

# China's Rise in Artificial Intelligence

## The New New China

China has emerged as a major global contender in the field of AI, the apex technology of the information era. In this report, we set out China's ambitious top-down plans, the factors (talent, data and infrastructure) that make China unique and the companies (Baidu, Alibaba and Tencent) that are making it happen. We believe the development of an 'intelligent economy' and 'intelligent society' by 2030 in China has the potential to drive productivity improvement and GDP growth in the next two decades.

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*Note: Prices in this report are as of the August 29, 2017 market close unless indicated otherwise.*

### OUR VIEWS ON BAT

#### **Baidu (BIDU, TP: US\$240, latest close: US\$220.65, Buy)**

Our 12-month SOTP-based target price is at US\$240. Maintain Buy. Key risks: slower recovery in search business; weaker macro.

#### **Alibaba (BABA, TP: US\$208, latest close US\$167.41, CL-Buy)**

Our 12-month SOTP-based target price is at US\$208 (25x PE for China e-commerce). CL-Buy. Key risks: slower GMV growth, lower monetization, competition.

#### **Tencent (0700.HK, TP: HK\$369, HK\$319.80, Buy)**

Our 12-month SOTP-based TP is at HK\$369. Maintain Buy. Key risks: Slower online gaming growth, fiercer competition in P4P ad.

### RELATED RESEARCH

*Profiles in Innovation: Artificial Intelligence - AI, Machine Learning and Data Fuel the Future of Productivity, November 14, 2016*

*Alibaba (BABA): Investor Day Redux: Personalization formula  $\int f(x)dx = \int AI(data)ddata$ , June 15, 2017*

## Executive summary: New China to be driven by AI

**China targets to build a Rmb1trn AI industry by 2030, with relevant industry size reaching Rmb10trn.**

China's shift from an industrial to a new consumer economy is well underway. In our view the next stage – to be a global leader in artificial intelligence (AI) and machine learning (ML) – will also be transformational and therefore just as important for investors. The government, the corporates, and their massive data sets are coming together to create value across multiple parts of the economy. In this report we set out the ambitious top-down plans, the factors that make China unique, and the companies making it happen. We expect the building of an “intelligent economy” and “intelligent society” by 2030 in China - with a Rmb1trn AI industry (and Rmb10trn relevant industries) targeted by the central government - to drive productivity improvement and GDP growth in the next two decades.

We believe the benefits of AI will initially accrue to companies with unique and substantial data sets, and right-sized resources - **BAT (Baidu, Alibaba, Tencent)**. For these three giants AI should help crystalize the value in the data from their multiple, distinct businesses as well as their associates. The frontier of AI/ML in China, meanwhile, has begun to move on to innovative AI/technology startups that boast the best in class global talent. These innovators have established core technology competencies, and are pushing AI adoption across various different industries to create new demand. As a result, the battle of the giants in China will extend to AI talent - encouragingly the large audience in a largely homogenous market is a magnet for international talent.

**BIDU 12m SOTP-based TP: US\$240**

*Fully loaded 2020 implied value: US\$326 (+36% upside vs. our TP) on pp. 19*

### **Baidu leads AI research, with cutting-edge capabilities**

Baidu, among the first movers in AI globally, is leading the technology for speech recognition and autonomous driving. As the first Chinese company to open source its deep learning platform in 2016 (PaddlePaddle for voice/facial recognition, data analysis, deep learning algorithms, etc.), the company continues to strengthen its AI ecosystem via launching the project Apollo autonomous driving platform in April 2017.

**BABA 12m SOTP-based TP: US\$208**

*Fully loaded 2020 implied value: US\$352 (+69% upside vs. our TP) on pp. 24*

### **Alibaba, a world-leading use case of AI**

Alibaba's gigantic ecommerce platform with a GMV of US\$547bn in FY17, is one of the largest use cases for AI. The success of Alibaba's personalization strategy over its 500mn+ shoppers has demonstrated how ML, when combined with data, is transformative. We expect Alibaba to continue to leverage its technology via AliCloud to further improve its algorithm and enhance yields across its assets.

**Tencent 12m SOTP-based TP: HK\$369**

*Fully loaded 2020 implied value: HK\$688 (+87% upside vs. our TP) on pp. 29*

### **Tencent, the biggest social network in China is mastering AI**

Although relatively a late comer on AI among BAT, Tencent's Seattle AI lab launch in 2017 signifies both the coming of age of neural networks as well as a shift toward fundamental research in China. We expect AI to improve targeting for Tencent's advertising and gaming assets, which will raise returns on a generally under-monetized portfolio that includes social network with the highest time spent on the internet, the world's most successful PC and smartphone games, and the world's largest online reading and music customer base.

### **Meituan, the largest O2O platform built by technology**

Meituan, one of Tencent's major investments, is the world's largest O2O services platform in a US\$1.5tn market. With 1PB data generated daily, the platform is disrupting traditional services industry with technology that re-defines online/offline connections, in our view.

*This report features interviews with GS Asia Chief Economist Andrew Tilton as well as Meituan and Rokid. It also takes a look at the leading AI companies and the major segments: speech recognition, computer vision, hardware, intelligent machine, healthcare and intelligent driving.*



## AI rises in the East

### China AI launches: A new national development plan

China has emerged as a major global contender in using AI to drive economic progress. Both the government and industry have identified AI and machine learning (ML) as the next big areas of innovation. And given that China is often home to unorthodox business models, we believe AI will play a broader role in the economy given the scale of operations of the giants that are adopting AI technology.

