has called for “mass innovation” and “mass entrepreneurship” to aid in the big transition⁴⁷. The two most important tech hubs in China are Beijing and Shenzhen, with Beijing being regarded as the software capital and Shenzhen the hardware capital of China.⁴⁸

In Beijing, the government designated the area of Zhongguancun as a software startup zone, luring in startups with very low rent until hub effects began to make the area attractive. Zhongguancun now puts out 4 trillion in revenue per year. Simultaneously, the government created the mass incubation organization Innoway, tasked with providing everything startups need to thrive and grow.

Shenzhen has become the capital of physical tech products because it has rich access to manufacturing services while also being home to tech giants such as Tencent and Ping'an Group. Shenzhen has risen to stardom as one of [China's Special Economic Zones](#) which introduced free market economy and lenient regulations before the rest of China. Shenzhen highlights both China's strengths and its weaknesses in tech: It's a powerhouse because of the scale of its output and the speed at which you can create new products. But the really high-end innovations still rely on imports and on software platforms based in America. Rui Yan, an AI innovation manager at a major Chinese manufacturing company, says: “We are worried because we're using TensorFlow and OpenAI. We're concerned about finding alternatives. In AI, we can't make everything by ourselves. We really rely on open source software. Python etc. comes from the US, so we're concerned about that. Most hardware can be found here in Shenzhen though. Except high-end CPUs and GPUs.”⁴⁹

46 Source: *Allen Institute for Artificial Intelligence*

47 [Premier stresses mass entrepreneurship and innovation](#) (The State Council of The People's Republic of China)

48 Hangzhou, home to Alibaba, is arguably a close third

49 Interview, November 2019



Capital of China

Beijing's Zhongguancun Science Park recorded **4.07** trillion yuan in revenues in 2015⁵⁰

Home to **26%** of China's AI companies

Ranked **#2** ecosystem in the world for AI⁵¹

Early stage funding per startup **\$599k** (global average \$284k)⁵²

Home to **79 unicorns** in 2018



Home to Tencent

Fastest product prototyping in the world

Enterprises, universities and institutes in Shenzhen spent more than **\$14** billion on R&D in 2017⁵³

Half of all China's international **patent applications** in 2017 came from Shenzhen⁵⁴

Known for its **large electronics markets** selling all kinds of hardware the heart might desire, and the so-called makerspaces where dozens of startups rub shoulders in the same buildings as they develop the next wave of technological products.

Whereas it was easy for AI startups to receive VC funding in the wake of the announcement of the AI plan in 2017, several sources have reported that times then changed in 2019. Startups were struggling to get funding and as many as 15-20% of VC's went broke.⁵⁵ However, following the pandemic, the Chinese government has introduced considerable stimulus measures for startups and small businesses which could help warm the investment climate back up⁵⁶.

50 World Economic Forum 2015

51 Ecosystems: Beijing (Startup Genome)

52 Ecosystems: Beijing (Startup Genome)

53 Facts and figures: Shenzhen vs Silicon Valley (CGTN)

54 IPO 2017

55 This may in part be because of the trade dispute but another likely reason is that the Chinese government is continually taking measures to limit the amount of debt in the Chinese economy.

56 China's Support Policies for Businesses Under COVID-19: A Comprehensive List (China Briefing)

Summary: Chinese AI

To sum up some of our most important findings on the state of AI in China:

- China is leading the world in adoption of AI when averaging a range of parameters, but this lead is very uneven. China is doing very well in some areas and less well in others.
- Because Chinese society is permeated by interconnected smartphone apps, Chinese AI companies theoretically have better access to user data than anywhere else.
- China's strengths lie in areas of AI implementation that draw on China's speed, scale and data advantages, such as computer vision (particularly face recognition), e-commerce, and FinTech.
- Some sectors in China, especially manufacturing, health care and agriculture, are not as well prepared for digital transformation as the same sectors in developed economies, and this is causing a delay in AI implementation.
- China is working hard to become more self-reliant, breaking their need for imports of industrial components as well as their reliance on foreign software.
- China needs more AI talent and has already implemented policies to attempt to catch up with the US.
- China needs more AI researchers and more influential and foundational research. They have already implemented policies to attempt to catch up on these fronts.

For those who wish to learn about China's AI development in more detail, South China Morning Post has recently published their [China AI Report 2020](#) focused on highlighting commercially relevant takeaways for businesses, which is available for purchase.

**Nordic AI
landscapes:
The Greater
Stockholm
Region case**



This section looks at current Nordic AI implementation and the conditions for future implementation, first focusing on Sweden and then specifically on the Greater Stockholm Region, with strengths and potential as the emphasis.

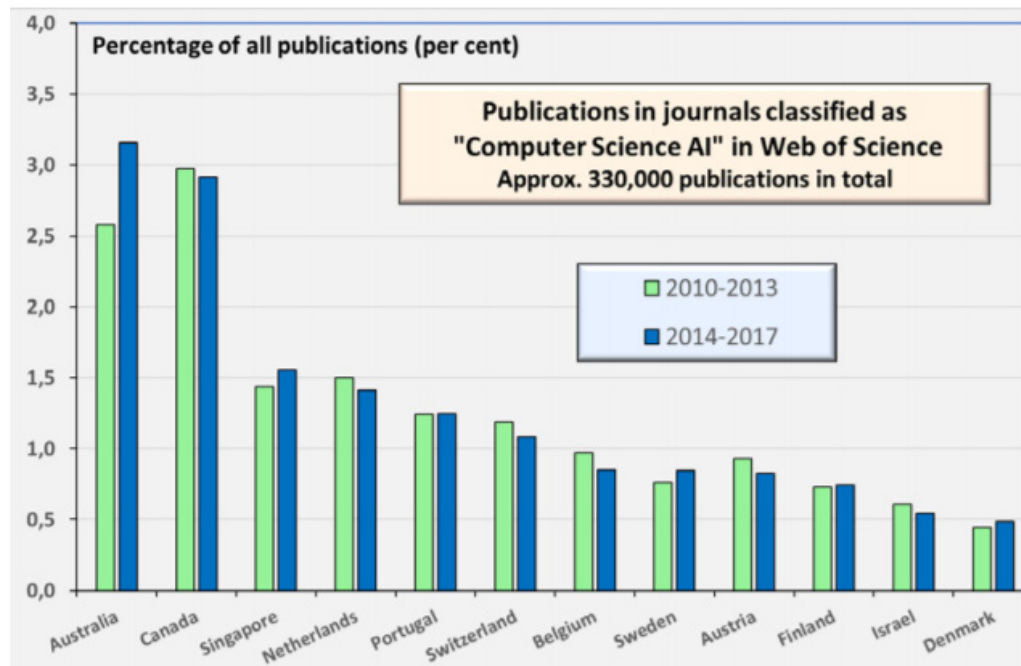
Swedish AI at a glance

In May 2018, the Swedish government published its AI strategy document, *National Approach To Artificial Intelligence*⁵⁷, thereby joining the growing group of countries that have an official AI strategy⁵⁸. The document focuses on aspects that demonstrate some of Sweden's greatest strengths: education, research, innovation and cooperation. Since its publication, several other national AI initiatives have followed: the collaborative government/industry/university initiative [AI Innovation of Sweden](#), the joint Swedish research institute's [RISE AI](#), the independent non-profit [Swedish AI Council](#), and the \$550 mn [Wallenberg AI fund \(WASP\)](#) with the mission of training at least 400 PhDs in AI and related fields.

Sweden's AI initiatives place it in a leading position in the Nordics. Only Finland also has a national AI strategy, but with its considerably bigger economy, Sweden could be in a better position to charge ahead in the coming years.

Following the publication of the government's AI strategy, Vinnova was commissioned to produce a report analyzing in detail the potential for AI implementation in Sweden. That report provides a general impression of the overall state of AI development in Sweden.

The available stats on AI research show that Sweden is on roughly the same level as comparable countries:



59

A survey has also been made of AI implementation in the Swedish public sector, showing that in 2018, 9% of municipal authorities, 24% of county authorities, and 8% of national government agencies were using AI to some extent.

No data exists about AI adoption in the Swedish private sector. However, field experts seem to agree that the situation here is similar to the situation in AI research: Sweden is doing quite well compared to the Nordics and the rest of Europe but is clearly behind the US and China.

57 [National approach to artificial intelligence](#) (Government Offices of Sweden)

58 [National and International AI Strategies](#) (Future of Life Institute)

59 [Artificial Intelligence in Swedish Business and Society](#) (Vinnova 2018)

Generally speaking, looking only at the averages, one could get the impression that Sweden is simply behind China in AI development and has little assistance to offer a country like China in its progress towards reaping the full benefits of AI technology. This is a decidedly false impression, as the rest of the report will show.

First of all, it's important to understand why Sweden is behind China in AI adoption overall. It is of course partly because of China's personal data advantage and the strong Chinese government investment in AI (announced nearly a year before Sweden's *National Approach to AI*), as well as some other China-specific factors as discussed in chapter 2. But it's also because Sweden's already advanced technological infrastructure reduces the incentive to introduce AI technology quickly. Whereas Sweden's private sector largely became digitalized decades ago, before Machine Learning AI was introduced, a large chunk of China's private sector is embracing digitalization now, in an era where AI implementation is the state of the art.

China is working on AI adoption at all levels of sophistication – from easy applications of AI in e-commerce apps to difficult applications in manufacturing – but its current overall AI adoption lead seems to come mainly from picking the low-hanging fruits⁶⁰; particularly the aforementioned areas of *scale without mass*.

China may catch up on all fronts later, so there seems to be a window of opportunity open for a country like Sweden to capitalize on its superior position to pick the high-hanging fruits of AI adoption which depend on physical assets and a generally advanced technological base.

In the following, the main advantages that Sweden holds in the quest for further AI implementation will be discussed. The specific conditions that distinguish the Greater Stockholm Region from the rest of Sweden will also be presented.

For further reading about the state of AI implementation in Sweden: SCB has been commissioned to survey the use of artificial intelligence in companies and public administration, including the university and higher education sectors. This work is due to be presented by November 30, 2020.⁶¹

“There is sometimes talk in Sweden about our modest abilities with regard to digitalisation and the AI domain. Yet, when one looks at various objective measures, it is difficult to understand the basis for such arguments. Sweden might not be able to compete with American universities or broad Chinese investments in AI, nor can it outperform companies such as Microsoft, IBM or Google. However, there are many areas in which Sweden is at the forefront. These include, but are not limited to: business-to-business, applied technology for industrial IT and automation, and our capability in the resources, process and manufacturing industries. This also applies to our infrastructure and general knowledge capital.”

Örjan Larsson, Blue Institute⁶²

Sweden's AI advantages

The conducted research shows that Sweden has four distinct advantages compared to China when it comes to AI implementation. There are of course many other positive things to be said about Sweden's AI capabilities, but these appear to be the most important points when comparing specifically with China:

1. A good technological starting position
2. Ample availability of highly educated ICT talents
3. Easy access to public data
4. Strong and institutionalized triple helix and business-to-business cooperation

⁶⁰ This conclusion is based on *AI Superpowers* (Kai-Fu Lee 2018) as well as interviews with Chinese experts.

⁶¹ See *Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019, p.97

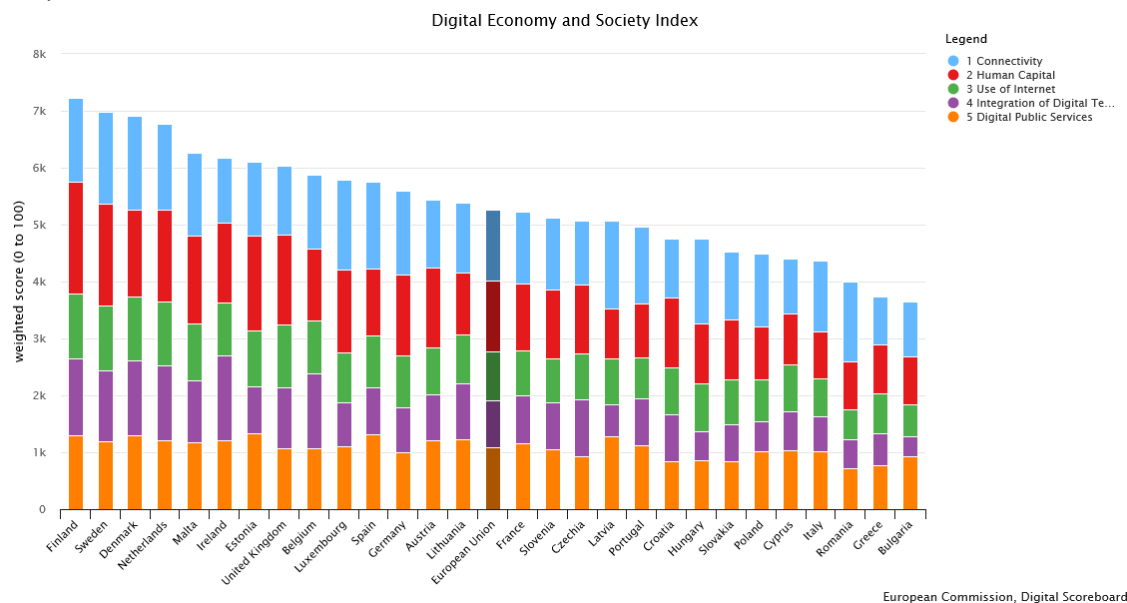
⁶² From *Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019

As it's pointed out in Vinnova's report, any AI transformation requires collaboration between industry experts, AI professionals, IT infrastructure companies, regulators and financiers. To the extent that this is accurate, a good environment for AI transformation is one where all of these are present and they are able to cooperate well. Therefore, AI transformation places tough demands not just on data availability or investments but also on talent availability and on the smooth interconnectedness of the entire ecosystem. Let's take a closer look at some of the areas where Sweden appears to have an advantage:

Technological starting position

There is a consensus among Swedish professionals that Sweden is world leading in most of the industries it is involved with. This is to some degree also borne out by statistics. World Economic Forum ranked Sweden as the 8th most competitive country in the world in 2018 (China 28th)⁶³ and the 5th most innovative country in the world in 2019.⁶⁴

The Digital Economy and Society Index ranks Sweden as the 2nd most digitally advanced country in Europe in 2019⁶⁵.



