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China's digital transformation. Why is artificial intelligence a priority for chinese R&D?

Guilhem Fabre

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China's innovation policies have been based on incremental applications of existing technologies and protectionist policies, which favored profitable oligopolies. The scale of the market has also been a decisive factor. The rise of the internet and e-commerce have been linked to widespread use of smartphones. Now, the rapid development of computer power and the accumulation of data by BAT (Baidu Alibaba Tencent, the three dominant firms), has opened the way for the rise of artificial intelligence (AI), the next frontier for productivity in key sectors (transport, health, manufacturing, energy). It is also an efficient tool for social surveillance and governance of the state-party system, and a technology that may determine geopolitical supremacy. The mix of cooperation and competition with the United States is especially relevant in AI, where China is catching up with the U.S in talent as well as in the chip technology, both crucial for machine-learning.

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China's digital transformation. Why is artificial intelligence a priority for chinese R&D?

Guilhem Fabre

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Abstract

China's innovation policies have been based on incremental applications of existing technologies and protectionist policies, which favored profitable oligopolies. The scale of the market has also been a decisive factor. The rise of the internet and e-commerce have been linked to widespread use of smartphones. Now, the rapid development of computer power and the accumulation of data by BAT (Baidu Alibaba Tencent, the three dominant firms), has opened the way for the rise of artificial intelligence (AI), the next frontier for productivity in key sectors (transport, health, manufacturing, energy). It is also an efficient tool for social surveillance and governance of the state-party system, and a technology that may determine geopolitical supremacy. The mix of cooperation and competition with the United States is especially relevant in AI, where China is catching up with the U.S in talent as well as in the chip technology, both crucial for machine-learning.

Keywords

Artificial Intelligence, Innovation, China, USA, Big Data, Governance

La transformation numérique de la Chine : pourquoi l'intelligence artificielle est-elle devenue une priorité de la recherche et le développement chinoise ?

Résumé

Les politiques d'innovation chinoises ont été surtout fondées sur des applications de technologies existantes stimulées par la taille du marché et par des mesures protectionnistes qui ont créé des oligopoles très profitables. La montée de l'internet et du commerce en ligne est liée à la généralisation de l'usage des Smartphones. Le développement rapide de la puissance de calcul des ordinateurs et l'accumulation de données par les trois firmes du BAT (Baidu Alibaba Tencent) a ouvert la voie à la montée de l'intelligence artificielle, qui est considérée comme la prochaine frontière de la productivité dans des secteurs variés (transport, santé, industrie, énergie), comme un outil efficace de surveillance et de gouvernance de l'Etat-Parti, et comme un technologie duale qui peut déterminer la suprémacie géopolitique. Le mélange de coopération et de compétition avec les Etats-Unis est particulièrement marqué dans le domaine de l'intelligence artificielle, où la Chine tente de rattraper l'avance des USA en termes de talents et dans la technologie des semi-conducteurs, décisive en matière de « machine Learning ».

Mots-clefs

Intelligence artificielle, Innovation, Chine, Etats-Unis, Big Data, Gouvernance

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China's R&D policy

Innovation requires human talent, financing, the capacity to discover, develop and distribute new products on growing markets with the help of intellectual property. Eco-systems of innovation may vary according to national economic conditions, i.e., the share of public versus private enterprises, the degree of confidence to intellectual property (I.P), the degree of interactions between the industrial-military complex, which is often at the vanguard of innovation, and the civil sectors, the insertion of the local economy in the global system. All these factors depend largely from national policies, which are the framework of the innovation dynamics.

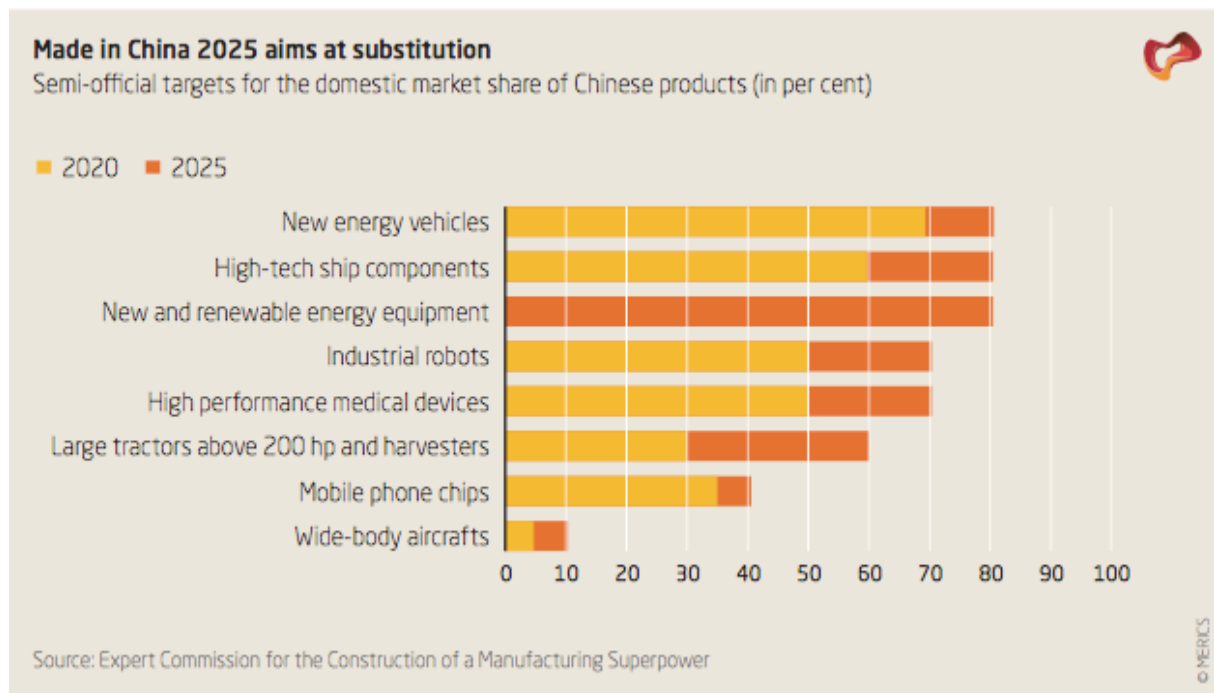
Besides, innovation is generally concomitant with creativity. Economic, social, institutional innovations tend to enhance artistic creativity. The best historical example is the « quattrocento » (XV th century) period, when Italy became the centre of institutional, scientific, and artistic innovation. The value given by education to the techniques of measurement and to the geometric concepts, allowed the people of quattrocento to develop a peculiar attention to the structures of forms, to the volume and superficies of the bodies. This union of science and art opened the way to the European Renaissance.

In the case of China, the picture is full of contrasts. On one hand, the artistic scene, especially since 2000, has become global, in the plastic arts, literature and film industry, with renowned artists who have sometimes emigrated abroad. On the other hand, it is quite challenging to measure the actual degree of innovation. The 2006 medium to long term plan for the development of Science and Technology (2006-2020) has embraced the concept of « indigenous innovation » (自主创新) which guides policy to this day. In 2010, the government identified seven strategic emerging industries (SEI) supposed to receive special support. Finally, the 13th five-year plan, adopted in march 2016, is completed by the Made in China 2025 plan (2015) and Internet Plus initiative.

All these plans are inspired by a techno-nationalist point of view, by import substitution and export promotion strategies : the market is opened to attract foreign technology, to enhance technological progress and management learning from foreign enterprises. Once Chinese companies are making significant progress in closing the technology gap, the Chinese government seeks to increase their market share by erecting barriers to foreign markets activities¹. (Following Figures) In the same time, Chinese policy makers support a strong wave of outward investment in cutting-edge technologies in the U.S and Europe. Despite the difficulties of this path, the aim is not only to be technologically independent, but also to challenge the U.S scientific as well as technological supremacy, after having bypassed the U.S as the first industrial country in 2010.

1. Jost Wubekke & al., Made in China 2025, The making of a high-tech superpower and consequences for industrialized countries, MERICS Papers on China n°2, Dec. 2016 , p.55:

https://www.merics.org/fileadmin/user_upload/downloads/MPOC/MPOC_Made_in_China_2025/MPOC_No.2_MadeinChina_2025.pdf



However, the measure of their success, is quite challenging from a macro-economic point of view, as there is a lag between inputs and outputs, according to a recent study by Scott Kennedy².

If we focus on human capital, education is highly valued in Chinese culture and society, with the Confucian heritage. Since the Real Leap Forward in education, launched in the beginning of this century, China annually graduates the world's largest pool of scientist and engineers. Although they are not especially encouraged to be creative in school, or to develop initiatives in the national system of education, China has sent millions of students abroad, attract foreign investors who tend to share technology and create R&D centres and train their Chinese employees. Chinese enterprises create representative offices in the top high-tech hubs like Silicon Valley and acquire technology through mergers and acquisitions (M&A), hiring talent from their western competitors, and also from Taiwan, which has long been a world hub in information technology (I.T), and has invested a lot in the continent with

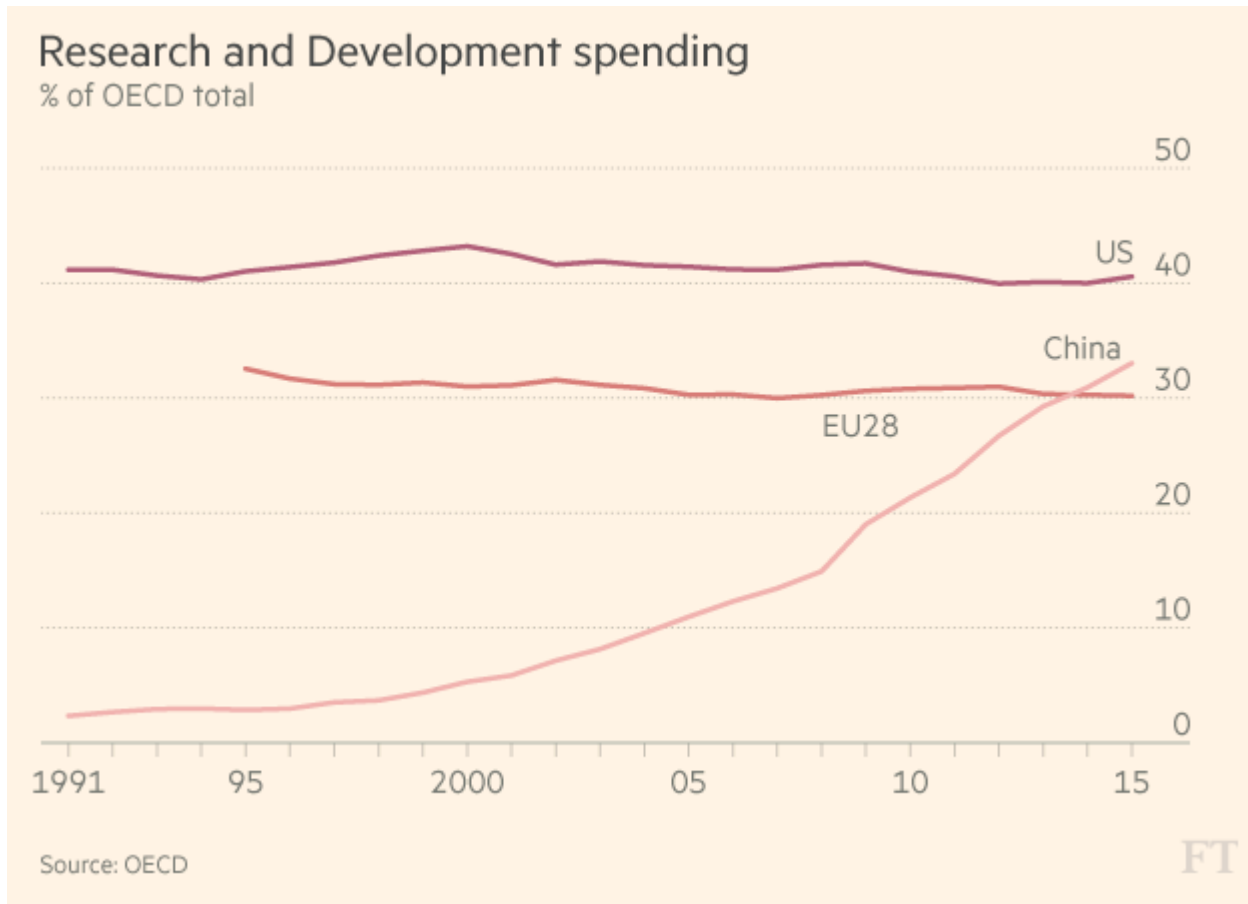
2. Scott Kennedy , The Fat Tech Dragon, Benchmarking China's Innovation Drive, Center For Strategic and International Studies, August 2017 : <https://www.csis.org/analysis/fat-tech-dragon>

around one millions Taiwanese, mainly managers and engineers, now living in China.

