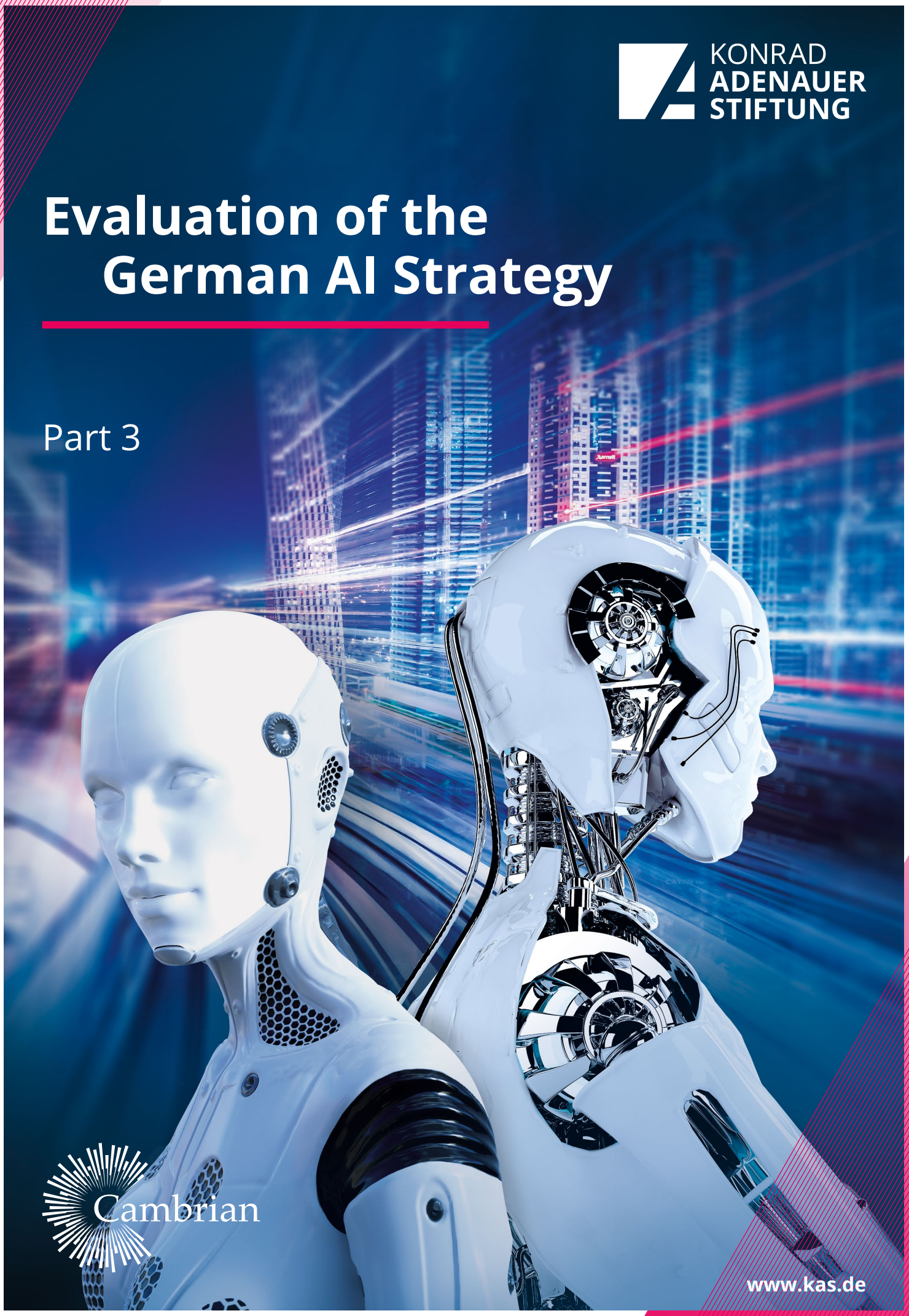
KONRAD ADENAUER STIFTUNG

Evaluation of the German AI Strategy

Part 3



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Background and Definitions

Artificial intelligence: rapid developments and designs of the initial conceptual AI frameworks.

In July 2018, the German federal government published a key issues paper on the German strategy with regard to artificial intelligence (AI) and there they acknowledge: "Artificial intelligence has reached a new stage of maturity in recent years and is becoming a driver of digitization and autonomous systems in all spheres of life."[1] Therefore, the state, society, the economy, the government, and science are urged to consider artificial intelligence in depth and to deal with its chances and risks.

The comprehensive German AI strategy was presented at the Digital Summit in December 2018. In this way, Germany is catching up with a large number of countries which in recent years have seen extensive initiatives for AI strategy finding processes.[2]

These strategies are motivated by partly spectacular developments in research and application of AI systems based on machine learning techniques (ML) as well as the sub-discipline of deep learning (DL) and its various forms of neural networks. The global relevance of AI technologies is also reflected in the constant presence of the topic on the international agenda.

The role of Artificial Intelligence as a potential key technology of dystopian future concepts, social control, and autocratic world power fantasies is also increasingly finding its way into public debate. While the two previous studies presented a comparative overview of the AI strategies of major economies, this part concludes the series and analyses the German CI strategy compared to the international situation.

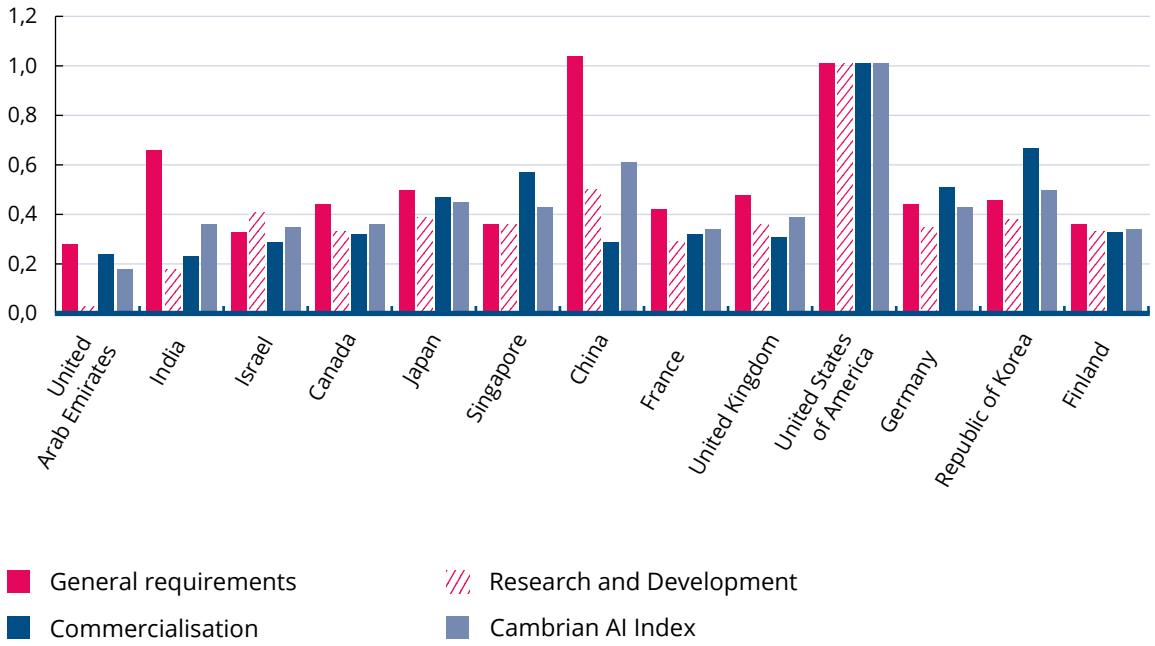
The following definition is used as a basis for the terminology:
"In the broadest sense, artificial intelligence is the ability of machines to learn, think, plan and perceive; the primary characteristics we identify with human cognition. This characteristic is achieved through digital technologies, or digital-physical hybrid technologies, which mimic human cognitive and physical function. For that purpose, AI systems do not only process data, they recognise patterns, draw conclusions, and become more intelligent over time. Their ability to adopt and refine newly developed skills has improved significantly since the turn of the century. This also means that what is referred to as AI changes with each major technological breakthrough, and the definition must therefore be periodically adjusted."

1 Cf. German Federal Government, Key Points of the Federal Government for an Artificial Intelligence Strategy (July 2018), https://www.bmbf.de/files/180718%20 Eckpunkte_ KI-Strategie%20final%20Layout.pdf.

2 To this end, see the OECD overviews, for example, http://www.oecd.org/going-digital/ai/initiatives-worldwide/, Future of Life Institute, https://futureoflife.org/ai-policy/, the Smart Data Forum, https://smartdataforum.de/ en/ services/international-networking/international-ai-strategies/, Charlotte Stix, https://www.charlottestix.com/ ai-policy-resources, und Tim Dutton, https://medium. com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd, all last retrieved on 17.9.2018.

Cambrian AI Index © as context for Germany

In the course of the analysis in parts 1 and 2 of the study “Comparison of National Strategies for the Promotion of Artificial Intelligence”, twelve countries (USA, China, Great Britain, France, Finland, South Korea, Canada, Israel, Japan, United Arab Emirates, Singapore and India) were evaluated on the basis of indicators related to the prerequisites, the research and development situation as well as the commercialisation of AI in the respective country. To integrate these indicators and determine the AI position of a country, the Cambrian KI Index © has been developed. The index is limited by proxy measurements for which reliable and comparable data are available at this early stage of the AI development (see chapter: Methodology of the Cambrian AI Index). There was no weighting of the data. The reference country for the index is the United States, the world’s leading AI nation.



Summary and Evaluation

The German Strategy for the Promotion of Artificial Intelligence (AI) was officially presented at the Digital Summit of the Federal Government in December 2018. The German strategy builds on the strength of German science, particularly in the field of fundamental research. This strength is to be further enforced and supplemented by an improved transfer of scientific findings to industry. In addition to these focal points, the German AI strategy also formulates the claim to globally integrate German added value in the AI sector and to shape the AI age ahead along ethical lines.