European Commission, Digital Scoreboard

This year, Global Finance named Sweden the 2nd most advanced country in the world on metrics including “technological knowledge, readiness for developing new technologies, and the ability to exploit and build on new innovations”.⁶⁶

Because of its advanced position, Swedish industrial players are able to be successful in highly specialized fields. Senior advisor at [Blue Institute](#), Örjan Larsson, explains:

“We have a very well invested industry with state-of-the-art machinery and processes. We also have a very well invested industry when it comes to automation and digitalization. We have a highly specialized industry in Sweden. We have proven our excellence in many extremely demanding niches requiring very much knowledge and advanced equipment”.⁶⁷

This is important in relation to AI implementation because it enables implementations of AI technology which would otherwise be impossible. For example, Sweden's industrial sector is particularly well prepared for AI transformation. Advanced measurement and control systems are already in use in most Swedish factories, many processes are already digitized, and sensor technology is well-developed.⁶⁸

63 [Sweden competitiveness rank 2007-2019](#) (Trading Economics)
 64 [These are the world's 10 most innovative economies](#) (World Economic Forum)
 65 [The Digital Economy and Society Index \(DESI\)](#) (European Commission)
 66 [Most Technologically Advanced Countries In The World 2020](#) (Global Finance)
 67 Interview, January 2020
 68 [Artificial Intelligence in Swedish Business and Society](#) (Vinnova 2018)

Swedish factories are already collecting the data necessary for training machine learning models, and factory workers are already highly trained at using digital systems. Sweden had the 5th most robots in manufacturing in 2019, and 2nd most in Europe.⁶⁹ If Sweden wants to keep up, as many factories and plants as possible must take advantage of the potential for data collection that the country's industrial leading position provides.

This technological starting position advantage is the result of Sweden having been on the forefront of industrial innovation for over 100 years and accumulating knowledge.

"It means we can make use of industrial datasets from the past:...", explains Managing Partner at Nordic Apiary, Kristoffer Lundegren. This could be all kinds of accumulated micro-knowledge. "...for example if you're putting pieces together in the factory and using a very specific kind of screws, you know exactly how the robots should put them together and how they should treat the material."⁷⁰

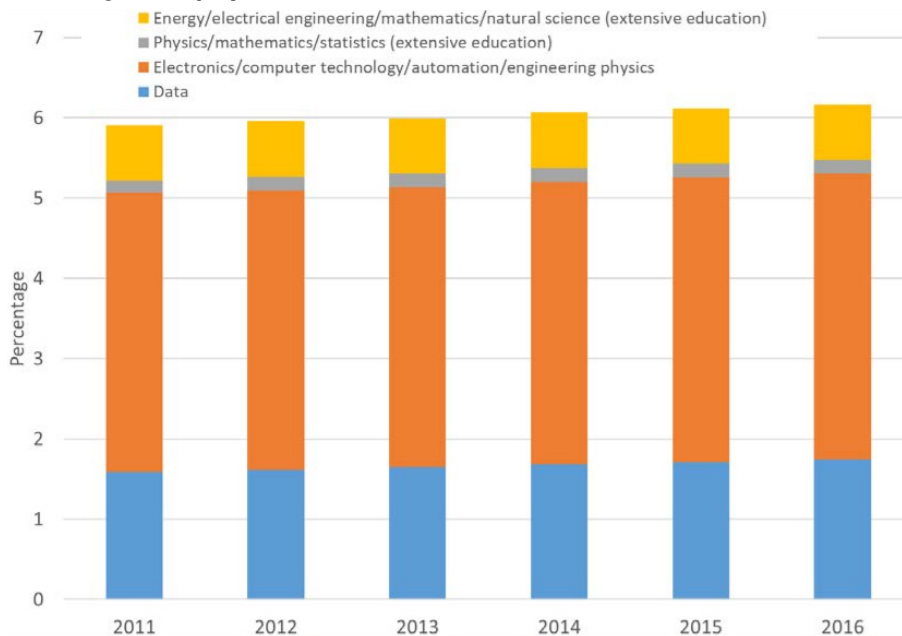
Because of this advantage, it's in these difficult niches that Sweden keeps its greatest AI prowess. At the end of this report, a case study will be provided to show how the competencies vested in the region supplement each other to make complex AI implementations possible.

Talent availability

Sweden is generally one of the best educated countries in the world, with one of the highest proportions of researchers⁷¹. Furthermore, Sweden has a particularly good position when it comes to availability of highly qualified ICT (Information and Communications Technology) professionals; an area where China is struggling.

When looking at specific educational backgrounds considered particularly relevant to AI⁷², one can see that 6,2% of the Swedish employed workforce has one of these educational backgrounds, and that this number is steadily rising:

Percentage of employed workers with an education within ICT/Mathematics in Sweden 2011–2016⁷³



69 5 Countries With The Most Robots In Manufacturing (Disruption Hub)

70 Interview, January 2020

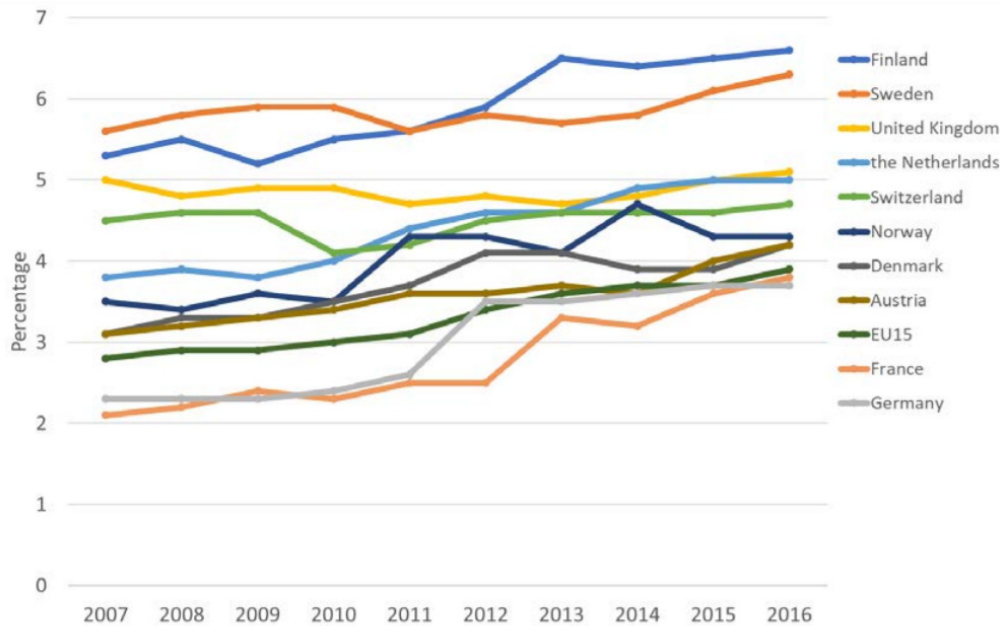
71 2016 Global Manufacturing Competitiveness Index (Deloitte)

72 These are defined as: Data • Electronics • Computer Technology • Automation • Master of Science in Engineering Physics • Post-secondary education (at least 3 years) within Physics/Mathematics/Statistics • Post-secondary education (at least 3 years) in Energy Engineering, Electrical Engineering and Mathematics/Natural Science.

73 Artificial Intelligence in Swedish Business and Society (Vinnova 2018)

Together with Finland, Sweden is at the very top of the EU countries when measuring what proportion of the population are ICT specialists, and as the above and the below figure both show, there has been an upward trend in the amount and saturation of ICT specialists.

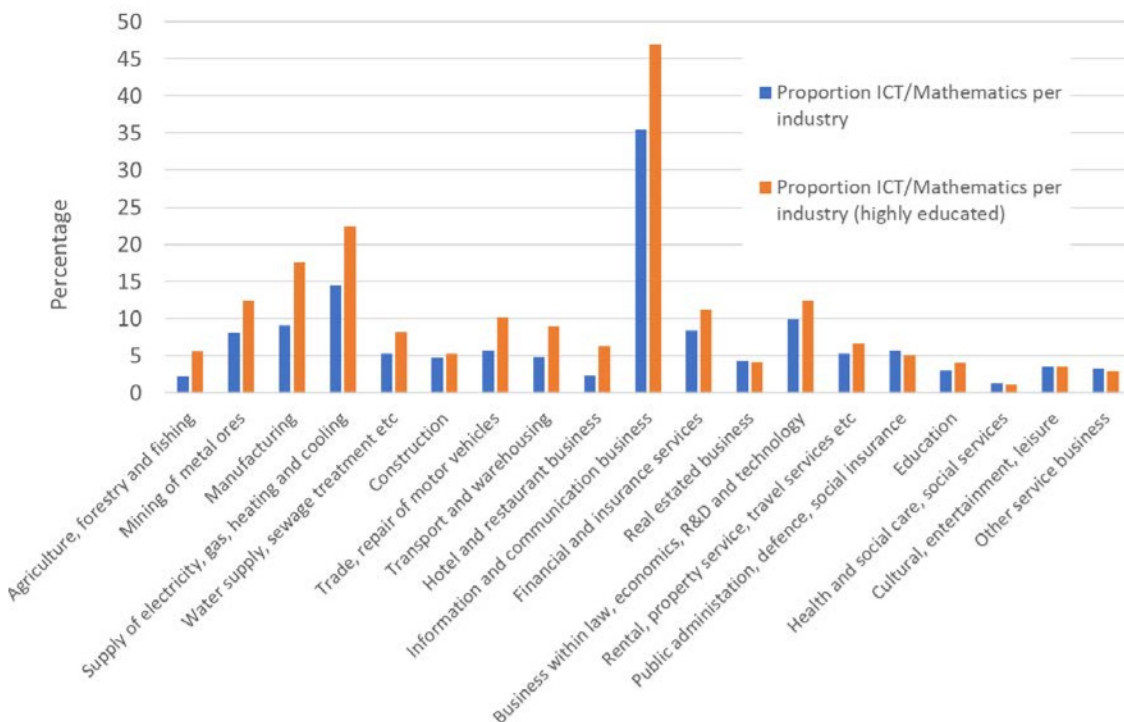
Percentage ICT specialists of total employment for a selection of countries 2007–2016⁷⁴



Source: Eurostat

So, what are all these ICT professionals doing? The biggest share is employed in the essential Information and Communications Technology sector, “Information and Communication Business”. Aside from those, the largest shares are employed in the fields of “manufacturing” and “electricity/gas/heating/cooling supply”.

Percentage of employed workers per industry with an education within ICT/Mathematics in 2016, for all levels of education and for those with extensive education⁷⁵



⁷⁴ *Artificial Intelligence in Swedish Business and Society* (Vinnova 2018)

⁷⁵ *Artificial Intelligence in Swedish Business and Society* (Vinnova 2018)

78% of workers engaged in R&D in Sweden are in the manufacturing sector, and a large amount of these have their educational background within ICT⁷⁶.

All these statistics reveal Sweden's propensity for using advanced technology a lot and for using it in the heavy industries.

In 2014, there was good news for Sweden's future talent mass in the fields relevant to AI: The Wallenberg Foundations announced their WASP program, pledging a total of 5.5 billion SEK⁷⁷ (of which 1.3 bn is supplied by the foundation's university and industry partners) to train at least 400 PhDs in Autonomous Systems and AI, along with several other ambitions⁷⁸.

“At least 1 billion of the WASP funds is for AI research. In practice, it's probably more than half of it. This private initiative has been very important, both because we're getting funding for Ph.D. students but also because they fund recruitment, so we've recruited international professors to come to Sweden to do their research here. What's very good is both its large volume but also its long term. This is a 10 year research program, in contrast to the short terms you usually get from government funding.”

Fredrik Heintz, AI researcher at Linköping University, delegate to the Swedish AI Council and member of the EU High-Level Expert Group on AI

So now and in the foreseeable future, Sweden has an unusually large and increasing amount of professionals in AI-relevant fields, and a significant amount of them has experience from manufacturing and heavy industry.

Open data

A well-known analogy to explain AI compares it with a car: The deep learning algorithm is the engine, the engineer is the driver, and data is the fuel. As mentioned previously, China's AI successes owe in part to the fact that they have a lot of data. Sweden cannot begin to compete with China when it comes to access to- and amount of personal/user data. But Sweden also has a data advantage; one that puts it in a better position for a wide variety of not directly consumer-focused AI implementations. The Swedish data advantage comes from two factors:

- 1) the public sector's efforts to make datasets openly available, and
- 2) the existence of many longitudinal (long-term) datasets accumulated through many years of well-organized production and research.

Public datasets

The Swedish public sector is constitutionally obligated by the “principle of transparency”⁷⁹, which states that all acts conducted by a public agency, except those classified as secret, must be available for scrutiny by all members of the public. This means that all data about things like court cases, company registrations, real estate transactions, central bank policies, and dozens of other affairs processed by public authorities, are in principle freely available to anyone. On top of this, Sweden's public sector has been making conscious efforts to organize certain datasets for commercial use.

Daniel Gillblad, Director of RISE AI⁸⁰, is part of this effort. “RISE is currently making satellite data available for people to analyze and compute on.”, he says. “...It's a pretty big dataset. We're setting that up as a data lab that people can use. We're moving in the right direction, spreading core datasets that we can do these things on.”

⁷⁶ Source of all figures in the “Talent availability” section: *Artificial Intelligence in Swedish Business and Society* (Vinnova 2018)

⁷⁷ \$580 mn

⁷⁸ More information here: [WASP Sweden](#)

⁷⁹ Offentlighetsprincipen

⁸⁰ The Swedish National Research Institute's AI department

So-called “data factories” (labs where data is collected, organized and made accessible in an environment with the computational power to make use of it) are popping up in Sweden. A Swedish language data factory is hosted by AI Innovation of Sweden, and the project “Datalab for results in the public sector” will seek to collect and organize data about all kinds of public processes and their outcomes. The Swedish Royal Library has collected all Swedish web data and newspaper articles to make them available for AI development.

Public data is in fact already being used for AI implementation. A simple example is that the Swedish traffic control agency applied machine learning to their app by training a model on stored traffic data. But there is still much untapped potential.

Several of the Chinese AI experts who have contributed to this report reacted with surprise and interest when asked about this kind of data, seemingly hardly cognizant of the potential presented by non-personal data. This was the case even for a prominent researcher and for a consultant specializing in Chinese AI.

Longitudinal datasets

Sweden's previously mentioned good technological starting position also provides a data advantage. For one, decades of data accumulation and well-ordered databases in the industrial sector provide a great potential for AI implementation. But the same goes for all the other sectors.

“We have good and sometimes plentiful data within health care, for example”, explains Daniel Gillblad. “... We have data from a very long time back, which is relatively rare. Because we have structured data from a very long time period, you can actually verify models and hypotheses you observe. That's definitely a competitive advantage.”⁸¹

This competitive advantage is already being leveraged by Swedish startups. A good example is Lexplore, an EdTech startup from Linköping in the Greater Stockholm Region. Lexplore screens school children for reading disabilities by tracking their eye movements when reading a text. They are able to do this because they found a dataset including data about a group of children's eye movements while reading and then how those children's reading abilities developed later on. The development of AI technology means that it's now possible to make a useful analysis of the children's eye movements from the dataset. This was not possible 30 years earlier when the data was recorded.

“Our company started from a research project. We gained access to a longitudinal dataset that we were able to use to get started. The instruments that you typically use for predicting reading difficulties and reading development are not very precise, but having data where you actually know how the children progressed later was very beneficial. So we had this dataset and then we started recording children's eye movements while reading. Then we trained classifiers based on that data: Either risk of reading problems or no risk of reading problems.”