If we focus on funding, with 2.1 percent of its GDP invested in R&D, China has already bypassed the E.U in absolute terms, from 10.9 US \$ billion in 2000 to US \$ 232 billion in 2016, and is now catching up with the U.S.A. But this does not mean that these massive inputs translate in comparable outputs. Basic research represent just over 5 percent, applied research 10.8 percent and 84.2 percent of funding is directed towards development (2015). Most of the funding goes to companies (77 %), which decide according to commercial competitiveness criteria. By avoiding spending on basic research and foundational technologies, whose share are at least two to three times higher in other developed countries (14 percent in the U.S, 17 percent in Russia, 11 percent in Japan in 2015³), income is less a result of new technologies and more a result of new applications or business models.

3. <http://www.oecd.org/innovation/inno/researchanddevelopmentstatisticsrds.htm>

R&D by sector of performance and type of R&D.



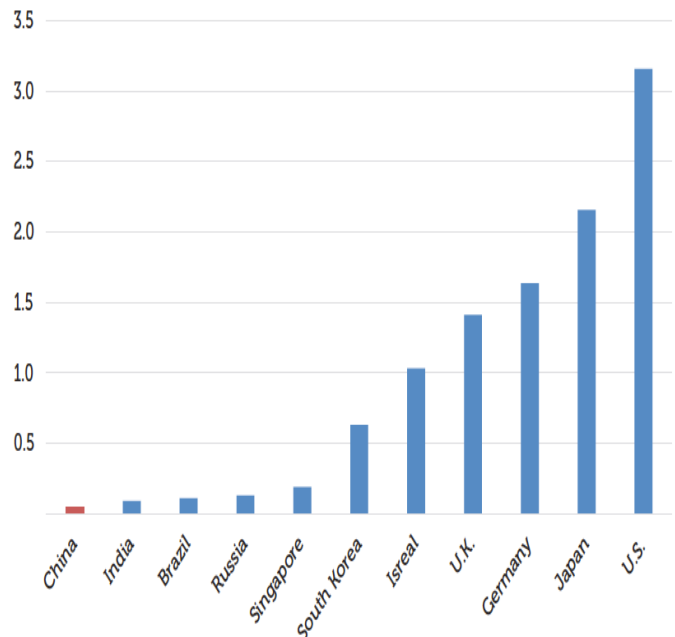
Source: Financial Times , OECD.

The same may be said for other indicators of innovation. The number of patents for example is very high on a national basis, with only 21 % on inventions, but low from an international perspective. The domestic as well as international value of patents is still quite low. Triadic patents, successful in the U.S, Japan and E.U are in 2014, the latest available year, six times less than for applicants from the U.S and Japan (2582 versus 14,994 for the US and 17,121 for Japan). In 2015, patent licensing has generated only US \$ 1.75 billion of local revenues and international sales of patent rights, US \$ 1.38 billion, while IP licensing revenue in the U.S generated for the same year US \$ 115.2 billion. If we turn to the balance of I.P receipts to payments, China is still a massive importer of I.P: US \$ 22 billion of payments versus US \$ 1 billion of receipts, according to the IMF.

The ratio of receipts to payment in international licensing (Following Figure) indicate that China is still primarily an assembler

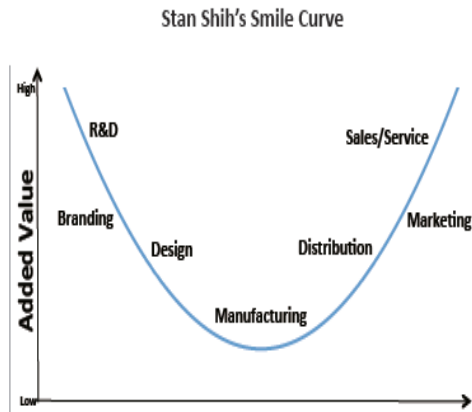
and manufacturer in the global supply chain (Following Figure)⁴.

Figure 16. IP International Licensing Ratio: Receipts-to-Payments, 2015



Stan Shi's famous smile curve is still valid for a lot of high tech exports:

4. Scott Kennedy, *op.cit.*



If we now focus on output, the commercial performance of innovation, the official vision is that the indigenous innovation works very well with indicators such as the National Innovation Index measuring essentially quantitative inputs (R&D intensity, human capital, etc.), and the Science and Technology Contribution Rate, constructed in such a way that it would be impossible to fall in the absence of a strong economic contraction.

A better approach, according to Scott Kennedy, is to look at the high tech's contribution to manufacturing value added, rising from 8.8 percent in 2010 to 14.2 percent in 2014, and the share of high tech exports from domestic companies, which has climbed from 15 percent in 2000 to 19 percent in 2015, with diverging tendencies between sectors:

Table 4. High-Tech Exports from Domestic Companies (Percent of Total)

	2000	2005	2012	2013	2014	2015
Total Average	15	8	11	12	16	19
Medicines	74	73	58	58	57	59
Medical Equip & Appliances	28	14	34	35	38	41
Airplanes	76	61	83	81	72	73
Communications Equipment	6	11	26	26	31	26
Electronic Appliances	17	7	6	9	11	16
Semiconductors	6	14	13	12	13	14
Integrated Circuits	5	2	5	9	10	12
Complete Computers	9	1	1	1	1	3
Computer Components/Parts	7	4	1	1	2	7
Computer Peripherals	7	4	10	12	14	17

Source: China Statistics Yearbook on High Technology Industry 2016, 8, 23.

Source: Scott Kennedy, *op.cit.*

If we turn to a micro-economic point of view, Price Waterhouse Cooper (PWC) ranks in its annual report « Global Innovation 1000 » the companies according to their investment in R&D and through a survey of business executives asking them to identify the most innovative companies. By either method no Chinese company appears among the top 25 of this grading. The first Chinese Company in terms of R&D is Alibaba, which occupy the 56th rank. However, according to PWC, which underlines the global tendency to economic nationalism, there is no statistical relationship between R&D spending and commercial metrics (in terms of sales growth, profits, or shareholders returns).

This is precisely the case of Chinese companies. The cross-finding between macro and micro data shows that prominent high tech Chinese companies (Following Figure in Scott Kennedy's Report) have not risen on technological innovation, but that their growth is the result of two main factors:

Table 5. Prominent High-Tech Chinese Companies

Companies	Product	Companies	Product
Vivo, Oppo, Xiaomi	Mobile phones	Goldwind	Wind turbines
Lenovo	Laptops & PCs	Trina Solar	Solar cells
Huawei, ZTE	Telecom equipment	HikVision	Security cameras
Midea, Haier	Home appliances	Geely, BYD	Autos
Alibaba, Tencent, JD	E-commerce	DJI Innovations	Drones
Baidu	Search	China Railway Corp	High-speed rail
Didi	Ridesharing	Tsinghua Unigroup	Semiconductors

Source: Scott Kennedy, *op.cit.*

1. Incremental innovations in applications and customization due to the scale of the market, from mobile phones (Vivo, Oppo, Xiaomi) and laptops (Lenovo), to telecom equipment (Huawei, ZTE), home appliances (Midea, Haier), E-commerce (Alibaba, Tencent, JD) or search (Baidu). The scale also allows to pursue a low margin high volume pricing strategy and to get an

unprecedented amount of big data from customers.

2. The second factor is relative to entry barriers. Chinese companies, have forged their competitiveness under a wide display of protectionist measures provided by state policies, not only in the public procurement system (Goldwind, Trina Solar, DJI Innovations, China Railway Corp.), but also in the financial, insurance, telecom and internet markets, which are based on profitable oligopolies.

Scott Kennedy's conclusions is that China's drive to innovation may be highly inefficient in the sense that there is a lag between top down policies and massive inputs and the modest scale of inventions and technological breakthrough. But he adds that it may not be a problem as large mistakes and waste may facilitate learning and investment down the road, and that China's size, not comparable to Japan and other NPI countries requires to judge the country's performance not only on the consequences for Chinese companies, but for entire sectors and the global economy.

Here is the point, as the lag between massive inputs and low immediate breakthrough innovations or technological Great Leap does not make sense in a development as well as historical perspective. From a development perspective, we can not deny, for instance that the high speed train program, based on retro engineering (Following Figure, Zhonghua wanglun tan) implemented before and during the global financial crisis, has been a success story, since China has built in less than ten years more high speed trains lines (20.000 km) than the whole world⁵.



国产 CRH1



庞巴迪为瑞典 AB 提供的 Regina, 200 公里级别 (营运速度 200KM/h, 最高速度 250KM/h)



国产 CRH2



日本川崎重工 E2-1000, 200 公里级别 (营运速度 200KM/h, 最高速度 250KM/h)



国产 CRH3



德国西门子 ICE3, 300 公里级别 (营运速度 330KM/h, 最高速度 380KM/h)



国产 CRH5



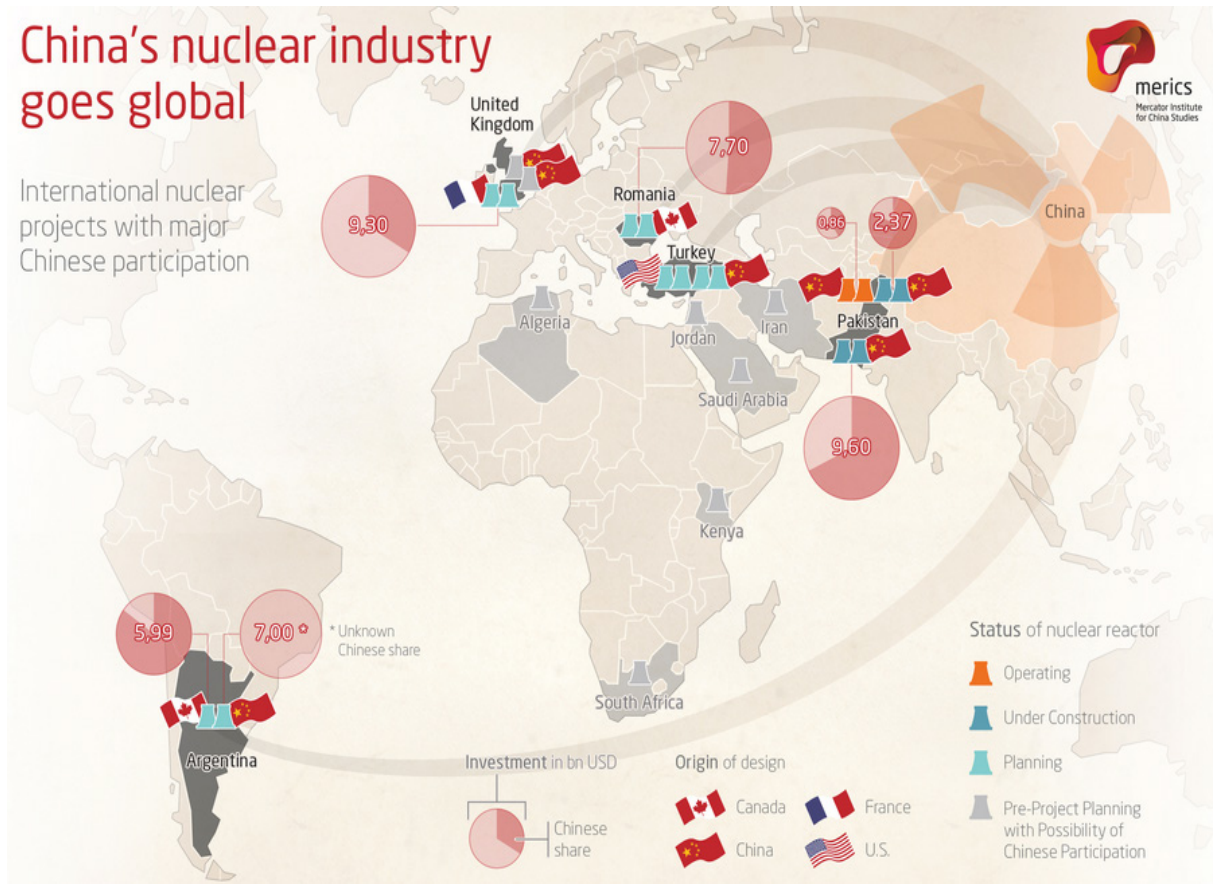
法国阿尔斯通为芬兰国铁提供的 SN3

型, 200 公里级别 (营运速度 200KM/h, 最高速度 250KM/h)。

Source: Zhonghua wang luntan

Another example of the Chinese catch up capacity is the multiplication of Chinese participation in nuclear industry projects (in U.K Romania, Pakistan, Turkey, Argentina), in association with U.S, Canadian and French firms:

5. « China sets its sight on dominating sunrise industries », *The Economist*, Sept.23, 2017.



