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China Today

8th China-Brazil Innovation Seminar

Directions of the Chinese Economy Today

Myths and Realities: Chinese Science, Technology and Innovation

School of Public Policy & Management

China Insititute for Science and Technology Policy

Tsinghua University

Prof. LIANG Zheng

September, 2022

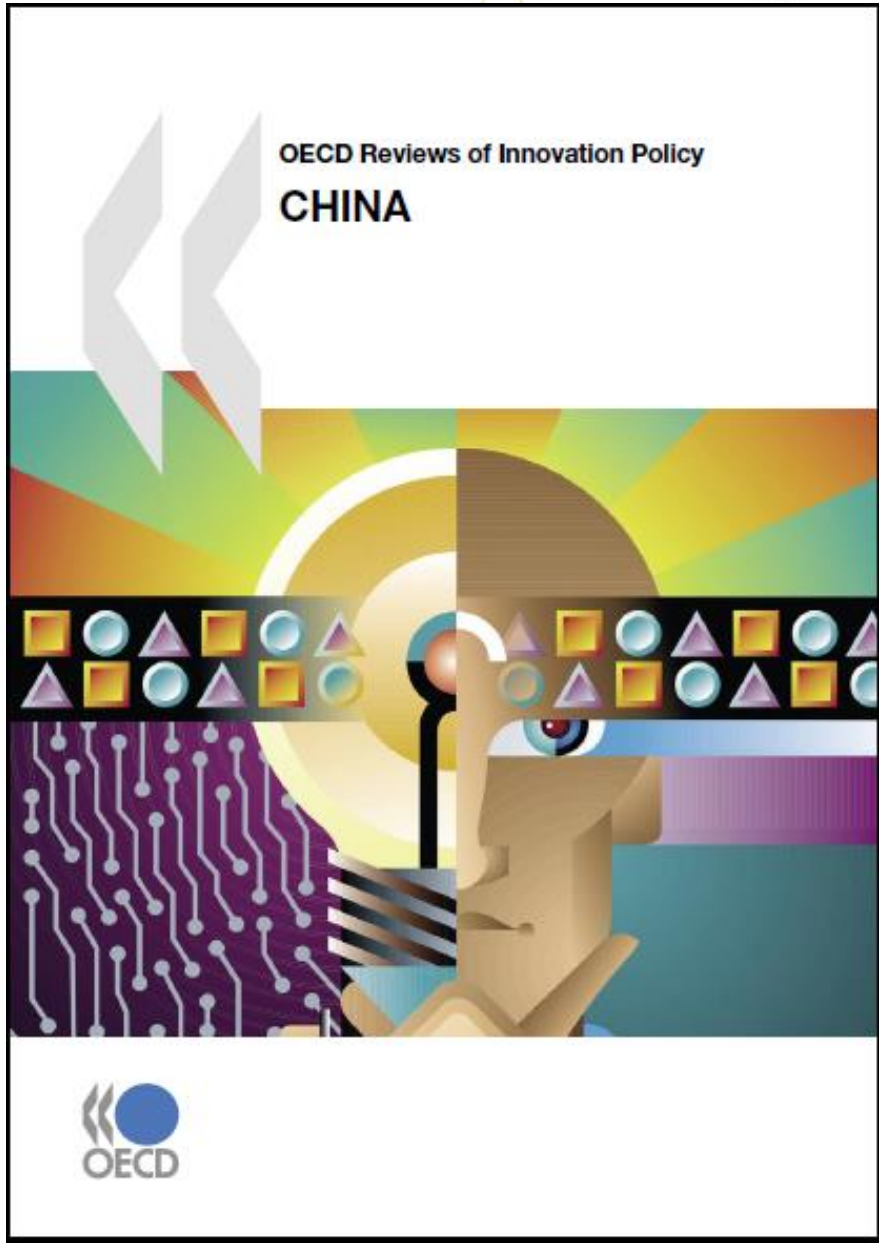
Introduction

China Institute for Science and Technology Policy at Tsinghua University (CISTP) was jointly founded by the Ministry of Science and Technology and Tsinghua University in 2003. It aspires to become a leading institution in S&T policy and development strategy through its research and educational activities.

Specifically, It will:

- Monitor the S&T development trends and international S&T policy changes;
- Engage in academic research in S&T policy
- Provide graduate educaiton and short-term training in S&T policy
- Facilitate international cooperation and communication between domestic and international S&T policy community.
- Provide consulting service to the government and industry in relevant areas

http://cistp.sppm.tsinghua.edu.cn



Foreword

This review of China's innovation policy is part of a series of OECD country reviews.* The review was requested by the Chinese authorities, represented by the Ministry of Science and Technology (MOST), and was carried out as a joint project between the OECD Directorate for Science, Technology and Industry (DSTI) and MOST, under the auspices of the OECD Committee for Scientific and Technological Policy (CSTP).

The review process was led by Jean Guinet (Head, Country Review Unit, DSTI, OECD), assisted by Gang Zhang and Gernot Hutschenreiter (both Senior Economists, DSTI, OECD) on the OECD side, and by Jing Su (Director, Policy Division, MOST), and Jianing Cai (Director, Multilateral Co-operation Division, MOST) on behalf of MOST. The China Institute for S&T Policy (CISTP) at Tsinghua University, entrusted by MOST and led by Prof. Lan Xue and Dr. Zheng Liang, provided overall organisational support and research co-ordination for the project on the China side.

The review draws on the analytical work of a number of experts from China, the OECD Secretariat and OECD countries (see the general acknowledgements as well as specific references in individual chapters) and on the results of a series of interviews with major stakeholders in China's innovation system. The synthesis report was drafted by Jean Guinet, Gernot Hutschenreiter and Gang Zhang. Gang Zhang also co-ordinated the preparation and served as editor of this volume, with contributions from and under the supervision of Jean Guinet.

* *See www.oecd.org/sti/innovation/reviews*

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Introduction

- **Dr. LIANG Zheng** now serves as the Professor of the School of Public Policy and Management, Tsinghua University, as well as the research fellow and deputy director of China Institute for Science &Technology Policy at Tsinghua University (CISTP), the research fellow and vice president of Institute for AI International Governance, Tsinghua University (AIIG).
- Dr. Liang got his doctor's degree of economics at Nankai University (2003) and accomplished the senior executive training program on leadership at Kennedy School of Government, Harvard University (2010). He had visited at MIT Industrial Performance Center (MIT IPC) as the Fulbright Visiting Research Scholar for one year (2012).
- The main areas of his research now focus on Science, Technology and Innovation Policy, Globalization of R&D, IPRs and Standardization, Emerging Technology and Innovation Governance etc. Besides academic publishing on peer review journals such as *National Science Review, Journal of Informetrics, World Economy* etc. Dr. Liang also participated in some important research projects such as the Strategic Research for National Medium and Long Term Science and Technology Development Program (MLP) of China. He used to be the member of National Innovation Survey Expert Group (2014-2017), as well as the member of Sino-US Innovation Dialogue Expert Group (2015-2018).

I. BACKGROUND

- In the last few years, there are increasing evidences that China has been making progress in promoting innovation-driven development. However, what is the real situation of Chinese science, technology and innovation? What are the driving forces behind and what are the challenges China faced? What are the future prospects?
- This presentation will try to draw a comprehensive map of Chinese science, technology and innovation development, from both positive and negative sides, mainly based on the universally accepted statistics, as well as the cases of Chinese companies such as Huawei and DJI.

II. STATUS AND PROBLEMS

Global Innovation Index 2021 rankings

GII rank	Economy	Score	Income group rank	Region rank
1	Switzerland	65.5	1	1
2	Sweden	63.1	2	2
3	United States of America	61.3	3	1
4	United Kingdom	59.8	4	3
5	Republic of Korea	59.3	5	1
6	Netherlands	58.6	6	4
7	Finland	58.4	7	5
8	Singapore	57.8	8	2
9	Denmark	57.3	9	6
10	Germany	57.3	10	7
11	France	55.0	11	8
12	China	54.8	1	3
13	Japan	54.5	12	4
14	Hong Kong, China	53.7	13	5
15	Israel	53.4	14	1
16	Canada	53.1	15	2
17	Iceland	51.8	16	9
18	Austria	50.9	17	10
19	Ireland	50.7	18	11
20	Norway	50.4	19	12

Ranking 12 in 2021 GII (WIPO, 2021)

II. STATUS AND PROBLEMS

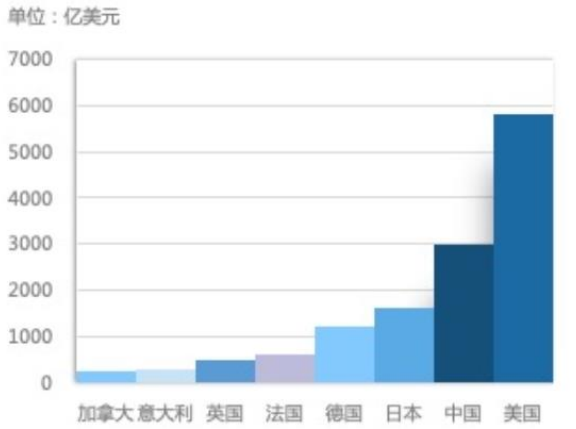
Table 6 Top S&T cluster of each economy or cross-border region, rank among the top 100, 2022

Rank	Cluster name	Economy	Rank change since 2021
1	Tokyo–Yokohama	JP	0
2	Shenzhen–Hong Kong–Guangzhou	CN/HK	0
3	Beijing	CN	0
4	Seoul	KR	0
5	San Jose–San Francisco, CA	US	0
10	Paris	FR	0
19	London	GB	0
23	Cologne	DE	−2
25	Amsterdam–Rotterdam	NL	−2
26	Taipei–Hsinchu	TW*	0
30	Tel Aviv–Jerusalem	IL	−2
31	Moscow	RU	−1
32	Tehran	IR	0
33	Singapore	SG	−2
35	Stockholm	SE	0
36	Eindhoven	NL/BE	−2
39	Melbourne	AU	−2
46	Istanbul	TR	4
47	Brussels	BE	−4
48	Madrid	ES	−1
51	Zürich	CH/DE	1
53	Milan	IT	0
54	Toronto, ON	CA	−5
59	Copenhagen	DK	−4
60	Bengaluru	IN	0
71	São Paulo	BR	0

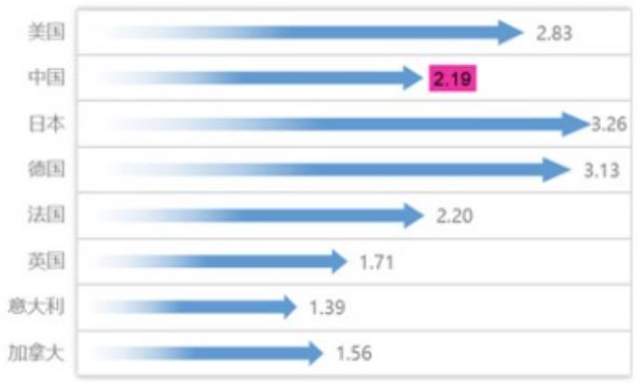
Ⅱ. STATUS AND PROBLEMS

- China's R&D expenses maintain rapid growth, accounting for second place in the world.