Gustaf Öqvist Seimyr, co-founder of Lexplore

Ample access to public data and accumulated longitudinal data in Sweden means that some AI implementations will be possible here that are not possible elsewhere.

Cooperation

The last Swedish AI advantage is a “soft” advantage, but there is much to suggest that it's very important and one of the features that sets Sweden apart from most of Europe: The pervasiveness and efficiency of cooperative efforts between businesses, research institutions and government agencies. The following are some examples of the collaborative nature of Swedish AI development efforts:

81 Interview, December 2019



Collaborative funding. The concept of “triple helix” (government, academia, business) collaboration is important in Swedish politics and society. As a result, most research and innovation funding is set up as collaborative funding, which means that in order to secure funds, you have to have several actors representing different parts of the triple helix working together.⁸² Collaborative funding like this may encourage local workforce system stakeholders to work together to develop solutions (especially to systemwide issues), and combine and more strategically target their resources. Collaborative funding may thus ensure a more strategic and less siloed approach to workforce challenges. This approach is of course only effective in a highly connected society with very effective communication flows. These are exactly some of the strengths of Sweden. Some of the people we interviewed spoke of it as the advantage of being a small country and a high trust society: “we all know what each other are doing in a lot of detail.”⁸³



AI Innovation of Sweden is one example of collaboration culture and high connectivity in Sweden. It's an agency whose focus is “accelerating the implementation of AI through sharing knowledge and data, co-location of competences, and collaboration projects”⁸⁴. It was founded by almost 70 different partners from all parts of the triple helix. The value produced by AI Innovation of Sweden consists of things like “data factories”, where large datasets are collected and made accessible; AI training courses, network activities, and testing environments for AI and IoT products. At the time of writing, AI Innovation of Sweden is engaged in nine different major projects, including organizing satellite image data and analyzing heart images. AI Innovation of Sweden plans six “nodes” (offices) across the country. Two are already open in Stockholm and Gothenburg.

82 Source: Daniel Gillblad, RI.SE, interview November 2019

83 Patrik Tran, chairman of Stockholm.ai, interview October 2019

84 AI Innovation of Sweden's website



Swedish language recognition AI. RISE, which is an innovation-focused umbrella organization of nearly all Swedish research organizations, has taken the initiative of creating a natural language processing algorithm for the Swedish language for use in public service. The project is a collaboration between RISE, three government agencies (the Public Employment Service, the Agency for Economic and Regional Growth, and the Tax Agency), Luleå Technical University, AI Innovation of Sweden, and the Stockholm AI company Peltarion.⁸⁵ Luleå Technical University focuses on original research in conversational technology. RISE and Peltarion focus on document level applications. Peltarion, as a commercial company, brings expertise in the actual deployment of AI solutions. AI Innovation of Sweden provides their language data factory as well as access to their extensive network of actors in all areas related to AI. The government agencies are then in constant dialogue with the other partners about their exact needs and how the technology can best be put to use.

These are the most important advantageous conditions for AI development that the country of Sweden has in comparison with China. The next section looks at the specific advantages presented by Sweden's Greater Stockholm Region.

The Greater Stockholm Region

The Greater Stockholm Region includes Stockholm City and most of what is also known as East Middle Sweden, including the towns of Linköping, Norrköping, Örebro, Eksilstuna, Västerås, Uppsala and Gävle⁸⁶.

The Greater Stockholm Region is the hotspot where Sweden's tech hub, one of its manufacturing hubs, and its best research institutions, are gathered in one place.

In basic terms, one can argue that Stockholm City is the tech capital of Sweden, whereas the uplands of the region are the high-tech manufacturing capital of Sweden.

⁸⁵ [Language models for Swedish authorities \(RI.SE\)](#)

⁸⁶ [Stockholm Business Alliance website \(in Swedish\)](#)

Stockholm Region: The technological capital...

Why is Stockholm perceived as the “tech capital of Sweden”? Let’s start by looking at its startup scene:

In 2018, there were about 8,000 startups in Stockholm County (not counting other active startup ecosystems in the region such as Linköping and Uppsala). Currently, it is estimated that this number has already grown to 10,000.⁸⁷ But it’s not just the amount of startups in Stockholm that’s high, it’s also their success rate. In the year 2016, there were a total of 49 tech exits in Stockholm. They accounted for no less than 58% of the total exit value in the entire Nordics, from a city that only accounts for 4% of the Nordic population.⁸⁸ The cherry on top of the Stockholm tech cake is that there are currently eight unicorns in the area, which means Stockholm has the second highest amount of unicorn startups per capita in the world, only surpassed by Silicon Valley.⁸⁹

Whereas such a fertile startup environment is of course in itself very beneficial to AI development and AI implementation, a glance at some of the likely reasons for Stockholm’s startup success points to some underlying factors that are highly relevant when considering the Stockholm Region as a potential zone of investment for AI development. Three important reasons are Stockholm’s **technological base**, **high talent availability**, and **organizational infrastructure**.

“Newer companies are benefiting from the global attention drawn to Stockholm by King’s New York IPO, Microsoft’s \$8.5bn takeover of Skype (its largest ever acquisition) and its \$2.5bn purchase of Minecraft maker Mojang in September, as well as Spotify’s mammoth VC-backed valuation and warfare with the likes of Taylor Swift and Apple. ‘When we started, we couldn’t compete,’ said Jonathan Forster, who runs Spotify’s Nordic operations. ‘Now, I’d be very worried for an investor if Sweden wasn’t on their road trip’.”

The Telegraph⁹⁰

Technological base

Specific data can also be found that backs the general claim that Stockholm is one of the most technologically advanced cities:

McKinsey Global Institute ranks Stockholm as having the most advanced technology base for smart city technology in Europe in 2018 (among 13 surveyed major cities) and 4th in the world after New York, Singapore and Seoul, measured by infrastructure parameters like sensor quality, efficiency of electronic communication, and open data.⁹¹

A few years earlier, a survey by Flurry Analytics showed that Stockholm had the highest smart device penetration in all of Europe, at 150% (1,5 smart devices per capita).⁹²

Stockholm was also the first place in the world to introduce 2G, 3G and 4G technology and is among the first to introduce 5G.⁹³

Stockholm’s tech advantage is reflected in the productivity statistics. Stockholm has the highest productivity and the highest productivity growth in Sweden⁹⁴ and contributes more than 50% of Sweden’s economic growth in the private sector (while hosting 10% of the population).

87 Sweden as a leader of the Nordic market. Many startups, global companies and high demand on IT services (Codest)

88 Source: The Nordic Web and Invest Stockholm

89 Atomico report: State of European Tech report

90 How Sweden became the startup capital of Europe (The Telegraph)

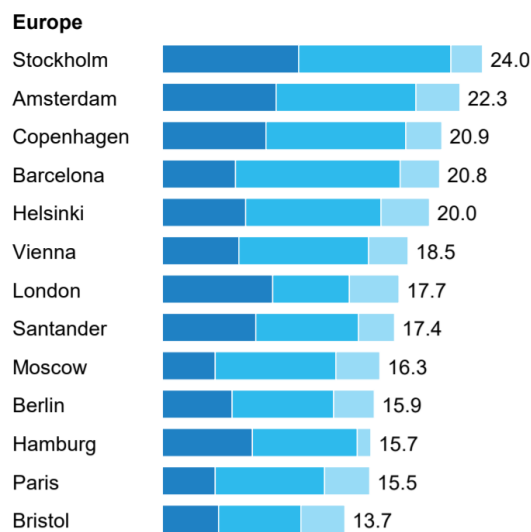
91 Smart Cities: Digital Solutions for a More Livable Future, McKinsey Global Institute, 2018

92 10 Most Impressive Facts About Stockholm’s Tech Scene (Startups & Venture Capital)

93 First in the world with 4G (Telia website)

94 Regions and Cities at a Glance 2018 –SWEDEN (OECD)

Most advanced technology base for smart city technology in Europe in 2018 (surveyed cities)⁹¹



Talent availability

Stockholm is by far the highest educated area in Sweden.⁹⁵ Over half of the Stockholm population has tertiary education.⁹⁶ And not only is the workforce well educated; they are also focusing on tech. In Stockholm, almost one fifth of the entire workforce works in tech. This is a higher share than in any other city in Europe.⁹⁷

Two of Sweden's top ten universities are located in Stockholm, and a total of six of them are located in the Greater Stockholm Region.⁹⁸ Stockholm's KTH Technical University ranks 53rd in the world for engineering and IT according to Times Higher Education, with Uppsala University also in the global top 200.⁹⁹

Notably, Karolinska Institute, where the educational AI startup Lexplore originated, ranks 12th in the world for medical science.¹⁰⁰ Stockholm School of Economics also offers several masters programs that are ranked among the best in the world.¹⁰¹

A map of Sweden's AI research by institution shows that three of the top five contributing institutions are located in the Greater Stockholm Region, with Stockholm's KTH in the lead, followed by Linköping University. These are then followed by Chalmers, Lund University and Uppsala University who all produce approximately the same volume of publication.¹⁰²

⁹⁵ Source: Statistics Sweden

⁹⁶ Source: EURES, 2019

⁹⁷ [Ecosystems: Stockholm](#) (Startup Genome)

⁹⁸ [Best universities in Sweden 2020](#) (Times Higher Education)

⁹⁹ [World University Rankings 2019 by subject: engineering and technology](#) (Times Higher Education)

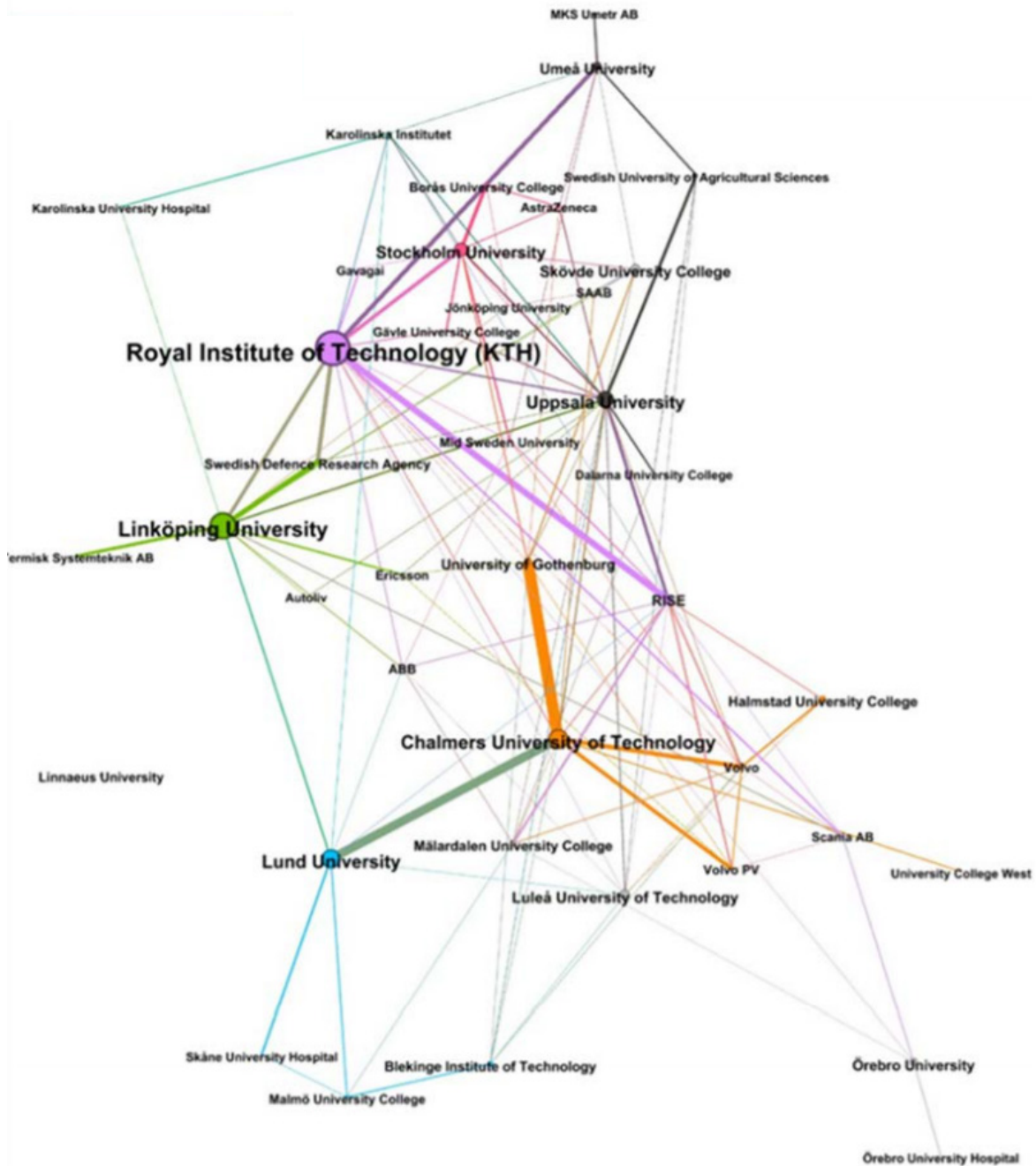
¹⁰⁰ [Best Universities \(Medicine\)](#) (Times Higher Education)

¹⁰¹ [Stockholm School of Economics](#) (Wikipedia)

¹⁰² [Artificial Intelligence in Swedish Business and Society](#) (Vinnova 2018)

Organisations in Sweden with at least two publications between 2014 and 2017

within 'Computer Science – AI' in the Web-of-Science database, as well as links between organisations through co-authorship¹⁰³