Source: Mercator Institute for China Studies

If we rely on an historical perspective, technology and innovations may move quickly from a country to another. Italy was the center of innovation and artistic creation in the 15th century, but Portugal and Spain became the global powers in the 16th because their states had the political will and the financial capacity to finance fleets and recruit the most enterprising sailors such as the Genovese Christophe Colomb. At the end of the nineteenth century, Europe discovered the automobile, the cinema and the aviation, but the United States, with the scale of their market, and their managerial capacity were able to develop Taylorism, Fordism, Hollywood and air transport on an unprecedented scale.

From inventions to applications: artificial intelligence as a priority

Thus, all the normative talk about the right path of innovations may be misleading, inventions may not be a precondition for technological breakthrough. Applications seem essential, in high tech industries as well as in the new frontiers of science, such as Quantum Technology. A recent U.S Congress Hearing (Subcommittee on Research and Technology & Subcommittee on Energy) has shown that although the United States retains global leadership in the theoretical physics that underpins quantum computing and related technologies, the country may be slipping behind others, and especially China in developing the quantum applications – programming know-how, development of national security and commercial applications⁶.

Artificial intelligence may be the best example of the priority of applications versus inventions. Artificial Intelligence is the idea,

6. <https://science.house.gov/legislation/hearings/american-leadership-quantum-technology>

first launched by Alan Turing in 1950, that a computer system can perform functions associated with the human mind, in what has since been known as the Turing test: can a computer communicate well enough to persuade a human that it, too, is a human?⁷ The term « intelligence » may be misleading, as the real question seems to decouple successful problem resolution from any need to be intelligent, or to cite the US computer scientist John Mc Carthy and colleagues, who invented the term and developed the field in 1955, « the problem is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving ». To paraphrase Clausewitz, with Luciano Floridi, from the Digital Ethics Lab, of Oxford University, « A.I is the continuation of intelligence by other means »⁸.

Intelligence does not mean here conscious thought or deductive reasoning or « understanding », but the capacity of computer systems to perform tasks normally demanding human intelligence, such as visual perception, voice recognition, translations between languages, the ability to make associations, or in an action domain to evaluate a situation and to act appropriately. AI models do not start at a very high level of comprehension or efficacy, they are learning systems that build intelligence as they absorb data⁹. In the past, computer systems had to be programmed to execute defined tasks. But now, Machine Learning (M.L), a type of artificial intelligence, provides computers the ability to learn without being explicitly reprogrammed. Machine Learning focuses on computer programs that can teach themselves to adapt to new data inputs, and grow¹⁰. Many M.L

systems are already developed for commercial use, such as Apple Siri, smart speakers such as Amazon's virtual assistant Alexa, which has partnership with more than 100 third party services, Google Home, which allows shoppers to complete orders with 50 participating Google Express retailers¹¹. A real-time recognition of handwritten Chinese characters developed by Apple is spanning a large inventory of 30.000 characters¹².

Other applications are still in the development stage, like the driverless car : the first computer chip designed to control a completely driverless car, developed by US chip-maker Nvidia, will be in operation for a trial in the streets of Germany in 2018¹³.

The most Advanced form of Machine Learning is Deep Learning (D.L), a breakthrough innovation in artificial intelligence functions that imitates the working of the human brain in processing data and creating patterns for use in decision making¹⁴. AlphaGo, a self-taught computer, made sensation when its creators from DeepMind, a London based Co. acquired by Google, beat China's world champion Go player, Ke Jie in may 2017. Since, a new development, Alpha GoZero, dispenses from human expertise and starts just by knowing the rules and objectives of the game. It learns to play by playing against itself. , and has defeated the previously published version of Alpha Go by 100 games to zero¹⁵. In the future, Deep Mind will focus

7. A.M. Turing, « Computing machinery and intelligence », *Mind*, volume 49, n°236, October 1950.

8. Luciano Floridi, « A fallacy that will hinder advances in artificial intelligence », *Financial Times*, June 1, 2017. <https://www.ft.com/content/ee996846-4626-11e7-8d27-59b4dd6296b8>

9. Gerbert, Phillip, « The power and limits of AI : An interview with IBM's David Kenny », BCG publications, March 12, 2018 : <https://www.bcg.com/publications/2018/power-limits-artificial-intelligence-interview-ibm-david-kenny.aspx>

10. National Academy of Sciences ; The Royal Society, *The Frontiers of Machine Learning: 2017 Raymond and Beverly Sackler U.S.-U.K Scientific Forum*: <https://www.nap.edu/catalog/25021/the-frontiers-of-machine-learning-2017-raymond-and-beverly-sackler>

11. « Google, Apple and Amazon sound out consumers on smart speakers », *Financial Times*, October 7, 2017; Dominique Barton & al. *Artificial Intelligence, The next digital frontier*, Mac Kinsey Global Institute Discussion Paper, June 2017, p.44.

12. Apple Machine Learning Journal, 2017/ 09: <https://machinelearning.apple.com/>

<https://machinelearning.apple.com/2017/09/12/handwriting.html>

13. « First chips for full control of driverless cars to hit the Streets » *Financial Times*, October 10 , 2017: <https://www.ft.com/content/99121e62-adbf-11e7-aab9-abaa44b1e130>

14. Yan LeCun « Power and limits of Deep Learning », MIT, November 1st, 2017: <https://esclips.com/video/0tEhw5t6rhcyann-lecun-power-limits-of-deep-learning.html>

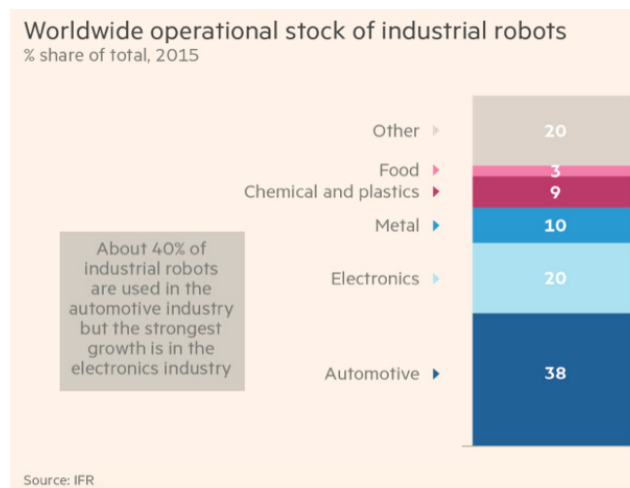
15. David Silver & alii, « Mastering the Game of Go without human knowledge », *Nature*, 550, 354-359, 19/10/2017:

https://www.nature.com/articles/nature24270?error=cookies_not_supported&code=7a186490-bb5f-4f41-8082-a6eb70174558

on « developing advanced general algorithms that could one day help scientists as they tackle some of our most complex problems, such as finding new cures for diseases »¹⁶.

As the new generation of A.I applications is based on the formation of digitization, leading sectors in digital tend to be leading sectors in A.I. High tech, telecom and financial services have a long history of digital investment and are generally well placed in A.I. Automotive and assembly, leaders in the use of robots, with nearly 40 % of the world's stock, (Following Figure) are also developing A.I with the driverless car project. But A.I can highly enhance the productivity and growth of other sectors¹⁷.

In the retail sector, A.I may anticipate demand trends, automate warehouses and store operations, (See Video, *Financial Times*, August 25, 2017, https://www.youtube.com/watch?v=j9nv_0MOOcI; similar machines are used in China in the depots of Tmall, part of Alibaba Co. <http://www.alizila.com/video/smart-robots-alibabas-intelligent-warehouse/>), optimize pricing and personalize promotions, offer assistance with virtual agent, and complete last-mile delivery by drones.



Source: *Financial Times*

16. Luciano Floridi, *Financial Times*, article cited, June 1, 2017.

17. For further details and a complete study, see: *Artificial Intelligence, The next digital frontier*, MacKinsey Global Institute Discussion Paper, June 2017. <https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/How%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/MGI-Artificial-Intelligence-Discussion-paper.ashx>

In electric utilities, A.I may enhance supply and demand prediction with smart meters, maximize the use of renewable power, optimize preventive maintenance and pricing, and reduce energy waste and theft. Digital Wind Farms, launched by General Electric, could boost a wind farm's energy production by 20 percent and China's State Grid Corporation announced plans to invest US \$45 billion in smart grid technologies, and another \$45 billion between 2016 and 2020¹⁸. Machine Learning can also reduce energy losses in transmission and distribution.

In manufacturing, A.I can improve product design and efficiency, automate supplier assessment, automate assembly lines, reduce material delivery time, predict sales of maintenance services or in the Aerospace industry, optimize flight and planning routes and enhance flight and pilots training.

In the health sector, A.I may bring more intelligence to imaging and radiology, help to predict diseases and discover new therapies, identify high risks patients groups, automate and optimize hospital operations, diagnostic test and make them faster and more accurate, adapt therapies and drug formulation to patients.

In education, A.I may help to predict job market demand, automate teachers routine tasks, identify early disengagement signs, personalize learning and build students self-awareness.

A lot of these applications are already in use such as image recognition with the automatic tags on Facebook or by videosurveillance cameras, the recommendation of films or musics (Netflix, Spotfire), the predictive maintenance, etc¹⁹.

All these developments show that we are not witnessing the boom and bust cycle that marked the growing role of I.T at the beginning of the 21 st century. We are at the beginning of a new age. A.I is powered by new entrants, such as UBER, who have already disrupted whole sectors such as the taxi industry.

18. Ibidem, p.44.

19. Comments by Fajwel Fogel, SANCARE.

Data is at the heart of the disruptions occurring across economies, and is actually recognized as a critical corporate asset. It is the fuel that powers A.I. The world creates actually 2.2 exabytes or 2.2 billion of gigabytes of data every day. More data means more examples, more insight and a better accuracy for Machine Learning systems, which can reduce computer error rates, in some application such as visual recognition, to about the same as the rate for humans. The scale of data determines the output of A.I programs.

The second condition for A.I development is computer power. Following the promotion of a national Integrated Circuit Industry, in 2014, with investment of more than \$US 20 billion, in June 2016, China broke record with the world's fastest supercomputer, Sunway TaihuLight, without US developed processors²⁰. China is now planning to boost its computer power tenfold within a couple of years, by building an exascale computer, which will help the country 's maritime expansion by processing data collected from the world's ocean²¹. It has bypassed the U.S for the number of the most powerful computers at the end of 2017²², but these machines are underused due to a lack of software support and high operating costs, including electricity consumption that runs up to to \$ 100.000 per day for *Tianhe 2*, launched in 2013. Besides, China is still dependant from the U.S for semi-conductors, and has planned to reduce its imports by half in the next years and to eliminate them completely in the long term. High Powered Computing (HPC) is essential for defense, manufacturing and health-care applications or scientific research²³, but it may not matter as much if other countries develop new, more efficient

supercomputers that are designed specifically for challenges like AI. But, the semiconductor industry is crucial for AI applications, as AI chips are used in data centers to train systems to analyse and find patterns in volumes of data that are compiled. Due to their long creation cycle, processor and chip development may be the most challenging component of China's AI strategy.

Powerful Graphic Processing Units (GPU), Integrated Circuits (I.C) originally developed for video games, can process images 40 to 80 times faster than the version available in 2013, they are used to train algorithms, and are the « real weapon in A.I ». Out of the top ten American chip-makers, 4 specialize in making GPU's, whereas none of the top ten Chinese chip-making company specialize in GPU's. As for chips designed to execute machine learning and deep learning algorithms, like Tensor Processing Unit (TPU) and Field Programmable Gate Arrays (FGPA), of the top ten Chinese chip-makers, 6 specialise in the first category, and both the U.S and China have two chip-making companies which specialize in FGPA out of their top 10 ten chip-making companies. But in the U.S, chip innovation is constantly occurring and seems to be ten years ahead of China²⁴.