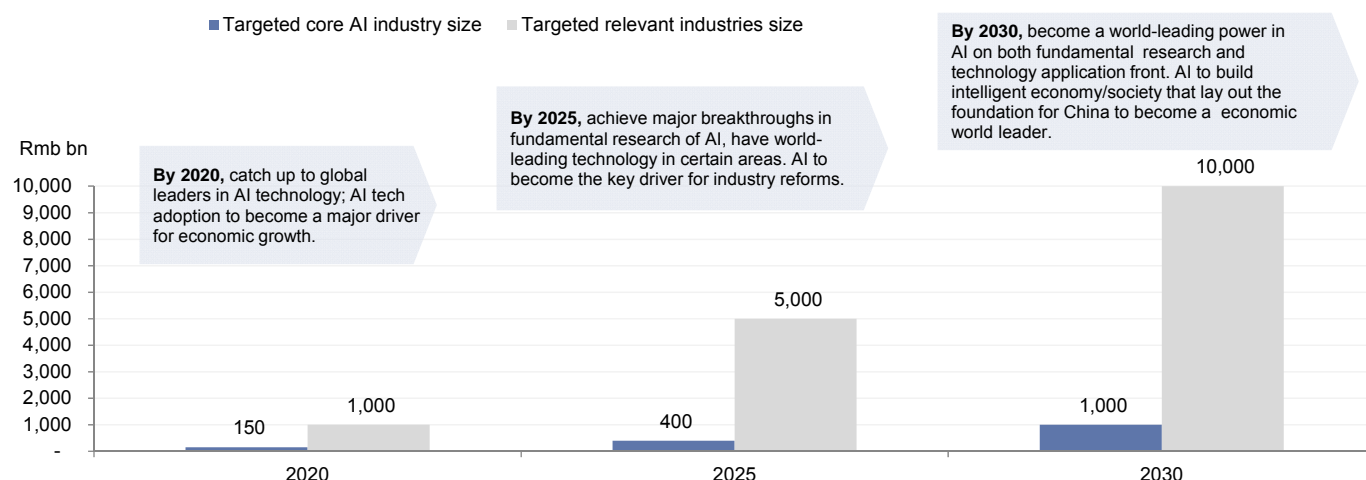
Artificial Intelligence (AI) made its first appearance in the China Premier's work report during the fifth session of the 12<sup>th</sup> National People's Congress held on March 5-15, 2017, the annual meeting where China's senior leaders discuss the major political, economic, and social issues concerning the country's development. At the fifth session, Premier Mr. Li Keqiang noted in his opening remarks that China will accelerate R&D and commercialization of new emerging sectors such as AI, New Materials, Integrated Circuits, Bio-pharmaceuticals and 5G.

On July 8, 2017, the State Council published a **national development plan on AI**, which aims to nurture fundamental research on AI and facilitate adoption of the technology in a wide range of areas including the economy, social welfare, environmental protection and national security. According to the plan, the government will provide greater capital resources, market guidance and policy support to AI development, and at the same time strengthen links among private enterprises, research institutions and military bodies to promote mutual development.

With this plan, China expects AI to drive technology-enabled business innovations and industry transformations, contributing to the country's early lead in building an "intelligent economy" and an "intelligent society" by 2030. The plan strategically identifies AI as the key engine of China's progress toward becoming a major economic power in the decade to come, and the details of the road map are shown in Exhibit 1:

#### Exhibit 1: China aims to become a world-leading power in AI by 2030

The strategic goals of the national development plan on AI



Source: The State Council.

The AI development plan has answered the calls by some of the most influential business leaders in China, who have been proposing that the government-lead collaboration in AI research and facilitate industrialization of the technology. Among them, Mr. Robin Li, the founder of the largest Chinese search engine, Baidu, Mr. Lei Jun, the CEO of smartphone maker Xiaomi, and Mr. Li Shufu, the founder of Geely Automobile (now Volvo's owner), have expressed their strong belief in the **possibility that China will surpass the United States as a global AI superpower.**

**With the national plan set down, we believe AI technology will become a priority on the government's agenda, and we expect further national/regional policy and funding support on AI to follow.**

### Other relevant policies on AI

#### Exhibit 2: AI-supportive policies in China

Time	Issue body	Policy	Note
2015.5	The State Council	Made in China 2025	The first ten year action plan that calls for green, innovative and intelligent manufacturing in china
2015.7	The State Council	The "Internet+" Action Plan	The plan listed Artificial Intelligence as one of the 11 areas of key focuses.
2016.3	The State Council	The 13th Five-year plan (proposal)	The plan reiterates the importance of focusing on new technological areas such as Artificial intelligence.
2016.5	NDRC	Three-year Implementation Plan for "Internet Plus" Artificial Intelligence	The plan targets the establishment of basic infrastructure and innovation platform, industry system, innovative service system and basic industry standardization of AI in China by 2018, reaching an industry size of hundreds of billions of Rmb.
2017.7	The State Council	The New Plan on Artificial Intelligence Development	The plan states China's goal to catch up to global leaders and achieve world-leading positions in AI by 2030 via solving issues such as a lack of high-end computer chips, software and trained personnel. The government will also play a bigger role through policy support and regulation.

Source: The State Council of People's Republic of China, China National Development and Reform Commission (NDRC).

On May 18, 2016, China National Development and Reform Commission (NDRC), together with other relevant government bodies, published the ***Three-year Implementation Plan for "Internet Plus" Artificial Intelligence*** ("the three-year plan"). The implementation plan identifies six specific areas of support for AI development, including capital funding, system standardization, IP protection, human capital development, international cooperation and implementation arrangement.

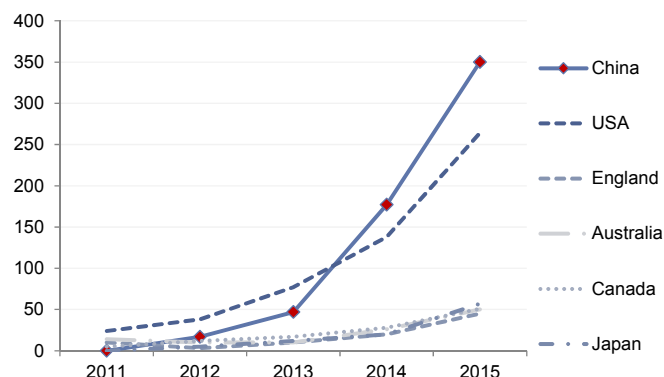
The three-year plan targets the establishment of basic infrastructure and innovation platform, industry system, innovative service system and basic industry standardization of AI in China by 2018, creating an AI market that is **hundreds of billions of Rmb** in size. NDRC expects the overall China AI industry to be synchronized with international development, and lead the global market in system-level AI technology and applications.