Organizational infrastructure

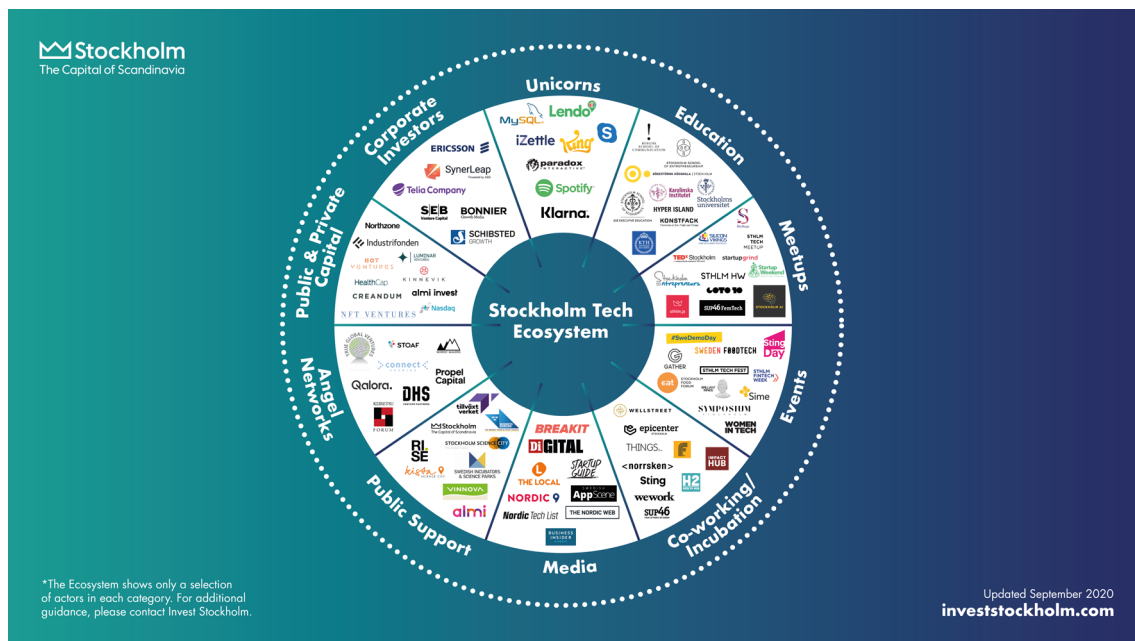
While an advanced technological base combined with a strong talent pool is very desirable and difficult to achieve, there are still quite a few cities in the world that boast these qualities. Something that sets Stockholm apart from other advanced, well educated and tech-savvy cities is the previously mentioned Swedish collaborative competence. In Stockholm, this has given rise to a number of public and private initiatives that each helps better connect and combine the elements required for innovation, so as to turn all the statistical advantages into tangible competitive products and solutions. EU's [Regional Innovation Monitor](#) highlights this in its analysis of the Stockholm Region:

¹⁰³ *Artificial Intelligence in Swedish Business and Society* (Vinnova 2018)

“The [innovation support] organisations work closely with higher education institutions, for example incubators (STING, KIAB and SUIAB), innovation support offices (KI, KTH and SU) and science parks (Kista Science City, Karolinska Institute Science Park and Södertälje Science Park).”¹⁰⁴

All major tech ecosystems have good incubators, but in Stockholm, the collaborative, composite nature of the organizational infrastructure, combined with a willingness of all actors in the ecosystem (startups, industry, academia, government) to indulge in collaborative activities, means that the right connections are more often made, key skills are shared, the right person is more often paired with the right task, and the most important questions and challenges are identified faster.

The following chart shows a selection of important institutions in the Stockholm tech ecosystem. The collaborative aspect of the ecosystem is mainly represented by the “Meetups”, “Events”, “Co-working”, “Education” and “Public support” wedges.¹⁰⁵



Here’s a closer look at two examples of ecosystem actors that are particularly important to the field of AI:

Stockholm.ai

The most important AI forum in Stockholm is the grassroots organization [Stockholm.ai](#). Stockholm.ai hosts many different kinds of AI themed events: technical workshops, academic reading groups, networking events and weekly [hackathons](#). “We have meetups and gatherings to help each other.”, Stockholm.ai chairman Patrik Tran says. He then lists some of the perks of having such a forum:

“We get to know what each other are doing in a lot of detail. We share knowledge. We share content... People in the AI field here in Stockholm get exposure to all aspects of AI and often learn about applications they haven’t tried but should try.”¹⁰⁶

The forum serves the important purpose of bridging the gap between theory and practice for AI students and thereby ensuring that AI education results in AI implementation. “It’s complementary with the education system.”, Tran says. “...To be good at applying AI, you need to know what’s going on outside academia. If it wasn’t for Stockholm.ai, I don’t know how students would know what’s going on in practice.”

¹⁰⁴ Regional Innovation Monitor Plus: Stockholm (European Commission)

¹⁰⁵ A nice overview of the Stockholm startup ecosystem, including brief descriptions of incubators, VC groups and research institutions may be found here (dated January 2019): Stockholm’s startup ecosystem at a glance (EU Startups)

¹⁰⁶ Interview conducted in October 2019

Another thing that Mr. Tran emphasizes is the enhanced connectivity between AI professionals that the forum provides. One startup that originated at a Stockholm.ai event is Greenlytics – a geological AI startup which uses weather data to predict the business impacts of weather conditions. They became one of seven startups selected for the ABB Industrial AI Accelerator in 2018.



"I was working as a power trader but I was interested in learning machine learning, so I started attending these events.", Greenlytics CEO Sebastian Haglund El-Gaidi says.. "The other co-founder, Mihai, was working as an IT and machine learning consultant for power companies. So we met through Stockholm AI and discussed the opportunities in the energy space. Then we got funding from Vinnova and the Swedish Energy Agency."

With the initial connection sparked by Stockholm.ai, the next connection then arose from a collaborative effort between academia and business: "We have been working quite tightly with professors from KTH.", Haglund El-Gaidi says, "...One of them has a course where they let 2nd year computer science students work on projects that are in demand among companies. So we asked for students to help us with our projects, and one of them actually joined our team completing the project."

What's crucial for anyone who wants to do business in Stockholm is that because organized collaboration is so thriving, the talent pool figures are not just numbers on a paper. It's possible to find the right people for a project in a much more flexible and efficient way than regular job postings. The network is electrified.

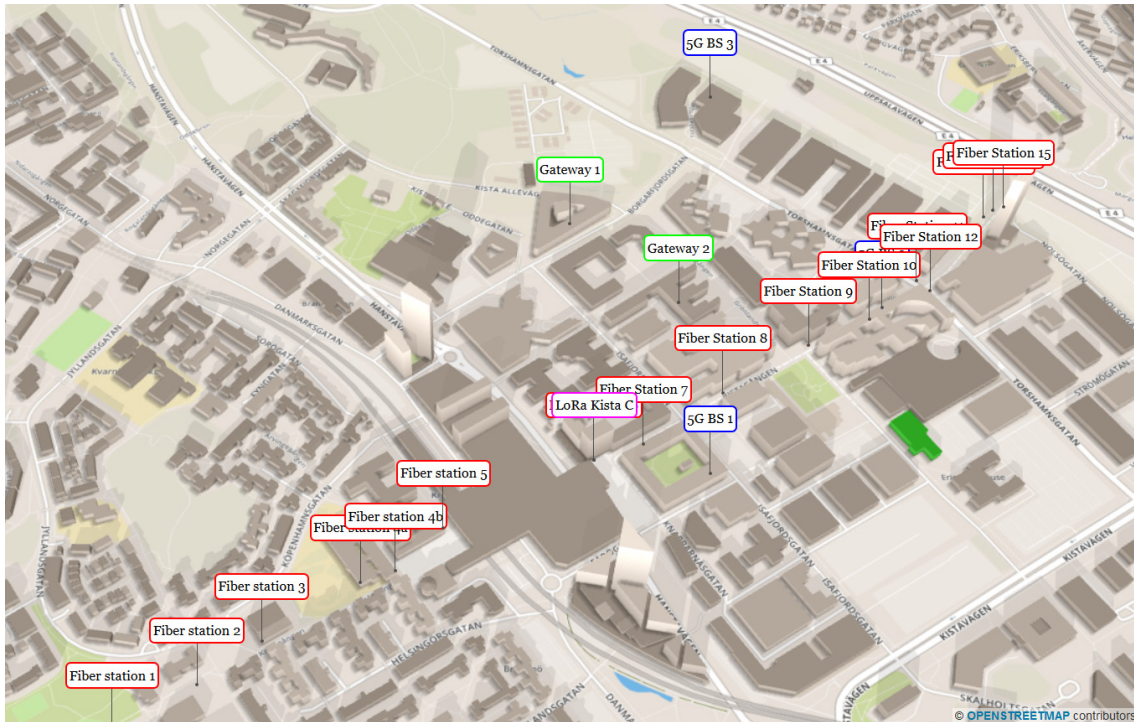
"We see a lot of recruitment based on our events. A lot of people move between different companies. We can evaluate each other in a very casual setting here. I can find out if you're good or not beyond your CV or interview."

Patrik Tran, chairman, Stockholm.ai

Urban ICT Arena

In Northern Stockholm lies the major ICT cluster known as Kista Science City. Ericsson has its headquarters here and many other ICT giants have offices, including Huawei, IBM, Philips and Fujitsu. Kista Science City also hosts the [Urban ICT Arena](#), which is a testbed for IoT and Smart City technology. It's also an example of organizational competence on a top-down, institutional level, as opposed to the grassroots competence exemplified by Stockholm.ai.

Urban ICT Arena was founded by eight founding partners, including research institutions, public agencies, and corporations. What makes it so useful is that it has a network of fiber stations which provides the area with all the different kinds of high to low-tech connectivity that IoT setups can run on. This allows local companies to test products in a real, urban setting.



So far, Urban ICT Arena is being used for testing solutions in smart waste management, air quality monitoring and self-driving buses.

Thriving collaboration in the innovation ecosystem is particularly interesting in relation to China because this is exactly one of the problems that the Innoday managers in Beijing pointed out. Innoday has had great success at gathering all the elements of an innovation ecosystem in one place, but most of the institutions there don't know what the others are doing, let alone collaborate. This is something that Innoday is working to try and change, and they could perhaps learn something from Sweden. The Stockholm collaboration culture means that, metaphorically speaking, the Stockholm innovation ecosystem is not just a lot of neurons but more like an actual neural network.

...and the high-tech manufacturing capital

What makes the Greater Stockholm Region unique is that these three factors (technological base, talent availability, organizational competence) are combined with all the heavy industry expertise also present here.

The EU Regional Innovation Monitor describes the manufacturing sector in the Stockholm Region outside Stockholm County as follows:

“The manufacturing sector in East Middle Sweden is an important engine for the regional economic development and many of the region’s businesses have for a long time been the backbone of the Swedish industry. The region is strong regarding export-oriented and high-tech industries, including research and development in the life sciences sector, energy, and environmental technology sector.”¹⁰⁷

The table below shows the top 20 machine manufacturing companies in Sweden (as of 2019), eight of which are located in the Stockholm region:

Rank	Company	Turnover (bn SEK)	Located in GSR?
1	Atlas Copco	95.36	yes
2	SKF	85.71	no
3	Husqvarna	41.09	no
4	Alfa Laval	40.67	no
5	Toyota Industries Europe	34.55	yes
6	Nibe Industrier	22.52	no
7	GKN Aerospace	92.22	no
8	Camfil	82.98	yes
9	Siemens Industrial Turbomachinery	81.88	yes
10	Systemair	73.01	yes
11	Munters Group	71.22	yes
12	Valmet	66.21	no
13	DeLaval International	56.94	yes
14	Gunnebo	51.28	no
15	Hiab	50.46	no
16	Mycronic	37.81	yes
17	Nederman Holding	35.54	yes
18	Komatsu Forest	30.26	no
19	UniCarriers Europe	27.77	no
20	Cargotec Sweden	27.56	no

108

The 500 automation companies located in the Greater Stockholm Region boast an annual turnover of SEK 30 billion (\$3.1 billion), or approximately 10 percent of the global turnover for the industry. Another figure shows that out of Sweden’s SEK 72 billion (\$7,5 bn) annual turnover in “industrial IT and automation”, 70% comes from the Mälardalen area in the Greater Stockholm Region¹⁰⁹.

The highly skilled workforce of some 15,000 people has experience in market segments such as process automation, power automation, robotics, and industrial IT. This yields good opportunities for investors to find the right technologies and for companies to develop new products and services.

This industry expertise opens a lot of doors for AI implementation. Most automated processes are controlled by systems that use AI, and the successful implementation and calibration of the AI depends on field-specific expertise and highly qualified engineers.

According to Automation Region CEO Bernt Henriksen, some of the current trends in automation are mobile robots as well as collaborative applications where people work together with robots in an open environment. Both of these implementations require very careful calibration for safety.

¹⁰⁷ [Regional Innovation Monitor Plus: East Middle Sweden](#) (European Commission)

¹⁰⁸ [The largest companies by turnover in Sweden in the industry Manufacture of machinery and equipment n.e.c.](#) (Largest Companies)

¹⁰⁹ [Automationslösningar i världsklass](#) (Automation Region) (in Swedish)

Corporate R&D in East Middle Sweden is dominated by some large, multinational firms, such as Atlas Copco, AstraZeneca, Scania, Alfa Laval, ABB, Bombardier and SECO Tools.¹¹⁰ [ABB](#) has invested SEK 1,4 billion (\$150 mn) in what they call “the most advanced robot factory in the world” in Västerås.¹¹¹ [Scania](#) has its main R&D facility in Södertälje. R&D investment in the region as a percentage of GDP is higher than the national average and twice as high as the EU average.¹¹²

The strong organizational infrastructure of the area is also manifest in the industrial sector outside of Stockholm City. Most of the industry actors in the region are coordinating their efforts towards automation in the organization [Automation Region](#), which the EU Regional Innovation Monitor describes as “one among three internationally leading regions in manufacturing and services concerning automation.”¹¹³ Apart from Automation Region, public-owned robotics incubator [Robotdalen](#) provides knowledge and expertise as well as a wide network of product developers, researchers, suppliers and end-users in order to assist companies in developing effective and sustainable automation solutions.

At Mälardalen University in Västerås, researchers work very closely together with industry professionals to stay on the cutting edge of advanced technology.

“Our research is based on a strong relation with the industry in the Stockholm area. Our university is constantly developing new courses and learning materials for AI and Machine Learning to educate industry professionals. We have regular meetings with industry representatives. We do interviews, workshops, and seminars but we also visit companies to find out how they are working and what they need.”

Shahina Begum, professor of Artificial Intelligence at Mälardalen University

In conclusion, for many industrial sectors, including manufacturing, construction, energy, robotics, and heavy transportation, Sweden’s advanced technical starting position described in the previous section, which is the foundation for efficient AI implementation in the heavy industries, is earned by the Greater Stockholm Region. The entire region is able to draw on technological innovations from Stockholm’s tech ecosystem and ICT talent from the top tier educational institutions in Stockholm to keep up a world-leading high-tech industrial sector that’s highly suited for advanced AI implementations that utilize many kinds of niche expertise accumulated over many decades.

AI implementations in the Greater Stockholm Region by sector

AI implementation in the Greater Stockholm Region is not concentrated around a few verticals. There’s something going on in nearly every sector. However, the following sectors are some of the ones where AI implementation seems to be most advanced:

- **Life Science / HealthTech**¹¹⁴ (Linkura, Sectra, Kry...)
- **Manufacturing / industrial robotics** (ABB, Alfa Laval, Sandvik, Epiroc...)
- **Telecommunications** (Ericsson...)
- **Gaming** (King, Mojang...)
- **FinTech** (Klarna, iZettle...)
- **Intelligent heavy trucks** (Scania, Zenuity, Einride...)
- **Clean energy** (Northvolt, Ferroamp...)