(*Report on China R&D Expenditure(2020)*, 2020)



2018年中国与G7国家国内研发经费支出比较



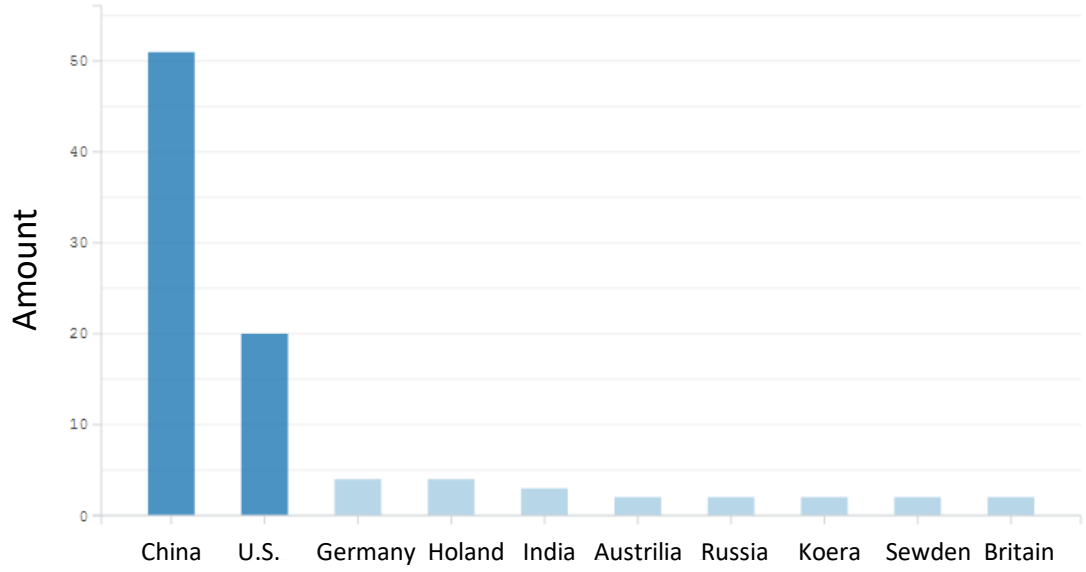
2018年中国与G7国家国内研发强度比较

注：换算根据本国货币按2018年平均汇率计算，而不是PPP。
数据来源： OECD数据库

Ⅱ. STATUS AND PROBLEMS

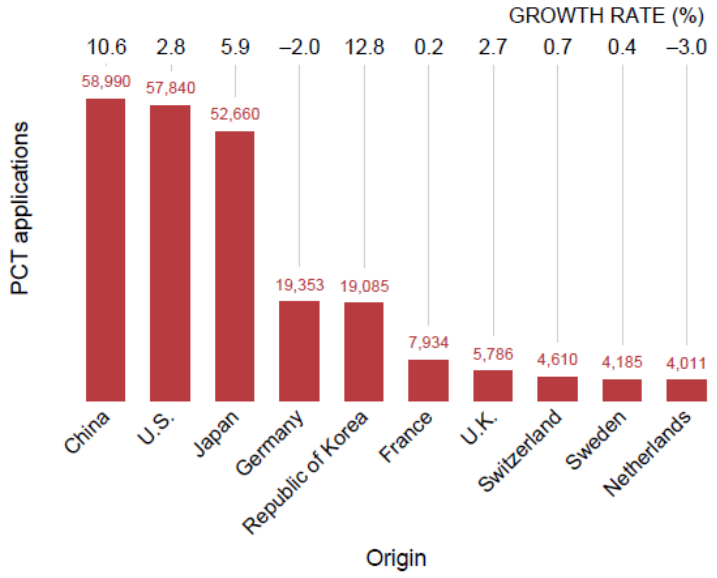
- Ranking 2nd place in the world for scientific papers published and citation rate（*Statistical Data of Chinese S&T Papers*, 2020）
- From 2015 to 2017，half of the top 100 institutes in the world are from China, and there are 9 institutes among the top 10, which highlights the rapid growth of high-quality research in China（*Nature Index 2018 Rising Stars*，2018）

Country	Papers		Times Cited		Average Times Cited	
	Number	Rank	Number	Rank	Number	Rank
America	4205934	1	80453805	1	19.13	6
China	3019068	2	36057149	2	11.94	16
Britain	1068746	4	21240295	3	19.87	4
Germany	1131812	3	20708536	4	18.3	8
France	773555	6	13818958	5	17.86	9
Canada	712343	7	13040162	6	18.31	7
Italy	704225	8	11845007	7	16.82	11
Australia	637463	10	11334092	8	17.78	10
Japan	847352	5	11307529	9	13.34	13
Spanish	610413	11	9933003	10	16.27	12

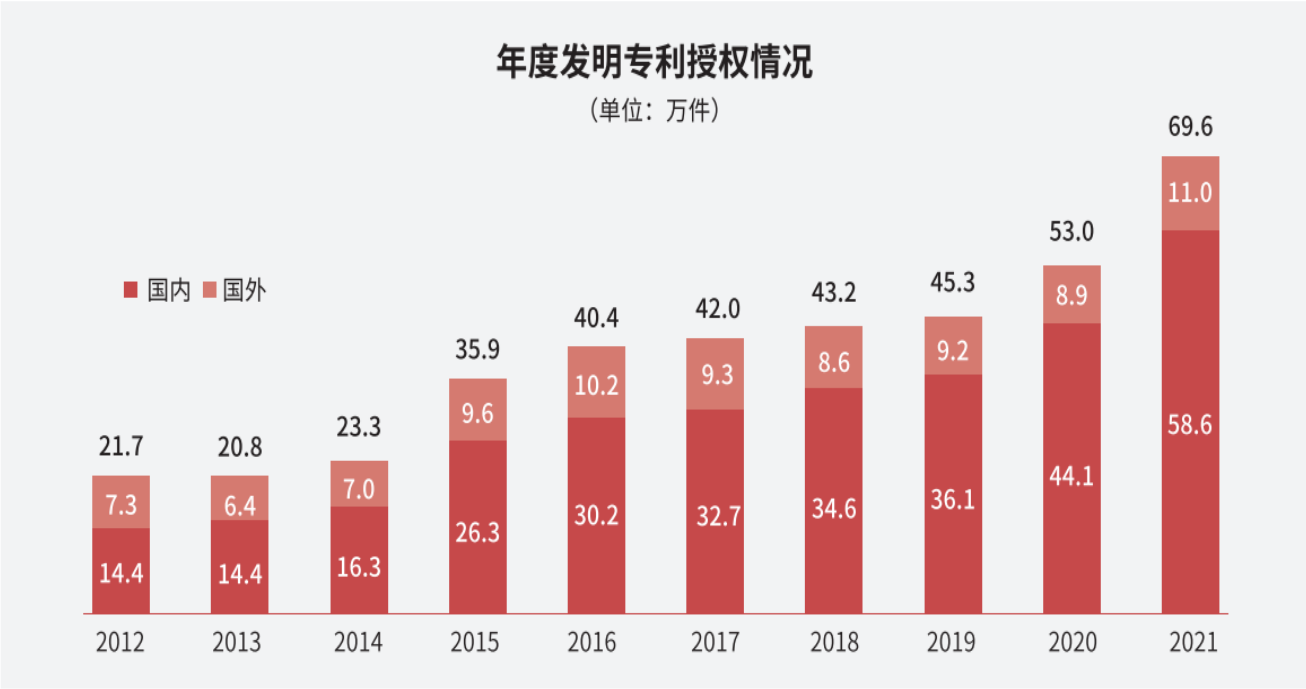


Ⅱ. STATUS AND PROBLEMS

- China is the main driving force for the increase in the number of global patents, ranking first in patent applications granted in 2020.
- Since 2003, the annual growth rate of PCT applications in China has been more than 10%. In 2020, the number of PCT applications in China ranked first in the world (58,990)（*World Intellectual Property Indicators 2020*, WIPO，2020)