## China has made major strides in AI vs. the rest of the world

**On Research:** China surpassed the US in 2014 in terms of the number of journal articles cited mentioning "deep learning" or "deep neural networks" (Exhibit 3). Lee Kai-Fu, Google China's Co-President before Google exited China, pointed out during the 2017 World Economic Forum Annual Meeting that 43% of the top academic papers relating to AI were published with one or more Chinese researchers in 2015, regardless of where in the world the work was primarily conducted (and despite the fact that top-level experts are still mostly from North America and the United Kingdom).

### Exhibit 3: China published the most research papers on AI in 2015...

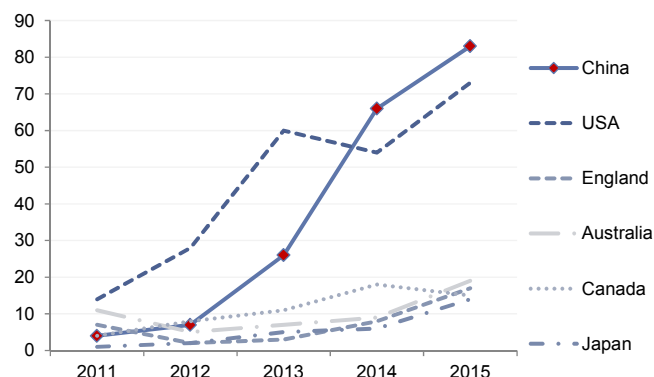
Journal articles mentioning "deep learning" or "deep neural network"



Source: US National Science and Technology Council.

### Exhibit 4: ...with the highest number of cited papers

Journal articles cited at least once, mentioning "deep learning" or "deep neural network"



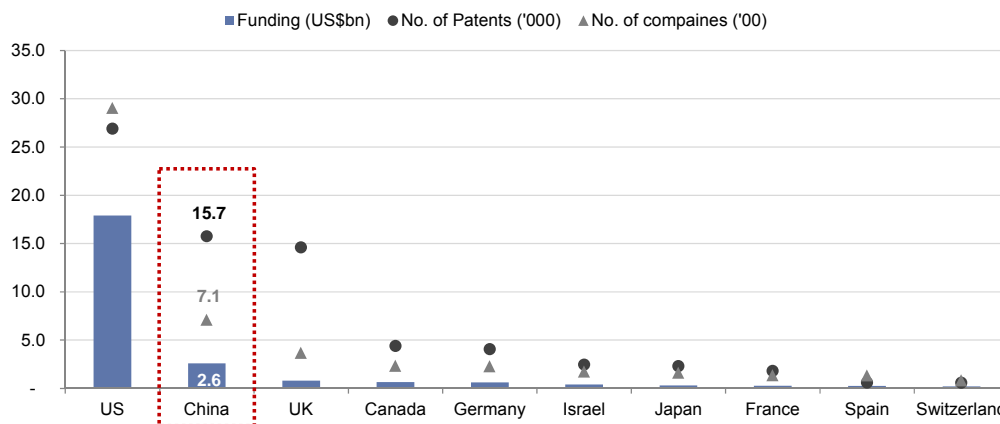
Source: US National Science and Technology Council.

Much of the research progress in China is driven by leading Chinese companies. **Baidu** has been the first mover with its AI-focused lab in Silicon Valley opening in 2013; **Tencent** launched an AI lab in 2016 and actively recruited AI talent in neural network and machine learning; **DiDi Chuxing** (Didi) has also built out a lab to work on autonomous driving.

**On industry:** With over 700+ AI-related companies in China, the country had over 16k patents in the area as of October 2016. Further, US\$2.6bn of capital flowed into the AI industry between 2012 and 1H16, roughly 1/7th of that of the United States and 3X of that of the United Kingdom, according to a joint report by Wuzhen Institute and NetEase Tech.

### Exhibit 5: China has the second-biggest AI ecosystem after the US

AI funding (between 1Q12 and 2Q16), number of patents and number of companies comparison in different countries



Source: Global Artificial Intelligence Development Report by Wuzhen Institute on Oct 2016.

China is the second-largest AI ecosystem worldwide, based on each of the metrics above. The initial focus of the AI in China has been skewed toward computer vision and voice tech. As per iResearch data, until a year ago, 71% of the AI-related companies in China were focused on developing applications with the remainder focusing on computer vision (55%), natural language processing (13%), and fundamental ML (9%).

**Exhibit 6: China Money Network's China top 10 AI ranking (as of March 2017)**

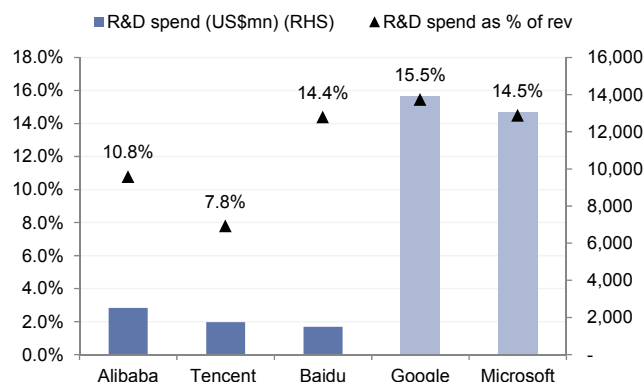
	Company	Sector	Financing total (US\$mn)	Valuation (US\$mn)
1	iCarbonX	healthcare	155	1,000
2	Face++	face recognition	147	Unknown
3	Cloudminds	robotics	130	Unknown
4	Ubtech	robotics	122	1,000
5	SenseTime	face recognition	120	Unknown
6	Roobo	robotics	100	Unknown
7	Unisound	voice recognition	80	1,000
8	Mobvoi	voice recognition	75	300
9	Appier	marketing	50	Unknown
10	Aispeech	voice recognition	45	Unknown

Source: China Money Network.