¹¹⁰ [Regional Innovation Monitor Plus: East Middle Sweden](#) (European Commission)

¹¹¹ [ABB bygger “världens mest avancerade robotfabrik”](#) (NyTeknik)


¹¹² Source: Eurostat 2019


¹¹³ [Regional Innovation Monitor Plus: East Middle Sweden](#) (European Commission)


¹¹⁴ For an in-depth look at AI/ML HealthTech in the Stockholm Region, please refer to [Stockholm Life Science AI/ML Guide](#) (Invest Stockholm 2019)

These sectors reflect the strengths of the region: The high technological base and smart device penetration is key to FinTech success. HealthTech is helped along by the presence of world-class research institutions. HealthTech and telecommunications are both helped along by the ready accessibility of advanced testing environments. The region's success at implementing AI for manufacturing, trucks and energy of course builds on the fact that it's a heavy industry hub.

Here's a few examples of AI startup companies that showcase some of the Stockholm Region's strengths:

 UNIVRSE S
UnivrseS
Field: Computer vision
Founded: 2015
Total funding: \$2.7 million ¹¹⁵
UnivrseS creates semantic perception AI which is used for both industrial robotics, autonomous cars and smart cities. According to CEO Jonathan Selbie, UnivrseS' heritage from VR/AR gaming enables them to achieve accuracy even from low-end hardware. UnivrseS works with municipal authorities on affordable digitalisation of urban environments by placing cameras and sensors on buses and other vehicles.

 Sana Labs
Sana Labs
Field: EdTech
Founded: 2016
Total funding: \$2.5 million
Sana Labs applies machine learning to personalize learning processes for greater efficiency. They are already working with major international players such as Learnosity and Duolingo.

 mavenoid
Mavenoid
Field: Software
Founded: 2016
Total funding: \$1.7 million
Mavenoid develops a machine learning engine and interface for customer service, which is able to internalize the specific problematiqués of any field and increase efficiency and reduce cost by identifying the relevant questions to ask and determining when and how a human supporter should be involved.

 PELTARION
Peltarion
Field: Software
Founded: 2005
Total funding: \$36.8 million
Peltarion is an AI platform company, designing deep learning applications tailored for other companies' specific needs. Peltarion is highly focused on collaboration and cultivating a partner network for sharing of expertise. They are currently participating in the state-run triple helix project to develop Swedish Natural Language Processing model for the public sector.

¹¹⁵ Source: Crunchbase

Summary: The state of AI in Sweden and the Greater Stockholm Region

Some of the most important findings about AI in Sweden and the Greater Stockholm Region are:

- Sweden is behind countries like China and the US in the overall statistics of AI implementation, AI research and AI funding but is in a reasonable position compared to the rest of Europe.
- Efforts have recently been made to help Sweden keep up in the AI race, including the \$550 mn WASP fund, the founding of RISE:AI, and the founding and expansion of AI Innovation of Sweden.
- Sweden enjoys a leading position in terms of its technological foundation in the heavy industry sector. High-tech equipment, inherited expertise and strong R&D investment means that the Swedish industrial sector is ideally suited for cutting edge innovation, including advanced AI applications. East Middle Sweden, in the Greater Stockholm Region, is a national hub for manufacturing, robotics and heavy vehicles.
- Sweden has one of the highest proportions and highest quality of AI relevant ICT educated talent. A plurality of them are trained in and work in the Greater Stockholm Region.
- While Sweden cannot compete with China on the availability of personal/user data, the principle of public transparency and the work of several open data initiatives means that Sweden can compete on high-quality, publicly available, non-personal data.
- The Greater Stockholm Region has a unique potential for AI development through its co-location of concentrated ICT competence and concentrated heavy industry competence.
- The Greater Stockholm Region has great organizational infrastructure and smooth triple helix collaboration in place, securing a fast and efficient ecosystem encompassing both the tech world of Stockholm City and the industrial sector in East Middle Sweden.
- AI implementation in the Greater Stockholm Region is spread across many sectors but particular strong points appear to be healthtech, fintech, gaming, telecommunication, manufacturing, smart mobility and clean energy.

**Leveraging
the advantages
for growth**

4

Introductory remarks: The Nordic and Chinese perspectives

This section will provide some examples of how, based on the findings from the previous chapters, the Greater Stockholm Region may be able to convert its position in relation to China with regards to AI implementation into sustainable growth.

As countries, a Nordic country like Sweden does not have much in common with China. China has 1,4 billion citizens and Sweden has 0,01 billion. China is an East Asian emerging economy and Sweden a North European developed economy. When exploring how Sweden can establish a mutually profitable business relation with China in the context of AI, it may be useful to consider the difference in what makes each country attractive to the other.

China is in the middle of a transition from an exports-based economy to a consumer-driven economy. This means China needs to raise the disposable income and living standards of the population, which in turn requires them to increase the productivity of the workforce. This is a key reason why AI transformation is so important to China, along with other technological upgrades.

As China's economy is in transition, China's workforce and educational system also face a tough challenge keeping up with constantly changing requirements. This results in a considerable skills gap. This situation has been acknowledged by the official government outlet, Xinhua:

"Like any economy in transition, China faces a substantial skills gap that it is actively trying to fill. The demand for all skilled workers is around 1.5 times the supply. For highly skilled workers, twice as many are needed as are available."¹¹⁶

What China needs from abroad is technology to aid in their transition and talent to fill the skills gaps. Aside from that, they are still a huge exporter so they also always need export markets.

Sweden is in a good position to deliver on all three of these parameters. However, because it has such a small domestic market, it might be more relevant to look primarily at the other two parameters: technology and talent.

Sweden is a developed economy with state-of-the-art technology in place in most of its industrial sectors. It is located next to a lot of countries with similar qualities that it needs to keep up with and preferably be ahead of. Sweden looks abroad for investments, partnerships and export markets.

To put it bluntly, potential investments and market access are the two aspects that make China attractive to Sweden. Although China's outbound FDI¹¹⁷ has been dropping recently, they were still the world's second largest foreign investor in 2018 according to OECD¹¹⁸. Chinese investments can be useful for creating sustainable growth in the Greater Stockholm Region as long as they either create jobs in the region directly or help make the local industries more competitive. Aside from that, the Chinese market is of course interesting to Swedish companies because of its size.

"I think there will be interest from both sides but for different reasons. For Swedish organisations, China is clearly a huge market but we need to be able to trust our counterparties and the system. For Chinese organisations, Sweden's institutions, organisations, and people are credible and competent. Furthermore, the infrastructure in Sweden – both social, physical, and ICT – is solid, and Sweden can offer a good segue into the European and US markets."

Ingrid af Sandeberg

¹¹⁶ Xinhua Insight: Narrowing China's skills gap (Xinhua)

¹¹⁷ China's Foreign Direct Investment into other countries

¹¹⁸ FDI In Figures (OECD 2019)

The systems approach

Three experts were interviewed about the general question of how Sweden can position itself in the light of China's development and the state of their AI implementation scheme:

Manager at Arthur D. Little and Vice Chairman of the Board of Stockholm AI **Ingrid af Sandeberg**, Managing Partner at Nordic Apiary **Kristoffer Lundegren**, and Professor of Artificial Intelligence at the Royal Institute of Technology **Carl Gustaf Jansson**.

As Sweden is in close competition with a handful of nearby countries (such as Finland, Denmark, Norway, Germany, the Netherlands and the United Kingdom), one strategic approach is to focus on existing strong points. As discussed in the previous chapter, these are (for the Greater Stockholm Region):

- Sweden's advanced technological foundation in heavy industry,
- a highly educated workforce with an abundance of people trained in fields relevant to AI implementation,¹¹⁹
- good availability of public data,
- strong organizational competence,
- an internationally competitive startup ecosystem in Stockholm.

While Sweden may be said to be a world leader on all of these fronts, strong organizational competence appears to be one of its most distinctive selling points. On the other points, Sweden is on about the same level overall as some of the above-mentioned competitors.

To spark China's interest, Sweden should probably focus efforts on those particular industrial niches where it has an edge even over the other European developed economies. In a greater perspective, the ability to have a good business relationship with China can itself be an important competitive parameter between Sweden and the other North European countries. The industrial sector will do much better in the long run if it can engage China in a profitable way on a large scale.

“The biggest chance we have is to build on our already existing strength. We have some sectors in this country that are successful. In order to promote them even more, we should encourage further digitalization, including AI”

Prof. Carl Gustaf Jansson

According to professor Jansson, a key competitive edge in AI for Sweden lies in what he calls “the systems approach”.

“We're very good at building integrated systems.”, he explains. “...take Ericsson, for example. Ericsson has always been good at offering systems solutions on a global plane. Maybe if our digitalization/AI components go into our traditional system building, that gives us a better chance than having companies make narrow AI products.”¹²⁰

What's interesting about the systems approach is that it gives rein to Sweden's organizational competence. You cannot make a system if you work in just one discipline, so system-building necessitates effective interdisciplinary collaboration. What's important to remember is that the function of most AI implementations is to decide a course of action based on a continuous inflow of data. The AI is thus most often a node in a system, situated between the source of its data and the object of its decisions – whether as the “driver” of a self-driving car receiving signals from cameras and transmitting orders to the engine, or as predictor of maintenance requirements in a building, receiving data from sensors and transmitting alerts to staff members. AI implementation often requires in-depth understanding and synthesis of multiple non-AI topics.

¹¹⁹ Note that this refers to the overall quantitative availability of workers with skills relevant to AI implementation. We still have a deficit of people with particular key skills, such as data scientists. See *Artificial Intelligence in Swedish Business and Society* (Vinnova 2018), p.103-117

¹²⁰ Interview, March 2020

And the more complex the system, the greater the advantage of Swedish strong suits such as systems expertise, interdisciplinary collaboration, availability of talents in a wide range of fields, and well developed organizational infrastructure.

“My guess is that over time, the systems we produce will be better and more robust because we consider many more aspects than other countries”, says Jansson, “...and I think it’s very appropriate to mention that the triple helix is a prerequisite for all of this.”

Some research has been made into the configuration of skills required for successful AI transformation. The following is from PiiA and Blue Institute’s report about Industrial Technology (IndTech):

“During the creation of this study and the associated dialogue with industry and suppliers that took place, the importance of assembling teams with relevant competences was constantly highlighted.”

According to PiiA and Blue Institute, the four basic roles required on a team are:

“Product or production managers (who can describe, in detail, which problem to solve), systems engineers (who know what data can be used), computer scientists (who know how to build good models), and cross-discipline specialists. This latter group can be called DevOps engineers or translators. In this context, this invaluable category of people (usually made up of engineers) create commitment and knowledge and are able to move relatively freely between production, process and operational development, as well as customers’ needs and preferences.”¹²¹

In addition to these, AI transformation will also test the core skills and collaboration abilities of business leaders and automation specialists.

This again emphasizes not only the relevance of domain expertise but also the relevance of a diverse talent pool and of collaborative competence. This is why Sweden should not give up when hearing that China has better AI engineers and far more data and is spending far more on AI than it ever could.

121 *Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry* (PiiA and Blue Institute 2019)

Concrete ways to create growth

Keeping all this in mind, here are three general ways Sweden could leverage its strengths:

1. Swedish companies with competitive AI applications seeking Chinese strategic partnership to explore the Chinese market
2. Chinese companies investing or seeking Swedish strategic partnership either to explore the Swedish/Nordic/European markets or to gain ownership of Swedish technology and talent
3. Chinese companies setting up AI R&D centres in Sweden

The following is an investigation of some of the perspectives for each three ways and how Sweden and the Greater Stockholm Region's strengths play into them.

1. Taking Nordic AI applications to the Chinese market

From a Stockholm point of view, the very straightforward concept of local AI companies taking their AI applications to the Chinese market is appealing because it plays to one of the region's two main strengths: deep domain knowledge and the tech-startup scene in Stockholm's innovation ecosystem.

China's market of 1,4 billion people is interesting to businesses in all sectors, but right now it's a particularly special time for the AI sector to be thinking about China. China's previously mentioned 2017 AI development plan created an advantageous environment for anyone developing AI applications and AI technology. Funding from the 2017 package is not only available to Chinese companies but also to foreign-owned companies, as long as they are registered in China¹²².

On the other hand, the 2017 plan also induced an "AI gold rush" with a frenzy of competition which has already weathered and hardened a big roster of local AI players, and which is now all but over¹²³.

Even now that the gold rush has passed, AI technology remains an important point of focus for the Chinese government and a key element in China's economic transition. And while the competition may be fierce, the nature of AI technology – that it can be applied to almost anything – means foreign players still have a good chance of establishing themselves on the market as long as they focus on specialized areas where deep domain knowledge is essential. Kristoffer Lundegren from Nordic Apiary explains it in this way:

"You can take whatever area, and if the Chinese government put all the resources in that area, the development would go really fast. But imagine that there's 1000 of these areas. Not even China can prioritize that many things. If you have an AI solution that analyzes fertilizers for some very particular agricultural area, you can be sure no one in China is specifically working on that."¹²⁴

"If you're able to access Nordic competence in areas that the Chinese are interested in, that's where you have an advantage because you have the domain knowledge but you can access a much bigger market in China."

Lars Traaholt Vågnes, Norwegian data scientist
in the maritime industry and former Shanghai-based entrepreneur

¹²² This is according to Lars Traaholt Vågnes who co-founded the Norwegian AI startup Nusic which received Chinese government funding. See more about Lars and Nusic's journey here: [Inside Chinese AI, part 1: Free Money](#) (Copenhagen University).

¹²³ According to a manager at JD.com's startup accelerator during an interview in November 2019, startups are struggling to get funding, 15-20% of VCs have gone broke, and the rest are being very careful with their money.

¹²⁴ Interview, January 2020

Other interviewed professionals also stressed the importance of domain knowledge when considering how to approach the Chinese market with an AI application. As discussed in chapters 2 and 3, it might be very difficult to compete with the Chinese on simple, low-context AI applications. So the interesting areas are those where Sweden has a specific domain advantage. Lundegren and Jansson both offer some examples:

Examples of AI export opportunities

Cross-country skiing

“How many AI firms are focused on cross-country skiing? Sweden has decades of infrastructure and knowledge in this field: Doctors, coaches, etc. It’s been a profession for many years in the Nordics. You can’t really copy that. You need to have the snow. You need to have a couple of million people actually doing cross-country skiing. We have the data for healthcare, training, etc. The AI can analyze medical data, videos of people skiing, etc. People say China is so good at computer vision and video recognition but that’s not enough. You need the whole ecosystem around it. China’s winter industry is booming at the moment. Hebei province is building ten ski resorts with 100,000 beds. Five years from now, when all these resorts are fully developed, they will be interested in that kind of tech.”

Kristoffer Lundegren, Nordic Apiary

Human-computer interaction

“One strong thing for Europe has always been human-computer interaction. And Sweden has always been a strong player among the European countries. For example participatory design – including people in our development.”

Professor Carl-Gustaf Jansson

“A big thing happening now is collaborative application where you’re working together with robots in an open environment. Safety technology has been developed where the robots use machine learning to find out where people are moving and working.”