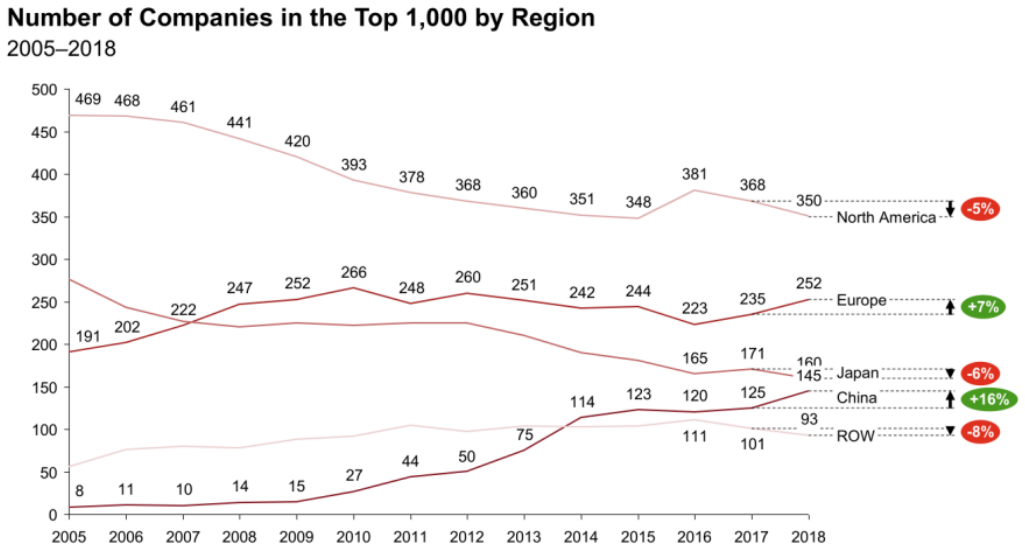


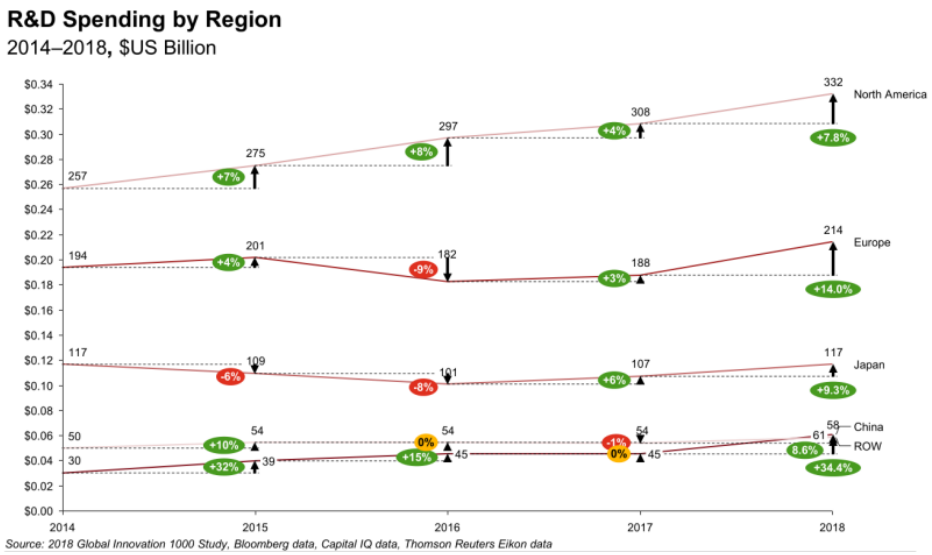
Ⅱ. STATUS AND PROBLEMS



Ⅱ. STATUS AND PROBLEMS

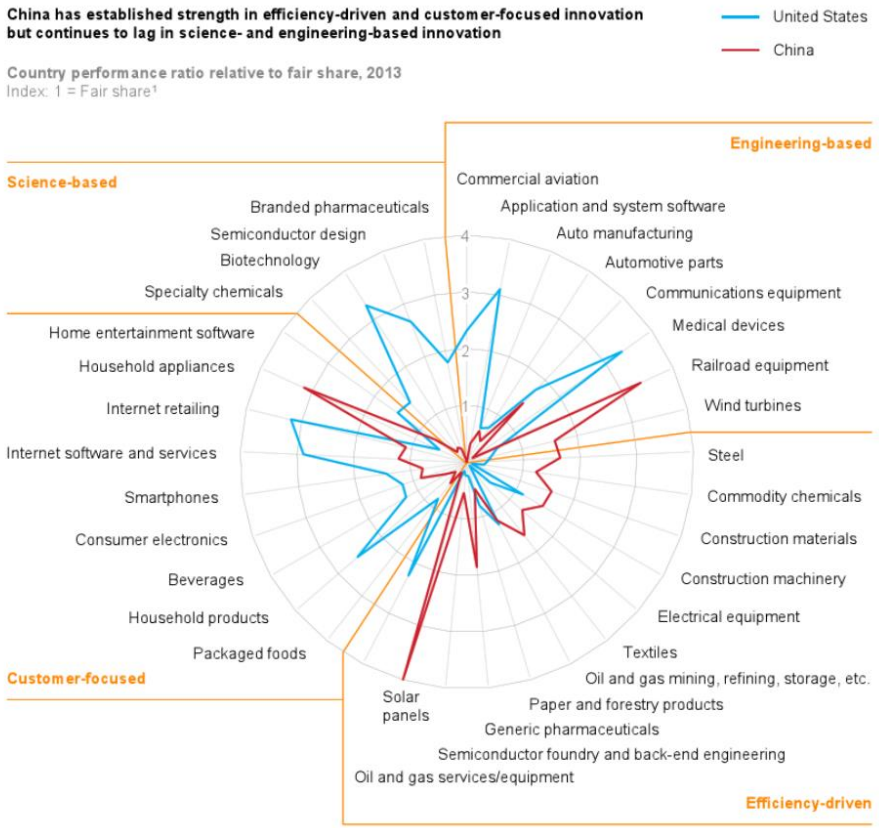
- In 2018, the R&D expenditure of Chinese companies increased by 34.4% to $60.08 billion, leading the global growth rate and the number of selected Chinese companies increased from 125 to 145. （*The Global Innovation 1000*， 2018）





Ⅱ. STATUS AND PROBLEMS

- China has the potential to transform from "learning innovation" to "leading innovation" (*The China Effect on Global Innovation*, 2015)

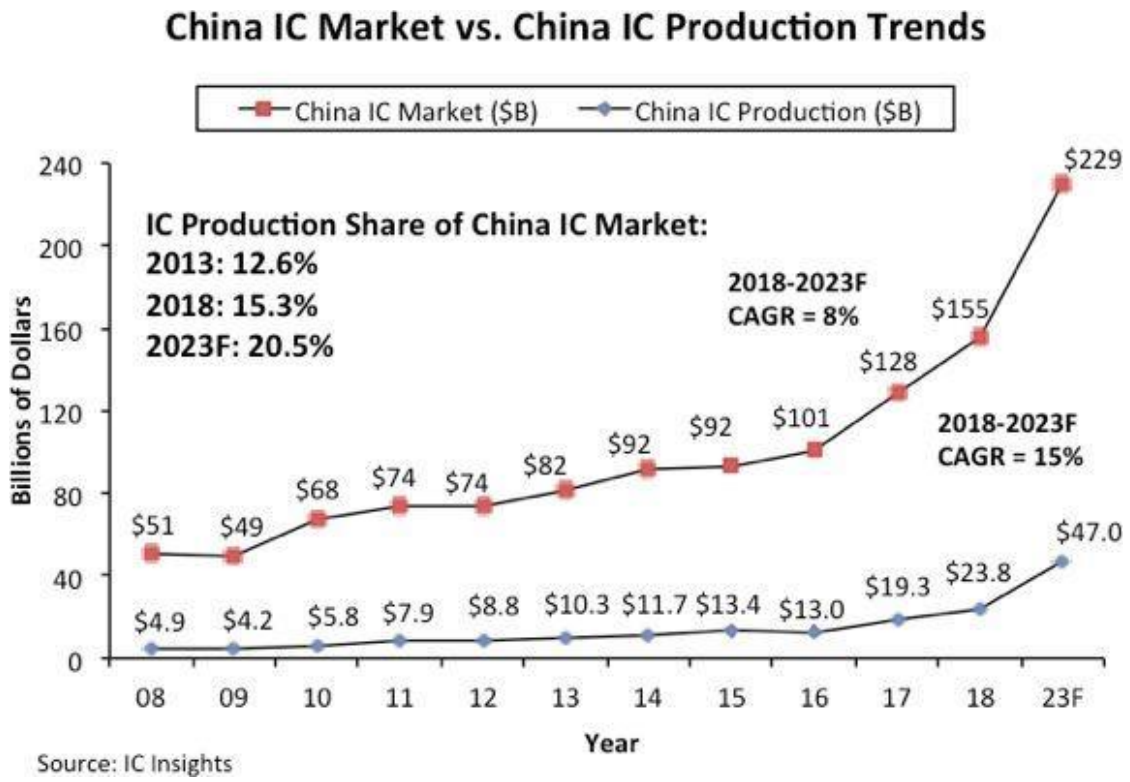


- Since the release of TR50 list, there has been no shortage of Chinese technology companies. From 2011 to 2017, Alibaba, Baidu, Tencent, Huawei, Xiaomi, DJI, iFLYTEK, Didi, and Megvii have appeared on the list. (*MIT Technology Review*, 2017)

1 Nvidia	2 SpaceX	3 Amazon	4 23andMe	5 Alphabet	6 iFlytek	7 Kite Pharma	8 Tencent	9 Regeneron	10 Spark Therapeutics
11 Face ++	12 First Solar	13 Intel	14 Quanergy Systems	15 Vestas Wind Systems	16 Apple	17 Merck	18 Carbon	19 Desktop Metal	20 Ionis Pharmaceuticals
21 Gamalon	22 Illumina	23 Facebook	24 Udacity	25 DJI	26 Mercado Libre	27 Microsoft	28 Rigetti Computing	29 Kindred AI	30 Sophia Genetics
31 Tesla	32 Oxford Nanopore	33 Foxconn	34 M-KOPA	35 ForAll Secure	36 Flipkart	37 Bluebird Bio	38 Adidas	39 IBM	40 General Electric
41 Alibaba	42 HTC	43 Blue Prism	44 Jumia (Africa Internet Group)	45 Veritas Genetics	46 Daimler	47 Salesforce	48 Snap	49 Ant Financial	50 Baidu