Taiwan may also be an asset for China's catch-up in A.I hardware, as it is home to two of the world's largest semi-conductor companies, Taiwan Semi-Conductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC). The industry accounts for 28 percent of Taiwan's exports in 2016²⁵, and there is a constant flow of ICT engineers with the continent.

20. Dominique Barton & al. *Artificial Intelligence: Implications for China*, McKinsey Global Institute, April 2017, p.8.

21. Stephen Chen, « The world's next fastest supercomputer will help boost China's growing sea power », *South China Morning Post*, Hongkong, 23 August 2017.

22. Huang, Echo, « China suddenly has way more of the more powerful computers than the U.S », *Quartz*, Nov.14, 2017 <https://qz.com/1128704/china-has-way-more-of-the-worlds-most-powerful-computers-than-the-us/>

23. Ezell, Stephen J. and Atkinson, Robert D., *The vital importance of high powered computing to U.S competitiveness*, IF TI, April 2016 : <http://www2.itif.org/2016-high-performance-computing.pdf>, p.36-37.

24. Ding, Jeffrey, *Deciphering China's AI dream : The context, components, capabilities and consequences of China's strategy to lead the world in A.I*, Governance of AI program, Future of Humanity Institute, University of Oxford, March 2018: <https://www.fhi.ox.ac.uk/wp-content/uplo> » « [Real Time Recognition/Deciphering Chinas AI-Dream.pdf?stream=future-of-work](https://www.fhi.ox.ac.uk/wp-content/uplo) Part III. ; Triolo, Paul and Goodrich Jimmy, « From riding a wave to full steam ahead : As China's government mobilize for AI leadership, some challenges will be tougher than others » Feb, 28, 2018: <https://www.newamerica.org/cybersecurity-initiative/digichina/blog/riding-wave-full-steam-ahead/>

25. Jao, Nicole, « Why Taiwan is down but not out in the global AI race », *Technode*, Jan 5, 2018: <https://technode.com/2018/01/05/explainer-taiwan-not-global-ai-race/>

The third condition for AI development is the variety and sophistication of algorithms. All these trends are growing rapidly, with a fast developing R&D investment, despite the scarcity of talent: China has a larger pool of STEM graduates, but only 39,000 AI researchers, less than half of the size of the U.S pool of over 78,000 researchers. Nearly half of the AI researchers in the U.S have more than 10 years of work experience, whereas only 25 percent in China have more than ten years of work experience²⁶.

Other estimations are much more restrictive: according to the Global AI Talent Pool Report, there are roughly 22,000 PhD educated researchers who are capable of working on AI research and applications and 5,400 AI experts who are publishing and presenting at leading AI conferences²⁷. The top-tier AI talent absorbed by more than 2,000 startups, is estimated by some to be just 10,000 individuals worldwide²⁸. High tech companies are actively buying start-ups, not only to acquire technology and clients, but to hire talents, as the pool of true experts is reduced²⁹. Many Chinese investors in Silicon Valley are focused on bringing U.S startups to China³⁰. Founders of China's top facial recognition companies, Sense Time, DeepGlint and Yitu, all have research experience at top American AI labs³¹. But Chinese talent recruitment is not a threat to the United States, as the U.S still takes more talent from China than its exports to China. Some 85 percent of Chinese nationals who pursue a doctorate in the

26. Ding, Jeffrey, *op.cit.*

27. Gagne, J.F, Element AI , « Global AI Talent Pool Report 2018 »: <http://www.jfgagne.ai/talent>

28. Kiron, David and Unruh, Gregory, « How Ai will define new industries », *MIT Sloan Management Review*, January 23, 2018: <https://sloanreview.mit.edu/article/how-ai-will-define-new-industries/>

29. <https://media.nips.cc/Conferences/NIPS2017/Poster/NIPS-2017-Poster.pdf>

<https://papers.nips.cc/book/advances-in-neural-information-processing-systems-30-2017>

30. Reuters, May 17, 2018 « Silicon Valley Chinese accelerators aim to bring startups home »: <https://www.reuters.com/article/us-usa-trade-china-startups/in-silicon-valley-chinese-accelerators-aim-to-bring-startups-home-idUSKCN1I0UG>

31. Sheehan, Matt, « Google China 2.0 and the ethics of AI engagement », *Macro Polo*, January 17, 2018: <https://macro-polo.org/google-china-2-0-ethics-ai-engagement/>

United States, for example, are still present ten years later³².

China's A.I craze

The OECD Science and Technology Industry Scoreboard 2017, provides comparative data on China's digital transformation, but does not give an idea of the scale of the market, and the development of AI³³. With its giant tech companies, China is one of the leading global hub of A.I development and seeks dominance at the world level. Beijing's blueprint for A.I, published in July 2017, aims to create a \$US 150 billion industry by 2030³⁴ (Following Figure).



China and the U.S are now the world leaders in A.I. While China ranks first for widely cited A.I related papers, US and UK research remains more influential (Following Figure)

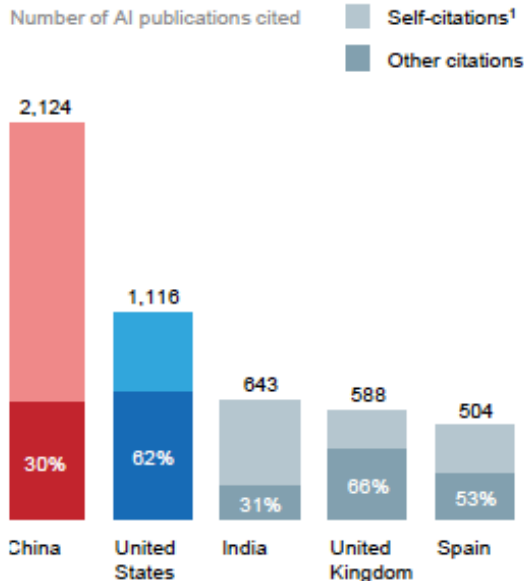
32. Sabri Ben-Achour, « China's quiet hunt to hire top U.S. researchers », *Marketplace*, June 05, 2018: <https://www.marketplace.org/2018/06/05/world/chinas-quiet-hunt-hire-top-us-researchers>

33. http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/oecd-science-technology-and-industry-scoreboard-2017_9789264268821-en#_WiGDurZ7RZ0; (Knowledge economies and digital transformation)

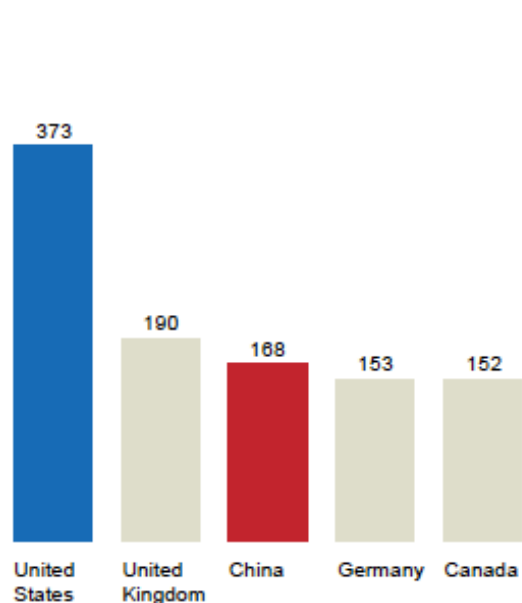
34. *Financial Times*, October 16, 2017; http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm in Chinese: State Council , The next generation AI Development Plan.

Although China produces a large number of widely cited AI-related papers, US and UK research remains more influential

While China ranks first for absolute AI citations, the United States holds an edge when self-citations are taken out



Publication influence
H-index²

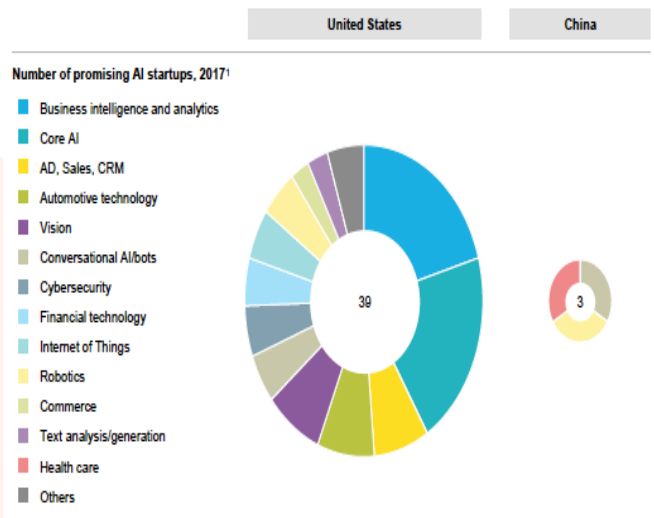


1 Self-citation occurs when a journal cites another article published in the same journal.
2 The H-index ranks both the productivity of scholars and the citation impact of their publications. A higher H-index number indicates more publications that are widely cited.

SOURCE: SCImago Journal Rank 2015; McKinsey Global Institute analysis

China's A.I ecosystem is not as vibrant as the United States, which has created a lot more AI start up companies than China (Following Figures):

The United States has a more robust AI startup ecosystem than China



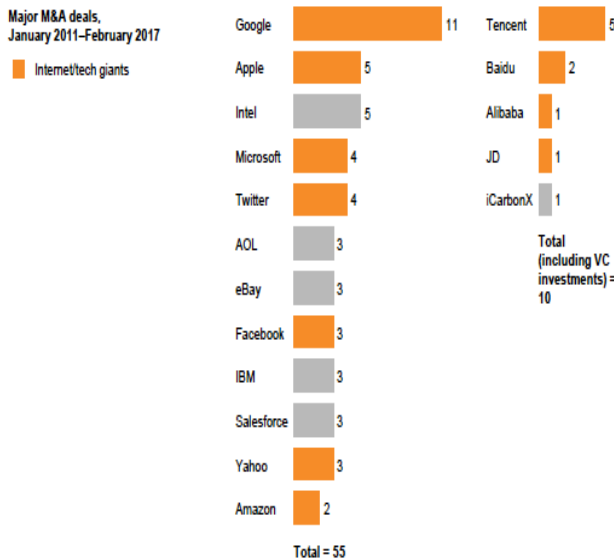
Source: Goldman Sachs Global Investment Research © FT

Source: Artificial Intelligence, Implications for China, McKinsey Global Institute, April 2017.

In 2016, the US, more attractive, absorbed around 66 percent of external investment (Venture Capital, Private Equity and Mergers & Acquisitions), China was a distant second at 17 percent. The San Francisco Bay Area and Silicon Valley were attracting alone 40 percent of global external investment,

followed by Boston, New York, and Beijing and Shenzhen AI tech eco-systems³⁵.

Major M&A deals which are also a way to recruit talents, were made mainly by U.S tech giants between 2011 and the beginning of 2017³⁶ (Figure):

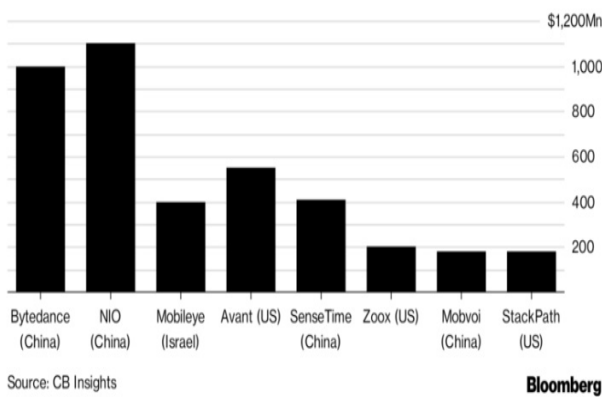


Source: McKinsey Global Institute, *Artificial Intelligence, Implications for China*, April 2017

But the situation seems to change very quickly as Chinese start-ups lead the pack for software and self-driving cars, in terms of investment³⁷:

Top AI Investments Since 2013

Chinese startups lead the global pack with software and self-driving cars.