Bernt Henriksen, CEO of Automation Region

Power distribution from solar panels

“We have some solar energy companies in Sweden who are working on how to distribute power from solar panels. That’s a huge problem for China. The solar panel market in China is huge but 60% of the electricity generated there never reaches the consumers because their steering systems are not advanced enough.”

Kristoffer Lundegren, Nordic Apiary

What to be aware of when entering the Chinese market

Regarding the Chinese market for AI products, there are a few immediate advantages: Consumer data is easy to come by. Online payment infrastructure is very advanced. Less IP protection means that it can in some cases be easier to obtain the data you need.

Everyone would like to conquer the Chinese market, but most ventures fail. Even Amazon had to finally give up their efforts in 2019. There is a huge difference in corporate culture between China and the Western world, in addition to legal frameworks that favor Chinese domestic companies in competition with foreign actors. Europeans who have ventured onto the Chinese market all seem to repeat the same two factors as being the difference between success and failure: *contacts and willingness to adapt*.

The importance of contacts is both due to how difficult it is for outsiders to truly understand how business and society work in China and because of *guanxi*¹²⁵ culture which requires firstly that you meet people by being introduced to them and secondly that you form a personal relationship with someone before you do business with them. The importance of Chinese partnership is due to the Chinese domestic market being favorable for Chinese actors. Foreign companies generally need to team up with Chinese partners to stand a chance. Erik Walenza-Slabe, who is CEO of the Shanghai-based consultancy *IoT ONE*, emphasizes the need to be very meticulous about finding the right contacts:

“Find a trusted local partner who really understands this market. This is not easy because trust takes time. Find partners through referral. Invest time in building a personal relationship. Have dinner. Look for red flags. Make sure to write proper contracts. Stay highly engaged at both the business level and personal level after the contract is signed.”¹²⁶

In Walenza-Slabe’s opinion, unwillingness to adapt was the downfall of a company like Amazon. “They thought they could import their management teams and their business practices along with their products.”

Chinese machine learning engineer Pan Tianyi, who grew up in Finland and has done AI-related work in both countries, offers one perspective on why the ability to adapt is so crucial. In his view, it comes down to a difference in culture which permeates every aspect of everyday life and can therefore not really be offset or calculated:

“People sometimes come here and assume a lot of things work the same way they work in the Nordics. Especially in the Nordics, because the markets are small and everything is highly regulated, people behave in a sort of uniform way. Then you come here and find out that it’s very messy. A lot of things don’t work as you expect. You can never take anything for granted.”¹²⁷

“If you come here with the attitude that you know how it works because you’ve made it in Sweden, for example, that’s the wrong attitude. You can’t force your culture into the locals. The one that should adapt is you. It requires a certain mentality.”

Pan Tianyi

The prospect of Swedish companies developing competitive AI solutions and taking them to the Chinese market is interesting because it offers the potential of converting deep domain knowledge within specialized fields into considerable revenue. It’s also especially interesting for the Stockholm area because Sweden’s biggest startup ecosystem is located here.

“It’s hard for the Chinese to come here. It’s a much better pitch to market our solutions and products powered by AI. Sweden is great at innovation and at putting ideas together and producing highly competent AI solutions. We should look where we’re already strong: automotive, life science, green technology, sustainable things, materials, computer products. All those things can be disruptive if we’re using AI to back them up. The Chinese would absolutely like to import AI solutions from those sectors above. They’re quite good at some quick and dirty ways, but when it comes to really refined products, that takes a long time, and that’s why our innovative AI products can do well.”

Ying Cheng, co-founder, The China Sweden AI Hub

But international competition on stand-alone AI implementations is shaping up to be very fierce. It might be even more interesting to look at an approach which also brings Sweden’s particular home-field advantages into play: talent pool, systems competence, accumulated heavy industry knowhow and organizational competence.

The following section discusses Chinese investments and R&D collaboration with Chinese actors around AI as two other possible means of creating sustainable growth in the region.

¹²⁵ *guanxi* is Chinese for “connection”

¹²⁶ Interview, October 2019

¹²⁷ Interview, July 2019

2. Chinese companies investing in the Nordics

China's foreign investment strategy

Outward foreign investment has always been a central element of the People's Republic of China's development strategy. In the current era, a couple of factors are making it especially relevant. As mentioned before, China is attempting a very swift economic transition that requires a considerable increase in productivity. This often requires them to take a shortcut and achieve a technological upgrade by obtaining technology and expertise from abroad where their domestic research can't keep up the pace with their economic development. This is all officially declared policy, known in a broader sense as the "going out"¹²⁸ strategy. A 2006 policy paper thus stressed the need to:

"...through the establishment of overseas research and development entities, fully utilize foreign science and technology resources, follow and study global advanced technology, and continually enhance the technological development and innovation capacity of Chinese enterprises."¹²⁹

China's five-year plan for robotics states that the government should "encourage enterprises to actively expand overseas markets and strengthen technology cooperation."¹³⁰

The same sentiment is reiterated in the 2017 AI plan, and some more specific methods are laid out:

"The Next-Generation Artificial Intelligence Development Plan, released in July 2017, calls for a 'Going Out'-strategy that includes overseas mergers and acquisitions, equity investments, venture capital (VC), and establishment of research and development centers abroad."¹³¹

In the context of these policy statements, it's worth noting the profound effect that Chinese state policy decisions have on the private sector. The state is in a much better position to guide private sector dispositions in China than in Western Europe or the US, so if the government says that the private sector should establish R&D centers abroad, that's likely to happen.

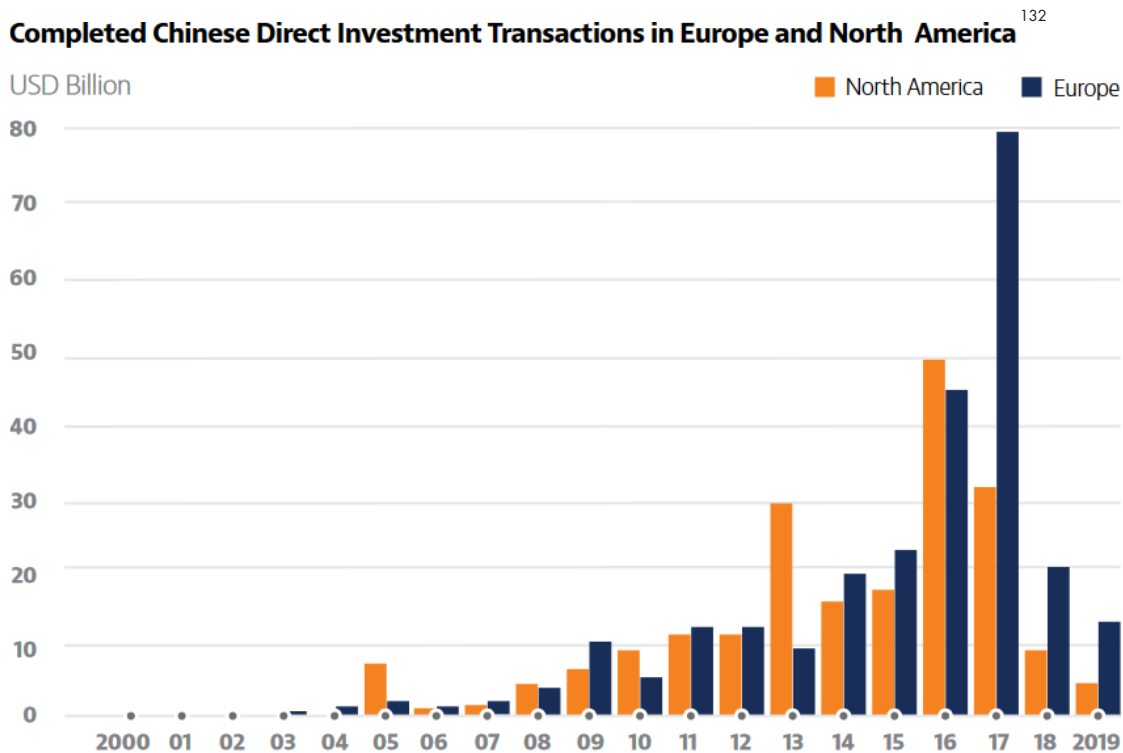
Rising tensions and the trade dispute with the USA has exacerbated China's need to achieve technological independence. There was a fear among several of the professionals interviewed in China that the US might suddenly cut off access to important resources. However, the trade dispute has also caused Chinese outbound FDI to drop sharply after a long upward trend, and the coronavirus pandemic is bound to see it drop still further. China's investment into America dropped first, but investment into Europe soon followed suit, possibly as a consequence of European nations joining the USA in blocking access for Chinese companies such as Huawei.

128 走出去 / zou chu qu

129 *Several Opinions on Encouraging Technology Introduction and Innovation and Promoting the Transformation of the Growth Mode in Foreign Trade* §3(10) (MOFCOM, NDRC, MOST, MOF, GAC, SAT, SIPO, SAFE, Shang Fu Mao Fa [2006] No. 13, issued July 14, 2006)

130 Chinese government document as quoted by the US government. *Robotics Five-year Plan* §4(6)

131 *Findings of the Investigation Into China's Acts, Policies, and Practices Related To Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974*, Office of the United States Trade Representative, 2018



Nevertheless, as recently as last year, Chinese conglomerate Evergrande Group acquired the Swedish electric vehicle manufacturer NEVS, located in Trollhättan, in a 9 billion SEK stake buyout.¹³³

Foreign investment in the field of AI

In order to speed up its AI transformation, China will look abroad to achieve those implementations they have difficulties achieving in a timely manner on their own. Sweden's lead in industrial development is the key here. Swedish industries that possess profound domain knowledge could be interesting for Chinese industries' AI transformation. Moreover, the suitability of Swedish industrial facilities for high-quality data collection gives them a readiness for effective AI implementation which many Chinese players are striving to achieve.

"Data quantity is important but so is data quality", remarks Ingrid af Sandeberg. "...Some of the major Chinese companies we have visited had tonnes of data that they were not using, as data collected are either of insufficient quality or not relevant for the intended purpose. In Sweden, on the other hand, we punch above our weight in terms of big industrial companies, many of whom are just now starting to collect data from their processes – a veritable treasure trove, if used wisely."

"Even if they start today, they can't start producing these unique datasets", Kristoffer Lundegren offers. "...Their factories are not up to digital standard. Not enough robotization." This is why China needs to invest in developed countries in order to reach their AI goals. The Swedish industrial sector, being already digitalized to a high degree and having accumulated domain and process expertise for a hundred years, is much better suited to collect data and implement AI than the Chinese industrial sector. If Sweden wants to take advantage of this position, there is a window of opportunity now for a decade or two until the Chinese catch up.

On the startup side, Nordic-China Startup Forum's experience shows that Chinese investments most often fall on Deep Tech¹³⁴ startups worth more than 10 million RMB (~13 million SEK).

¹³² 2019 Chinese Investment in North America and Europe: Reaching the bottom? (Baker McKenzie)

¹³³ Evergrande Group Acquires 51% Of NEVS (Inside EVs)

¹³⁴ Startups with the objective of providing technology based on substantial scientific advances and high-tech engineering innovation. (Wikipedia)

“I think there are several vertical clusters here that could be attractive to global players. For example, we have a large life science cluster in the Stockholm-Uppsala region, a lot of expertise in robotics and intelligent transport systems around both KTH and Chalmers, and the gaming cluster around Södermalm (in Stockholm) is influential globally.”

Ingrid af Sandeberg

What does Chinese FDI mean for Sweden?

Foreign investments and takeovers may often have a positive effect on the host region's economy.¹³⁵

¹³⁶ Foreign inward direct investment raises productivity by enhancing access to international trade and enhancing governance in the targeted enterprises, and by the effect it has on host country competition. Foreign-owned firms generally outperform domestic firms in host economies: they often have higher labor productivity, investment, skill and R&D intensity, they pay higher wages, and they are more profitable. In addition, domestic suppliers may upgrade their production processes in response to the demands of an internationally competitive client.¹³⁷ In the case of Chinese takeovers, there is the significant added benefit of easier access to the Chinese market.

However, these effects are by no means a given. Whether foreign investment is beneficial to the host region depends completely on the circumstances. There are also empirical studies which find neutral or negative effects of foreign takeovers on the host economy.^{138 139} A study done in Sweden in 2005 showed that foreign takeovers raised wages for high-skilled workers but lowered them for low-skilled workers.¹⁴⁰

Especially at a time when the Chinese government cites securing its own technological independence as its main motivation for foreign investment, it is advisable to be mindful that the investments taken in are actually beneficial to the local economy and society. This is why R&D collaborations on Swedish soil could be a desirable way of collaborating with China about AI.

The important thing here is to offer assets that cannot easily be moved: human capital and ecosystem competencies.

“It's important to understand why this is a business opportunity. If a Chinese company acquires a manufacturing business, then there is an obvious risk that they'll move it to China. But if you buy innovation and R&D, that's human capital. You can't easily move that.”

Kristoffer Lundegren

As seen in the next section, Sweden is in a good position to be a host country of bilateral R&D collaboration with China.

¹³⁵ *Foreign Direct Investment for Development: Maximising Benefits, Minimising Costs*, OECD 2002

¹³⁶ *Economic and Other Impacts of Foreign Corporate Takeovers In OECD Countries, International Investment Perspectives: 2007 edition, OECD 2007*: “Based on empirical studies so far, it is fair to conclude that inward direct investment generally helps host countries raise total factor productivity and, in consequence, their GDP.”

¹³⁷ *Economic and Other Impacts of Foreign Corporate Takeovers In OECD Countries, International Investment Perspectives: 2007 edition, OECD 2007*

¹³⁸ John P. Weche Geluebcke (2015): “The impact of foreign takeovers: comparative evidence from foreign and domestic acquisitions in Germany”, *Applied Economics*, 47:8, 739-755

¹³⁹ Jorge Bermejo Carbonell & Richard A. Werner: “Does Foreign Direct Investment Generate Economic Growth? A New Empirical Approach Applied to Spain”, *Economic Geography*, volume 94, issue 4, 2018

¹⁴⁰ Heyman et al. (2005)

3. Nordic-China R&D collaboration on Nordic soil

China's motivations for offshore R&D

Offshore R&D has long been a component of China's "Going out" strategy. In 2004, a high-ranking official from the Ministry of Commerce explained that, as one of seven aspects of "Going out", enterprises should "set up R&D centers in regions endowed with intensive science and technology"¹⁴¹.

From the Swedish perspective, foreign investment in bilateral R&D collaboration on Swedish soil presents a number of opportunities:

- attracting international talent
- creating high-skilled jobs
- catalyzing AI transformation of local industries
- gaining access to new technology

When Volvo Cars was acquired by the Chinese conglomerate Geely Group, billions in local R&D investments followed, with Business Region Gothenburg representative Patrik Andersson calling the takeover a "win-win situation" and Geely representative Gang Wei citing locally based expertise as the main reason Geely is continuing to invest heavily in its Gothenburg operations.¹⁴²

"Everyone wants to attract talent, and having bilateral cooperations between China and Sweden could be a way for both bi-directional recruitment and learning. I think bilateral collaboration will be an important way for Sweden to differentiate ourselves and create sustainable growth."