II. STATUS AND PROBLEMS

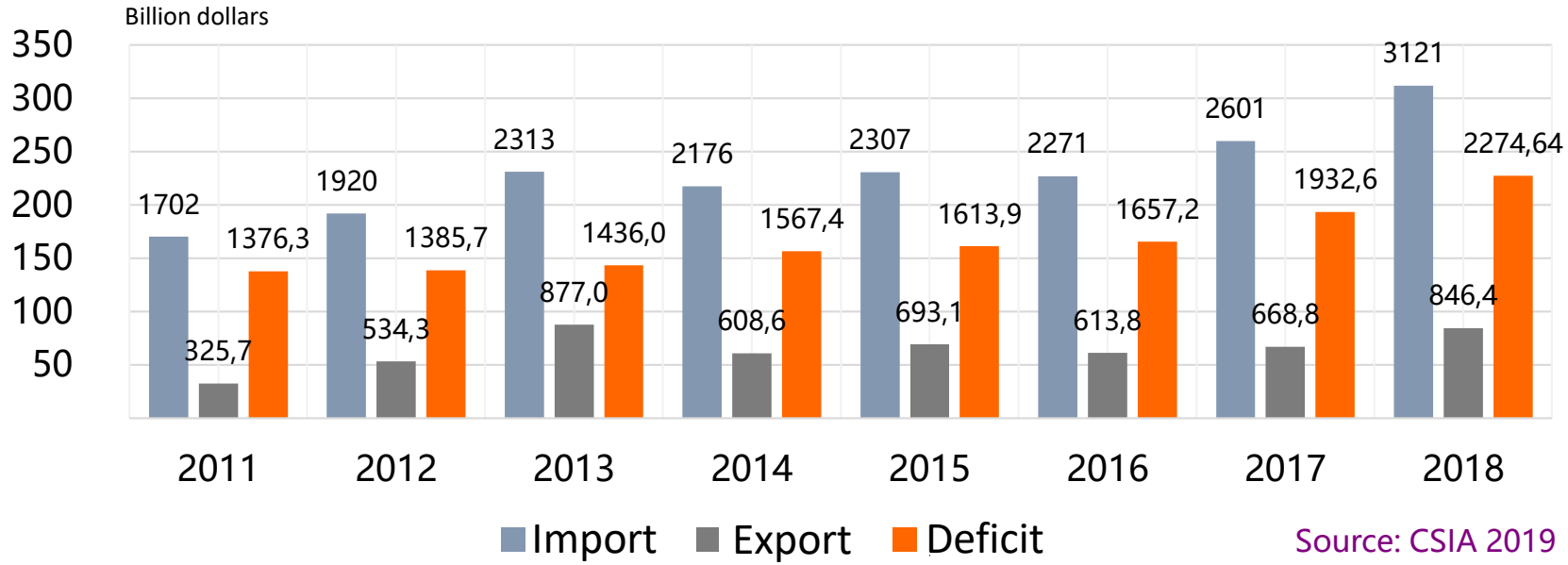
- **How to cultivate the innovation capability and solve the bottleneck problem of China's development?**
  - China's semiconductor trade deficit exceeds the oil trade deficit.



Ⅱ. STATUS AND PROBLEMS

- Since 2013, China has imported more than $200 billion worth of integrated circuits every year. In 2018, 417.6 billion pieces of integrated circuits were imported, with a value of US $312.1 billion; 217.1 billion pieces of integrated circuits were exported, with a value of US $84.6 billion. The resulting trade deficit reached a record high, reaching US $227.5 billion.

China's chip import and export value and trade deficit in 2011-2018

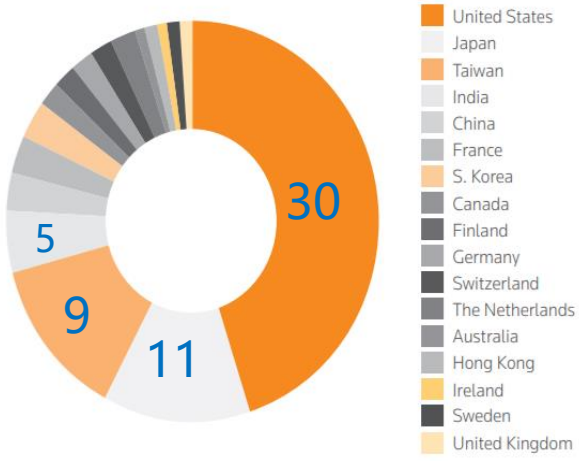


Source: CSIA 2019

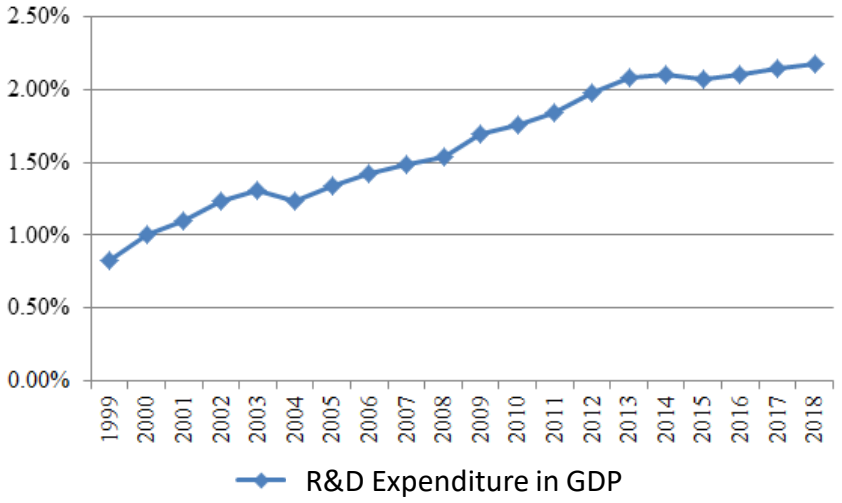
Ⅱ. STATUS AND PROBLEMS

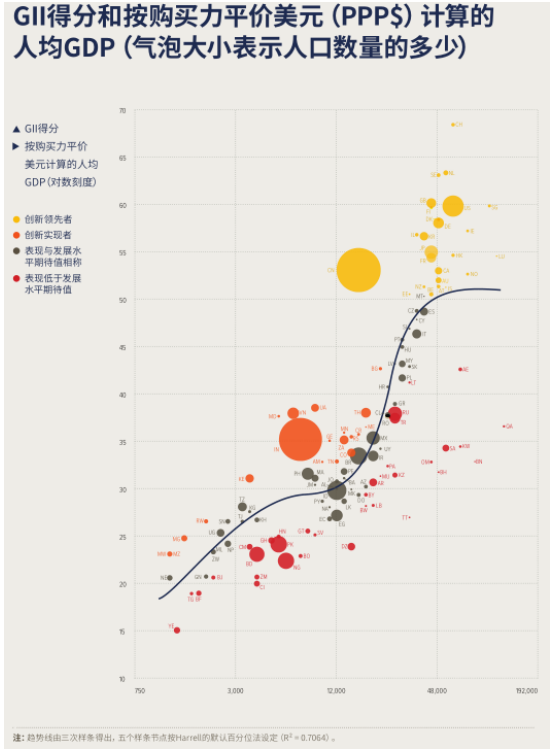
- **How to improve input efficiency, transforming from a follower to a leader?**
- China’ s growth rate of R&D investment is the highest in the world, and the investment intensity has reached the level of a moderately developed country. But among the top 100 global technology leaders, there are only three in China（*Top100 Global Technology Leaders*, 2018）