Source: CB Insights

Bloomberg

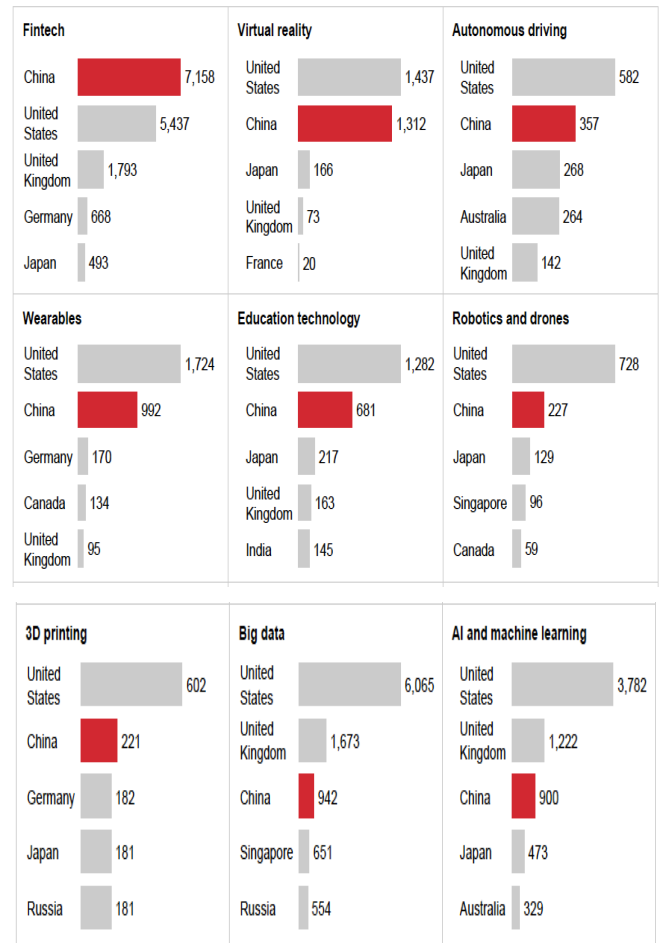
35. McKinsey Global Institute, *Artificial Intelligence, The next digital frontier*, *op.cit.*

36. Dominique Barton & al.: *Artificial Intelligence : Implications for China*, McKinsey Global Institute, Discussion Paper, April 2017.

37. Mark Bergen and David Ramli, « China's Plan for World Domination in AI Isn't SO Crazy After All », Bloomberg, August 15, 2017.

In Venture Capital Investment, they are second to the U.S in most leading technologies (Following Figure).

Venture capital investment in leading technologies, 2016¹
\$ million



1 Based on the nationality of the venture-capital investor. Coinvested deals are counted under each nationality. Investments in startups with multiple technologies are counted in each category of technology.
NOTE: Not to scale.

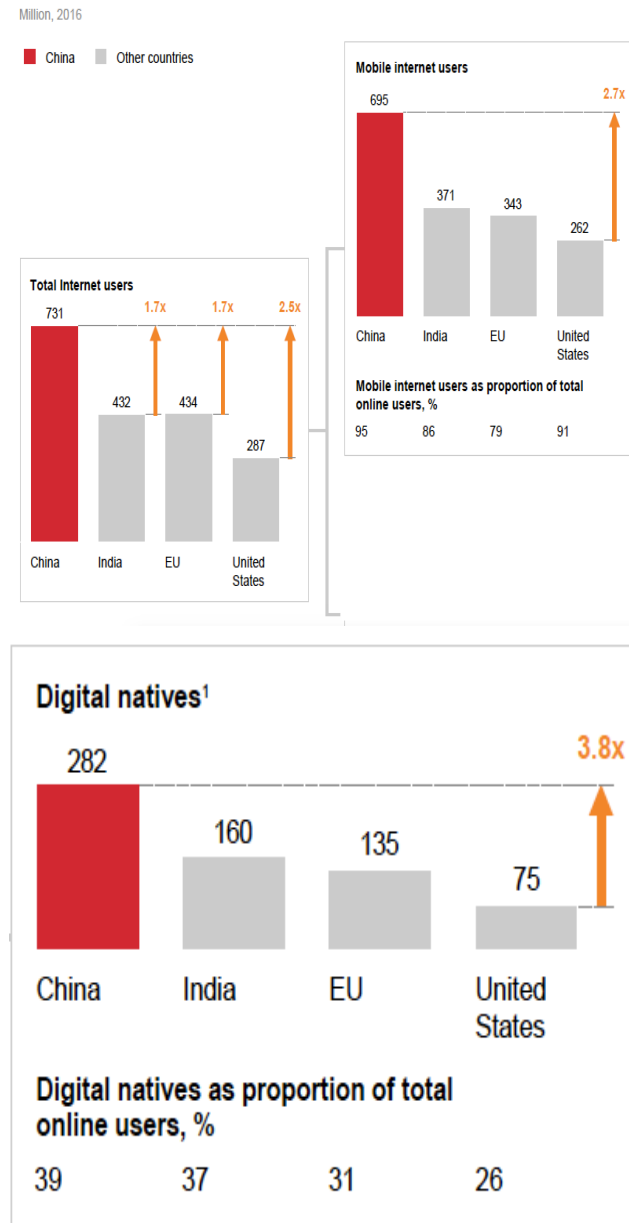
SOURCE: PitchBook; McKinsey Global Institute analysis

Source: Jonathan Woetzel & al. *China's Digital Economy: A Leading Global Force*, Mc Kinsey Global Institute Discussion Paper, August 2017.

The secret of this rapid catch-up may be the idea that market size is the key driver of innovation³⁸. As of December 2016, China had 731 million Internet users (more than E.U and U.S combined), 95 percent of which are Smartphones users. Digital native Internet users, defined as internet users aged 25 or under, number 280 million, practically the same as the total number of U.S Internet

38. Acemoglu, Daron & Joshua Lin, 2004, « Market Size in Innovation: Theory and Evidence from the Pharmaceuticla Industry », *Quarterly Journal of Economics*, 119 (3): 1049-1090.

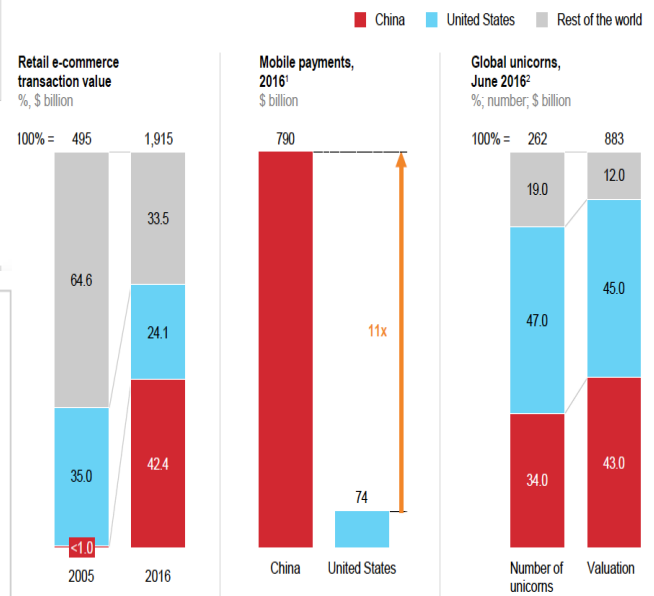
users. 496 million internet users, or 68 percent, made digital payment with their smart phones. (Following Figures)



Source: Ibidem, *MacKinsey Global Institute Discussion Paper*, August 2017.

It is interesting to note that China's digital expansion is strongly linked to low costs products supplied by domestic manufacturers. The penetration of cheap and high quality smart phones enabled the rapid spread of the mobile internet. In just ten years, from 2007 to 2017, Chinese brand mobiles rose from 5 percent to 90 percent of the market, the best example of the import substitution policy launched in 2006, with the Medium to Long-Term Plan for the Development of

Science and Technology. In addition, the lax regulation of digital content in terms of intellectual property rights strongly enhanced the penetration and the use of these devices, with free and easy access to music, books and movies. In 2008, 99 percent of international music downloads in China were free of charge or « illegal » according to the terms of the International Federation of the Phonographic Industry (IFPI) which sued search engine like Baidu, before a second phase of stronger enforcement of intellectual property rights (IPR) on the Internet³⁹.



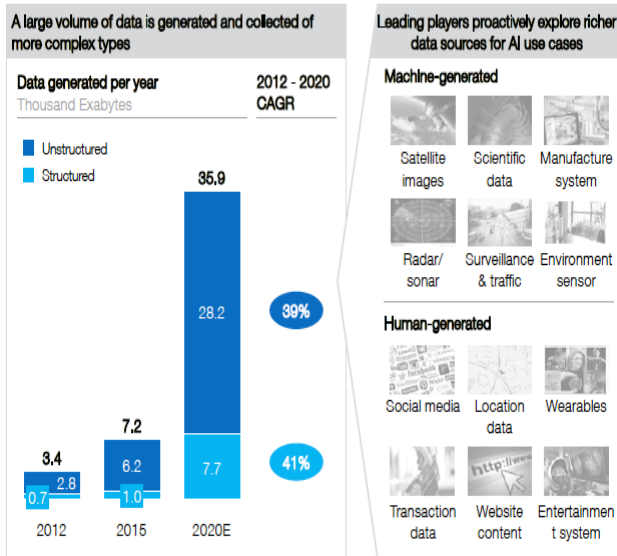
Source: Ibidem, *China's digital economy, A leading global force*, MacKinsey Global Institute, 2017.

The strong penetration of the internet and smartphones enhanced the expansion of e-commerce. China accounted for less than 1 percent of the value of worldwide digital payments in 2005, but raised to more than 40 percent in 2016, a value larger than those of France, Japan, Germany, the UK, and the US combined. The value of its mobile payments related to consumption by individuals was 11 times that of the U.S. (Following Figure)

Apart from the sheer volume of China's Internet users, machine-generated data also provides a massive amount of raw material

39. *China's digital economy, A leading global force*, McKinsey 2017, p. 12-14 ; The French Chamber of Commerce and Industry in China, « China, The digital revolution », Connexions Magazine, february 2, 2017: <http://www.ccifc.org/single-news-connexions/n/connexions-79-china-the-digital-revolution/>

for the expansion of A.I, (Following Figure for the world tendency).



Source: IDC executive summary 2015 (https://www.datanami.com/solution_content/hpe/media-entertainment/navigating-unstructured-retail-data-storm/)

Computer power has been stimulated by government policies as well as the expansion of e-commerce. During Singles Day on November 11 2016, which has become a huge online shopping day, with promotions such as the US Black Friday which hit US \$ 3.34 billion in 2016, Alibaba made \$ US 17.8 billions in sales, up from \$ 14.3 billion in 2015 (Following Figure)