**AI at China internet giants:** BAT (Baidu, Alibaba and Tencent) have been investing in AI to use the technology for customer targeting across their platforms, consumer finance, autonomous driving and other applications.

**Exhibit 7: BAT slightly underspent on R&D vs. Google/Microsoft...**

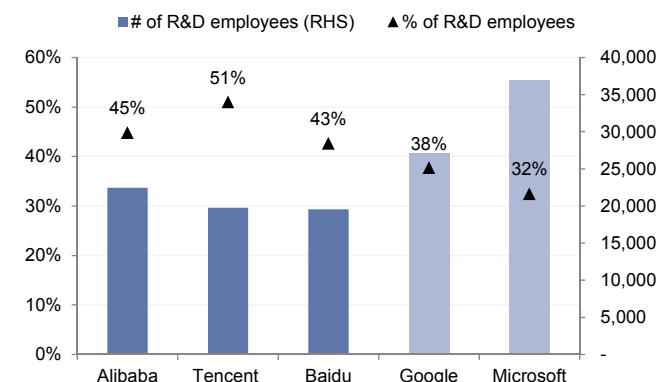
R&D spend as percentage of revenue



Source: Company data.

**Exhibit 8: ...yet the China internet giants are equipped with higher percentage of R&D human capital**

R&D employees



Source: Company data.

At the first World Intelligence Conference held in Tianjin, China on June 29, 2017, Baidu CEO Mr. Robin Li commented in his speech entitled "Artificial Intelligence: Ongoing now" that AI could be the major driver for economic development in the next 30-50 years globally. Li believes the success of AI development will require cooperation among OEMs, chip developers and other supporting parties, and the integration of hardware and software will become increasingly important. He also noted great potential for AI development in China, as the country has a large amount of capital, talent, and 700mn netizens who speak the same language.

At the conference, the chairman of Alibaba, Mr. Jack Ma, stressed the importance of data in making machines smarter. While he does not expect machines to have human-level intelligence anytime soon, he expects a technological revolution to take place in terms of the power of data, where machines tackle problems that cannot be solved by humans. In his view, the goal of AI should be making machines do things humans cannot do, rather than making them like humans.

## Exhibit 9: Internet giants Baidu, Alibaba and Tencent (BAT) are leading the China AI market

### BAT AI development

Baidu		
2015 Sep	DuEr ("Du secretary")	Voice controlled AI personal assistant (integrated in Baidu mobile Search app)
2015 Nov	Deep Speech 2	Voice technology that consists of a very large neural network, which learns to associate sounds with words through samples. This was listed in MIT Tech Review as one of the 10 Breakthrough Technologies in 2016
2015 Dec	Autonomous driving unit	Baidu's driverless car complete tests on roads in Beijing, and the company set up a new Autonomous Driving Unit (ADU) in Silicon Valley
2016 Aug	DuSee	An AR platform geared towards mobile devices (integrated in Baidu mobile Search and Map app), wide application in search advertising
2016 Sep	Baidu Brain	Officially introduced as the AI platform of Baidu
2016 Sep	Paddle Paddle	A deep learning toolkit Baidu newly open sourced
2016 Sep	Partner with Harman	Partnership to develop speech-enabled smart speakers integrated with Baidu's AI technology
2016 Oct	Baidu mobile app 8.0	Upgraded mobile search app with an integrated system of intelligent search, personalized newsfeed powered by AI, NLP, and deep learning
2016 Dec	Partnership with KFC	Smart restaurant that makes recommendations on customer order based on facial recognition to make recommendations based on age, gender, and facial expression
2017 Jan	Baidu AR Lab	Established to research and build experience that tightly integrate digital experiences with personal devices, and to integrate AR into search
2017 Jan	Partnership with BAIC Motor	Partnership to develop smart car tech and Level 3 autonomous driving
2017 Feb	Baidu invested in Raven Tech	A lab launched to focus on artificial intelligence, big data, and the next generation operating system. Has developed an AI voice assistant platform.
2017 Mar	Partnering with Comet Labs	Comet Labs is a San Francisco based fund specializing in machine intelligence
2017 Apr	Baidu invested in xPerception	xPerception specializes in computer vision, such as modules for object recognition and depth recognition
2017 Apr	Partner with Harman	Partnership to develop cloud-based AI solution for in-car use
2017 Jun	Partner with Bosch and Continental	Partnership to further develop autonomous driving and mobility services in cars
Alibaba		
2015 Jul	Ali Xiaomi ("Ali secretary")	Virtual AI customer services, ~80% problem solving rate as reported by the company in Oct, 2016
2015 Aug	DT PAI	A services provided on AliCloud to handle machine learning process, noted the first AI platform as such in China by the company
2016 Mar	GnomeMagic Lab	A lab launched to focus on VR and AR technologies that help sellers on Alibaba's platform to set up 3D product inventories, and eventually VR stores.
2016 Jun	Alimama OCR (Optical Character Reader)	The technology of the company broke the previous record and won the first place of ICDAR Robust Reading competition
2016 Aug	AliCloud ET	A comprehensive suite of AI solutions in video, image and speech recognition technologies
2016 Aug	Buy+	A VR online shopping product introduced during Taobao Maker Festival in Aug 2016 and launched to the public during 2016 Singles' Day, the very first product of its kind globally
2017 Jan	GPU driven cloud service on Alicloud	Cloud computing service driven by GPU that is suitable for AI
2017 Mar	Alibaba invested in WayRay	WayRay produces augmented-reality dashboards for smart cars, including holographic navigation systems
2017 Mar	PAI 2.0	AliCloud's new service that support deep learning and machine learning
2017 May	Cainiao (47% owned by BABA) partners with SAIC Motor and Dongfeng Motor	Partnership to equip 1 million delivery vans with AI-aided logistics tech
Tencent		
2014 Jul	Tencent invested in Scaled Inference	Scaled Inference operates in stealth mode and offers AI as a cloud services
2015 May	Tencent invested in CloudMedx	CloudMedX is a medical and healthcare data provider that also produces health analysis and forecasts compliant with HIPAA standards. Tencent invested US\$6.3mn in its seed rounds
2015 Jun	Youtu Lab (open.youtu.qq.com)	Tencent opened its facial recognition, among other core technology of Youtu Technology, to public developers
2015 Aug	Tencent Intelligent Computing and Search Lab (TICS)	A intelligent computing and search lab launched by Tencent in 2015 with four areas of research focus: search, NLP, data mining, and AI
2015 Sep	Dreamwriter	Tencent launched China's first robot for news reporting
2015 Nov	WHAT LAB	WeChat-HKIST Joint Laboratory on Artificial Intelligence Technology launched on No 26, 2015
2016 Feb	Tencent invested in Diffbot	Tencent and Felicis lead US\$10mn Series A for Diffbot, a profitable AI company that achieves human-level accuracy in business applications when accessing unstructured data cross web.
2016 Apr	Tencent AI Lab	Focused on AI fundamental research
2016 Apr	Tencent invested in iCarbonX	iCarbonX is China's first Biotech Unicorn (AI-enabled health data mining start-up) valued at ~Rmb\$1bn in its series A funding in Apr 2016, led by Tencent.
2015 Sep	Tencent invested in SkyMind	SkyMind develops an open-source deep-learning library for Java, and raised US\$3mn from Tencent and other investors in Sep 2016.
2016 Dec	Cooperation with Microsoft Research Asia	XiaoIce, chat-bot developed by Microsoft to be embedded in QQImshow.
2016 Dec	Tencent Angel Platform	Tencent's 3rd generation computing platform that is designed for machine learning and high-performance distributed computing framework
2017 Feb	Tencent invested in Innovega	Innovega develops augmented reality contact lens and eyewear
2017 Mar	Tencent invests in Tesla (5%)	Invested to strengthen development in connected cars and artificial intelligence
2017 Apr	Tencent AI Research Center	New research center to be built in Seattle will focus on machine intelligence and to integrate on older products
2017 Aug	Tencent to support AI in autonomous driving	Formed alliance with multiple industry players (e.g. Beijing Automotive Group) to develop AI in autonomous driving
Partnership/Investment		