So far, the lack of permeability between science and the private sector has prevented the scaled transition of research results into commercial applications. Among other things, there is a lack of global platform companies in the digital economy (exception: SAP), which could scale innovations worldwide through ethical business models. A focus on industry 4.0 will not be sufficient to achieve the power to shape and influence the entire breadth of the field at the global level. Beyond the economy, society as a whole will be more strongly penetrated by AI in the future and thus also the ability to bundle, clean up and analyse data, and draw conclusions from such data. Consequently, Japan, for example, relies on the model of a *Society 5.0.*

The planned measures of the German AI Strategy are more complex than those of many other countries. Germany's planned financial expenditures also exceed the investments of other European countries, such as France or Great Britain. In an international comparison, however, it must be stated that Germany is rather late in terms of its comprehensive funding of AI. On the one hand, this is evident in the lead that other countries, such as Israel or Canada, besides the USA and China, have been able to gain with targeted funding of AI, above all in the so-called B2C area.

On the other hand, it is made clear by the warning words from science and industry, which also call for the urgency of targeted AI funding by the federal government and the European Union if the full potential of AI is to be opened in the sense of German and European values.[3] The development of a digitally competent and mature civil society, the safeguarding of the efficiency of the German AI research landscape as well as the wide-ranging application of new technologies takes time, as does experimenting with new models.

Whether Germany can keep up with the international competition for talent, data pools and computing power will not be decided solely by the financial issue of whether the 500 million Euro per year envisaged in the strategy will suffice until 2025. The Chinese city of Tijan alone is planning to promote AI spending with a sum of 12.8 billion Euro and the Chinese company Alibaba has even budgeted up to 16 billion Euro. Rather, the decisive factor will be how open and constructively critical all parts of society will be towards the potentials and risks of artificial intelligence. For only if the AI strategy sparks a similar social fire – as the Apollo Program in the 60s and 70s in the USA – and stimulates people to do research and found new ventures, can Germany continue to help shape the cognitive age in the future. To this end, the federal government must not only involve the elites from business and science in the implementation of the strategy, but also take into account prospective green powers, schools and representatives of civil society. A communications campaign, as it is currently planned in the strategy is expedient and necessary, but should at the same time be underpinned by socially meaningful showcase projects. The lighthouse projects envisaged for this purpose in the strategy in the area of climate change are a good start and should also be transferred to other areas. Lighthouse projects would be promising in the health sector, for

example. It is precisely in this area that there is potential for stronger transatlantic cooperation. For example, the USA follow the goal of promoting innovative neurotechnology through the *BRAIN Initiative*, a partnership between the public and private sector.

In order to make the implementation of the German AI strategy effective and to establish Germany as one of the leading AI nations, 14 recommendations for action are also proposed. These are not intended as a sort of criticism of the strategy, but as measures that are explicitly based on the German AI strategy and intended to supplement or substantiate existing approaches:

1) **Create commercial incentives for the provision of data and establish data exchange protocols,** to ensure the availability of high-quality data while maintaining high security standards. **One focus here should be on the promotion of cross-company data pools in SMEs, which supports application-oriented AI development for the backbone of the German economy.**

2) **Make investments in the development and commercialisation of computing power based on CPU, GPU, TPU and Quantum Computing,** for example in cooperation with European (model: CERN) and American partners, or Japanese and Korean semiconductor manufacturers.

3) **Prioritise the expansion of the further training portfolio on AI. S**ociety must be provided further education in digital literacy and data science. Preferably already in schools, and later through education vouchers for training offers at adult education centres, technical colleges, universities and private further education institutes.

4) **Consider and integrate security policy as an AI field of application in the strategy.** In contrast to the USA or Russia, for example, the German Federal Government's AI strategy has no reference to security policy. Against the background of the dangers emanating from AI-supported cyber attacks or the risks of the military application of AI in lethal autonomous weapon systems, this gap must be closed.

5) **Establish a central and digitally competent steering structure in the form of a digital ministry,** which can bundle, coordinate and, where necessary, manage the implementation of the strategy and the associated initiatives of the various ministries.

6) **Strengthen global networks with developing and emerging countries.** Through culturally sensitive and locally adapted approaches for AI promotion, Germany can support developing and emerging countries in the field of AI and increase the potential of an ethically reflective *AI made in Germany/Europe* to emerging countries.

7) **Support of a "Digital Magna Carta",** which goes beyond AI observatories and cooperation with the UN, G7 and G20, and which, through a new AI-driven consensus mechanism, will include **Civil society in all regions of the world.**

8) **Expansion of recruitment programs** for leading academic staff in international countries, based on the already existing *German Academic International Network* (GAIN).

9) **Further promote permeability between science and industry along existing value chains** to strengthen commercialisation and scaling of excellent fundamental research. Examples and best practice models for this can be identified in the USA, Israel, Finland, France and Japan, for instance.

10) **Expansion of research cooperation also outside Europe** with complementary institutes in the USA, Canada, Japan and South Korea. Concerted strategic participation of German players in these institutes and networks would have to be possible with the help of a dashboard of different target values in order to be able to moderate the exchange of knowledge in a targeted manner.

11) **Implementation of the previously planned tax deductibility of costs for research and development (R&D) in the private sector,** especially for small and medium-sized companies doing research. Countries such as the USA and China emphasise that the private sector can play an important role not only in commercialisation but also in R&D.

12) **Promotion of more efficient innovation ecosystems.** However, measures under the AI strategy should not only focus on strengthening start-ups at national level. In particular, Germany should work towards comprehensive enforcement of the pan-European innovation ecosystem. It is precisely through more intensive networking of existing innovation centres across national borders that existing AI potentials in Europe can be better mobilised. This would also further facilitate Germany's efforts. Particular emphasis should be placed on the further development of the European digital single market and improved availability of risk capital. Both aspects are essential to ensure that innovations scale appropriately in Europe and that innovative German companies have the chance to become the digital champions of tomorrow.

13) **Promote knowledge transfer among officials, entrepreneurs and employees.** Possible ways of implementing this are work shadowing schemes between companies, authorities and science institutes, as provided for in the American AI strategy of the Obama government.

14) **Strengthen public authorities as users and procurers of ethically appropriate AI.** This requires a more agile procurement system that makes use of more competitive dialogues and innovation partnerships within the framework of EU law, as well as the instrument of innovation competitions. One example of such a competition is the DARPA Robotics Challenge in the USA, for instance.

3 "Europe is not keeping up", is the unanimous verdict of the signatories of the ELLIS open letter with reference to the AI research laboratories in North America, the AI investments in China and the attractiveness of American and Chinese companies for AI researchers from the Continent. With reference to the attractiveness of their location, *Head Hunters* of American companies regularly try to entice top scientists away from the current European AI hotspots. (Armbruster, 2018a; ELLIS, k. D.).

Germany

A late but multi-faceted approach for “AI made in Germany”

- 3 billion Euro of additional funds for AI until 2025
- Development of a national network of twelve AI centres and application hubs as well as creation of 100 additional AI professorships
- Focus on research and transfer to industry, especially for SMEs.
- The use of AI by the public sector remains a marginal issue.
- International networking through bilateral partnerships, via Brussels and global multilateral bodies (G7, G20, UN)

I.) Introduction

On 14 November 2018, the Artificial Intelligence Strategy of the Federal Government was published. The declared objective: Making Germany the world’s leading AI location, both in research and in the application of AI, under the quality label “*Artificial Intelligence (AI) made in Germany”.* The strategy focuses on social benefits, ethical and legal issues as well as Europe itself. To achieve this goal, the Federal Government will provide additional funding of 3 billion Euro until 2025 and assumes that the federal states and companies will invest the same amount. The strategy recognizes that AI as a basic technology has developed “into the driver of digitalisation and autonomous systems in all areas of life”. Therefore, the state and the administration system are required to work together with stakeholders from society, business and science to develop the potential of AI and to constructively and efficiently deal with the risks. In contrast to other countries, the German strategy was developed through a step-by-step approach.

Based on a key issues paper of July 2018[4] it was developed into a multi-faceted strategy document through expert forums and a public consultation process. Thus, their focus is on the research and commercialisation of AI. At the same time, however, it contains interfaces to almost all political areas, such as health, agriculture, environment and climate, or development cooperation. In addition to new aspects, the AI strategy also encompasses already existing sector strategies and measures (such as the *High-Tech 2025* Strategy of the Federal Government or the *Industry 4.0 Platform).*

II.) Requirements for AI

As far as the requirements for AI are concerned, Germany has so far tended to be in the midfield of the countries surveyed (see the first two parts of the study). Although it is the leader in Europe in terms of the absolute number of Internet users, it is not in an international comparison. The nearly 74 million German internet users (2016) as an indicator for the size of the national data pool, 88 percent of the German population, correspond to only about ten internet users in China or 35 percent in the USA.[5] In terms of availability and quality of public sector data, the country ranks seventh in comparison (behind Japan).[6] In contrast to the USA or China, where the business models of technology companies are based on the collection and processing of data, German technology companies are more strongly based in the manufacturing industry.

Due to a high degree of automation, Germany has immense potential for the development of industrial data pools, especially in this sector. In order for these to be accessible to SMEs as well, cross-company data pools would have to be set up. In addition, German actors lack access to large-volume and cross-border data pools, due in part to fragmentation in Europe. The strategy rightly considers this to be a disadvantage, which it intends to counteract with a comprehensive list of measures. These include support for the creation of a European data space, the examination of data partnerships between companies and research institutions and the establishment of a national research data infrastructure, support for international and German *(International Data Spaces* or M-Cloud and MDM) data initiatives, the promotion of open training data sets, research on the interoperability of industrial data and the improvement of the accessibility of public data.