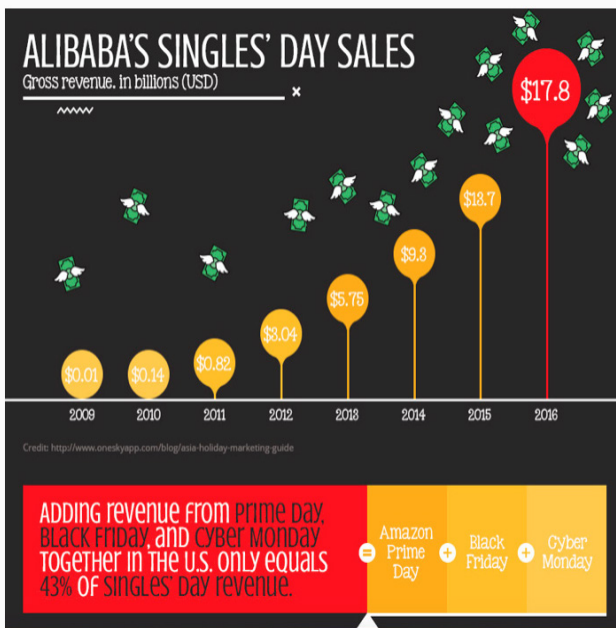


Image credit: Carvaka

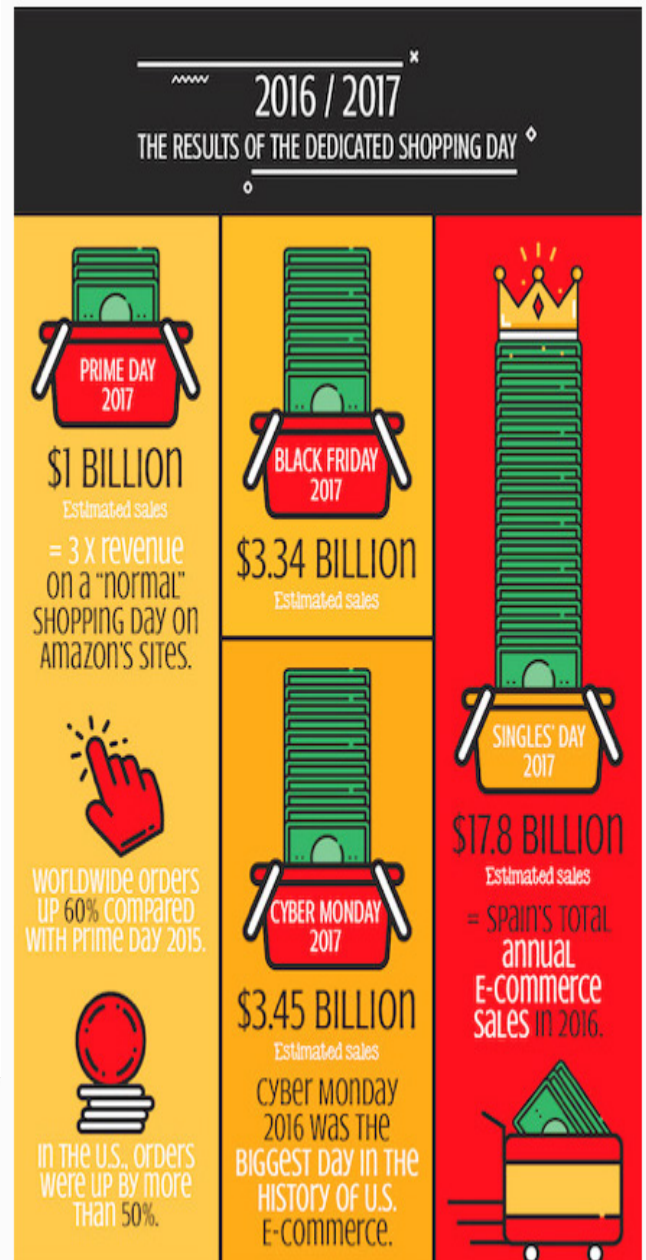
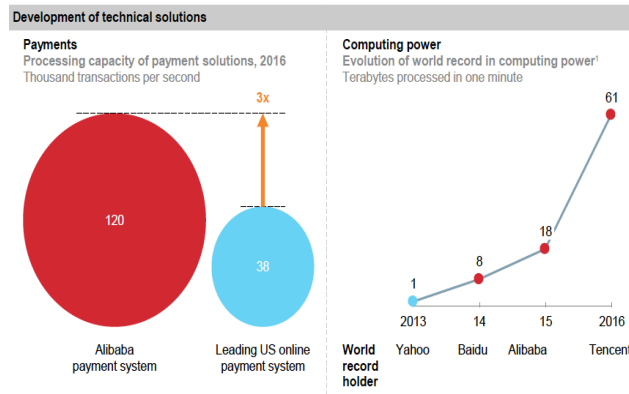


Image credit: Carvaka

, its payment platform processed 120,000 transactions per second, three times higher capacity than than one of the leading world Platform (Following Figure). During Singles Day 2017, Alibaba broke its own record by selling the equivalent of US \$ 25.3 billion, a growth of 40 percent over the previous year. Chinese cloud providers also hold the world record of computing efficiency, since 2014, with Baidu, Alibaba (2015), and Tencent (2016) in the Sort Benchmark's world

competition, regarded as the computing Olympics⁴⁰.



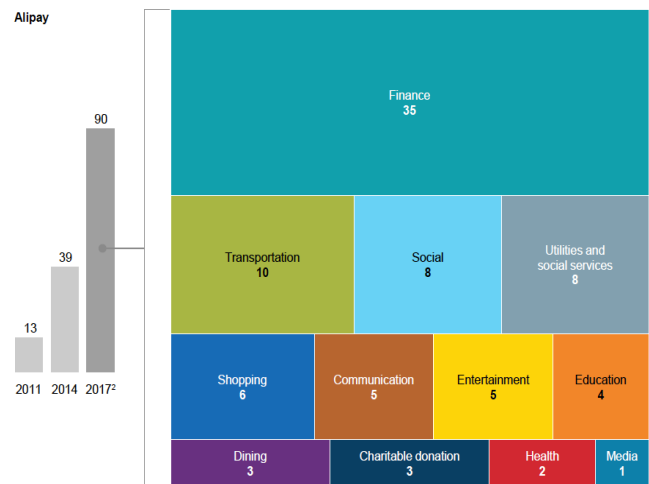
¹ According to an assessment of how much data can be processed in a minute in terms of general sorting.
SOURCE: Company official announcements; Profit Confidential; 360doc; Alizila; Sankei; Sort Benchmark; McKinsey Global Institute analysis

Source: *China's Digital Economy, A Leading Global Force*, McKinsey Global Institute, 2017.

The Baidu Alibaba & Tencent (BAT) have diversified their applications, by providing solutions to sectors fragilised by inefficiencies. Alibaba for instance, for its core business through its online shopping website Taobao (founded in 2003) later bet, with its Alipay digital payment business, for the retail market in the small and middle sized towns, which were badly deserved by traditional retailers. Now the Alibaba Distribution Platform (ADP), a retail management system established in May 2016, which has more than 500,000 clients, offers marketing, training and logistics services to independent shop owners. The goal is to rebrand 10,000 mom and pop stores under the name of its online marketplace, Tmall (founded in 2008). But the potential is enormous as they are more than 6 million of these stores, most of which are family-run, according to Aliba Vice-President and general manager of ADP. Alibaba rival JD.Com 京东, is also tapping the market of traditional retailing. It announced plans to open 1 million convenience stores in five years, half of which will be located in rural China. JD.com will focus on decoration and inventory supply while Alibaba aims to concentrate more on data⁴¹. In the financial sector, Alipay launched Yue Bao, which offers interest rates two to four percentage

40. *China's digital economy*, op.cit. McKinsey 2017, p. 6.
41. Wang Qionghui & Coco Feng, « Alibaba wants to bring data to 1 million Mom-and-Pop stores », *Caixin*, August 29, 2017.

points higher for depositors, than the low or negative rates they had to accept from public banks. Yue Bao is now the world's biggest management fund, with \$ 250 billion of assets. Alipay also diversified in entertainment and other sectors (Following Figure) and has now 90 functions. Alibaba decided to invest \$ US 15 billion in the three years from 2018 to 2020 in A.I applications, and to hire hundred of scientists across the tech nexus of the US, China and Israel. Its labs will especially focus on data intelligence, internet of things, quantum computing and human-machine interaction⁴².



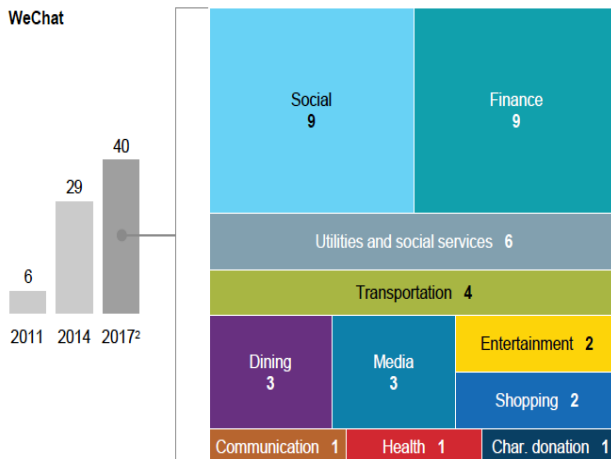
Source: MacKinsey 2017, *China's digital economy*, op.cit.

Tencent main business is social media, services such as WeChat (Weixin 微信), a messaging application which has more than 900 million active users in 2017. Tencent later diversified in payments (Tenpay), online banking (Webank), entertainment (videos) and on demand dining services (Meituan-Dianping). WeChat has now more than 40 functions⁴³. Alibaba and Tencent in collaboration with venture capital firms from Silicon Valley are now investing in more efficient diagnostic tools, helping for instance eye doctors to screen patients for diabetics retinopathy, the leading cause of blindness among China's working-age population⁴⁴.

42. Louise Lucas, *Financial Times*, October 11, 2017.
43. https://transact.ft.com/en-gb/?play=china-tech-titans&utm_source=FT&utm_medium=Email
44. Sui-Lee Wee and Paul Mozur, « Amazon wants to disrupt health care in America. In China, Tech giants already have », *New York Times*, January 31, 2018.

Chinese players have developed super apps that offer a one-stop solution to consumers

Number of features by key application categories¹



Source: MacKinsey 2017, *China's digital economy*, op.cit.

Finally Baidu started with its search engine, which today accounts for 80 percent of the market share, and later diversified on mobile services with 660 million users in mobile search, and on O2O (online to offline) services such as food delivery, group buying, and financial products. With the strong support of the National Development and Research Commission, Baidu launched with partners Tsinghua, Beida, and Beihang, a National Engineering Laboratory, an open Platform on A.I which is focusing on machine-learning based visual recognition, voice recognition, new types of machine Learning interaction, and Deep Learning. It is helping more Chinese researchers, companies and universities to access the most Advanced AI technologies in China. Baidu's Artificial Intelligence Group (AIG) now focus on deep learning's commercial applications in diverse sectors, an Amazon Alexa-style chatbot, DuerOS, and the driverless vehicles with its Apollo project, described as a « complete and reliable software Platform » designed to help partners from the automotive and autonomous driving industry by supplying them with data »⁴⁵. Baidu Brain is developing a platform for third-party AI applications. Partnership has already developed with Chinese car makers BYD, Chery and BAIC, and with Bosch, the world's biggest automotive supplier. If successful, Baidu could be with Apollo, the

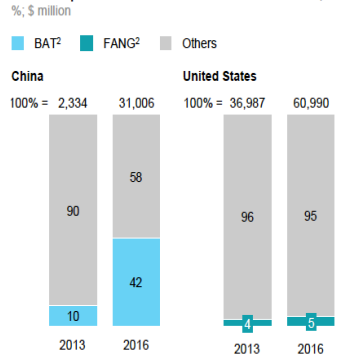
45. *South China Morning Post*, February 24, 2017; MacKinsey 2017, *China's digital economy*, op.cit. p.9-10.

automotive equivalent of Google's Android software for Smartphones⁴⁶. Baidu also develops collaboration with aviation services, by testing its facial recognition system in Beijing's Capital International Airport. Thus China's tech giants are increasingly blurring the boundaries between sectors⁴⁷.

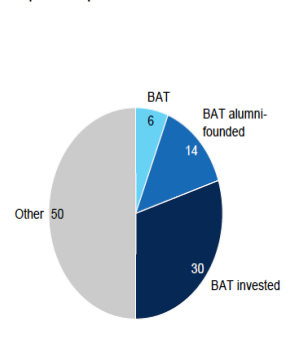
Alibaba Tencent, and Baidu are financed in the US and Hongkong stockmarkets, but they also plan to move to China. With capitalizations as high as \$ US 400 billion each, they take shares or control about half of the leading start ups (Following Figure).

China's Internet giants are providing funding and talent to the broader digital economy

Venture capital investment from China vs. United States, 2016¹



Top 50 startups in China³



1 Includes completed domestic venture capital investment deals only.
 2 BAT = Baidu, Alibaba, and Tencent. FANG = Facebook, Amazon, Netflix, and Google.
 3 According to CrunchBase, which ranks global startups based on number of connections within the platform, community engagement, funding events, news articles, and acquisitions.

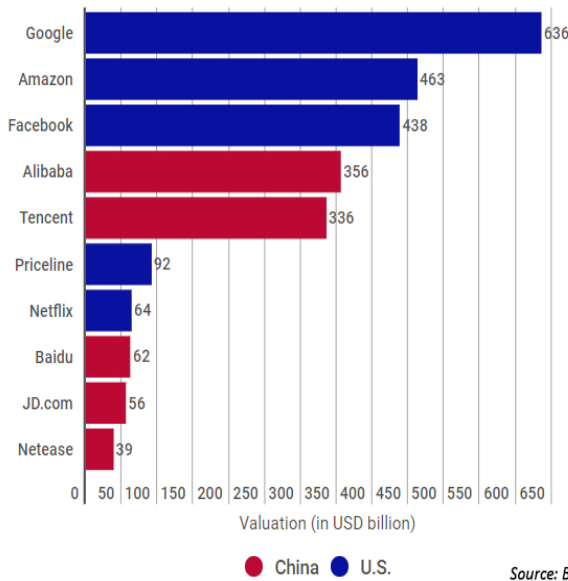
Source: MacKinsey 2017, *China's digital economy*, op.cit.