Source: Company data, MIT tech review, Sina Tech news reports.



## Key drivers of value creation in China AI

In *Profiles in Innovation: Artificial Intelligence: AI, Machine Learning and Data Fuel the Future of Productivity*, published on November 14, 2016, the key inputs to AI are identified as **talent, data, infrastructure and silicon**. In this section of the report, we discuss AI development in China by examining the four key inputs, and **we conclude that China has the talent, data and infrastructure needed to fully embrace AI**.

### Talent: China attracting the world's best minds

The commercialization of deep learning has created a scarcity for AI talent as we see the tech giants opening research labs worldwide to attract talent (e.g., Google opened an AI lab in Montreal in 2016, and Facebook opened an AI lab in Paris in 2015). According to Microsoft Research Chief Peter Lee, the cost of acquiring a top AI researcher is comparable to the cost of acquiring a National Football League (NFL) quarterback. We expect this may remain the case until the industry matures, so that talent is no longer the industry's bottleneck.

**Chinese companies** also have to compete with the global companies for this talent. They have opened research labs in Silicon Valley and offer comparable salaries (Exhibit 10). According to Baidu CEO Mr. Roblin Li, talent being attracted by Chinese companies is still predominantly overseas Chinese, which is why he urged Beijing to further ease visa restrictions to attract overseas talent.

According to Xing Yao, the Vice President overseeing the AI lab at Tencent, Chinese companies are well-positioned in the recruitment of AI talent, as a lot of ML researchers have a Chinese background. We note that Google's Cloud Machine Learning group is co-headed by two renowned Chinese American scientists, Jia Li and Fei-Fei Li.

**Exhibit 10: Baidu offers competitive salary in hiring machines learning talent**  
ML Scientist Salaries

US\$'000	Amazon	Google	Microsoft	Apple	Facebook	Baidu
Base	139	119	158	143	160	126
Annual Bonus	29	25	40	23	25	20
Annual Equity	39	71	46	35	88	74
<b>Total</b>	<b>207</b>	<b>215</b>	<b>244</b>	<b>201</b>	<b>273</b>	<b>220</b>
Signing Bonus	40	25	22	33	42	24
Paysa CompanyRank*	7	3	42	12	5	551
No. of profiles included	126	<20	20	33	<20	<20

Note: Paysa CompanyRank measures the quality of technical talent at a company over time, based on its analysis of 7.45 million job changes across 198k companies over the past 15+ years.

Source: Paysa.

**Baidu** has attracted global AI talent as evidenced by the appointment in May 2014 of Dr. Andrew Ng, the adjunct professor at Stanford University and Co-founder/Chairman of Coursera, as the Chief Scientist (Dr. Ng left Baidu in March 2017) and most recently Dr. Qi Lu, the former Microsoft Global Executive Vice President and a well-known AI expert, as the Group President and COO in January 2017. The innovative nature of the company, together with its focus on AI, and a team consisting of world-leading AI researchers, has attracted young talent from top universities in China and worldwide.

**We believe that talent of the highest caliber has and will continue to drive the innovative nature of the industry in China.**

## Data: 44 zettabytes to be exploited in benign regulatory environment

China, the most populous country in the world, is home to 1.4bn people, 700mn of whom are on the net communicating in the same language. As a result, China understandably generates ~13% of the digital information globally. By 2020, we expect this to grow to 20%-25% as China's economy emerges as the world's largest. Based on IDC's estimates of the world's total data generation of 44 zettabytes (ZB, 44bn GB) in 2020, we estimate China will generate 9-10 ZB of data.

In our view, China's three internet giants – **Baidu, Alibaba, and Tencent (BAT)** – are well-positioned to capture this incremental data growth. With a combined market cap of more than US\$910bn, BAT has distinct datasets underpinned by their unique core offerings: search, ecommerce and social/gaming. In addition, BAT has grown the breadth of its offerings around their main businesses with online video and payments being the common elements (Exhibit 11).

BAT are equipped with comprehensive online ecosystems that are increasingly penetrating into most aspects of daily life of internet users in China. We expect information generated via online offerings will power the AI advances made by the companies.