Figure 1: Top 100 Global Tech Leaders by Headquarter Country

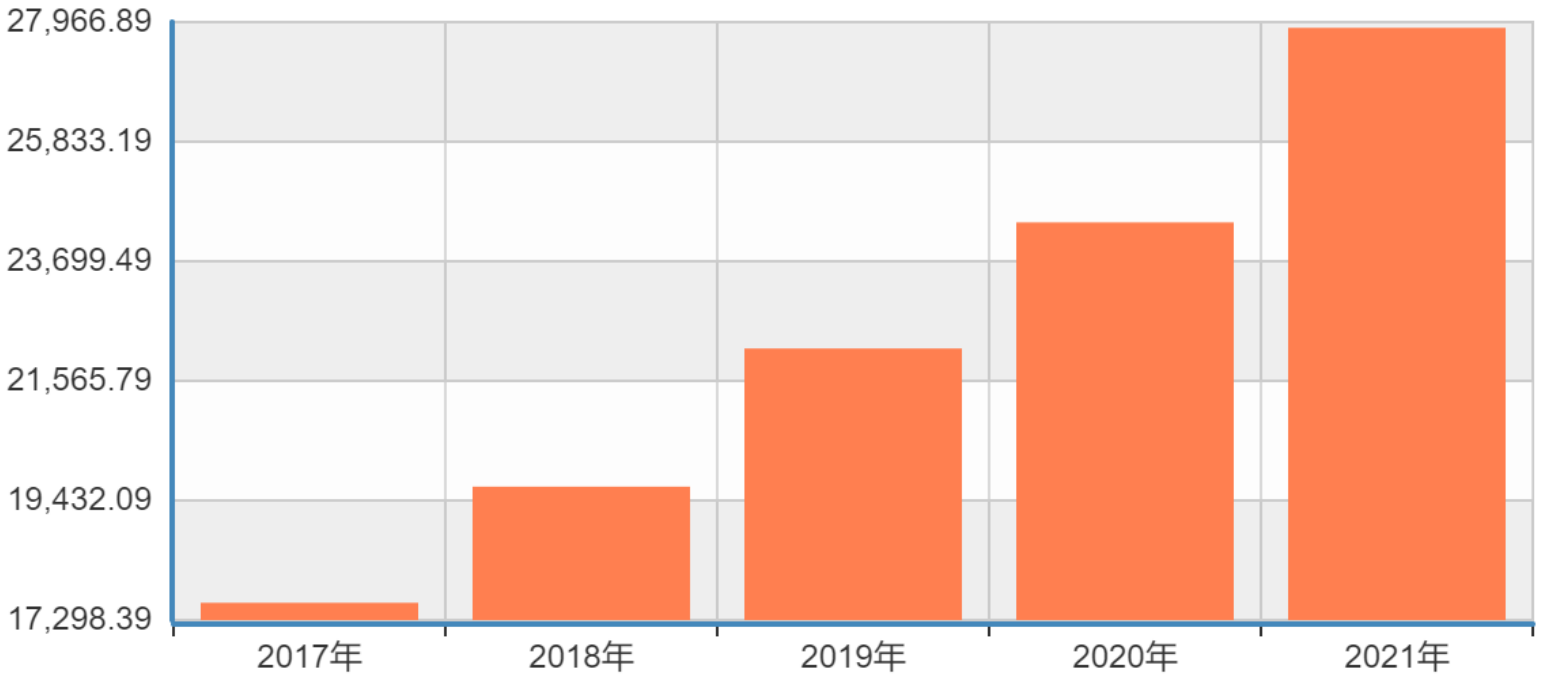


Source: Thomson Reuters Data & Analysis





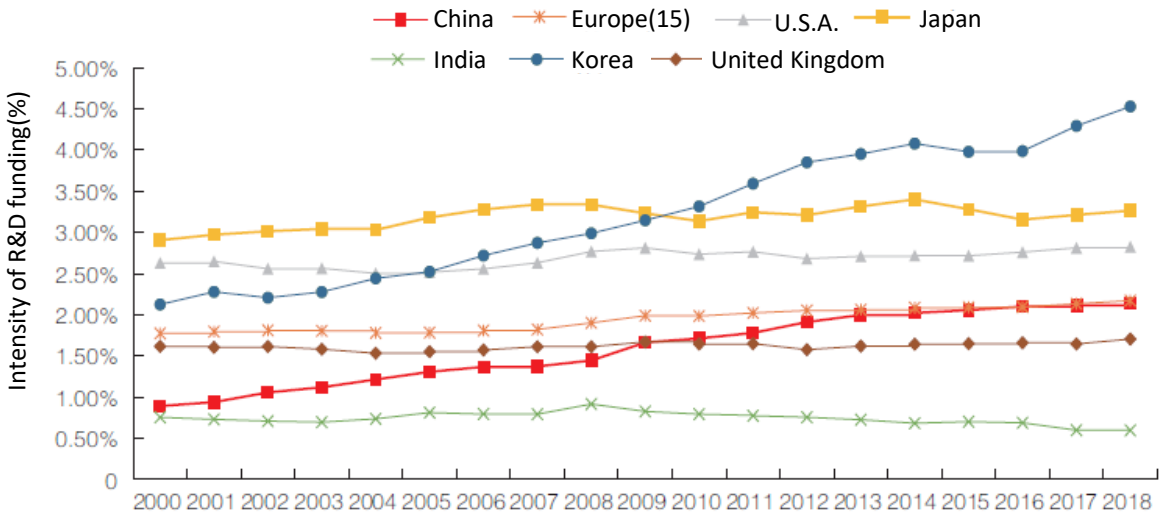
Ⅱ. STATUS AND PROBLEMS

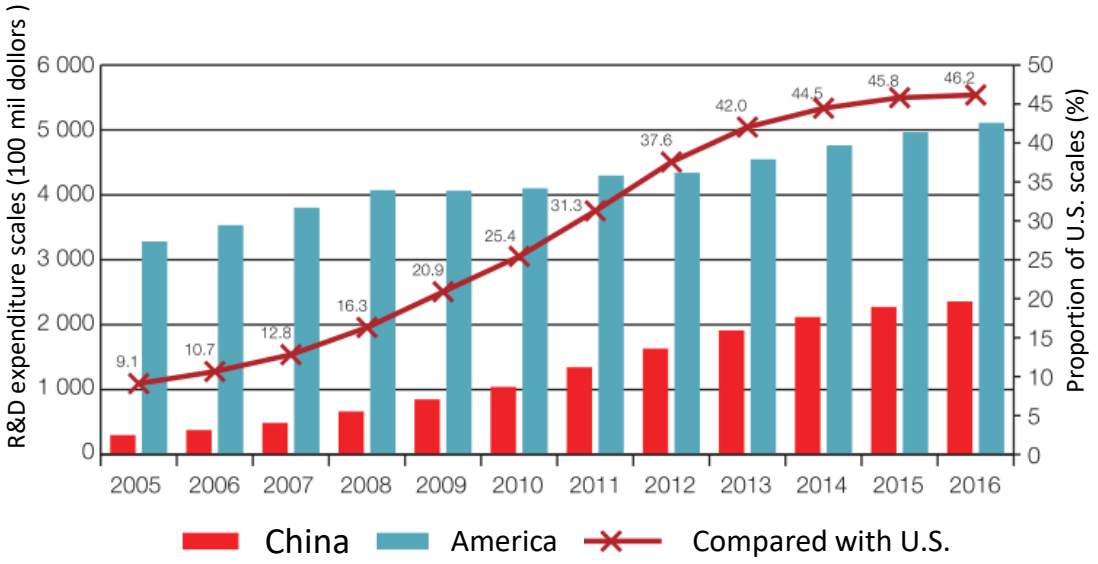


China’s Research and experimental development expenditure (100 million yuan)

Ⅱ. STATUS AND PROBLEMS

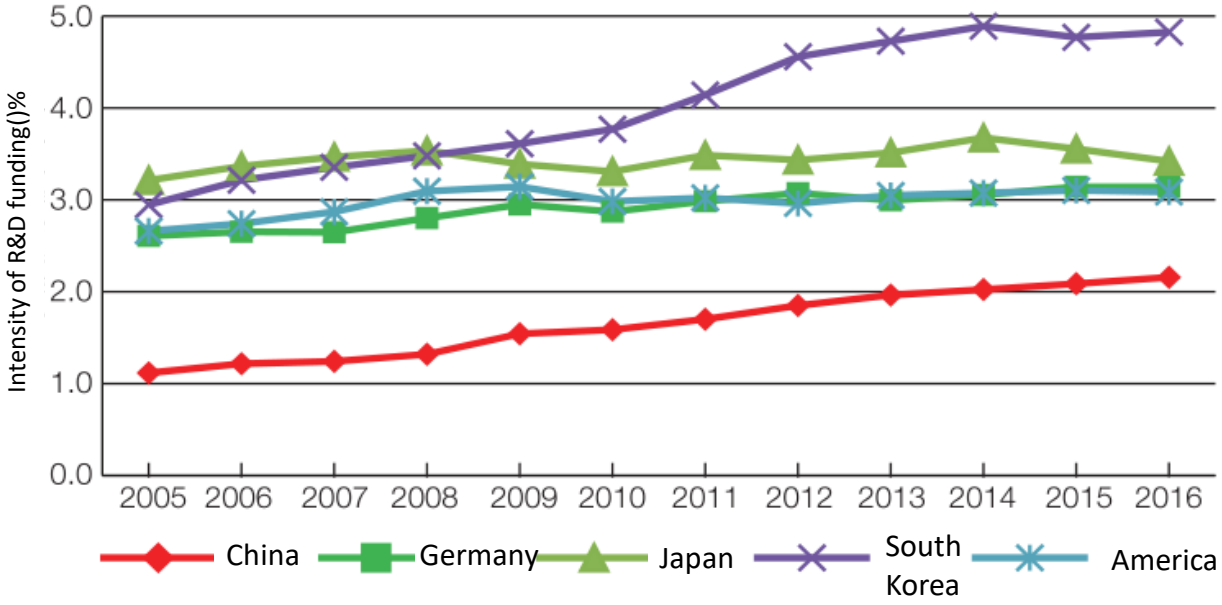
- Compared with the major innovative countries in the world, China's R&D investment intensity still has a certain gap; from the perspective of the development of R&D investment in different countries, China’ s R&D investment intensity needs to be further improved （ *National Innovation Index Report*，2020 ）

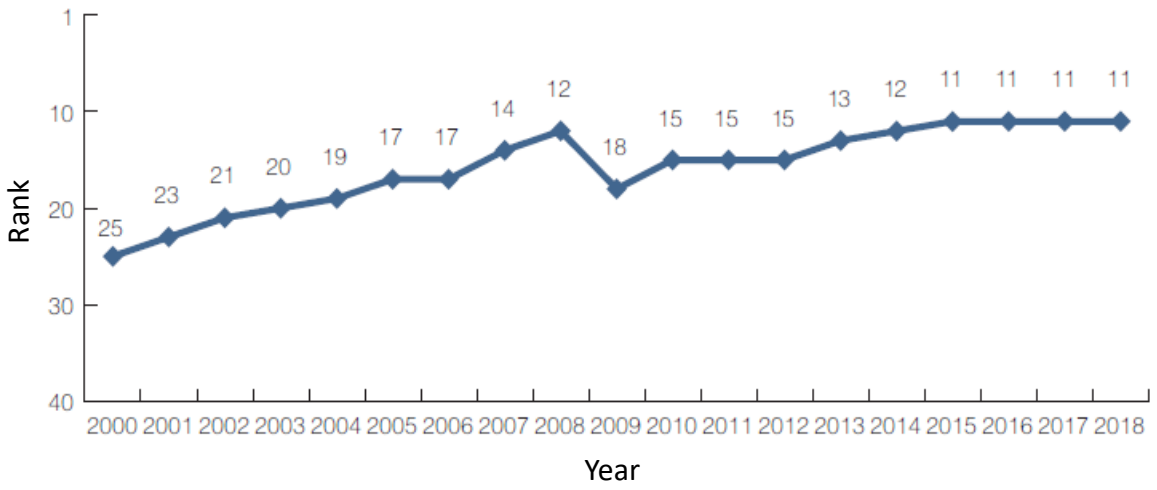




Ⅱ. STATUS AND PROBLEMS

- Compared with the U.S., Germany, Japan, and South Korea, Chinese companies have lower investment competitiveness in R&D expenditure and innovation;
- However, China's Enterprise innovation index ranks 11th, remaining unchanged for 4 consecutive years （*National Innovation Index Report*，2018 & 2020）