Recommendations

Improvement of the availability of data: As a stand-alone country, Germany is likely to continue to have difficulties keeping up with the size of data pools in countries such as the USA and China in the future. Therefore, first and foremost, a European solution within the framework of the basic data protection regulation (EU-DSGVO) is needed which can also be joined at a later stage by major players from overseas. Accumulation of a critical mass of high-quality data is difficult, however, and commercial incentives for companies should therefore be examined within the framework of the desired data exchange formats so that these data can also be shared across companies. The initiative of the Finnish innovation agency SITRA to develop a secure data protocol (IHAN) could be a starting point for Germany in order to enable a platform for the exchange of data and its secure transport. Against this background, it is also recommended that the German Open Data platforms (such as MDM or M-Cloud for applications beyond mobility) be further expanded and transferred to a European portal. This can be done with the help of start-up companies in Berlin, Hamburg, Munich, London and Paris, which demonstrate the value of the platform through pilot projects. The *Open Data* approach coincides with initiatives in the USA, Canada and Finland, which offer a high-quality but cost-effective basis for *digitally native* startups using *Open Government Data*. With such a model, Europe could also globally emerge as an alternative to the USA and China for developing and emerging countries. Europe's strengths in the combination of personality protection and security are also of increasing priority for technologically less developed countries in the global South in order to exploit the potential of AI.

Germany hosts 21 of the top 500 commercially available supercomputers (Germany is thus in

fifth place among the 13 countries surveyed behind China and the USA, as well as smaller countries such as Japan and Great Britain).[7] Unlike other European countries, Germany is home to internationally renowned semiconductor manufacturers.[8] However, their sales are low compared to Chinese and American manufacturers. Although semiconductors are traded internationally and computing power is available worldwide via cloud systems, current trade conflicts show that dependence in this area can prove to be a strategic disadvantage.[9]

Recommendations

Initiation of strategic investments in computing power: AI design power on the global stage requires the availability of computing power at different levels of technological development (including GPU, TPU and Quantum Computing). The USA and China are increasingly defining these capacities within the framework of national security. The dependence on foreign semiconductor manufacturers or *cloud* service providers is therefore a strategic disadvantage for Germany and Europe. Thus, to compete with China or the USA in semiconductor production is hardly possible in the short term. Nevertheless, existing producers such as Infineon should be promoted more strongly in order to keep strategic options open for Germany in the medium to long term and to actively participate in technological developments. Just as Europe has joined forces to create the world's largest particle accelerator at CERN, Germany should work together with its European partners on the development of quantum computers. Such cooperation should include the integration of a start-up ecosystem tailored to this area, which will bring about an upswing to the European semiconductor industry. Here, too, the aim is to develop skills that will put Germany and Europe in a position, in the medium to long term, to act with a competent position in the global development race and to help shape the development of this field in favour of their own values and interests. Against this background, existing cooperations with the USA, Japan or South Korea – which already exist in the production of semiconductors in the automotive industry – should be consolidated and expanded.

The estimated number of Master's students who each year graduate from the computer science institutes where AI is actively researched is just over 400 (eighth place among the 13 countries surveyed).[10] The start-up ecosystems in Berlin, Munich and Hamburg with their university, cultural and natural offerings as well as their global links to networks and infrastructure are increasingly attracting foreign talent[11] – but not yet with the same success as San Francisco or London. To promote education and training of local experts, the strategy states that AI should, among other things, become an integral part of vocational training and further education. Early support in schools is also planned, although this will be delayed due to the rejection of the Digital Pact by the Federal Council at the end of 2018.

Recommendations

Prioritise the expansion of the further training portfolio on AI: Society must be given the opportunity to further its education in *digital literacy* and *data science.* In Singapore, for example, the government offers free AI workshops for the general population (*AI for Everyone),* to enhance understanding and acceptance AI applications and to promote the identification of possible applications in the companies or in the daily lives of citizens. Another possibility is to offer education in the fields of data science, robotics, and system design, as introduced by the Singapore government, for example. Through further education offers for young university graduates of all disciplines, the transfer of creative ideas into the industry is also supported. This would also offer the possibility of interdisciplinary and critical reflection at the interfaces to ethics, sociology, anthropology and psychology. At the same time, however, it should be made easier for employees to acquire new digital skills. It would make sense to have paid educational leave or receive educational vouchers, which can be used for courses at adult education centres and technical colleges, universities or private further education institutes for appropriate offers. Such facilities could offer workshops, which could be co-designed by industrial players and data or AI experts, where employees can work together with employers on future occupational and competence profiles and where project

groups can support each other. In the USA, Israel and the United Arab Emirates, high-tech companies and universities organize so-called *coding boot camps* to expand the AI capabilities of engineers and computer scientists. The Israeli Innovation Agency (IIA), for example, would be an ideal cooperation partner for Germany. Both employers and employees can be rewarded for this with tax reductions, bonuses or a points system for pensions. This is the only way to ensure that the potential of AI is used responsibly across the entire range.

III.) Institutional framework

"We also want to assert our position in the competitive arena and be at the forefront," said Chancellor Merkel in April 2018 with a view to China's AI strategy.[12] In the coalition agreement, the federal government also announced that it would "make Germany one of the world's leading locations for research into artificial intelligence".[13] In order for this to succeed, three Federal Ministries were commissioned with the development of the German AI strategy, the Ministry of Education and Research (BMBF), the Ministry of Economy and Energy (BMWi) and the Ministry of Labour and Social Affairs (BMAS), flanked by the Minister of State for Digitisation, the Digital Council of the Federal Chancellor and other bodies. The Federal Ministries of Transport and Digital Infrastructure (BMVI), of Internal Affairs (BMI) and Justice and Consumer Protection (BMJV) deal with AI, for example on the challenges of automated and networked driving or the modernisation of administration.[14] Unlike in the USA, Israel or China, for instance, the area of security policy is not of central importance in the German CI strategy.

Recommendations

Consideration and integration of security policy: Not only in comparison with other nations, but also against the background of the dangers of cyber attacks for the democracy and infrastructures, security policy components make sense in a national AI strategy. This requires a discussion of the role of AI in security policy and a definition of the interfaces between the various political areas and AI. The hacker attacks of recent months have already triggered a corresponding discourse. However, this must be translated into concrete policy proposals and institutional structures. The Agency for Innovation in Cyber Security, the foundation of which was announced in 2018 is an important first step in this direction.[15] The *Defense Advanced Research Projects Agency* (DARPA) of the US military, among others, shows what a powerful organisation for the development of security-policy-relevant AI could look like. DARPA invests in the research and development of AI, on the one hand for military purposes and on the other hand at the important interface with climate change. With the JEDI programme, initial steps have already been taken at European level, which Germany should further strengthen in addition to the efforts at national level. Only if Germany is given a global voice in security policy fields of application can it continue to play a part in multilateral forums and help shape the further development of international law in AI issues.

Overall, there is a lack of a central organisational unit to manage the implementation of the strategy, as is the case in Great Britain, South Korea or China. Instead, the AI strategy is to be implemented primarily via national and international networks of existing institutions. Only the Agency for Leap Innovation announced by BMWi and BMBF in August 2018[16] will add a new kind of player to the institutional structure. The agency is to open up scope for innovators to produce "disruptive innovations" that have the potential to open up new markets or market segments.[17] For this purpose, the agency should also make-use of the approach of innovation competitions, so-called *challenges* as known for example from DARPA (USA), NESTA (UK) , the *Innovation Foundation,* and the *Alan-Turing-Institute* (Great Britain). This may introduce new impulses in the promotion of innovation. However, the agency's financial resources will be much smaller than those of the American model.

Recommendations

Establishment of a central and digitally competent control structure in the form of a digital ministry, as already demanded by various entities involved

in the 2017 federal elections. To globally position the *"AI Made in Germany"* brand with its quality promise and to ensure the effective and efficient use of available resources for the promotion of AI, Germany needs such a ministry which will coordinate and manage implementation of the strategy. This would involve pooling the work of the various bodies the digital strategies and ministry initiatives, advising them on implementation and networking at European level. Such a ministry should also have an alternating transition function for the promotion of AI in areas of security policy and civil application, in order to prevent a civil-military merger, as can be observed in China (see Study Part 1). As an alternative to a digital ministry a national Digital Council (NDR) would also be possible. It could be organised by the Chancellery as the main responsible entity and controlled/managed by a coordinator for AI and cognitive technologies. A first step in this direction has already been taken together with the Digital Council, which acts in an advisory capacity in particular. In contrast to the Digital Council, however, such a managing body should be able to coordinate the AI efforts of individual ministries more closely and advise them on their national and international orientation. Such a National Digital Council should also be supported by a small interdisciplinary group of think tank experts (Digital Integration Think Tank, DID). This think tank would support the NDR through research and advice. Among other things, DID could help to design target and monitoring systems that provide a framework for the desired progress of the new strategy and allow its evaluation. Also constant observation of AI developments in other countries could be another of its tasks. Such a structure would enable Germany to coordinate, if necessary adapt, scale and internationalise investments in AI. It is difficult to predict the extent to which greater centralisation is really feasible.

Germany's federal state system is both an advantage and a disadvantage for the implementation of the AI strategy. On the one hand, federal structures increase competition between locations, as the example of *Cyber Valley* in Baden-Württemberg shows.[18] In the strategy, this is considered an opportunity to take up all the different currents in AI development instead of making specifications from above. On the other hand, however, there are legitimate concerns that the bureaucracy and the fight for funding between the federal states could slow down the implementation of the strategy.[19] The federal system is also seen as the main reason for the high fragmentation of the state data pools and IT system landscape, which in turn slows down the digitisation of the administration.[20] It is true that the USA is also organised on a federal basis. But in contrast to Germany, future issues such as AI are being dealt with more quickly by authorities such as DARPA, addressed by politicians as relevant topics and coordinated and orchestrated in more detail by the *Office of Science & Technology Policy.*[21]

Compared to the other strategies examined (see study parts 1 and 2), the explicit embedding of German AI promotion in international networks is unique. Thus, for example, cross-connections with the EU are established in almost all fields of action (with the exception of the "kindling start-up dynamics" field of action, which is purely national in nature). In addition, a separate field of action is explicitly dedicated to the national and international networking of the German AI Strategy. It is intended to be integrated into multilateral bodies, such as the G7, G20 or the OECD, as well as into bilateral partnerships, for example in the context of development cooperation.