### Exhibit 11: BAT data assets

Detailed discussions of each company's data assets can be found in the company section of this report

	Alibaba	Tencent	Baidu
Assets (data source)	Ecommerce & O2O Tmall, Taobao, Ele.me	Social/ Media Weixin/WeChat, QQ Messenger, Qzone, QQ Music, Tencent Literature	Search Web search and mobile search
	Finance/ Payment AliPay, Ant Financial, Paytm, Mynt, Kakao Pay, Ascend Money, MyBank	Finance/ Payment Tenpay, Weixin Payment, WeBank	O2O Nuomi, Baidu Takeout Delivery
	Social Weibo (31.0%)	Online games Tencent Games Platform / WeGame	Locations Baidu Map
	Location & logistics Cainiao, YTO, BEST Logistics, Amap (by Autonavi)	Ecommerce & O2O JD (18.1%), 58.com (23.2%), Meituan (15%), WeChat Mini Programs	Finance Baidu Financial Services Group (FSG), incl. consumer finance, Baidu Wallet payment, online insurance, etc.
	Video and others Youku, UC browser, Shenma	Video and others Tencent Video, Tencent map	Video and others iQiyi
Data type	Transaction & logistics data	Social networks data	Search data
	Payment data	Payment data	Location data
	Social networks data	Transaction data	Transaction data
Data usage	Targeted marketing	Targeted marketing (in both social/gaming assets) Customized feeds recommendation	Targeted marketing
	Personalized shopping experiences		Improved search results
	Credit score system		Baidu Brain
	Improved logistics efficiency		Public opinion monitoring
	Cloud solutions		

Source: Company data, Sina news reports.

## Infrastructure

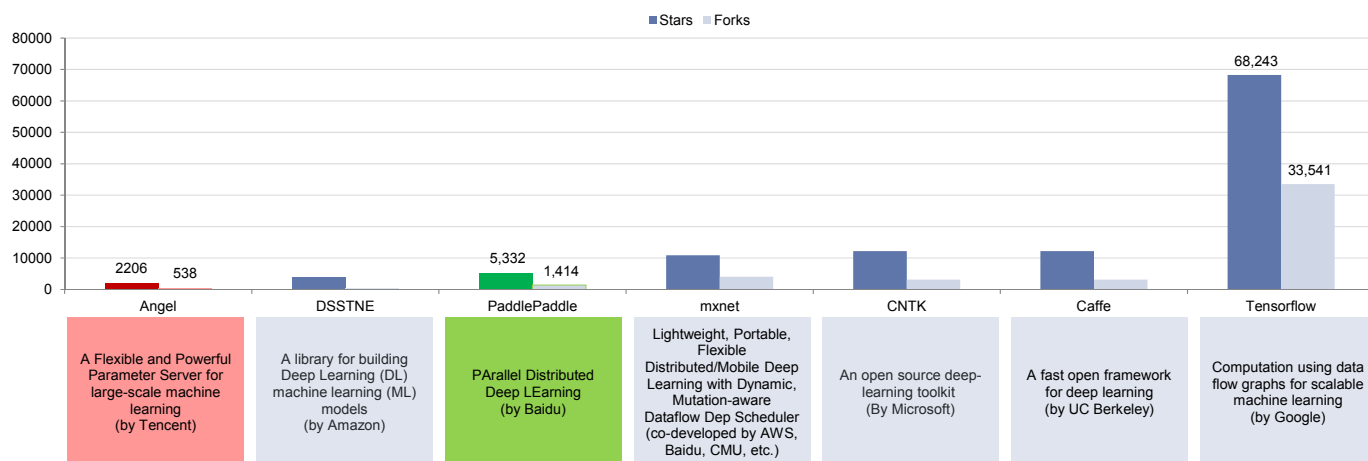
The large tech companies worldwide have open-sourced their deep learning platforms to attract both resources and talent into their ecosystems. Google open sourced its deep learning engine TensorFlow in November 2015, which has become the most popular platform for software engineers. Around the same time, Facebook also open sourced its AI software, Torch, and in early 2016 both Microsoft and Yahoo released their own AI software that could be used on multiple servers.

Following this trend, Baidu open sourced its ML platform **PaddlePaddle**, which stands for Parallel Distributed Deep Learning, in September 2016. PaddlePaddle is used by over 30 of its major products and services, covering technologies of various sectors such as search, image identification, speech semantic recognition, emotional analysis and user portrait recommendation.

In April 2017, Baidu also announced project **Apollo**, which launches an open, complete and reliable software platform for unmanned driving. Baidu's COO, Dr. Lu Qi, has called Apollo the Android of the autonomous driving industry, but one that is more open and powerful. This autonomous driving ecosystem platform now counts over 50 partners, including FAW Group, Chery, Changan and Great Wall Motors, as well as Bosch, Continental, Nvidia, Microsoft Cloud, Velodyne, TomTom, UCAR and Grab Taxi. FAW will work with Baidu on commercialization of the tech.

#### Exhibit 12: Baidu's open source platform vs. other popular platforms

Number of Stars and Forks on GitHub for popular open-sourced ML platforms



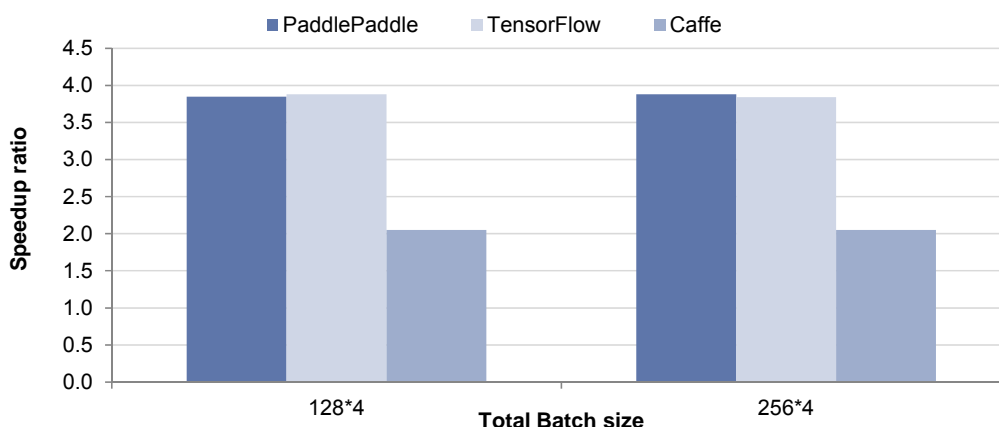
Note: Information as of August 29, 2017. GitHub Stars: Starring a repository allows you to keep track of projects that you find interesting, even if you are not associated with the project. GitHub Forks: A fork is a copy of a repository. Forking a repository allows you to freely experiment with changes without affecting the original project. CMU stands for Carnegie Mellon University.