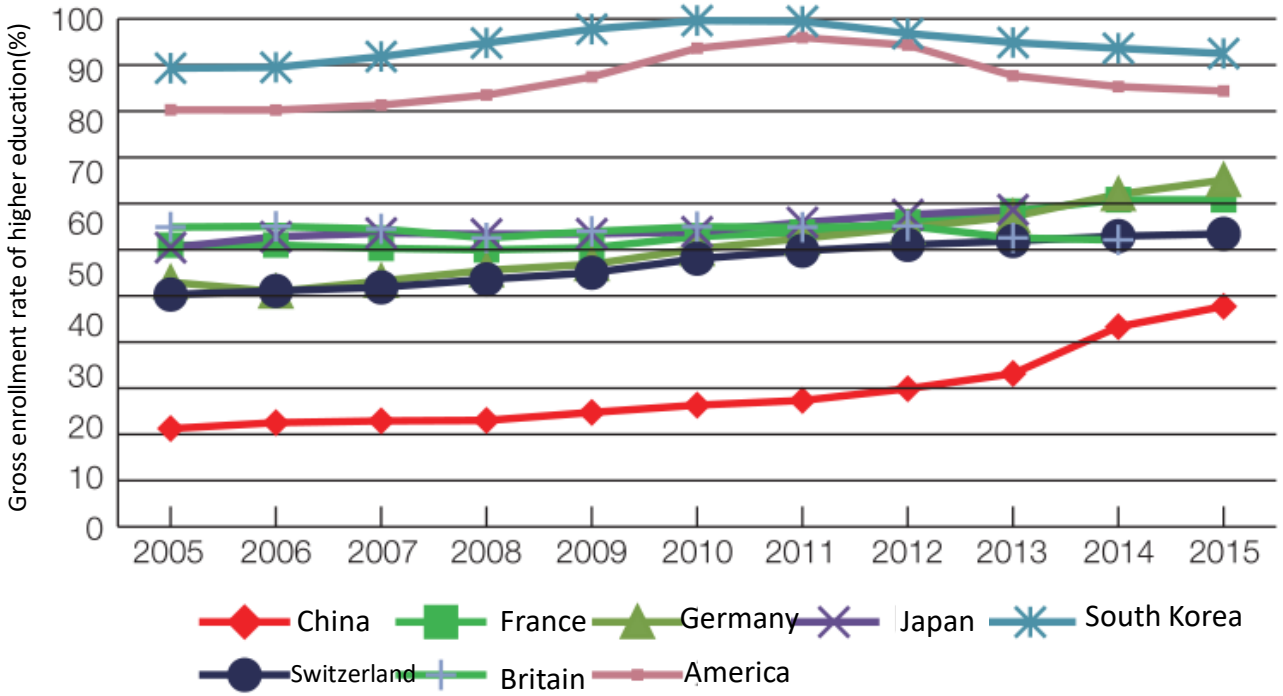


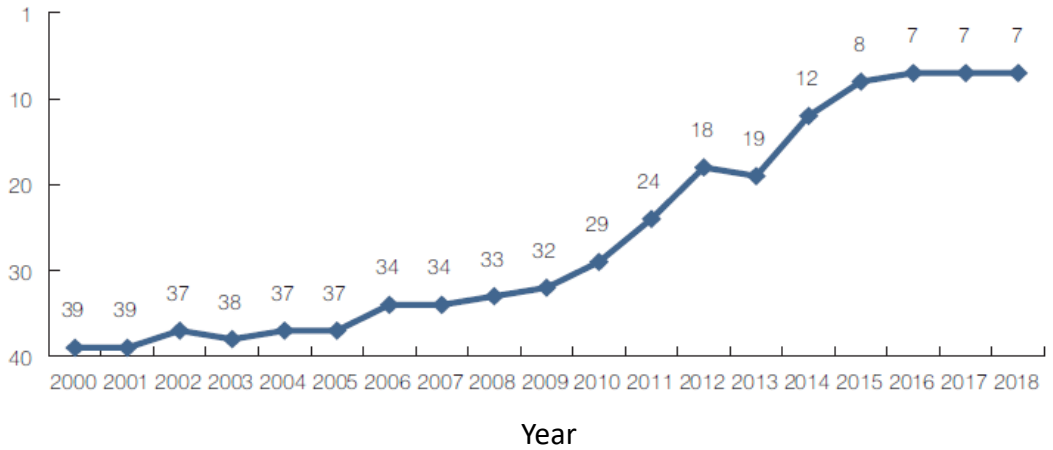


China Enterprise Innovation Index World Ranking

Ⅱ. STATUS AND PROBLEMS

- The gross enrollment rate of higher education in China has increased from 19.3% in 2005 to 42.7% in 2016. China's talent training in higher education, scientific and technological is still lagging behind.
- China's knowledge creation index has improved significantly, ranking 7th in the international rankings for three consecutive years （*National Innovation Index Report*，2018 & 2020）