A recent report (in Chinese) by the Boston Consulting Group together with the research division of Alibaba, Baidu and Didi underlines the speediness of the internet economy's rise in China, which is a comparative advantage on the U.S. China now equals the US for the number of top ten internet companies by market capitalization:

46. *The rise of the machines, How Chinese executives think about developments in Artificial Intelligence ?*, McKinsey, December 2016, p.1 ; Emilie Feng and Patrick Mc Gee, « Baidu forges alliances with German auto suppliers » *Financial Times*, June 1, 2017. Yuan Yang and Yigzhi Yang, « Baidu bets its future on AI revolution », *Financial Times*, August 30, 2017. <https://www.bloomberg.com/profiles/companies/BIDU:US-baidu-inc>

47. Technode, October 2, 2017 <http://technode.com/2017/10/02/chinas-tech-giants-are-increasingly-blurring-the-boundaries-between-sectors-mckinsey-report/>

The top 10 internet companies in the world by market capitalization



Source: BCG. Image credit: TechNode.com

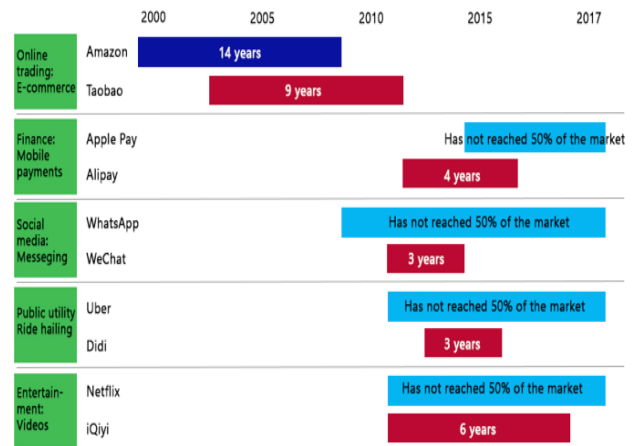
Chinese unicorns, (defined as start-up which reach US\$ 1 billion market value, by public or private investment) take 4 years on average to reach this status, while American unicorns take 7 years. The US has 112 unicorns while China has 63. But as Chinese unicorns grow in number and market capitalization, their market capitalization could soon overtake their U.S counterparts. Three of the world's top five unicorns are chinese (Following figure).



Source: CB Insights © FT

Finally, the Chinese internet is more concentrated than the US, in a few companies that have reached over 50 percent market penetration, much more rapidly than their US counterparts⁴⁸. And apart from central government support, Chinese municipalities have announced local plans to help AI development such as a \$ 2.1 billion AI tech park in Beijing and a \$ 16 billion AI fund in Tianjin⁴⁹.

The time taken to reach over 50% market penetration by U.S. and Chinese internet companies



Source: BCG. Image credit: TechNode.com

From fast follower to future challenger?

As much of China's internet sector is off-limit to foreign tech giants, such as Google, Facebook and Amazon, Chinese tech companies have exclusive access to Chinese internet users' data, they can consolidate without competition from outside. Apart from their comparative advantage in data and in computing power, they have an easy access to algorithms. Much of AI research is available

48. <https://www.bcg.com/zh-cn/d/press/13sep2017-china-internet-170385>

<http://technode.com/2017/09/18/fast-and-furious-chinese-unicorns-to-overtake-american-counterparts-says-bcg-report/>

49. Aaron Tan, « China to open \$2.1bn AI tech park in Beijing », *Computer Weekly*, 09 January 2018

<https://www.computerweekly.com/news/450432800/China-to-open-21bn-AI-tech-park-in-Beijing>

Reuters: China's city of Tianjin to set up \$16 billion artificial intelligence fund: <https://www.reuters.com/article/us-china-ai-tianjin/chinas-city-of-tianjin-to-set-up-16-billion-artificial-intelligence-fund-idUSKCN1I10DD>

with open-source softwares, as the basic techniques of machine-learning – algorithms that becomes smarter as they are trained on a massive amount of data- are now well-known. It makes it easier for China to position itself as a « fast follower »⁵⁰. All the conditions, dataset collection, computing power, and mass collaboration on open source platforms which propel Deep Learning and other techniques are now converging to enhance the rise of A.I (Following Figure).

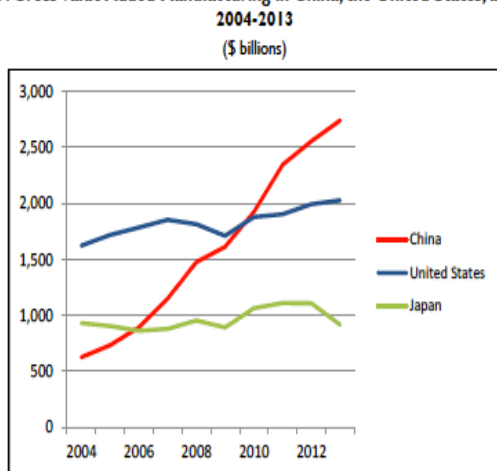
The recent great progress in core computing technology, algorithm, dataset, and application drive AI towards its tipping point

	Growth Drivers	Take-away	Current Status	Future Outlook
Technology Drivers	1	Core computing technology	Major GPU producers and leading players heavily invest in AI-specific and ready-to-use computing devices and solutions	2014: Double precision ~1864 ¹ GFLOP/s ² 2017: Double precision ~7000 ¹ GFLOP/s
	2	Programming platform & Algorithm	Mass collaborations on open source platforms largely propel deep learning and other techniques	2016: 98% ⁸ accuracy rate in voice recognition 2020: over 99%
	3	Dataset collection	An explosive amount of machine/human-generated, unstructured data is available for AI applications	2013: Over 4 ZB/year of digital data generated ⁴ 2020: 44 ZB/year of digital data generated ⁴
Adoption Drivers	4	Application and use cases	Tech giants and venture capitals are hyped up for startups of AI applications across functions and industries	2015: AI application market size of \$8B ⁵ 2020: AI application market size of \$20B ⁵

Source: *The Rise of the machines: How Chinese executives think about the developments in Artificial Intelligence*, McKinsey & Co. December 2016, P.4.

Another comparative advantage of China in this regard, is its position as the world leader in terms of industrial value-added, since 2010, when it bypassed the U.S. (Following Figure).

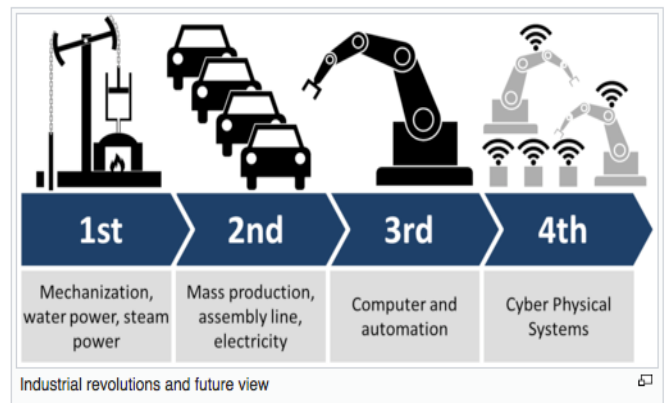
Figure 7. Gross Value Added Manufacturing in China, the United States, and Japan: 2004-2013



Source: United Nations, UNdata.

50. Richard Waters, « China ready to cash in on rise of machine Learning » *Financial Times*, June 1, 2017.

Artificial intelligence is actually at the core of the fourth industrial revolution, or « Industry 4.0 », originating from a project in the high tech strategy of the German government, which promotes the computerization of Manufacturing. The first, second and third industrial revolutions resulted from the development of mechanical production driven by water and steam power, the adoption of assembly lines for mass production driven by electricity and a move toward automation through the utilisation of electronics and information technology (I.T) respectively. The emerging fourth revolution encompass increasing digitisation of manufacturing with cyber-physical systems of production, in which big data and cloud computing enable information to be shared and analysed along entire industrial value chains, as connected networks of humans and robots interact and work together⁵¹. (Following Figure)



Source : Wikipedia, Industry 04.

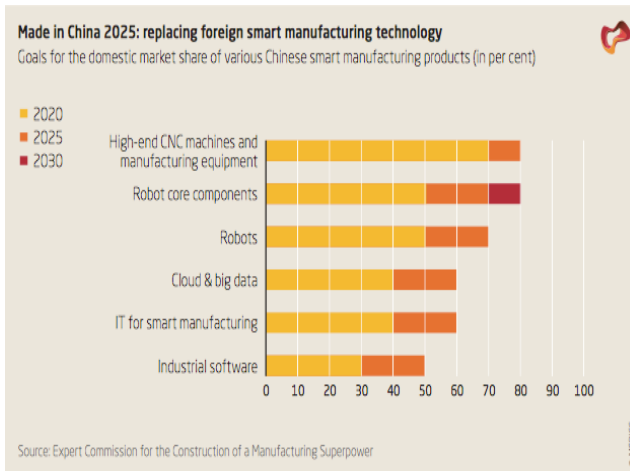
The first and second priorities of the Made in China 2025 Plan, launched in May 2015, are the Next Generation Information Technology and High-end Numerical Control Machinery and Robotics. They are basically completed by The Internet Plus Action Plan, adopted in the same time, which aims, according to Premier Li Keqiang to « integrate mobile Internet, cloud computing, big data and the Internet of Things with modern manufacturing »⁵².

51. *China Manufacturing 2025*, European Chamber of Commerce in China, p.6.

<http://www.europeanchamber.com.cn/en/china-manufacturing-2025>

52. *China Manufacturing 2025*, European Chamber of Commerce, op.cit., p.10.

The Technical Area Road Map of Made in China 2025 fixes goals to reach advanced international level in these two top priorities by selecting sectors such as integrated circuits (IC) and specialized equipment, information and telecommunication equipment, wireless mobile communication, next generation internet and high performance computers and servers, where (except for integrated circuits), the domestic market share is supposed to reach 50 to 80 percent in 2030 (Following Figure⁵³) and the international market share is supposed to raise dramatically.



All this means that China carries on its import substitution and export promotion policy defined in the 2006 Medium to Long-Term Plan for the Development of Science and Technology, and refined in all the following plans.

This a question of concern for China’s economic partners since there is a growing asymmetry between China’s more and more restrictive market access, and the conditions of market access fixed by them. For instance, the Cybersecurity Law, which is applied since June 2017, in the name of « building secure and controllable information technology systems », requires operators of critical infrastructure, without defining them clearly, to undergo a security review. It seems that IT producers will have to submit information on their products’ design and source code to

53. Jost Wubekke & al., Made in China 2025, The making of a high-tech superpower and consequences for industrialized countries, MERICS Papers on China n°2, Dec. 2016: https://www.merics.org/fileadmin/user_upload/downloads/MPOC/MPOC_Made_in_China_2025/MPOC_No.2_MadeinChina_2025.pdf

government affiliated review organisations, and that cloud service operators will have to locate their services facilities and network data within Chinese territory. If cloud computing is « the delivery of on-demand computing resources –everything from applications to data centers- over the internet on a pay-for-use basis », foreign companies are able to use this capacity only if they are fully confident that their cloud service provider is able to protect their proprietary data at all times, which may not be the case following the new official regulation⁵⁴. China for instance is notoriously secretive concerning government data, as it ranks 93rd for data openness (Following Figure). The next generation AI development plan, published by the State Council in July 2017 allows to revise the policies of data protection by launching pilot projects to open government data, to mine its commercial value with the collaboration of the public and private sector, and promote the innovation of AI applications.

China ranks 93rd globally for the openness of government data

	Global ranking for data openness, 2015 ¹	
	United States	China
Weather forecasts	13	80
Water quality	15	74
National statistics	1	106
Government spending	8	82
Government procurement	1	36
Location (postcodes)	49	61
National maps	1	88
Legislation	1	39
Land ownership	66	85
Pollutant emissions	1	30
Election results	83	87
Company register	33	71
Government budget	1	49
Overall	8	93

Source : McKinsey Global Institute, *Artificial Intelligence, Implications for China*, 2017.

As all aspects of the AI value chain, from fundamental research and applications development to hardware manufacturing involve global collaboration⁵⁵, China’s AI strategy is progressive but resolute for three main reasons.

54. *Made in China 2025*, European Chamber of Commerce in China, *op.cit.* p. 23-25

55. Dominique Barton & al. *Artificial Intelligence : Implications for China*, McKinsey Global Institute, April 2017, p.8.

First of all, beyond the available pool of talent within China, an estimated 43 percent of the world's trained AI scientists, China is trying to overcome its main weakness in fundamental research by recruiting massively in the U.S and elsewhere. Baidu, Tencent Alibaba and a pleiad of Chinese based startups, such as the one directed by Kai-Fu Lee, a former senior executive for Google and Microsoft in China who has more than 50 million followers on the Chinese microblogging Platform Sina Weibo, have been looking for the best AI experts in the Silicon Valley and the Boston area, mostly Chinese scientists who work in the US⁵⁶.