Source: GitHub.

According to Xu Wei, the head of PaddlePaddle development, the ML tool provides simpler solutions vs. other platforms such as Amazon's DSSTNE and Microsoft's CNTK, and offers a simple on-ramp to deep learning, while also providing scalability (The Verge, September 1, 2016). In his view, easy-to-use quality is the key to achieving wider adoption of the technology, and PaddlePaddle has a quarter of the lines of code that its competitors have.

#### Exhibit 13: PaddlePaddle has similar scalability to that of TensorFlow

Benchmarking PaddlePaddle with other platforms on Speedup ratio with 4 GPUs



Note: with Total Batch size of 128 \* 4, speedup ratio is calculated by  $\text{time\_at\_1gpu\_batch\_128} * 4 / \text{time\_at\_4gpu\_total\_batch\_512}$ . The closer the Speedup ratio is to 4, the better the scalability of the platform.

Source: PaddlePaddle.

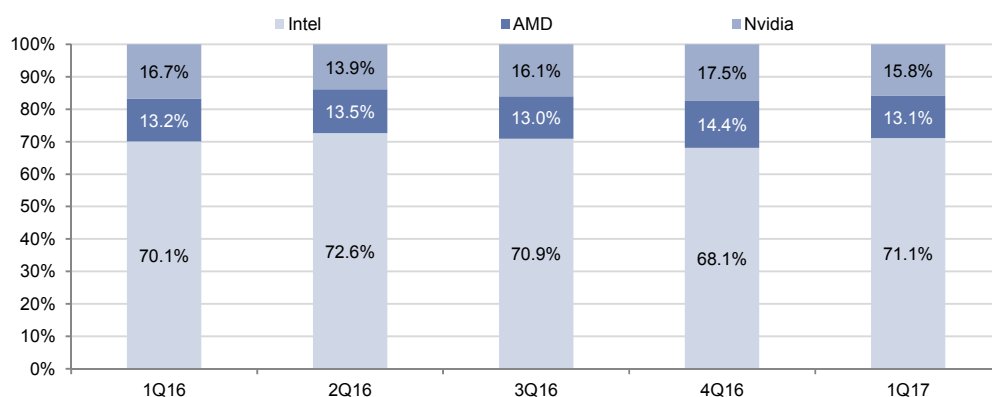
## Silicon

While a good AI algorithm can improve the efficiency in calculations, computing power is usually capped by the performance of the processing unit. The central processing unit (CPU) has been known as the brains of the computer where most calculations take place, yet it is in fact composed of a few cores with lots of cache memory that can only handle a few software threads at a time.

A graphics processing unit (GPU), on the other hand, consists of hundreds of cores through which parallel computing is possible. GPU was originally intended for display devices, yet in recent years GPU-accelerated computing has become mainstream, where the combination of CPU and GPU delivers computing power that is able to support the resource-intensive training of AI algorithms. The GPU industry, or the chips industry in general, has very high entry barriers that are dominated by three players globally – Intel, AMD and Nvidia.

### Exhibit 14: The GPU market is dominated by Intel, AMD and Nvidia globally

Total graphics chip market shares



Source: Jon Peddie Research.

In 2015, the US government banned Intel, along with other chip-making giants, from selling high-end processors to China, specifically Xeon processors, which are vital for high-performance computing needed for scientific research. Despite efforts to develop its own PC processors since early 2000 (two decades later than the US), China has been heavily dependent on foreign suppliers for chips. Nonetheless, we do see encouraging progress as evidenced by the rapid growth of local mobile chip makers such as HiSilicon Technologies.

On the research front, Sunway TaihuLight, a Chinese supercomputer, secured the No.1 place on the latest TOP500 list of supercomputers released at the ISC High Performance conference (ISC) held in Frankfurt, Germany in June 2017. Sunway TaihuLight is a system developed by China's National Research Center of Parallel Computer Engineering & Technology (NRCPC) and is installed at the National Supercomputing Center in Wuxi. According to top500.org, TaihuLight's Linpack performance of 93 petaflops makes it the most powerful processor on the planet. The No. 2 slot is occupied by Tianhe-2, (Milky Way-2), a system developed by China's National University of Defense Technology (NUDT) and deployed at the National Supercomputer Center in Guangzhou, China. Tianhe-2 has a Linpack mark of 33.9 petaflops, and it was the No. 1 system in the TOP500 list for three consecutive years before TaihuLight surpassed it in June 2016.

Although the progress of building an indigenous semiconductor industry has been slow in China, and the commercialization of supercomputers is yet to take place, we expect lower foreign dependency over time as the country moves forward in a supportive policy and market environment for technological innovations.



## Baidu.com Inc (BIDU): “All in AI”

### Scientists and research team at Baidu

**Dr. Qi Lu**, the former Microsoft Executive Vice President, joined Baidu as Group President and COO in January 2017 where he is responsible for products, technology, sales, marketing and operations. Dr. Lu earned a PhD in Computer Science from Carnegie Mellon University, and worked at IBM, Yahoo and Microsoft. At Yahoo, he managed a team of 3,000 engineers working on search. In 2008, he joined Microsoft to work on its search engine Bing, Skype and Microsoft Office.