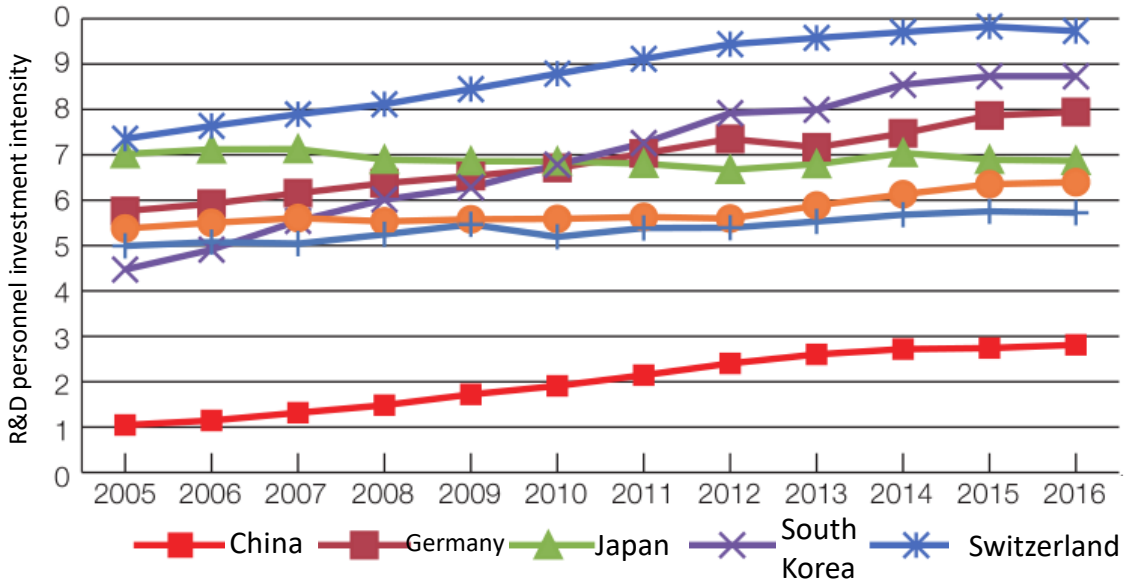


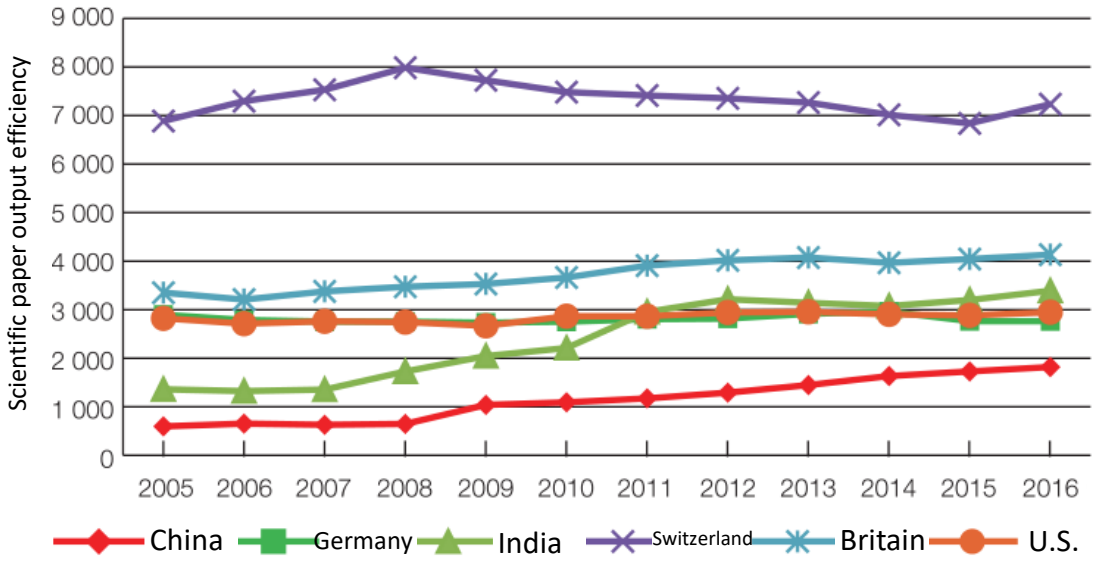


China Knowledge Creation Index World Ranking

Ⅱ. STATUS AND PROBLEMS

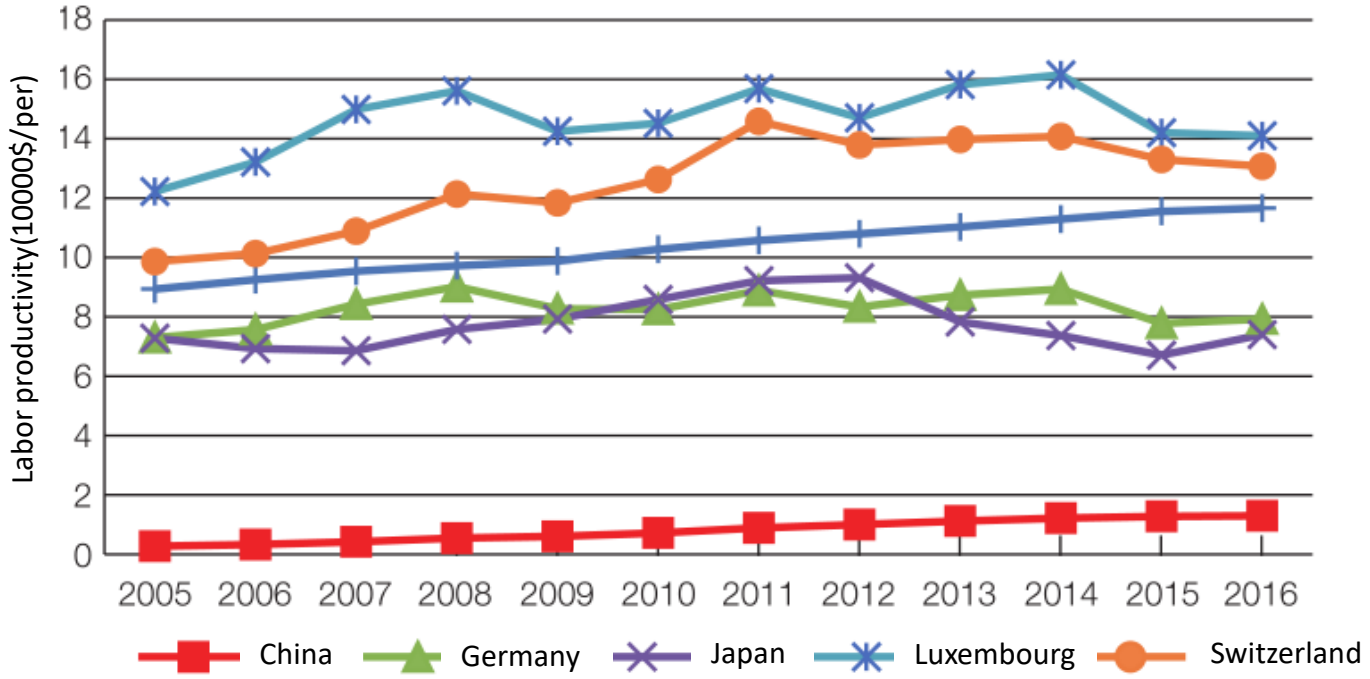
- China's scientific and technological human input is less than 1/2 of the U.S. and Japan, about 1/3 of Switzerland, South Korea, and Germany. The number of Chinese researchers publishing international scientific and technological papers is not only much lower than Europe, U.S., and Japan, or even India. (*National Innovation Index Report*, 2018)





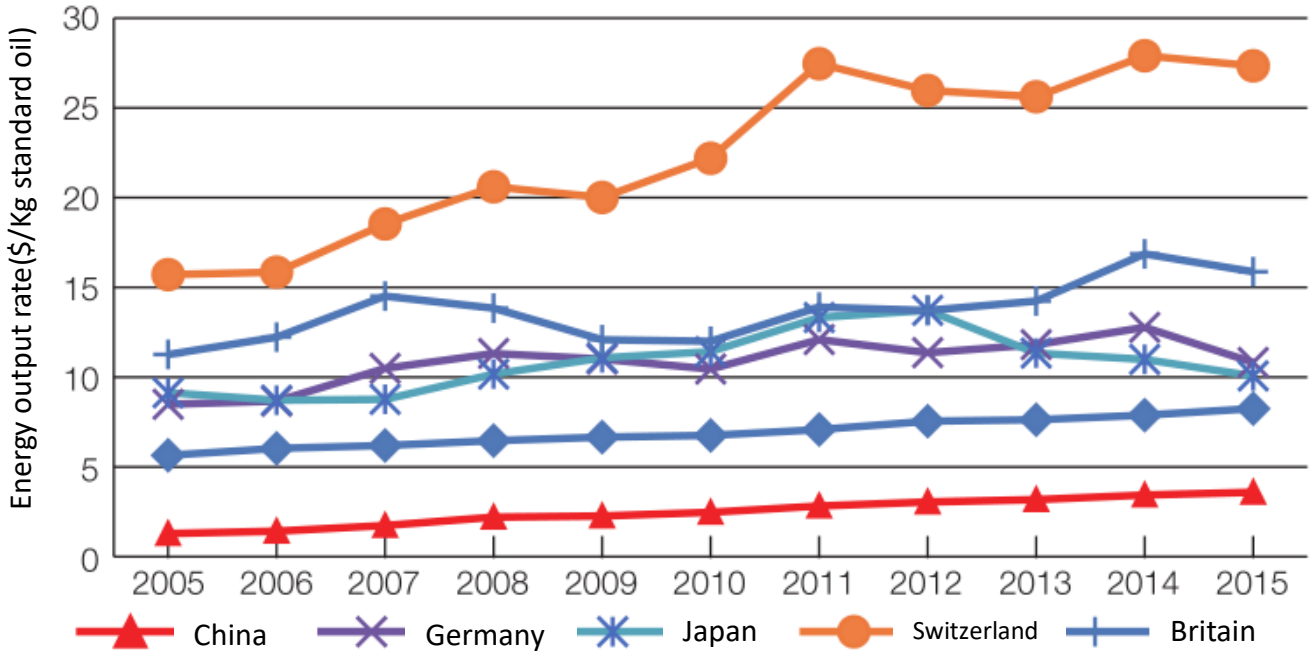
Ⅱ. STATUS AND PROBLEMS

- From 2005 to 2016, China's labor productivity increased from $3,000 to $14,000 per person, with an average annual growth rate of 15.1%. However, due to China's large population, its productivity is still far lower than that of developed countries. (*National Innovation Index Report*, 2018)



Ⅱ. STATUS AND PROBLEMS

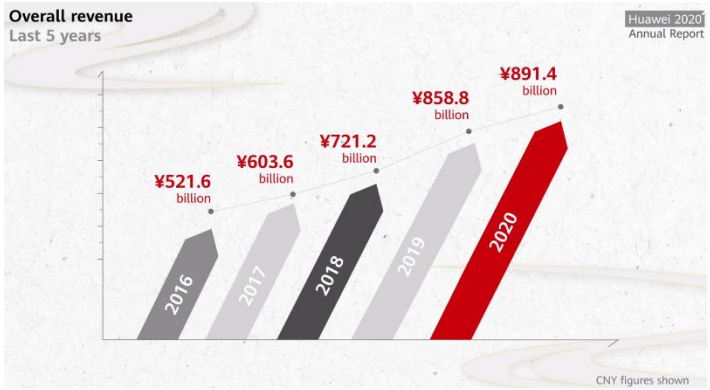
- Considering economic output for per unit of energy consumption, China has increased at a faster rate than developed countries. But from an absolute level, there is still a huge gap between them. (*National Innovation Index Report*, 2018)

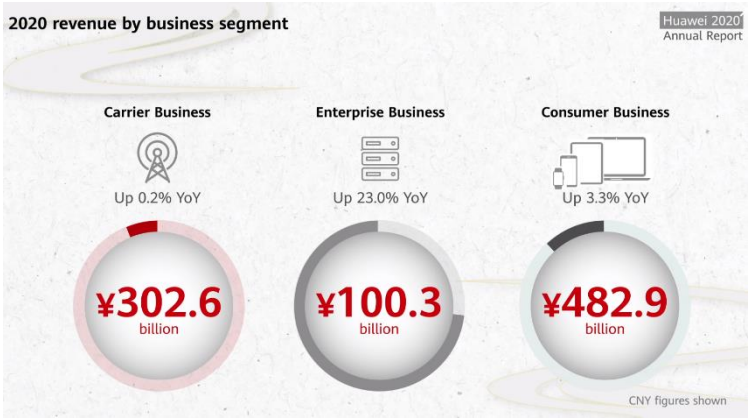


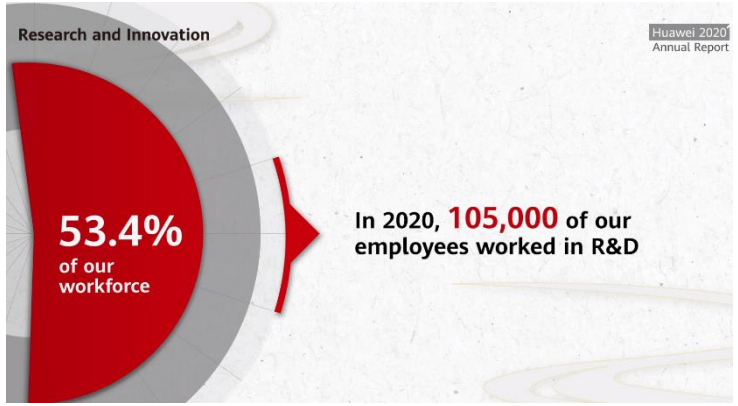
Ⅲ. CHINA'S INNOVATION CASE: HUAWEI

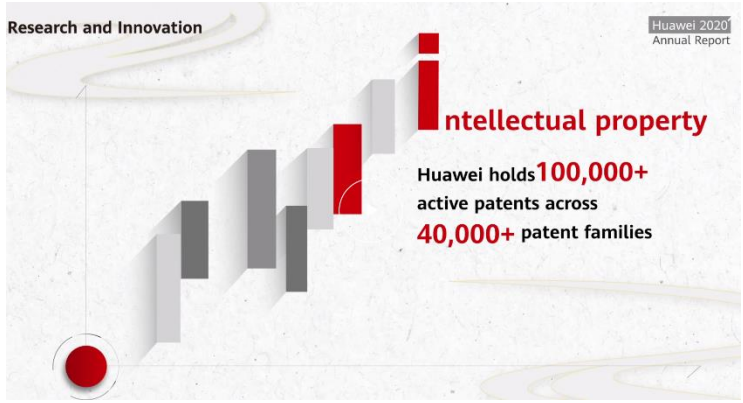
Who is HUAWEI

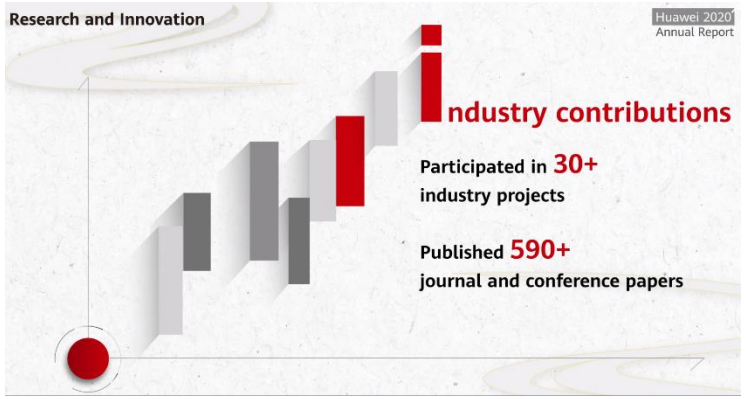
Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. With integrated solutions across four key domains – telecom networks, IT, smart devices, and cloud services – we are committed to bringing digital to every person, home and organization for a fully connected, intelligent world.