Recommendations

Creation of global networks: Global networking is of central importance for two reasons: On the one hand, data flows are oriented at best randomly and not fundamentally to geographical borders and digital enterprises, as hardly any other economic sector questions territorially organised policy. Accordingly, strictly national strategies even impair the innovative power of the global digital economy.[22] On the other hand, an important proportion of future AI users do not live in the USA or China, but in developing and emerging countries, the markets of tomorrow. No matter which company wants to be the next Facebook or Google in the AI age, it needs a strategy to win the users in these markets. At the same time, there is a danger that these countries will

lose their global competitive advantage – in the form of the cheapest labour force and thus lower production costs – due to the increasing degree of automation in the industrialized countries.[23] Through its international economic and political presence, Germany has important strategic assets to develop these markets and at the same time support the countries in the development of their own technological capacities. Germany should therefore distinguish itself by being able to offer adequate support to developing countries and by creating and strengthening local competencies, by scaling German solutions cooperatively and thus by exerting influence on development policy. Such a globally oriented approach could provide Germany with the necessary support to be able to participate as a shaping power in a global AI governance structure.

In developing the AI Strategy, the Federal Government built on initial experience with the *High-Tech Strategy 2025,* in the framework of which two measures relating to AI are already being implemented.[24] These are the Learning Systems platform on the one hand, which brings together "leading experts from science, business, politics and civil society organisations in the fields of Learning Systems and Artificial Intelligence" in order to "to examine the opportunities, challenges and framework conditions for the development and responsible use of learning systems".[25] On the other hand, projects under the "Development of digital technologies" framework programme[26] test their technical feasibility and economic viability in particular for small and medium-sized enterprises.

Ethics – surprisingly late: Germany is considered to be one of the central drivers behind the European General Data Protection Regulation (DSGVO). However, the country is late in dealing with questions on ethics and AI: Japan, Great Britain, Finland, the EU and a partnership between Canada and France have already set up working groups or developed initial drafts for ethical guidelines. In the key issues paper, the initial document for the German AI strategy, ethics was only mentioned defensively. The strategy is now intended to change that. At the suggestion of the Data Ethics Commission of the Federal Government, ethics has already been embedded in the objectives of the AI strategy. The German government is planning ethical requirements in accordance with an *ethics* by, in and for design approach as an integral component in the entire process of the development and application of AI. As early as November 2018, the Commission recommended testing such an approach in the development of an electronic patient record.[27] In addition, a enquete commission of the German Parliament ("Social responsibility and economic, social and ecological potentials") has been dealing with legal, political and ethical questions in connection with AI since September 2018. The first results and recommendations for action are expected within the current legislative period until 2021. In the context of ethical AI, the Federal Government also considers the research of pseudonymisation and anonymisation procedures, the compilation of synthetic training data *(differential privacy),* standardisation for AI in autonomous machines and the establishment of national and international observatories for the systematic observation and analysis of the effects of autonomous systems on the working world to be important. However, the regulatory framework to ensure ethical AI remains open. Currently, the BMJV is proposing a *Corporate Digital Responsibility* approach, based on the idea of the *Corporate Social Responsibility.*[28] SAP's principles for artificial intelligence, published in September 2018, show what such a commitment could look like.[29]

Recommendations

Support of a Digital Magna Carta: Considerations on ethics should also be made and promoted on a global level from the outset Only in this way can the necessary social trust be established, which is essential for economic and social success of AI. In the German strategy, this is only marginally provided for through AI observatories and cooperation with the UN, G7 and G20. However, all these are organisations with little technological competence and which, for their part, only allow limited participation by civil society. It's true that London took the initiative in the development of an international AI governance architecture, but progress of the project was weakened by the Brexit. At the same time there are a number of initiatives in countries (Scandinavian countries, France, Canada and Japan) which correspond to Germany's basic social orientation and which Germany could join with the aim of developing a kind of new global Magna Carta. This is an inclusive charter of rights and values that will guide us in the development of AI in the future. Ideally, such a charter could also serve as a basis for international agreements in the medium to long term. It should pave the way for the future coexistence between man and machine as well as for an inclusive advancement of humanity. Its goal should be to build a global AI governance system, which will be supported by a multi-party partnership of politics, civil society, research and business. Connected to it is a kind of staff unit that can be imagined as a global centre of tracking and analysing AI developments (think tank function) and make them a subject of discussion in the public space (congress function). Further information on this topic can be found in the article "Rules for Robots", published in *Auslandsinformationen.*[30]

IV.) Research and Development

The former head of DFKI, Professor Wahlster, is of the opinion that German researchers play "in the Champions League of AI.[31] Many of the basic AI algorithms used worldwide today, not only in *machine learning* and automatic action planning, but also in language technology, machine knowledge representation, inference procedures and image sequence analysis, were invented by German AI researchers.[32] The Stiftung Neue Verantwortung (New Responsibility Foundation), on the other hand, argues that Germany has been "late in recognizing" AI trends in fundamental research.[33] A warning example should also be the invention of the MP3 format by German scientists, whose commercialisation did not take place in Germany, but predominantly in the USA, China and South Korea.

It is clear that comprehensive investments are needed to ensure the competitiveness of basic research and the transfer of research results into practice, especially into German SMEs. General R&D spending in 2016 amounted to around 92.5 billion Euro (2016), equivalent to 2.9 percent of gross domestic product (GDP), compared to 511 billion Euro in the USA (2.7 percent of GDP) and 4.2 percent of GDP in Israel (13.5 billion Euro). The contributions of the private sector accounted for just under 65 percent of this figure, which roughly corresponds to the ratio in the USA.[34] The amount of AI research funding provided by the federal government to date is shown by a small inquiry in the Bundestag. Accordingly, in the past 30 years, cooperation between industry and science in the field of AI has been funded with approx. 500 million Euro (which corresponds to an average of less than 17 million Euro per year).[35] An analysis by the New Responsibility Foundation on the basis of this request assumes that approximately 27 million Euro are currently spent annually on the promotion of AI.[36] This figure results from commitments for the promotion of *machine learning* amounting to 77 million Euro (for the term from 2017 to 2021) and 30 million Euro for the institutional promotion of the German Research Center for Artificial Intelligency (DFKI) from 2018 to 2022 (May 2018). To implement the AI strategy, this amount is to be significantly increased. Three billion Euro are to be made available by 2025. This exceeds the funding sum of the British *AI Sector deal* and is about twice of what Macron intends to invest in AI in France over the next four years. Nevertheless, these expenditures are relatively low, as is revealed in the comparison with other research disciplines. In the area of non-nuclear energy technologies

alone – a field that can be seen as a basic technology area similar to AI – the Federal Government's research expenditure amounted to 641 million Euro in 2015.[37] Especially in view of the immense expenditure of today's leading AI nations, it will be important, in addition to expenditure at the national level, to coordinate European research expenditure sensibly at the EU level, to strengthen European research networks and thus generate leverage effects.

German Research Center for Artificial Intelligence (DFKI)[38]: The DFKI was founded in 1988 as a non-profit *Public Private Partnership* (PPP). With a budget of 45.9 million Euro and 550 employees from 60 countries (2017), it carries out projects in 18 research areas and groups and *Living Labs*.[39] From the work in these fields over the years 80 *Spin-off* companies were created. According to its own statement, the DFKI is the largest centre of its kind in the world in terms of external funding and the number of employees. Google, BMW and Rexrodt are just a few of the big names that come together under the DFKI umbrella in the framework of research programmes. It represents a successful model of global cooperation using German skills and unique selling points. Accordingly, against the backdrop of the planned national network of twelve AI centres and application hubs, it is to "take on a special role" and be further developed as public private partnerships.

According to the *CSRanking,* twelve IT institutes[40] in Germany employ approx. 60 teachers who have been actively researching in the context of AI since 2016 and who accompany an estimated 180 doctoral candidates on their doctorates every year.[41] Even if these figures are only a small part of the total AI research landscape[42] the international comparison shows that the country is numerically inferior to the USA, Great Britain, but also Israel. Against this background, establishment of 100 additional professorships, as envisaged in the strategy, is an important step. The just over 2,000 citable publications on AI, measured by the H-Index, achieved the fifth highest influence among the compared countries.[43] This is proof of the quality of German research, but not yet a leading position. In the area of statistics and probability, the country ranks third among the countries compared.[44] In addition, Germany also occupies a leading position in the scientific field of mechanical engineering and industrial and manufacturing engineering (third in terms of the influence of scientific publications).[45] In this context, it will also be decisive to closely link this potential with AI research and to transfer it to commercialisation.

Research areas and instruments

The focus of research funding in the German AI strategy is explicitly on *Narrow AI*, meaning "weak" AI, i. e. "the solution of concrete application problems on the basis of methods from mathematics and computer science". In contrast, *General AI* or strong AI embodies the idea that AI can attain or exceed the same intellectual skills of humans. Although the chosen approach is comprehensible, due to the higher and more rapid possibilities for exploiting *Narrow AI,* the country will miss an opportunity. By focusing on *General AI* Germany would have had the opportunity to strengthen its complementary position in the global AI research landscape, especially since other countries have not stated any specific goals in this area. Cross-linking of heuristics in computer science with research areas such as brain and neurosciences as well as quantum computing would be desirable: Not in order to create an intelligence similar to that of a human being, but in order to complement the orientation of mechanical intelligence and to help shape it. In addition, such a focus, similar to the US *"brain program"* under President Obama, would have a lighthouse or signal effect for the general public, young people seeking careers, as well as international partners and investors.