Secondly, if AI is the key to future growth, by enhancing the productivity of inefficient industries and services and helping to create new businesses that leverage the technology, as underlined by Will Knight (article cited, note 57), it may also be disruptive in terms of regulations and employment. The next generation AI development plan aims to adapt the framework of laws, regulations and ethic, and the training of reemployment workers who may loose jobs because of AI.

Thirdly, the race towards preeminence in A.I, has considerable geopolitical consequences, since it is a dual use technology with both military and civilian implications⁵⁷. As most of the research and advances are made by private companies, the Chinese leadership has created in 2017 a Central Commission for Integrated Military and Civilian Development, directed by the President Xi Jinping in order to ensure that all the advances in cloud computing, big data, internet of things and artificial intelligence meet defense requirements⁵⁸. The defense objective (国家安全), as well as the recruitment of talents as a top

priority, are clearly precised in The next generation AI development plan published by the State Council⁵⁹.

The PLA seeks to capitalize on the transformation of today's informatized (信息化) ways of warfare into future « inteligen-tized » (智能化) warfare. Lieutenant General Liu Guozhi, director of the Central Military Commission's Science and Technology Commission plan to integrate civil and military advances in A.I with an approach of « shared construction, shared enjoyment, and shared use » (共建 共享 共用)⁶⁰. The PLA bets on the asymmetric tactic of drone swarms, first implemented by the US in 2013, a light attack force inspired by Attila and the Huns, to defeat more powerful and sophisticated opponents with their sheer numbers⁶¹. Swarm intelligence is present in the next generation AI development plan.

The US have developed autonomous weapons systems, but the lethal autonomous weapons (LAWS) or « killer robots » raise a lot of questions. The founders of 116 robotics and artificial intelligence companies have called for their ban in an open letter, following the postponement of UN talks on regulating killer robots. They estimate that LAWS would permit « armed conflict to be fought on a scale greater than ever, and a timescale faster than humans can comprehend »... « If LAWS become part of a military industrial complex they will end up being used against civilians »⁶². The robots created by Boston Dynamics, could be equipped with lethal weapons.... (Following video) : https://www.youtube.com/watch?time_continue=81&v=M8YjvHYbZ9w

For the astrophysicist Stephen Hawking, « we spend a great deal of time studying history, which - let's face it- is mostly the history of stupidity. So it's a welcome change

56. Elsa Kania, « Beyond The Committee on Foreign Investment in the Unites States (CFIUS) : The strategic challenge of China's rise in artificial intelligence », Yale Law School, Paul Tsai China Center, June 20, 2017 <https://lawfareblog.com/beyond-cfius-strategic-challenge-chinas-rise-artificial-intelligence>; Will Knight, « China's AI Awakening », MIT Technology Review, October 10, 2017: <https://www.technologyreview.com/s/609038/chinas-ai-awakening/>

57. Helène Lavoix , « When artificial intelligence will power geopolitics, Presenting AI », *The Red Team Society*, Nov 29, 2017; <https://www.redanalysis.org/2017/11/27/artificial-intelligence-will-power-geopolitics-presenting-ai-open-access/>

58. Xinhua, Beijing, Sept 22.

59. In chinese: http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm?from=timeline&isappinstalled=0 in english: <https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/>

60. Elsa Kania, article cited.

61. Emilie Feng & al. « Drone swarms vs conventionnal arms: China's military debate » *Financial Times*, August 24, 2017. <https://www.ft.com/content/302fc14a-66ef-11e7-8526-7b38dcaef614>

62. Jamie Smyth, *Financial Times*, August 21, 2017.

that people are studying the future of intelligence ». But in the same time the creation of AI will be « either the best or the worst thing, ever to happen to humanity ». A few forums of discussion and research have been created on the potential and risks of AI. The Leverhulme Centre for the Future of Intelligence (LCFI), an international multi-disciplinary institute at Cambridge University⁶³, and the United Nations Interregional Crime and Justice Research Institute are deepening the reflexion, in collaboration with world scientists⁶⁴. For the first time in November 2017, the group of governmental experts on the lethal autonomous weapons (LAWS) met in Geneva, at the invitation of UNODA (United Nations Office for Disarmament Affairs) and realised a multidisciplinary report which may set the base for international regulations⁶⁵.

But the US-China race goes on, as AI will not only be decisive in military capacities but also for future economic competitiveness. In June 2017, the US government commissioned six companies including IBM, Intel and Hewlett Packard Enterprise to come up with countermeasures against China's lead on high performance computer, which has reached an « inflection point », according to Horst Simon, the deputy director of Lawrence Berkeley National Laboratory in California. A US exascale computer is expected by 2021⁶⁶.

Two factors may explain the US sense of urgency, apart from China's advances in AI, high performance computing and quantum computing. As innovation is largely driven by consumers preferences⁶⁷, China, as the most massively connected country in the world, with practically 300 million digital natives, is

a huge experimental lab for AI applications. Developments are very quick in China, and much slower, as we have seen, in the U.S. Secondly, the close military-civil integration in China as regard to AI comes at a time when ties between the US military, university research and companies become strained and tech group are becoming ambivalent about working with the military⁶⁸. US-China's competition in the field of AI extends far beyond the traditional control of technology transfers made by the Committee of Foreign Investment in the US (CFIUS)⁶⁹ as they are numerous collaborations between the US and the Chinese tech eco-systems, which imply flows of scientists and company executives.

Secondly, as access to the Chinese market is more and more conditioned by technology transfers, some companies may be more and more involved in China's high tech import substitution strategy. Qualcomm, the world's dominant mobile chip maker, which was making more than half of its global profits in China, has been fined for anticompetitive behavior (\$ 975 million in 2015 or 8 percent of its annual revenue in China), and had to lower its prices and shift more of its high-end manufacturing from Taiwan and South Korean contractors to partners in the country. It is led to compete with Intel by developing leading edge microchips, to help Chinese start-ups, to collaborate with Chinese companies to develop drones, virtual reality goggles, internet-connected devices, supercomputers, and mass-market smartphone chips⁷⁰.

Conclusion: From chimerica's coopetition to concerns about AI use & abuse

The mix of cooperation and competition (coopetition) between the two AI giants, will certainly evolve with the development of quantum computing, another new frontier. If the new computers that harness quantum effects will not only be much faster, but also

63. *The Guardian*, 19 October 2016 ; <http://www.cam.ac.uk/research/news/the-future-of-intelligence-cambridge-university-launches-new-centre-to-study-ai-and-the-future-of>

64. UNICRI, The risks and benefits of Artificial Intelligence and Robotics, A workshop for media and security professionals, Cambridge, February 6-7, 2017: http://unicri.it/in_focus/files/Report_UNICRI_Cambridge_Workshop_Feb_2017.pdf

65. UNODA, Geneva, Perspectives on Lethal Autonomous Weapons Systems, November 2017; <https://www.un.org/disarmament/publications/occasionalpapers/unoda-occasional-papers-no-30-november-2017/>

66. *South China Morning Post*, Hongkong, 23 August 2017.

67. *China Manufacturing 2025*, European Chamber of Commerce, *op.cit.* p.22.

68. Henny Sender, « Advanced tech outfits give Chinese military the cutting edge », *Financial Times*, August 8, 2017.

69. Elsa Kania, *art.cit.* June 20, 2017.

70. David Barboza, « How this US tech giant is backing China's tech ambitions », *The New York Times*, August 4, 2017.

more sophisticated, able to design molecules to create new drugs or breakthrough materials⁷¹, we may expect unintended applications in the civil as well as defense sector, which underlines the urgency of a global reflexion and regulation of these new developments, certainly disruptive for the economy, and maybe constructive or destructive for humanity⁷².

Let us focus on the present. China for example, had 176 million surveillance cameras in operation in 2016, a \$ 6.4 billion market for that year, and is expected to see that figure more than triple to reach 626 million by 2020. Various stories have emerged on China's efforts to increase surveillance of its people with the added capabilities of AI facial and gait recognition. Beijing announced in October 2015 that it now had 100 percent coverage⁷³. Brain Reading technology, to detect changes in emotional states in employees on the production line, the military and at the helm of high speed trains, has been applied by China on an unprecedented scale⁷⁴.

The famous « social credit system », first launched in digital finance as a tool of trustworthiness and creditworthiness in the marketplace, has an important role in transforming the overall governance strategies and tactics of the CCP⁷⁵. The goal is to establish

by 2020 « a cybernetic mechanism of behavioural control, where individuals and organizations are monitored in order to automatically confront them with the consequences of their actions ». The « uniform social credit code » (统一社会信用代码), a 18-digit code, enables government to increasingly connect incoming data point to individual and businesses. Private social credit systems coexist with the public one, such as the Sesame Credit developed by Ant Financial Group, an affiliate of Alibaba⁷⁶.

A study based on a dataset of 13.2 billion blog posts published on Sina Weibo, the most prominent Chinese microblog platform over the period 2009-2013, has shown that the use of social media for surveillance and propaganda, is likely to improve regime stability and power. Strict censorship would diminish the value of social media, as there is a trade-off between political control and economic benefit⁷⁷.

As we are entering a world that will be increasingly organized through the interplay of algorithms and data, a « data-based economy and society where observation and interpretation of our individual behavior and optimization of our physical systems will be based on computation »⁷⁸, access and manipulation of data become a key issue⁷⁹.

In the Chinese case, there is the conviction that « digitalization has brought the Chinese people the historic opportunity of a millennium », or an « extremely rare opportunity » to cite Xi Jinping⁸⁰. There is a strong alliance

<https://journals.openedition.org/chinaperspectives/7454>

76. Creemers, Rogier, « China's Social Credit System: An Evolving Practice of Control » https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3175792

77. Qin Bei, Strömberg, David, Wu Yanhui, « E-autocracy: surveillance and propaganda in Chinese social media », Vox, CEPR Policy Portal, 25 May 2018: <https://voxeu.org/article/e-autocracy-surveillance-and-propaganda-chinese-social-media>

78. Zysman, John, and Kenney, Martin, « The next phase in the digital revolution: intelligent tools, platforms, growth, employment », *Communications of the ACM*, Vol. 61, n°2, p.54-63: <https://cacm.acm.org/magazines/2018/2/224635-the-next-phase-in-the-digital-revolution/fulltext>

79. Shaw, Tamsin, « The new military-industrial complex of Big Data psy-ops », *The New York Review of Books*, March 21, 2018: <https://www.nybooks.com/daily/2018/03/21/the-digital-military-industrial-complex/>

80. Bandurski, David, « The revolution China intends to lead » *China Media Project*, May 8, 2018: <http://chiname->

71. Richard Waters, « Quantum computing rivals muster software power in new 'arms race' », *Financial Times*, October 2, 2017 ; Morgan Stanley Research, Oct. 4, 2017 : « A quantum leap toward a computing revolution », <http://www.morganstanley.com/ideas/quantum-computing>

72. John Thornhill, « AI's rapid advance sparks call for a code for robots », *Financial Times*, August 31, 2017; Anjana Ahuja, « Robot behaviour is creeping beyond our control », *Financial Times*, August 2, 2017; W. Brian Arthur, « Where is technology taking the economy », *Mc Kinsey Quarterly*, October 2017.

73. Technode, November 22, 2017; <http://technode.com/2017/11/22/china-to-have-626-million-surveillance-cameras-within-3-years/> ; Reuters, 12 Nov 2017 « Backing Big Brother : Investors are pouring into Chinese facial recognition firms » : <https://www.reuters.com/article/us-china-facialrecognition-analysis/backing-big-brother-chinese-facial-recognition-firms-appeal-to-funds-idUS-KBN1DD00A>

74. Stephen Chen, « Forget the Facebook leak : China is mining data directly from workers' brains on an industrial scale », *South China Morning Post*, Hongkong, 2 May 2018: <http://www.scmp.com/news/china/society/article/2143899/forget-facebook-leak-china-mining-data-directly-workers-brains>

75. Loubere, Nicholas, « China's Internet Finance Boom and Tyrannies of Inclusion », *China Perspectives*, 2017/4.

of interests between the BAT's billionaires, who accumulate most of the data and the state-party system, which has favoured their expansion through protectionist policies founded on the principle of digital sovereignty⁸¹. It remains to be seen if Big Data will lead to Big Brother, or a new, softer version of e-autocracy. And the future of A.I., will not be only determined by the race for data but also by the competition for talents, where the attractiveness of China is uncertain.

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