Source: Huawei Annual Report 2020

Ⅲ. CHINA'S INNOVATION CASE：HUAWEI

Milestone

- In 2014, HUAWEI released 400G Core Router, one year ahead of competitors in the industry, and is the only product of that kind which has achieved large-scale commercial use.
- Before Qualcomm, it released the world's first chip "Kirin 910T" which supports 4G LTE-Cat6. This chip is used in Huawei's smartphone-Ascend P7, which has achieved great success in the mobile phone market.
- In 2016, it released Mate 9 equipped with the Kirin 960 chip. The Polar Code scheme proposed by Huawei became one of the 5G standard coding schemes.
- In 2017, it released the world's first SoC chip equipped with a discrete GPU unit-"Kirin 970".
- In 2018, Huawei released the next generation of AI chip for smartphones, the Kirin 980.
- In 2019, Huawei launched the Arm-based CPU, the Kunpeng 920, and the TaiShan series servers and cloud services powered by the Kunpeng 920.
- In 2020, Huawei supported the stable operation of 1,500+ carrier networks across 170+ countries and regions. Multiple third-party test reports on 5G network experience in large cities ranked Huawei's 5G networks top.

Ⅲ. CHINA'S INNOVATION CASE：HUAWEI

- In 2021, the number of Huawei devices equipped with HarmonyOS will exceed 220 million; HarmonyOS Connect has more than 1900 ecological partners, more than 4500 types of products certified by Hongmeng Zhilian, and the shipment of new products will exceed 115 million in 2021.

- In 2021, there will be about 107000 people engaged in research and development, accounting for 54.8% of the total number of the company.

- In 2021, R&D expenditure will be 142.7 billion yuan, accounting for 22.4% of the annual revenue

- As of December 31, 2021, Huawei has held more than 45000 families (more than 110000) of valid patents worldwide.

Ⅲ. CHINA'S INNOVATION CASE：HUAWEI

- On Augest 31, 2018, it released mobile SoC processor "Kirin 980".
- On September 6, 2019, it released a new generation of mobile SoC processor "Kirin 990 and 990 5G"

	Kirin 990 5G	Kirin 990
Chipset Process	7nm+ EUV	7nm
CPU	2X Cortex-A76 Based @2.86GHz 2X Cortex-A76 Based @2.36GHz 4X Cortex-A55 @1.95GHz	2X Cortex-A76 Based @2.86GHz 2X Cortex-A76 Based @2.09GHz 4X Cortex-A55 @1.86GHz
GPU	16 Core Mali-G76	16 Core Mali-G76
NPU	2 Big-Core +1 Tiny-Core	1 Big-Core +1 Tiny-Core
UFS	UFS 3.0, UFS 2.1	UFS 3.0, UFS 2.1
Modem	2G/3G/4G/5G	2G/3G/4G

Ⅲ. CHINA'S INNOVATION CASE：HUAWEI

- Status：from a chaser to a leader
  - Entering the unknown area, it has to face the uncertainty of new technologies.
  - Ren Zhengfei： “A cup of coffee absorbs cosmic energy.”
  - “Black swan” and coffee cup
- Environment：from uniqueness to convergence
  - From “excellent” to “outstanding”
  - Be committed to cultivating "core competence" and give up relying on local advantages such as human/labor resources

——John Jullens “How Emerging Giants Can Take on the World”，Harvard Business Review, 2013.12

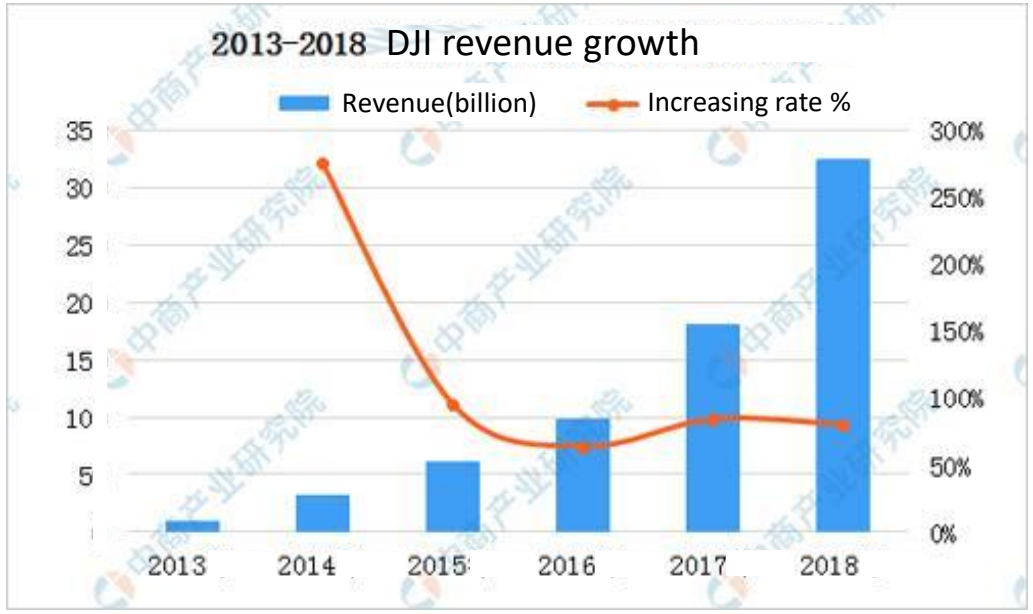
Ⅲ. CHINA'S INNOVATION CASE：HUAWEI

- Change in thinking: from “follow the rules" to "make rules"
  - Publish 5G white paper, defining 5G ecosystem (2013)
- Change in strategy: Increase investment in basic research
  - 2012 laboratory, algorithms, materials, energy
- Change in Corporate culture：more open-minded and flexible
  - Open to media, internal "blue forces", tolerance to "dissidents"
- Potential risks
  - The success of current model will make it difficult to change.
  - ——Christensen，” The Innovator's Dilemma”

Ⅲ. CHINA'S INNOVATION CASE：DJI

- DJI（DJI Technology Co.,Ltd.）
  - The world's leading UAV aerial photography technology company, with 70% global market share.
  - Base in Shenzhen, with more than 2,800 employees, the total turnover in 2019 exceeds 20 billion yuan.
  - Founder：Wang Tao，founded the company with classmates in Hong Kong University of Science and Technology in 2006.
  - By 2016, there were more than 1,500 patent applications and more than 400 patent authorizations.
  - Selected as one of the top ten innovative consumer electronics companies in 2015 by the US "Fast Company" and ranked third. It is the only local Chinese company.
  - Rated as the most innovative Chinese company by Forbes.
  - In June 2017, it was selected into the list of the world's 50 smartest companies.

Ⅲ. CHINA'S INNOVATION CASE： DJI



The most popular product of DJI-Phantom, considered as the Ford "Type T" in the field of UAV.

Ⅲ. CHINA'S INNOVATION CASE：DJI

- DJI's innovation model
  - New concept of product;
  - Innovation based on technological breakthroughs ("disruptive innovation");
  - Comprehensive solution;
  - "Global market orientation" replaces "local market orientation";
  - Deeply rooted in the local industry cluster (Shenzhen), while maintaining contact with the world;
  - "Internet thinking ‘‘
  - Online sales, promotion based on social platforms, user community

Ⅲ. CHINA'S INNOVATION CASE：RISING UNICORNS

- **IFlytek**：Provide voice and language solutions
- **Yitu Technology**：Won the global championship in the face recognition test (FRVT) sponsored by the National Institute of Standards and Technology (NIST) for two consecutive years
- **SenseTime**：The world's leading artificial intelligence platform company, and "the world's most valuable AI innovation company"
- **MEGVII**：Rated as one of the top ten breakthrough technology leaders in the world by MIT Technology Review
- **Cambricon**：Cambricon is the world's first smart chip company that has successfully taped out with mature products
- **Horizon Robotics**：Based on BPU, it launched China's first world-leading embedded artificial intelligence vision chip.

Ⅲ. CHINA'S INNOVATION CASE：PERSPECTIVE

- Change of Chinese enterprises: from cost-oriented to competitiveness-oriented
  - For leaders as HUAWEI，it needs to tranform from “rule followers” to “rule makers”.
  - For new Innovative enterprise as DJI, its commercial mode is similar with companies in Silicon Valley, but has unique local advantages (such as Industrial clusters).
  - More global, more innovative.
    - Case：HAX and YC

IV. SUMMARY

- China achieved marvelous successes on science, technology and innovation(STI) in past decades mainly based on learning from the world and combined with the market-oriented competition.
- But there is still huge gap between China and the leading countries such as US, EU and Japan.
- In STI areas, China still need to learn from the world, but at the same time could contribute to the world more.

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Thank you for listening
Questions are welcome!

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