In contrast to France or Japan, for example, the German AI strategy focuses on individual fields of application such as biotechnology, consumer protection, food safety, the labour market, civil safety or climate change; however, in terms of other areas it follows a decentralised and broadly based approach for research funding. This corresponds to the grown structures of research fund-

ing by the Federal Government and the Länder. The Länder support the universities and technical colleges of the respective Land as sponsors. The Federal Government and the Länder also launch public funding programmes and support the development of clusters. One example of a funding programme is "IKT 2020 – Research for Innovation",[46] which is part of the *High-Tech Strategy 2025* and sees *machine learning* in particular as an "important technology building block".[47] The funding is intended for R&D measures which relate to the "robustness" of methods for the collection and evaluation of Data, "traceability and justification" of machine learning processes or "efficiency" for the scalability of algorithms.[48]

The acquisition of third-party funding, also from funding programmes, which is common in German higher education, is often viewed critically in the scientific community. "After the application is before the application" is therefore a much heard quotation and in particular the large expenditure and/or the strongly bureaucratic application structures for the procurement of third-party funds are often deplored. Moreover, funding is often not distributed to the most innovative applicants, but to the most creative authors.[49] Research funding in the USA and Great Britain is also competition-oriented. But in contrast to Germany researchers there have access to more comprehensive basic equipment, which gives them the freedom to publish. A strengthening of the basic financing must therefore continue to be discussed. The AI strategy thus strives for ensuring "internationally attractive and competitive working conditions and remuneration". In addition to financial aspects, it is planned to improve the networking of research with start-up ecosystems or to temporarily commissioning researchers in companies and vice versa. Both are necessary not only to ensure top research, but also to occupy the planned 100 AI professorships. Whether, despite these efforts, German research institutions, for example in Karlsruhe and Saarbrücken, can compete with the attractive conditions and salaries in the USA, Canada or China, is doubted by experts.[50] A courageous step, such as the flexibilisation of salary regulations and the distribution of shares within the framework of the Freedom of Science Act is currently planned for non-university institutions only.[51] At the same time, it will be crucial to strengthen non-monetary incentives as well and to find innovative solutions in order to increase the attractiveness of Germany as a research location for top AI researchers.

Recommendations

Expansion of recruitment programs for top expert personnel: The *German Academic International Network* (GAIN) shows how German scientists can be persuaded to return from abroad. Although it does not offer financial incentives to scientists working in North America, it does offer advisory and promotional services. At the same time, the programme creates opportunities for networking "scientists among themselves and with employers in research and industry".[52] Expansion of the offer beyond North America would be an important first step. Moreover, further incentives should be created for foreign scientists to conduct research in Germany. This would include promoting attractive context conditions, such as better reconciliation of family and research. A similar approach has been established by the Finnish government, for example. For further development of such a programme it is also worth looking at the Far East. Since 2008, the *Thousand Talents Plan* in China has been supporting and attracting international scientists (mainly Chinese living abroad), entrepreneurs and innovators and companies such as Alibaba are using the DAMO programme (14 billion Euro) to expand their global network for research-based talent development outside the country. Among the affiliated universities are the RISE Lab of the University of California in Berkeley and the Nanyang Technological University in Singapore. Further cooperations in Tel Aviv and Moscow are planned.

According to the strategy, the German research infrastructure should be further developed decentrally. The aim is to build up a national network of twelve AI centres and application hubs in order to make use of the competences and advantages of existing research locations and clusters. In addition, the establishment of a national research consortium is planned. A "network of method/technology oriented and domain/application oriented locations" is to be established.

A repeatedly mentioned focus of the strategy is the transfer of research results into commercial practice. The fact that in Germany the permeability between the economy and science has so far only succeeded to a limited extent is due on the one hand to the suspicious attitude of higher education institutions towards the flexible pursuit of secondary employment by their scientists in the private sector, among other things.[53] In addition, there are legal hurdles, because since the abolition of the university teacher privilege in 2002, the inventions of university personnel have belonged to the university, which makes commercialisation by their inventors more difficult. Although this is theoretically no different in the USA, in practice the universities there give teachers more freedom to commercialise their inventions. The technology transfer and closer practical relevance of AI research is to be achieved through close cooperation within the research network, supplemented by so-called and unspecified "transfer hubs" and the "Mittelstand 4.0 competence centres". The strategy thus makes use of a cluster approach, which represents a central element in the tradition of German research funding. Clusters are geographically located nodes that reflect the technology and industry fields of the respective region and, with the support of governments, promote the networking of universities, science and industry.[54] The support is provided by funds, through further education offers or services such as joint public relations work. Although cluster policy has proven its worth in many areas since its invention in the 1990s, it must be further developed and adapted to the digital and globally interconnected present.

Recommendations

Improve the commercialisation of intellectual property: In order to promote the permeability of the fortresses of science and industry, the laws and regulations from the USA can serve as a model (Bayh-Dole Act, *Small Business Innovation Development Act* and *Small Business Research and Development Enhancement Act*), through which the cooperation structures between the different actors have grown in recent decades. Another addition would be the creation of platforms such as the British Konfer,[55] that connects researchers and users. Moreover, the technology transfer offices existing at American, British and Israeli universities are good examples for Germany. Their tasks go beyond those of the German exploitation companies and include advising on the commercialisation of intellectual property by supporting researchers in the foundation and financing of *spin-out companies,* the market launch of new ideas and the exchange of university expertise with the industry and governments. Measures to increase permeability between science and the private sector should also start at the individual level. This means creating formats and forums that allow innovators from industry and science to gain visibility in the other sector and to work on a temporary basis. For this purpose, Macron's initiative serves as a model to allow researchers from public universities to work as employees/owners of privately owned companies up to 50 percent of their time, in addition to their teaching assignment. In Japan, the *cross-appointment system* gives researchers and developers from science and the private sector the opportunity to work part-time in different fields. These are important prerequisites for the attractiveness of the location. In Singapore, the *100Experiments* programme connects researchers and developers from the field of AI with entities from the industry who want to solve their specific challenges using AI. The local government finances the resulting cooperation projects in equal shares with the companies. This will ensure that the high and high-risk initial investments in AI solutions for companies are overcome. The Finnish funding approach for AI even considers the separation of science and the private sector obsolete and rather thinks in terms of "eco-systems" that are important for the country. The German cluster approach could also learn from this, because the physical clusters based on old patterns must also be able to accommodate virtual global networks withing which top German researchers living abroad and guest scholars who have visited Germany can be integrated into a wide range of networks. Political entities who master this global digital network entrepreneurship will be ahead of those who limit themselves to clusters within their physical borders.

The abolition of the geographical limitation of German cluster approaches through virtual net-

working, as is done in Canada, is only basically laid out in the strategy, but is to be expanded further.[56] A first important project is planned to this end with the "establishment of a Franco-German research and innovation network ("virtual centre"). This also responds to a demand from European AI scientists. They see the need for a *European Lab for Learning & Intelligent Systems* (ELLIS), which is characterised by close links between research and the private sector and provides researchers with long-term funding commitments and excellent research facilities and computing power.[57] In order to keep up with the internationally leading AI research centres, the scientists argue that an institute for fundamental AI research such as ELLIS requires at least 100 million Euro for infrastructure and 30 million Euro for annual research funding with long-term perspectives. It remains to be seen whether the announced funds of 3 billion Euro will include corresponding amounts for the AI centres. The concrete distribution of the funds has not yet been decided. An acceleration of decisions would be desirable here.

If it takes too long to set up a European joint venture project of this kind, it will be necessary for the international claim of *"AI Made in Germany"* that the national German institutions are also equipped with adequate resources.

It needs money, talent and networking as quickly as possible. The competition from the Far East and North America does not wait.

Recommendations

Creation of opportunities for cooperation with research networks outside Europe[58]: For international networking and interconnection of German AI research, it is not only European universities and research institutions, such as the planned Franco-German network or the *Alan Turing Institute* in Great Britain that are available.

In Canada, for instance, there are three institutes, the *Institute for Learning Algorithms* (MILA) in Montreal, the Vector Institute in Toronto and the *Alberta Machine Intelligence* Institute (AMII) in Edmonton, that are interested in cooperating with the German research institutes. For decades, these institutes have been dedicated to fundamental AI research, currently in particular in the areas of *deep learning*, neural networks, reinforcement learning, *pattern recognition*, *computer vision applications*, unattended learning, *natural language processing*, *deep networks*, learning theory and optimisation of *deep learning*, statistical theory and algorithmic game theory. There are also interesting cooperation partners for German research institutions in the East. In Japan, for example, various centres do research, the *Artificial Intelligence Research Center* (AIRC) in the area of interaction between AI and IoT and pattern and image recognition (for medicine, security), the *Center for AI Development* (AIP) in the fields of AI and society or the *National Institute of Information and Communication Technology* (NICT), which also deals with the interface between the human brain and machine. The *Korea Advanced Institute of Science and Technology* performs work on brain research and *emotional intelligence*, among others. India, too, is very interesting for AI R&D, not only due to its size but also because of the diverse society – and an associated heterogeneous data pool. This particularly applies to research in the field of speech recognition. There, potential cooperation partners are the AI Research Excellence Centres (CORE), which are dedicated to basic research, and the International Centres for Transformative AIs (ICTAIs), which focus more strongly on applied research. Although academic research in China has so far been relatively weak, this may change in the medium term due to China's immense investments. Already today there are institutions such as Tsinghua University that are increasingly making a name for themselves on the global stage of AI research. Research in China is otherwise mainly taking place in the private sector. In the USA, collaboration with five to six centres, which make up the top of the AI, is recommended: the *Schwarzman College of Computing* at MIT, which is just beginning to deal with the topic of AI on an interdisciplinary basis between the humanities and computer sciences; the *Berkeley AI Research Lab* (BAIR), the *Center for Human-Compatible AI* (CHAI) and the *Center for IT Research in the Interest of Society* (CITRIS) at the University of California Berkeley; the Carnegie Mellon University *AI Initiative*; the *Human-centered AI* (HAI) Program of

Stanford University; the *Open AI Institute*, which is dedicated to *OpenSource AI* and the demonopolisation of AI and the *Allen Institute for AI* (AI2) in Seattle. A well thought-out strategic participation of German players in these institutes and networks, which goes beyond random and individual initiatives, would have to be possible by means of a dashboard of various target parameters. Only in this way can the exchange of knowledge between the various partnerships be facilitated in a targeted manner.

In addition to the direct funding instruments, i. e. the clusters and project-related funding programmes, indirect funding instruments are lacking in Germany, such as tax incentives for R&D. These exist in a majority of the other countries examined (including the USA, China, Great Britain, Japan, France and Israel).[59] As early as 2009, the BDI called for making ten percent of the total entrepreneurial R&D expenditure tax-deductible.[60] This approach to research funding would be of benefit to all companies and complement government research programmes.

Recommendations

Strengthen applied research through tax incentives for the private sector: As the USA and China, but also Japan and South Korea, show, the private sector is the driver of AI development. To be able to also explore the full R&D potential of companies in Germany, indirect instruments are also needed to promote R&D as a complement to existing research funding programmes. This particularly refers to tax incentives for companies, as already provided for in the 2018 coalition agreement. Such funding promises particularly positive effects in the context of AI if it is geared towards long-term research success and creates incentives for the resulting economic returns to benefit further research. In addition, the United Arab Emirates with their special economic zones (e. g. Internet City) and South Korea *(Daedeok Innopolis)* show how tax incentives can promote the development of technology and innovation zones.