Ingrid af Sandeberg

The concept of offshore R&D appeals to China's urgent need for more innovation¹⁴³. Research indicates that offshore R&D, especially captive R&D,¹⁴⁴ generally allows the source company to improve innovation performance through benefitting from location-specific and specialization advantages.¹⁴⁵ Offshoring of R&D can allow developing countries such as China to significantly increase their gains from global integration.¹⁴⁶

AI implementation is a very relevant field for offshore R&D. It's a field which requires high precision because any errors or biases in the algorithms will quickly defeat the entire purpose of using AI, which will usually be to make accurate predictions. Achieving such accuracy in complex contexts raises demands on domain knowledge very high, and this can be a motivating factor for Chinese actors to "learn from the best" when transforming their industries. As mentioned before, AI transformation of heavy industry is very high on the agenda for China at the moment.

"In the consumer side of the market, China may be the leading AI country in the world. But if you look at the enterprise side, it's totally different. The difference between applied AI on the enterprise side and more generic solutions for the consumer side is huge. To be successful on the enterprise side, you need to have huge datasets with a long history. And besides having unique datasets with a long history, you also need to have the ecosystem and the developed industries."

Kristoffer Lundegren

141 *Findings of the Investigation Into China's Acts, Policies, and Practices Related To Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974*, Office of the United States Trade Representative, 2018

142 Gang Wei: Gothenburg is Geely's second home (Business Region Göteborg)

143 Recall premier Li Keqiang's call for mass innovation. *Premier stresses mass entrepreneurship and innovation* (The State Council of The People's Republic of China)

144 Captive R&D: acquiring foreign entities for R&D purposes, as opposed to offshore outsourcing.

145 Nieto, M., Rodríguez, A.: "Offshoring of R&D: Looking abroad to improve innovation performance." *J Int Bus Stud* 42, 345–361 (2011)

146 Fan Jingting: "Talent, Geography and Offshore R&D", *Labor: Human Capital eJournal* 2019

Why Sweden is in a good position for bilateral R&D collaboration

Empirical studies show that there are big differences between what factors go into the decision about where to locate offshore R&D depending on whether the R&D is being offshored to a developing economy or to a developed economy. For the purpose of this research, the factors that lead a company to set up R&D in a developed economy are what's relevant.

According to a renowned empirical study by Thursby and Thursby in 2006: "When companies located R&D facilities in a developed economy, the most important factors were the quality of R&D personnel and the quality of intellectual property protection. Next in importance were the expertise of university faculty and the ease of collaborating with universities."¹⁴⁷

Other studies, working with different parameters, have shown **technological capability** and **high knowledge infrastructure**¹⁴⁸ to be important^{149 150}, which squares quite well with Thursby and Thursby's findings. Output market has also been found to be of relative importance, whereas costs do not seem to be important at all when offshoring to developed economies, which is of course good news for Sweden.

Sweden scores quite high on each of these parameters:

- **Quality of R&D personnel:** As seen in chapter 3, a relatively large proportion of the Swedish workforce has an educational background within fields deemed important for AI implementation, especially ICT professionals and especially employed within the sectors of *Information and Communication Business, Manufacturing, and Electricity/gas/heating/cooling supply*.¹⁵¹ Total R&D personnel and researchers as a percentage of the labor force is high, although slightly lower than in some comparable EU countries.¹⁵²
- Sweden's **IP protection** legal framework is solid.¹⁵³
- In terms of **quality of universities**, Sweden is strong though not world-leading (except in the life science area where Karolinska Institutet ranks very high¹⁵⁴)
- In terms of **ease of collaboration with universities**, Sweden is doing very well, as described in the section about organizational competence in chapter 3.
- In terms of **knowledge infrastructure**, Sweden's organizational competence and the fact that it is termed a "high-trust society" adds force to its good research institutions and well-functioning public sector.

147 National Research Council 2006. "Here or There?: A Survey of Factors in Multinational R&D Location" – Report to the Government-University-Industry Research Roundtable. Washington, DC: The National Academies Press.

148 Knowledge infrastructure includes universities, government agencies, communities, media, and their associated assets composed of people, knowledge itself, organizational skill, and a host of shared infrastructure (e.g. transportation and communication) that undergirds their function.

149 Mehmet Demirbag and Keith W. Glaister: "Factors Determining Offshore Location Choice for R&D Projects: A Comparative Study of Developed and Emerging Regions", *Journal of Management Studies* 2010

150 Rao, Polavarapu M.; Shin, Jongtae; and Chandra, Ramdas: *R&D Offshoring in Multinational Enterprises: Relevance of Transaction Cost and Internationalization Theories* (2012), Faculty of Marketing & International Business Publications.

151 *Artificial Intelligence in Swedish Business and Society*, Vinnova 2018

152 Total R&D personnel and researchers by sectors of performance, as % of total labour force and total employment, and by sex (Eurostat)

153 *Intellectual property in Sweden* (Nordea Trade)

154 See chapter 3



AI Innovation of Sweden is an agency whose focus is “accelerating the implementation of AI through sharing knowledge and data, co-location of competences, and collaboration projects”¹⁵⁵. It was founded by almost 70 different partners from all parts of the triple helix. The value produced by AI Innovation of Sweden consists of things like: “data factories”, where large datasets are collected and made accessible; AI training courses, network activities, and testing environments for AI and IoT products.



RISE is an innovation-focused umbrella organization of nearly all Swedish research organizations. RISE.AI is RISE’s initiative to promote AI research and development in Sweden. RISE.AI combines AI research with interdisciplinary research, a wide range of test beds, innovation hubs, educational programmes, digital platforms and extensive experience in software.



The **WASP** program for AI, Autonomous Systems and Software is a 5.5 billion SEK¹⁵⁶ program created by the Wallenberg Foundation and its university and industry partners for the purpose of training at least 400 PhDs in Autonomous Systems and AI, along with several other related ambitions.

“Our open data initiatives enable (co-)innovation, and connectivity in Sweden is good and quite affordable.”

Ingrid af Sandeberg

Sweden’s overall productivity is reflected in comparative “value added per worker” figures. This table shows value added per worker in industry¹⁵⁷ for Sweden and some comparable countries in 2018:

Country	Value added per worker (constant 2010 USD)
Sweden	141761
Denmark	141385
Netherlands	128073
Finland	122082
Germany	95371
China	23157

¹⁵⁸

But the most important point is that AI implementation in complex industrial settings offers an area where Sweden’s various advantages are all brought into play. This is because, as mentioned, successful AI transformation hinges on the effective formation and cooperation of interdisciplinary teams. This places demands both on industrial domain knowledge, talent availability, organizational competence and systems competence. Anyone who wants to reap the benefits of these qualities has no choice but to base R&D operations in Sweden, which can in turn produce sustainable growth here.

“All in all, our conclusion is that Sweden has excellent potential to scale up what is already one of the world’s most advanced industrial technology bases to a connected, intelligent structure that brings in value through integration, analysis and increased automation.”

PiiA and Blue Institute¹⁵⁹

¹⁵⁵ AI Innovation of Sweden’s website

¹⁵⁶ \$580 mn

¹⁵⁷ ISIC (revision 4) tabulation categories B-F

¹⁵⁸ Industry, value added per worker 2018 (constant 2010 US\$) (Index Mundi).

¹⁵⁹ See *Swedish IndTech: How Artificial Intelligence & Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019, p.97

If Sweden wishes to improve, it can consider giving data science education to more people. For one thing, the country has a shortage of data scientists compared to other European nations. This is one weakness of an otherwise strong talent pool. For another, if it is generally accepted that the AI transformation is really coming, it might be useful to make sure all engineers get some degree of data science training.

“If we believe that this continuous digitization process is going on, it’s extremely important that the engineers we educate also have an IT education component embedded from the start. We could increase the volume of the people the industry asks for.”

professor Carl-Gustaf Jansson.

The case for the Greater Stockholm Region as location for bilateral R&D

Within Sweden, the Greater Stockholm Region offers some obvious advantages. The Greater Stockholm Region is the location of the bulk of the nation’s knowledge infrastructure. As the table below suggests: While one cannot claim that the Greater Stockholm Region is the only place in Sweden where you are geographically close to top-level industrial facilities, one can perhaps claim that it’s the only place in Sweden where you are close to top-level industrial facilities as well as to the country’s top research institutions.

Value added by region in the total non-financial business economy by industry (NACE sections) 2018¹⁶⁰

	Agriculture, forestry, fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food services	Information and communication	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Education	Human health and social work activities	Arts, entertainment and recreation	Other service activities
01 Stockholm	0.3	0.2	10.8	2.5	0.5	8.0	15.9	5.3	3.1	14.8	9.1	13.5	6.9	2.0	5.0	1.4	0.9
03 Uppsala	2.7	0.1	23.8	4.2	0.8	12.6	12.9	4.5	2.5	5.7	6.8	8.3	6.2	1.9	5.5	0.8	0.7
04 Södermanland	2.9	0.1	36.0	1.5	1.2	10.9	13.0	4.7	2.5	2.1	7.9	5.1	4.1	2.1	4.2	0.7	1.1
05 Östergötland	3.9	0.1	23.9	3.1	1.0	9.5	14.3	6.1	2.5	7.5	7.1	6.8	6.5	1.5	4.5	0.8	1.0
06 Jönköping	3.6	0.1	37.8	1.9	0.7	8.1	17.4	6.3	2.0	3.3	5.0	4.3	4.5	0.9	2.6	0.5	0.9
07 Kronoberg	3.2	0.0	31.0	1.8	0.2	8.0	17.2	5.3	1.8	5.8	5.6	12.0	3.0	1.2	2.5	0.6	0.8
08 Kalmar	7.0	0.3	32.1	4.8	1.6	9.4	12.9	5.5	3.1	3.0	5.9	5.0	4.3	1.1	2.5	0.7	0.8
09 Gotland	8.1	0.4	8.7	4.4	0.4	11.8	11.0	4.9	5.7	1.6	4.7	3.5	4.0	1.6	4.8	23.6	0.8
10 Blekinge	3.3	0.1	34.8	2.1	1.8	8.7	9.8	5.4	2.3	10.3	5.4	6.1	4.8	1.3	2.3	0.7	1.0
12 Skåne	2.6	0.1	17.0	3.3	0.8	10.6	19.5	6.6	2.5	6.6	7.6	9.7	5.3	1.7	4.5	0.7	0.9
13 Halland	3.4	0.1	20.3	6.9	0.9	11.8	20.0	5.8	3.3	2.3	6.5	6.4	4.4	1.6	4.3	0.9	1.1
14 Västra Götaland	1.8	0.1	27.4	2.1	0.7	9.0	16.1	6.8	2.7	5.9	7.5	9.1	5.1	1.2	3.0	0.8	0.8
17 Värmland	4.1	0.3	32.0	5.0	0.5	10.3	14.6	5.4	2.9	4.8	4.8	6.3	3.8	1.0	2.5	0.8	0.9
18 Örebro	2.9	2.0	29.8	1.4	0.8	9.9	14.6	5.4	2.2	4.4	7.6	5.3	4.2	1.0	6.8	0.9	0.9
19 Västmanland	1.9	0.1	33.4	2.7	0.4	10.0	14.5	4.5	2.2	2.9	6.1	7.9	5.9	1.7	4.5	0.5	0.8
20 Dalarna	5.2	3.8	25.8	3.5	0.8	11.2	15.6	5.2	3.1	2.9	4.7	5.6	4.1	1.5	3.7	2.4	0.8
21 Gävleborg	3.7	0.3	33.1	5.3	1.0	11.3	12.0	5.9	2.7	3.2	4.7	5.5	3.9	1.4	4.3	0.8	1.0
22 Västernorrland	4.3	0.2	25.8	6.4	1.3	9.9	12.0	5.9	2.3	10.1	6.5	6.3	3.7	1.2	2.5	0.7	1.0
23 Jämtland	6.9	0.4	12.2	10.2	0.2	12.5	13.3	7.4	4.9	4.3	7.1	6.4	4.8	1.7	3.7	3.1	1.0
24 Västerbotten	3.7	5.5	25.6	4.9	0.9	11.3	12.2	6.3	2.7	5.6	5.7	6.3	3.5	1.3	2.9	0.6	0.9
25 Norrbotten	2.6	24.8	16.3	4.8	0.6	10.2	9.1	6.8	2.7	3.9	3.9	6.0	3.7	0.8	2.5	0.6	0.7
TOTAL	2.2	1.0	21.2	3.1	0.7	9.4	15.6	5.8	2.8	8.3	7.4	9.5	5.4	1.6	4.1	1.1	0.9

The value of this and the importance of the innovation ecosystem in Stockholm are reflected in the bare numbers about R&D in Sweden:

R&D investment in the Greater Stockholm Region as a percentage of GDP is higher than the national average and twice as high as the EU average¹⁶¹.

The region has 39,6% of the Swedish population but 46,6% of Sweden’s R&D personnel¹⁶².

In total, 50,2% of intramural R&D in Sweden is already taking place in the counties of the Greater Stockholm Region.¹⁶³ Other centres are the Gothenburg area and Southern Sweden¹⁶⁴.

¹⁶⁰ Value added by region in the total non-financial business economy by industry (NACE sections) 2018 (Statistics Sweden)

¹⁶¹ Source: Eurostat 2019

¹⁶² Source: Eurostat

¹⁶³ Stockholm, Uppsala, Södermanland, Östergötland, Västmanland, Örebro, Gävleborg

¹⁶⁴ Regional distribution of intramural R&D, 2017 (Statistics Sweden)

But the key question will be about which specific sectors present in the region are particularly suitable for R&D collaboration with China around AI.¹⁶⁵

Below is a table of industries in Sweden ranked by value added per non-manual, private sector worker (2017), which might give a hint about which sectors are most interesting for foreign enterprises to study:

Sector (ISIC rev. 4)	Value added (mn SEK)
All sectors, average:	2.77
A-F: "Goods"	4.04
C10-33: "Manufacturing"	3.38
C20-21: "Chemicals and pharmaceuticals"	4.64
C17: "Paper"	4.11
C29-30: "Transport industry"	3.9
C25: "Fabricated metal products"	3.5
C26-28: "Computers/electronic, electrical equipment, machinery and equipment"	2.76
D-E: "Energy and environmental companies"	4.9
D35: "Electricity, gas, steam and hot water plants"	5.15
E37-39: "Sewerage, waste collection, materials recovery and other waste management services"	5.06
F41-43: "Construction"	4.52

This shows the most efficient industries to be energy, waste/sewage, construction, chemicals/pharmaceuticals, and paper. These are all industries which are present in the Greater Stockholm Region.