V.) Commercialisation

The success of the German economy is based on physical assets. While in the Anglo-Saxon countries the commercialisation of AI is driven primarily by an active start-up scene with access to sufficient risk capital, in Germany the potential lies more in established industrial production and small and medium-sized enterprises.[61] The concept of "Industry 4.0" expresses this by describing the potential of networking digitisation in industry. Its relevance is underlined by the already high number of robots in the manufacturing industry (2016: 309 per 10,000 employees).[62] In the comparative year there were more only in South Korea and Singapore (631 and 488, respectively).[63] However, the German industrial companies not only use robots, but also produce them. After the USA, Germany, for example, is the country with the highest number of manufacturers of service robots (33).[64] Despite the high penetration of automation technologies, only a quarter of all companies already use AI, deal with it, plan to do so in the near future or at least consider the technology important.[65] In the UAE, the proportion of executives planning to invest in AI in 2019 is equal to 50 percent.[66] With an average share of 2.1 percent of internationally enforceable AI patents between 2015 and 2017, the country is far behind the USA (74 percent), Japan (five percent) and South Korea (three percent) in fourth place.[67] Digital players, in particular start-ups, whose agility and innovative strength can make an important contribution to the commercialisation of AI, are having a hard time in Germany. 106 KI start-ups were based in Germany,[68] none of which ranked among the top 100 AI start-ups according to CBInsights 2017.[69] With this figure, Germany ranks eighth among the 13 countries compared. In discussions with the authors of the study, *Innovation Labs* and *Maker Spaces* staff stated that there was a lack of role models to encourage digital founding. The founders themselves demand from politics the reduction of bureaucracy when hiring employees from abroad or expanding into other markets as well as tax concessions and support in raising capital.[70] At 2.9 percent, the share of global equity investments made in German AI start-ups was very low in 2016.[71] Thus, the opportunities for start-ups to

acquire and scale the necessary venture capital for the growth phase in Europe themselves and to acquire it internationally are still limited.[72] This complicates the international projection of a European, AI and related normative achievements, such as the DSGVO.

Support for companies and startups:
In the public debate, the discussion about the promotion of the digital economy is often narrowed down to the expansion of broadband and fiber optics. However, this focus does not sufficiently cater for AI. The AI strategy recognises this and wants to change it through many but vaguely formulated measures. For example, transfer structures are to be expanded, employees are to be prepared for the cognitive age through further training, networking formats are to be developed and AI trainers are to be hired to advise companies on the use of AI via the "Mittelstand 4.0 Competence Centres". Similar to France, Finland, South Korea or Japan, test fields and real laboratories are to be set up, for example to test automated and networked driving. In order to systematically observe the penetration of AI in German medium-sized businesses, a map with AI application examples and AI monitoring are to be introduced. How such a monitoring system could look like was recently designed by the Cambrian Group.[73] Whether these measures will be sufficient to keep up with the digital economic power centres in China and the USA will have to be seen. Companies from Germany are increasingly becoming suppliers or investors for companies such as Tesla. This is to be welcomed as long as it is ensured that the same companies do not lose touch and integrate their own, internationally competitive AI into their products. Observers assume that the future of autonomous driving will be decided in the USA or China and not in Germany or Europe.[74] In addition, cutting-edge technology is channelled off abroad as a result of takeovers, as shown in the case of KUKA, one of the world's leading robotics manufacturers, which was taken over by Chinese investors in 2016–17. In order to better protect strategic key industries, the the Foreign Trade and Payments Ordinance was tightened in 2017 in a first step and in 2018 in a second step.[75] Among other things, a number of economic sectors have been added within which foreign takeovers are subject to reporting and, in some cases, approval. However, this must be justified by a threat to national security. It would be possible to use an institutional solution for the protection of digital key technologies, as exists in the USA through the *Committee on Foreign Investment in the United States.*

In contrast to the promotion of the established economy, the list of measures for "kindling of start-up dynamics", i. e. the strengthening of ecosystems for start-ups, is surprisingly short: Expansion of start-up consulting, expansion of public support in the venture capital sector (including an increase in KfW's investment volume in *venture capital* and *venture debt funds* to 200 million Euro per year by 2020) and the strengthening of collaborative innovation within the framework of a *digital hub initiative* are planned. In order to support players in the digital economy, who scale internationally, and thus position Germany's complementary contributions globally in the value-added process of this economic segment as well, we need much more powerful ecosystems in addition to the essential further development of the European digital single market at the EU level.

Recommendations

Promotion of start-ups through more efficient, globally digitally networked and financially strong ecosystems: As mentioned above, globally networked digital ecosystems are not locally bound in contrast to clusters. Moreover, they are characterised by a high diversity of players and a higher permeability of innovations from different fields. Against this background, all measures of the CI strategy should be examined for their accessibility to start-ups and investors and conceived as a pan-European and non-national concept. This also includes measures to commercialise intellectual property at universities, to reduce bureaucracy and to set up special regulatory zones. In order to improve access to capital, the support already provided in the venture capital field could be an important starting point. Comprehensive leverage effects in the *venture capital market* could be achieved through tax relief for investors of *venture capital funds.* A model that Great Britain and

France follow for example. The British plan goes in a similar direction. The aim is to enable pension funds to be invested in assets that support innovative companies. In addition, the growing number of millionaires in Germany is an important pool of potential *fishing investors* who are an important source of capital in the start-up ecosystems at the beginning of the financing process of young entrepreneurs. This potential has hardly been tapped. The Israeli *Angels Law* – which allows such investors to deduct up to 1.2 million euros per start-up as current expenses – can serve as a good example. The Agency for Leap Innovation could also learn from the Israeli innovation agency IIA or from *"Business Finland"* when setting up funding strategies. In addition, the combination of start-up capital and mentoring platforms would be appropriate, because the wealth of experience of older founders or global networkers is just as valuable as financial resources. German industrial companies could also participate and thus gain early access to young talent and ideas. US-American organisations such as *Y-Combinator* or the *Band of Angels* serve as role models in this context. But diligence is mandatory, because incubators and *Accelerators* are plenty but very few of them are based on sustainable concepts. Similar to Recommendation 10, a dashboard of different targets should be used to measure the effectiveness of these partnerships in pursuing their objectives, and then, based on those findings, to be able to facilitate a targeted exchange of knowledge between the various partnerships.

Regulation: As early as June 2017, a uniform legal framework for motor vehicles with advanced automated systems came into force.[76] Accordingly, autonomous journeys on roads for which the automated systems were developed are possible, but not driverless travel. Although this did not result in a significant increase in autonomous vehicles on German roads, the strategy already considers the existing regulatory framework "a stable foundation with high standards". In addition to the test zones, real laboratories and consideration of "ethical aspects in standardisation for AI in autonomous machines and vehicles" mentioned above, no further regulatory approach is foreseen for autonomous systems. In contrast, the Federal Government's strategy focuses on the traceability and verifiability of AI-based decision-making processes, the promotion of applications for the social participation of citizens while taking privacy into account, and the "adaptation of the copyright legal framework to facilitate *text* and *data mining* (TDM) for both commercial and non-commercial purposes". The strategy also expresses the need to become more involved in the development of AI standards at European and international level. However, this has not yet been substantiated with concrete proposals and will only be successful if German industry and research continue to make a contribution to global AI added value. Just as important as *safeguards,* which protect society from the negative consequences of AI, is it to promote national AI developments in order to be globally recognised.

Recommendations

Promotion of exchange and work shadowing for public employees: The development of effective regulation requires close interaction between stakeholders and an understanding of technology and its implications among officials. Connecting people from different disciplines and perspectives and supporting collaboration therefore is an essential component of prudent and at the same time supportive regulation. This is all the more true with regard to the complexity of AI. Against this background, the Obama government already recognised the necessity of work shadowing programs between companies, science and government. Similar programmes also exist in other countries, such as Singapur and Finland. Unfortunately, such concepts are often met with reluctance in Germany, because of a prevailing prejudice of conflicts of interest between state and economy. However, this can be counteracted by ethical and legal guidelines, transparent project assignments and contractual obligations of the respective partners. To this end, it is recommendable to establish contact with appropriate decision-makers in the respective countries in order to find suggestions for ethically clean regulations.

The state as user: Although a survey by the World Economic Forum ascribes a central role to the German procurement industry as a driver of inno-

vation[77] and according to the strategy it should take a leading role in the use of AI – AI has so far only been used in very limited cases in the German administration. This includes, for example, the analysis of incoming mail at the Federal Ministry of Economic Cooperation and Development (BMZ), the testing of biometric facial recognition at Berlin-Südkreuz railway station by the Federal Police, and the performance of air traffic control tasks.[78] The ways of strengthening increased use of AI by public authorities is a field with room for expansion in the German AI strategy. At present, it is merely stated that, in addition to the regular administrative services, the fields of application of AI in the security authorities are also to be examined. The opportunity to demonstrate the practical benefits of AI to the general public through the use of AI in public authorities should be used even more decisively.

Recommendations

Strengthening the state as users of AI: As the Obama government has already stated, the state can stimulate the development of ethical AI with its procurement system and strengthen the national innovation ecosystem through a corresponding demand for social applications. Similar approaches can also be found in China in the area of *Smart City,* in Great Britain and the UAE in the area of better government services or in Japan in disaster control. In order to gain access to the technical solutions, the American and British innovation competitions have proved to be a functioning instrument. The winners of the *Defense Innovation Unit* (DIUX) competitions by the innovation agency of the US Department of Defense, receive capital in the form of pilot procurement contracts. In addition the winners have easier access to follow-up orders if the innovative technical solution is successfully implemented. This is not only a benefit for small and medium-sized companies, but also and explicitly start-ups. The "competitive dialogue" and "innovation partnerships' are two forms of award procedures under European public procurement law which are already increasingly used by France and could form the basis for this. However, in order to also offer start-ups the opportunity to serve as suppliers to the public sector, the hurdles to participation in the award processes must be further reduced. DIUX, for example, makes award decisions within 90 days, which should also serve as a benchmark for Europe. French authorities *(La French Tech),* on the other hand, are deliberately locating themselves close to innovation ecosystems in order to closely accompany the potentials and risks of AI developments. Also "Innopolis" in South Korea accommodates regulatory authorities in the proximity developers from business and science. In addition to the technological dimension, AI also has the potential to redefine administrative action. In Great Britain and the United Arab Emirates, however, the first priority is the redesign and reorganisation of administrative processes, followed by technological support. This has proven to be a successful model. Both states have established their own innovation management and work with user-centered methods such as *design thinking* to orient new services to the needs of citizens and business. To this end, incentives and support structures for public authorities must be created, such as the *Design Council* in Great Britain. It advises authorities on how to develop and adapt their own processes and products in a user-centered manner. On a smaller scale *Business Finland* supports administrations in the development of user-centered AI solutions. For the promotion of technological innovations in the security sector or the strengthening of capacities in the field of *Cyber defense* it is also worthwhile to conduct an in-depth analysis of the Israeli military's recruitment and training system.

4 German Federal Government. 2018b.

5 World Bank, 2016 (cf. Methodology of the Cambrian AI Index).

6 15th place worldwide in the Open Data Barometer, 2016 (cf. Methodology of the Cambrian AI Index).

7 Top500.org, 2018 (cf. Methodology of the Cambrian AI Index).

8 Statista, 2016 (cf. Methodology of the Cambrian AI Index).

9 The Economist, 2018.

10 CS Ranking, 2018 (cf. Methodology of the Cambrian AI Index).

11 Hensellek, Kensbock, Kollmann, Stöckmann, 2017: 27, 33.

12 Giersberg, 2018.

13 Federal Government, 2018a: 35.

14 German Bundestag (Parliament), 2018: 7.

15 BMI, 2018a.

16 Michael Meister (CDU), Parliamentary State Secretary in the BMBF, announced at a discussion event organised by the FDP parliamentary group on the topic of "Agency for Leap Innovation – Toothless Tiger or Radical Innovation?" that opening is expected by mid-2019. This means that the establishment of the agency is six months behind schedule (Wiarda, 2019).

17 BMBF, 2018.

18 Cyber Valley, k. D.

19 Deckler, 2018; Hecking, 2018.

20 Discussions between the authors and officials of the BMI.

21 Cf. chapter on USA, part 1.

22 Esposito, Tse, Entsminger, 2018. 23

23 Lee, 2018:169–170.

24 Search (full text) "Artificial Intelligence" in the catalogue of measures of the high-tech strategy (https://www.hightech-strategie.de/de/massnahmen-1697.php).

25 Ibidem.

26 Current funding measures address digital cutting-edge technologies such as autonomous systems, artificial intelligence, robotics, visualisation *(Augmented Reality, Virtual Reality, 3D), Blockchain, Smart Living, Cloud Computing, Smart Services* and ecosystems (platforms).

27 BMI, 2018b.

28 Billen, 2018.

29 Machmeier, 2018.

30 Esposito, Groth, Nitzberg, 2018.

31 DFKI, bitkom, 2017: 9.

32 DFKI, bitkom, 2017: 9.

33 Harhoff, Heumann, Jentzsch, Lorenz, 2018: 9.

34 UNESCO, k. D. (cf. Methodology of the Cambrian AI Index).

35 German Bundestag (Parliament), 2018: 4.

36 Harhoff, Heumann, Jentzsch, Lorenz, 2018: 10–11.

37 BMWi, 2017a: 44.

38 DFKI, k. D.

39 These are: Smart Data & Knowledge Services, Cyber-Physical Systems, Multilingual Technologies, Plan-based Robot Control, Educational Technology Lab, Interactive Textiles, Robotics Innovation Center, Innovative Retail Laboratory, Institute for Business Informatics, Embedded Intelligence, Smart Service Engineering, Intelligent Analytics for Mass Data, Language Technology, Innovative Factory Systems, Intelligent Networks, Agents and Simulated Reality, Augmented Reality and Cognitive Assistance Systems.

40 University of Bielefeld, CISPA Helmholtz Centre, Max Planck Institute, RWTH Aachen, TU Braunschweig, TU Darmstadt, TU Dresden, TU Munich, University of Freiburg, University of Constance, University of Passau and University of Stuttgart.

41 CS Ranking, 2018 (cf. Methodology of the Cambrian AI Index).

42 The Federal Government has 20 universities with a focus on AI in computer science courses (German Bundestag, 2018: 4). These are supplemented by institutions that have no educational/training schemes in place, such as the German Research Center for Artificial Intelligence (DFKI).

43 SJR, 2017 (cf. Methodology of the Cambrian AI Index).

44 Ibidem.

45 SJR, 2017.

46 BMBF, k. D.a.

47 BMBF, 2017.

48 Ibidem.

49 Kempf, 2014.

50 In the USA, entry-level salaries are between 300,000 and 500.000 US dollars. In Germany, the top salary of professors is just over 100,000 Euro. (Armbruster, 2018b; Metz, 2017; Burchard, 2017).

51 Federal Government, k. D.

52 GAIN, k. D.

53 Discussions between authors and scientists at German universities.

54 BMWi, BMBF, k. D.

55 https://konfer.online.

56 The German-Polish centre for digital innovations in systems research planned in the coalition agreement is not mentioned in the strategy.

57 ELLIS, k. D.

58 Cf. parts 1 and 2 of the study "Comparison of national strategies for the promotion of artificial intelligence".

59 Ernest and Young, 2018.

60 BDI, 2018a.

61 The Motley Fool, 2017; Otte, 2018.

62 IFR, 2017 (cf. Methodology of the Cambrian AI Index).

63 Ibidem.

64 Statista, 2016 (cf. Methodology of the Cambrian AI Index).

65 BMWi, 2018.

66 Elsaadani, Hakutangwi, Purdy, 2018: 5–6.

67 M-Cam, 2018 (cf. Methodology of the Cambrian AI Index).

68 Asgard Human Venture Capital/Roland Berger, 2018 (cf. Methodology of the Cambrian AI Index).

69 CB Insights, 2017b (cf. Methodology of the Cambrian AI Index).

70 Hensellek, Kensbock, Kollmann, Stöckmann, 2017: 34, 58.

71 Ibidem.

72 Aridogan, 2018.

73 https://www.cambrian.ai/fair-index.

74 Lee, 2018: 104–139.

75 BMWi, 2017b; BDI, 2018b.

76 German Bundestag (Parliament), 2017.

77 World Economic Forum, 2017: 126–127 (cf. Methodology of the Cambrian AI Index).

78 German Bundestag (Parliament), 2018: 12–14.

Methodology of the Cambrian AI Index ©

The analysis on which this report is based assessed the countries on the basis indicators that incorporate the countries' preconditions, the research and development situation and the degree of commercialisation of AI. In an attempt to integrate these indicators and determine the AI position of a country in an international comparison, the Cambrian AI Index © was developed. The Cambrian KI Index consists of the three segments mentioned above, which in turn consist of different components for which one or more proxy indicators have been identified. The methodology must be specified more, since the index is defined by proxy measurements for which reliable and comparable data from different countries are available. The reason for using the proxies is that the field of AI in its latest phase only provides limited measurable outputs. This is likely to change over the next few years, as the accompanying research on AI is also developing rapidly.

The values of the different *proxies* are indexed from 0 to 1, with the USA representing the "benchmark" value 1 against which the other countries are measured. Due to the world leadership in AI, the United States have been chosen as reference country. The mean value of the indexed proxy values of a component is the component's intermediate value. The mean values of all components of a segment, in turn, result in the total value of the segment. The mean values of the three segments result in the comprehensive Cambrian KI Index. Weighting was not carried out at proxy, component or segment level, since well-founded empirical studies are required for adequate weighting.

Segment	Component	Proxy	Survey Method/Source
General requirements	**Framework conditions**	**Network Readiness Index Value (2016)** Explanation: The index provides insights about the performance of national economies in the use of information and communication technologies to enhance competitiveness, innovation and well-being. Thus it serves as a proxy for the framework conditions of AI.	Survey based on a scale from 1 (worst) to 7 (best). World Economic Forum: https://widgets.weforum.org/gitr2016/
	Data	**OpenData Barometer (2016)** Explanation: In addition to individuals with internet access and businesses, the public sector is the third important source of AI-related data. The OpenData barometer assesses governments worldwide in their willingness to implement OpenData initiatives. It also measures the impact of OpenData on business, politics and civil society.	The data for the OpenData barometer is collected through expert interviews, self-assessments by governments and secondary data sources. World Wide Web Foundation: https://opendatabarometer.org
		Number of Internet users (2016) Explanation: Internet users are persons who have used the internet (from anywhere) via computers, mobile phones, personal digital assistants, gaming machines, digital television, etc. in the last 3 months. This proxy measures internet users in absolute numbers rather than as a percentage of the population, since the quantity of data is what counts for AI.	World Bank: https://data.worldbank.org/indicator/IT.NET.USER.ZS
	Computing power	**Number of 500 most powerful supercomputers per country (2018)** Explanation: Even if computing power can be used across borders, the availability of supercomputers to cope with large amounts of data and increasingly complex algorithms is a strategic factor for a nation.	The website Top500.org counts and lists the top super computers that are publicly known and commercially available worldwide in semi-annual surveys (June and November). It is possible that military high-performance computers exist which are not known. Top500.org: www.top500.org

Segment	Component	Proxy	Survey Method/Source
		Number of 10 most powerful supercomputers per country (2018) Explanation: The Top 10 of the 500 most powerful supercomputers shows that in some countries, e. g. China, the most supercomputers are installed, but they are not the most powerful.	Top500.org: www.top500.org
		Turnover of leading semi-conductor manufacturing companies in billions (2017) Explanation: Turnover from semiconductor companies per country gives information about the dominance and thus innovation power in this industry segment. Even though the production of semiconductors is not indicative of the use of semiconductors, production capacities are a strategic factor for a nation.	**China:** HiSilicon Technologies Uni Group Sanechips Huada Goodix **Japan:** Toshiba Renesas Electronics Sony ROHM Semiconductor **Republic of Korea:** Samsung Electronics SK Hynix **USA:** Intel Micron Technology Broadcom Qualcomm Texas Instruments nVidia Skyworks Solutions SanDisk / Western Digital Analog Devices ON Semiconductor Freescale Semiconductor AMD **Statista:** https://www.statista.com/statistics/271553/worldwide-revenue-of-semiconductor-suppliers-since-2009 supplemented by the evaluations of individual annual financial statements.