“It would be interesting to see more partnerships between industrial companies and start-ups with complimentary offerings (say an industrial player looking to enter a new niche market and a startup established in said niche). Academic collaboration can also generate insights into local competence strongholds.”

Ingrid af Sandeberg

Of these, energy and construction are of special interest because they correspond to sectors that have been prioritized for “international expansion” (including M&A and offshore R&D) by the Chinese government. The government has put several incentives in place to encourage this¹⁶⁷.

The Greater Stockholm Region has opportunities to benefit off R&D collaboration with Chinese companies around AI implementation in many different sectors. Here are a few examples of where the opportunities seem particularly good:

Environmental technology

China is the world’s biggest investor in renewable energy.¹⁶⁸ Their air pollution problems and their quest to become independent from fossil fuel imports have forced them to invest heavily in this field. China always has a lot of sustainability challenges because the country is hosting 18% of the world’s population on 7% of the world’s arable land. Energy is one of the 11 sectors that the Chinese government has prioritized for international expansion.

¹⁶⁵ Note that some sectors are not taken into consideration due to the China-specific focus. For example, there is a thriving powertrain/driveline cluster in the Mälardalen area in the Greater Stockholm Region, but since powertrains are only necessary for fuel-driven cars and China has recently decided to phase out fuel-driven cars to focus exclusively on electric cars, this sector is not likely to be of great interest from a Chinese perspective.

¹⁶⁶ Official statistics for value added per worker by industry in Sweden are not available. The figures here have been calculated from independently available statistics from Statistics Sweden about value added and about the number of people employed in each industry. They should be taken as indications rather than solid facts.

¹⁶⁷ (1) steel and nonferrous metals, (2) construction materials, (3) rail equipment, (4) power generation and infrastructure, (5) resource development, (6) textiles, (7) automotive, (8) information technology, (9) machinery, (10) aviation, and (11) shipbuilding. *International Cooperation Opinion* §3(7-18).

¹⁶⁸ Joel Jaeger, Paul Joffe, and Ranping Song: “China Is Leaving the U.S. Behind on Clean Energy Investment”, World Resources Institute, 2017

AI is presenting new opportunities for sustainability (as well as challenges) and the sector is hard at work implementing it. The international community's fight to counter climate change and protect the environment is an area that may benefit greatly from AI implementation. Furthermore, it's an area where international cooperation is a necessity and where countries and companies have already shown a strong willingness to cooperate across borders.^{169 170}

"I think the sustainability field is growing strong. It's become much, much stronger lately", professor Carl-Gustaf Jansson says about the sustainability field in the Greater Stockholm Region. As a quick example, the paper manufacturer BillerudKorsnäs – featured in the case study below – recently placed #1 on EcoVadis' sustainability ranking¹⁷¹.

Life science and pharmaceuticals

This is one of Sweden's most efficient industries measured by value added per worker, and it's an area where China's AI implementation is trailing. Given the significance of vicinity to high-quality research institutions when choosing a location for R&D, Stockholm's Karolinska Institutet, ranked 12th in the world among medical universities¹⁷² is an important asset.

For a great introduction to the Stockholm Region's HealthTech ecosystem, check out Invest Stockholm's report, [Stockholm Life Science AI/ML Guide](#).

Construction

According to [the European Construction Sector Observatory's country profile on Sweden](#), the Swedish construction sector has recently experienced strong growth and has a positive outlook. The table above also shows that construction is one of the most efficient sectors by value added per worker. "Construction materials" is one of the sectors singled out by the Chinese government for international expansion. Stockholm is Sweden's construction hub, being home to four of Sweden's five biggest construction companies.¹⁷³

[This article](#) lists 10 of the important AI implementations in the construction industry, several of which require deep domain knowledge that is hard to access.¹⁷⁴

Manufacturing

On the following pages is a case study of The DEEP Project – an AI implementation in the Greater Stockholm Region's manufacturing sector which highlights some of the competence embedded in the ecosystem. The manufacturing giants in the Greater Stockholm Region: ABB, Alfa Laval, Sandvik Comorant, Epiroc etc. have not been willing to reveal their AI implementations, but they are sure to be in possession of technology that would be of interest to Chinese industrial players, especially in combination with the favorable ecosystem factors discussed above and in the case study.

These are only some selected examples. Collaboration is probably possible in many other fields as well.

"If they want to prepare for the future, they should come to the Nordics. They should partner up here, and not only with ABB or the big robotics companies. A lot of startups in the Nordics are focused on automation for the industry."

Kristoffer Lundegren

¹⁶⁹ [What artificial intelligence means for sustainability](#) (GreenBiz)

¹⁷⁰ Ricardo Vinuesa et al.: ["The role of artificial intelligence in achieving the Sustainable Development Goals"](#)

¹⁷¹ [BillerudKorsnäs number one in global sustainability rating](#) (BillerudKorsnäs web)

¹⁷² [Best Universities \(Medicine\)](#) (Times Higher Education)

¹⁷³ [The largest companies by turnover in Sweden in the industry Construction of buildings](#) (LargestCompanies.com)

¹⁷⁴ [The Benefits of AI In Construction](#) (Constructible)

Case study:

The DEEP Project¹⁷⁵

The pulp and paper industry is one of many advanced industries in the Greater Stockholm Region in which automation and AI implementation is already ongoing. The DEEP Project at BillerudKorsnäs' production facility in Gävle utilizes deep learning to optimize processes in paper production based on meticulous data collection in different stages of the production process. The DEEP Project is an example of a difficult but possibly very profitable AI implementation in the industrial sector, made possible by the expertise present in the Greater Stockholm Region.

Background: Sweden's starting position for technological transformation in the forestry and paper industry

While China is the largest paper producer by volume, Sweden is only surpassed by Finland in paper production per capita. When looking at paper production compared to GDP, Sweden still outproduces China by a factor of three. One reason Sweden and Finland are able to compete so well with countries where the cost of production is lower is inherited expertise. With 69% of the Swedish land being covered in forest, the Swedish have been developing their forestry techniques for over a thousand years. The first paper mill opened in 1621, the first paper machine was put to use in 1832, and the world's first paper mill using the modern Kraft process for papermaking was opened in Sweden in 1890¹⁷⁶. But an equally important reason is that Swedish factories optimize their processes to the highest possible degree to maintain a technological lead. The groundwork that made this AI implementation feasible was laid in the 1980s when the Swedish pulp and paper industry adopted the state-of-the-art computer technology of that time.¹⁷⁷

Moreover, the inherited expertise is what enables the Swedish industrial sector to swiftly adopt the latest technology. The successful use of machine learning as a tool always depends upon a deep understanding of the processes that are to be optimized.¹⁷⁸

Processes in the pulp and paper industry

The pulp and paper industry has an advanced supply chain with multiple levels of complexity and difficult, resource-intensive processes. First the tree needs to be felled and barked and the wood chipped. Then the cellulose fibres in the wood must be separated from lignin and hemicelluloses through the process of pulping. After that, the pulp must be formed into a paper web and then pressed and dried in a Fourdrinier machine. The properties of the resulting paper products are determined by complex relationships between the different stages of the manufacturing process.

¹⁷⁵ This case study is adapted with permission from *Swedish IndTech: How Artificial Intelligence And Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019

¹⁷⁶ *Essentials of Pulping and Papermaking*, Christopher J. Biermann 1993

¹⁷⁷ *Swedish IndTech: How Artificial Intelligence And Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019, p. 33

¹⁷⁸ *Swedish IndTech: How Artificial Intelligence And Digital Platforms Are Changing Industry*, by PiiA and Blue Institute 2019

The partners

The DEEP Project is a consortium between BillerudKorsnäs, Peltarion, PulpEye and FindIT, in collaboration with PiiA.

	<p>BillerudKorsnäs is the second largest paper producing company in Sweden and the largest producer of packaging for food and beverages¹⁷⁹. It builds on 150 years of experience in the forestry sector. BillerudKorsnäs has one of the highest sustainability rankings in the industry.¹⁸⁰ The Gävle facility produces packaging for liquids.</p>
	<p>Peltarion is a Stockholm-based AI company specializing in tailor-made AI applications for business customers. Peltarion delivers the core software for the project, drawing on their expertise at deploying AI solutions in varying contexts.</p>
	<p>PulpEye is a local company that specializes in data collection specifically for the pulp and paper industry. They have developed products that can carefully monitor dozens of the many different processes and subprocesses involved in paper production.</p>
	<p>FindIT is a regionally funded automation consultancy whose purpose is to help companies transform through automation.</p>
	<p>PiiA (Process-Industry IT and Automation Initiative) is a national strategic innovation program whose purpose is to ensure that the Swedish process industry has the advanced IT and automation solutions it needs to harness digitalisation more effectively than its global competitors.</p>

¹⁷⁹ The largest companies by turnover in Sweden in the industry Manufacture of paper and paper products (Largest Companies)

¹⁸⁰ BillerudKorsnäs number one in global sustainability rating (BillerudKorsnäs web)

The project

Process industries produce huge amounts of data and have a high degree of automation, but they also face a variety of challenges. These challenges can't always be addressed through traditional analysis methods. As such, the data produced can be a valuable asset, capable of being refined through AI to generate insights, predictions and automation algorithms – thus enabling the next stage of productivity, quality and automation.

The purpose of the DEEP Project has been to realize the efficiency potential identified in the manufacturing process by enabling online evaluation and adjustment of machine operational parameters. The data collection required for this purpose has been realized through PulpEye's production of high-resolution microscopy images which provide information about the pulp's fibre properties, as well as camera images from the drying cylinder which provide information about the de-watering of the pulp, in combination with various measurement values from sensors in the system.



One essential feature of the finished liquid packaging board is the carton's stiffness. This property is determined by parameters in all the previous stages of the process and how they relate to each other. In this case, data may be collected and AI then be employed to suggest optimal configurations for certain degrees of stiffness ideal for certain uses. A general objective is to produce strong packaging using less raw material.

A specific AI implementation carried out during the feasibility study for the DEEP Project was using AI to predict the kappa number of pulp after boiling. The kappa number is a measure of residual lignin in the pulp, and determines the boiling process required for different pulp qualities. The project was successful and resulted in a useful technique for predicting the kappa number. This success encouraged further development of the approach in other process steps.

The takeaways

The DEEP Project is one piece of evidence that the possibility of AI (deep learning) implementation is one of the major benefits of industrial digitalization. The process industry is characterized by a combination of large amounts of data and a high degree of automation, which produces conditions that differ from other fields that apply machine learning. Harnessing the power of the data which is present in the production process requires technology, talent, and deep domain knowledge enabling the formulation of the right problems and pinpointing exactly what data needs to be collected and how it can be put to use.

The DEEP Project is possible because of the co-location of BillerudKorsnäs' high-tech industrial facility with its 150 years of accumulated domain experience, Peltarion's core AI software competency bred by the Stockholm City tech ecosystem, PulpEye's specialized sensors, and public automation and network support from FindIT and PiiA.

Deep learning is on its path to being implemented in all the other process industries as well and solving many more problems that affect efficiency and quality.

The outlook for Nordic-China AI collaboration

The field of AI shows promising opportunities for Nordic-China collaboration in the Greater Stockholm Region. However, in order for such collaborations to succeed, a couple of issues need to be addressed.

Any collaboration requires each side to trust the other. From a Nordic point of view, China can seem distant and opaque. More competition from more actors, a less regulated economy, and a far more cut-throat corporate culture¹⁸¹ means that Chinese enterprises have more work to do to establish trust than Nordic ones. As mentioned before, establishing solid, personal contacts and trust in China is essential. However, a reliable legal framework for IP protection is also needed. The issue of IP protection is a concern for all countries, and China is no exception. China is already in the process of working to establish adequate protection of Intellectual Property Rights.¹⁸²

At the time of writing, an investment treaty between the EU and China is due to be signed in 2020. Its main purpose is to secure better conditions for EU companies operating in China.¹⁸³ More initiatives would be welcome. Ingrid af Sandeberg suggests that a matchmaking function for Nordic-China collaboration might be helpful:

“As a next step, it could be useful to also have some sort of matchmaking platform to act as a ‘cultural and communication buffer’. E.g. if Swedish and Chinese companies sign up and are vetted, the platform can help translate across both linguistic and cultural barriers. A good pitch for a Chinese investor, industrial or start-up looks very different from one that a Swedish equivalent would bite.”

Bilateral trade opportunities are also closely related to bilateral relations, both in the sense that good relations create better business opportunities and that more business usually creates better relations. The potential gains from increased collaboration are great, not just economically and technologically but also in terms of long-term security.

There is a range of framework that could be useful in order to improve Nordic-China trade opportunities, including:

- a legal framework to protect IPR
- a legal framework to protect sensitive technology and infrastructure if there are national security concerns
- a good investment treaty between China and EU
- to supplement this treaty, possibly more trusted platforms where Chinese and Nordic companies can verify each other’s authenticity and set up corporations

It might also be worth considering whether collaborative frameworks between individual cities could also be further developed in order to create smoother and more direct paths for business.

China’s open commitment to AI presents an opportunity to anyone who has something to contribute. As this report aims to demonstrate, this definitely includes Nordic regions. If China’s technological development continues its fast pace, the current moment might be considered a window of opportunity, during which the Nordic countries have the possibility of leveraging their technological advantages for growth. Conversely, as China has already surpassed Europe and the US in some aspects of AI implementation, Nordic-China collaborations may also over time increasingly become a source of technology access in addition to economic growth. To stay on the front line of development, it might be wise to study and interact with the place where the fastest development is occurring.

181 As documented in Kai-Fu Lee’s *AI Superpowers*

182 [China’s invention patents and royalty income are on the rise as it steps up IP protection amid trade war with US](#) (South China Morning Post)

183 [EU-China Comprehensive Agreement on Investment](#) (European Commission)

Further reading

If you're interested in the topics discussed in this report, here are some of the books, reports and sources that have been referred to in the making of this report:

- *Artificial Intelligence in Swedish Business and Society – Analysis of Development and Potential* (Göran Marklund, Vinnova – Sweden's Innovation Agency 2018)
- *Swedish IndTech – How Artificial Intelligence & Digital Platforms Are Changing Industry* (Örjan Larsson, PiiA and [Blue Institute](#) 2019)
- *Stockholm Life Science AI/ML Guide – Shaping The Future of Healthcare Intelligently* (Ylva Hultmann, Invest Stockholm 2019)
- *Who Is Winning the AI Race: China, the EU or the United States?* (Daniel Castro, Michael McLaughlin, and Eline Chivot; Center For Data Innovation 2019)
- *Red AI – Victories and Warnings From China's Rise In Artificial Intelligence* (Nina Xiang 2019)
- *AI Superpowers – China, Silicon Valley, and the New World Order* (Kai-Fu Lee, Houghton Mifflin Harcourt 2018)
- *China Internet Report 2020* (South China Morning Post 2020)

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