Segment	Component	Proxy	Survey Method/Source
		Number of leading semiconductor manufacturing companies (2017) Explanation: Complementing the proxies stated above, the number of semi-conductor companies provides information about the strength of a country's semiconductor environment.	Statista, supplemented by further research (see above)
		Revenues from FPGA chips in million USD (2016) Explanation: Intel and Microsoft are confident that FPG chips will be the dominant AI hardware in the future. A paper recently published by Intel engineers titled "Can FPGAs Beat GPUs in Accelerating Deep Neural Networks" provides some of the technical reasons for this speculation. It should be noted that the industry has developed strongly since 2016 (see chapter on China).	EE Times: https://www.eetimes.com/author.asp?doc_id=1331443 Nurvitadhi, E.; Venkatesh, G.; Sim, J.; Marr, D.; Huang, R.; Ong, J. G. H.; Liew, Y. T.; Srivatsan, K.; Moss, D.; Subhaschandra, S.; Boudoukh, G. (2017): Can FPGAs Beat GPUs in Accelerating Next-Generation Deep Neural Networks? http://jaewoong.org/pubs/fpga17-next-generation-dnns.pdf
	Human resources	**Number of students enrolled in all tertiary education programs, both sexes (2016)** Explanation: AI is considered to be basic research technology, which is why the number of students per country is a proxy for the amount of qualified human resources.	UNESCO: http://data.uis.unesco.org
		Estimated number of Master's graduates in AI-relevant fields, at computer science institutes with actively researching teachers Explanation: Master graduates in the above-mentioned areas provide information on the size of the pool of young talents for AI research and commercialization. In contrast, the index assigns the number of doctoral students to the "Research and Development" segment.	The estimate is based on the number of scholars at computer science institutes who have been actively researching artificial intelligence, computer vision, machine learning & data mining, natural language processing and robotics since 2016, i. e. whose publications have been presented at relevant conferences. In order to determine the annual number of Master's graduates, the

Segment	Component	Proxy	Survey Method/Source
			number of scholars was multiplied by a factor of 7. This factor was determined by Mark Nitzberg, Chief Scientist for Cambrian and Head of UC Berkeley CHAI, on the basis of a random sample survey of top AI research laboratories in the USA (potential regional/national differences were not considered). CS Ranking: http://csrankings.org/#/index?none
Research and Development	**General R&D framework conditions**	**Gross domestic expenditure on research and development in 000 USD (2016)** Explanation: The gross domestic expenditure comprises the R&D investments of the private sector, the government, higher education institutions and civil society. This proxy is presented in absolute terms in USD as opposed to the percentage ratio of GDP to reflect the global and mobile value chains of AI.	The data are available in the respective national currency. For comparability, all values have been converted to USD (average exchange rate of 2016). The 2016 expenditures from Singapore and India are not available, which is why they were projected based on historical values. UNESCO http://data.uis.unesco.org
		Number of researchers per 1 million inhabitants (2016) Explanation: The "density" of researchers is a proxy for the serendipity in research in a country. The importance of serendipity in the field of AI is high, since AI is a basic technology with practically unlimited application areas.	UNESCO http://data.uis.unesco.org
	AI-relevant R&D (Input)	**Number of computer science institutes with actively researching teachers in AI-relevant areas** Explanation: The number of computer science institutes provides information about the size of the relevant R&D ecosystem.	Number of scholars at computer science institutes who have been actively researching artificial intelligence, computer vision, machine learning & data mining, natural language processing and robotics since 2016, i. e. whose publications have been presented at relevant conferences. CS Ranking 2016–2018: http://csrankings.org/#/index?none

Segment	Component	Proxy	Survey Method/Source
		Number of scholars actively doing research in areas relevant to AI Explanation: The number of teaching staff is a proxy for research and training of qualified human resources of a country.	Number of scholars at computer science institutes who have been actively researching artificial intelligence, computer vision, machine learning & data mining, natural language processing and robotics since 2016, i. e. whose publications have been presented at relevant conferences. CS Ranking 2016–2018: http://csrankings.org/#/index?none
		Estimated number of doctorate students supervised by scholars actively engaged in research in AI-relevant areas Explanation: The number of doctorate students provides information about the R&D relevant human resources of a country.	The estimate is based on the number of scholars at computer science institutes in universities who have been actively researching artificial intelligence, computer vision, machine learning & data mining, natural language processing and robotics since 2016, i. e. whose publications have been presented at relevant conferences. To determine the annual number of doctorate students, the number of scholars was multiplied by a factor of 4. This factor was determined by Mark Nitzberg, Chief Scientist for Cambrian and Head of UC Berkeley CHAI, on the basis of a random sample survey of top AI research laboratories in the USA (potential regional/national differences were not considered). CSRanking 2016–2018: http://csrankings.org/#/index?none

Segment	Component	Proxy	Survey Method/Source
	AI-relevant R&D (Input)	**Number of citable publications in the subject area of AI (2017)** Explanation: The number of citable publications in the field of AI provides information about the scientific productivity of a country in the field of AI.	Scimago Journal & Country Rank: https://www.scimagojr.com Cf. the methodology used there
		Influence of publications in the subject area of AI (2017) Explanation: The influence of publications is a proxy for the quality and innovative power of research in the field of AI. It is unknown whether the index takes into account co-authors and their nationality.	The influence of publications is measured on the basis of the H index. The figure is based on bibliometric analyses, i. e. on citations of the scientist's publications. Scimago Journal & Country Rank: https://www.scimagojr.com
Commercialization	**Knowledge and technology transfer**	**Cooperation between universities and industry on research and development (2017–18)** Explanation: This proxy delivers information on the knowledge and technology transfer between universities and the private sector.	Opinion polls among executives: In your country, to what extent do business and universities cooperate in research and development (R&D)? (1 = not at all; 7 = intensively). Weighted average. World Economic Forum: https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018
		Public procurement of cutting-edge technology (2017–18) Explanation: This proxy provides information about the incentives that the public sector creates by demand for certain technologies and thus innovations.	Opinion polls among executives: To what extent do government purchasing decisions promote innovation in your country? (1 = not at all; 7 = to a large extent). Weighted average. World Economic Forum: https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018

Segment	Component	Proxy	Survey Method/Source
	Patents	**AI patents (with international enforcement expectations) by assignee country in % (average of the years 2015, 2016 and 2017).** Explanation: This proxy provides information on the patent activities of a country's companies. Nevertheless, this proxy is subject to reservation, since the patents are not indicative of the quality of an innovation and are often merely incremental in nature.	Although various sources suggest that China has overtaken the US in terms of AI-related patent applications, most Chinese patents have no international equivalents and are therefore unenforceable outside China. The patents cover AI as well as Machine Learning and Deep Learning. Notice: The process of patent application for patent publication is associated with a considerable time delay, which is why the figures may also vary retroactively. Research by M-Cam: https://www.m-cam.com
	AI startup landscape	**Number of AI startups (2017)** Explanation: The number of AI startups provides information about the diversity of the potentials of AI and the innovative strength of the national economies.	The data collection focused exclusively on startups active in the AI technology industry and ignored companies dealing with other digital topics and technologies. These are startups that produce AI solutions and expressly excludes startups that use existing AI solutions on the market to develop new services or products. Asgard und Roland Berger/Lemaire, A.; Lucazeau, H.; Carly, E.; Romain; Rappers, T.; Westerheide, F. (2018): https://asgard.vc/global-ai
		The 100 most influential AI startups (2017) Explanation: While the above proxy reflects the quantity of AI startups, the number of AI startups in the list of the 100 most influential AI startups per country is a proxy for the quality and future potential of the companies.	The companies were selected from a pool of more than 2,000 startups based on several criteria, including investor profile, technological innovation, team strength, patent activity, financing history, valuation and business model. CB Insights: https://www.cbinsights.com/research/artificial-intelligence-top-startups

Segment	Component	Proxy	Survey Method/Source
		Share of AI private equity deals in all AI private equity deals worldwide (2016) Explanation: This proxy provides information about the countries with the startup landscapes with the highest future potentials in AI as seen by investors.	CB Insights: https://www.cbinsights.com/research/artificial-intelligence-startup-funding
		Number of most active venture capital investors (2012–2016) Explanation: This proxy indicates in which countries the most AI-savvy investors are based and thus have the largest influence in terms of AI startups.	CB Insights: https://www.cbinsights.com/research/artificial-intelligence-startup-funding
	Robotics	**Number of industrial robots installed per 10,000 employees in the manufacturing industry (2016)** Explanation: This proxy provides information about the automation of the manufacturing industry and the consumption and implementation of robot technology, and thus is indicative of the level of experience of the labor market in interaction with machines.	International Federation of Robotics: www.ifr.org
		Number of manufacturers producing service robotics (2016) Explanation: Complementing the proxy, specified above, the number of manufacturers of service robots provides information about the size of the ecosystem in this future technology.	The data only represent the individual figures for the eleven countries with the largest number of such companies. The other thirteen countries in which companies produce service robots have been consolidated in the category “Rest of the world”, with an average of four companies per country. Statista: https://www.statista.com/statistics/658048/service-robotics-manufacturers-by-country

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The race for world leadership in Artificial Intelligence (AI) technologieshas begun. Since the publication of the AI strategy of the Obama government in 2016, other countries have also started to explore ways to support research and development (R&D) as well as the commercialisation of AI and to catch up with the U. S. as the leading AI nation. After the Konrad-Adenauer-Stiftung presented a comparative overview of the CI strategies of important national economies in two previous studies, this section analyses the German AI strategy in an international comparison. In times of technology-driven change we are convinced: “Tech is politics” – and politics and civil society should give this more attention and discuss this more vigorously.

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