**Dr. Andrew Ng**, adjunct professor at Stanford University and Co-founder and Chairman of Coursera, joined Baidu in May 2014 as the company's Chief Scientist, and he resigned in March 2017. Dr. Ng founded and led the Google Brain project at Google in 2011. In joining Baidu in 2014, Dr. Ng commented in his interview with the press that **“I thought the best place to advance the AI mission is at Baidu,”** (VentureBeat, July 2014). According to Dr. Ng, Baidu has much shorter product cycles, and is also well equipped with the capital (data and computation) needed for AI take-off.

**Baidu research** runs three dedicated labs globally with 2,000+ AI R&D engineers - **1) IDL:** Institute of Deep Learning; **2) BDL:** Big Data Lab in Beijing; and **3) SAVIL:** AI Lab in Silicon Valley, which were all founded during 2013-14, and have been publishing fundamental advances regularly. Recently on March 2, 2017, Baidu also reorganized its previous autonomous driving unit into **IDG:** Intelligent Driving Group, where its three major business units (autonomous driving, intelligent automobiles and internet of vehicle) were headed by the new Group President and COO Dr. Lu.

The research team at Baidu focuses on technology applications as well as fundamental research. The company's earlier fundamental research, on both neural machine translation and computer vision, has delivered application values.

### Data at Baidu

Baidu's data includes tens of millions of user labels, hundreds of millions of speech requests/ global PO/ daily location requests, billions of knowledge graphs/ voice transfers/ audio clips, and tens of billions of knowledge/search queries.

The ability to collect and understand the quantum of data enables Baidu to deliver targeted marketing services to advertisers, improve search results to users, and empower ML. The large datasets essentially drive innovation and feed Baidu's deep learning process. Baidu's DuerOS has also been able to collect a wide variety of consumer data, all of which will be available to its developers, lowering the threshold of technology innovation in a data-driven AI age, as per the Baidu AI developer conference in July 2017.

#### Exhibit 15: DuerOS consumer data examples

DuerOS Consumer Data		
190,000 Properties	48,000 Car Retailers	20,000,000 Songs
130,000 Flights	470,000 Trains	347,000 Hotels
1,500,000 Cars	1,200,000 Reviews	870,000 Novels
6,000 Funds	30,000,000 Short Videos	50,000 Weather Forecasts
30,000,000 Job Openings	15,000 Stocks	3,600,000 Restaurants
45,000 Attractions	1,000,000 Games	2,800,000 Artists

Source: Company data.

## AI at Baidu

AI is pervasive throughout Baidu's business lines – its major products such as search, advertising, translation and O2O (Online-to Offline) services including restaurant recommendations all adopt AI technology for better performance. The company owns a super massive neural network built upon hundreds of thousands of servers, and it also has the largest GPU group in China.

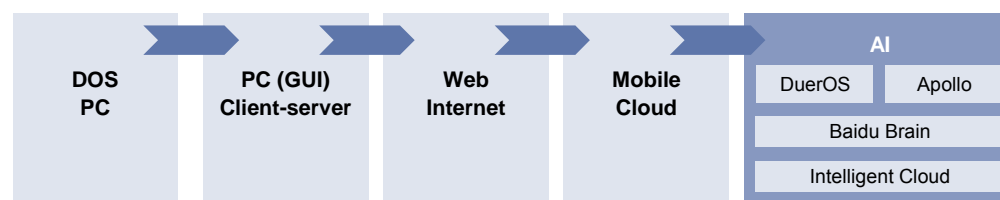
In Baidu CEO Robin Li's Feb 2017 internal letter to employees (publically available online) titled "Embracing the New Era", he identified four area of focus for Baidu – content distribution, connecting services (e.g., O2O), financial innovation, and AI. Specifically on AI, Li expects opportunities to come from:

- 1) **Integration of software and hardware**, as evidenced by Amazon's success with smart speaker Echo. Baidu launched AI digital assistant Little Fish in CES 2016, and the company is also providing DuerOS to its partners to develop smart home devices such as intelligent fridge and TV.
- 2) **Development in vertical industries**. The CEO mentioned the healthcare industry, where Baidu's AI doctor is becoming more useful for patients. He also envisioned a future where Baidu's AI could reach the average level of a professional physician and assist doctors in diagnosis. Applications of AI should include gene sequencing, new drug development, logistics, retail, and sales and marketing.

Specifically on Baidu's AI strategy, Dr. Lu Qi noted that the company will focus on the commercialization of AI technology across its AI-enabled new business initiatives - cloud, financial services, autonomous driving and DuerOS, all of which have the potential to become Baidu's core businesses.

### Exhibit 16: Baidu has the key assets needed to capture the opportunities in the AI era

Evolution of the internet Age



Source: Company data.

### Exhibit 17: Baidu ABC - AI, Big Data, Cloud

Baidu Brain	A	Platform layer	Open AI Platform		
		Cognition layer	NLP	Knowledge graph	User profile
		Perception layer	Voice	Image	Video AR/VR
		Algorithm layer	Machine Learning Platform	Deep Learning	
Intelligent Cloud	B	Big Data	Big Data Analysis	Data labelling	Data Collection
	C	Cloud	Computing Services, CPU/GPU/FPGA	Storage Services	Network Services

Source: Company data.

a) **Baidu Intelligent Cloud** consists of AI and Big Data, i.e., ABC - AI, Big data, Cloud computing, according to Dr. Lu at Baidu Create 2017. During Baidu's ABC Summit on November 30, 2016, the company laid out an Rmb10bn (US\$1.5bn) "Yuntu" plan to build

an influential cloud technology ecosystem, in which Rmb2bn will be spent on Baidu's core technologies, Rmb3bn on Baidu Pay-Per-Click (PPC) advertising, and the remaining Rmb5bn on funding cloud projects. Additionally, Baidu launched its AI platform "Tianzhi" to expand the commercial usage of cloud. In July 2016, three new platforms were also newly launched for Baidu Open Cloud customers:

- **Baidu TianSuan:** Intelligent Big Data platform that offers fully managed big data services and cognitive APIs where enterprise users can collect, store, process and analyze big data. Built-in solutions of the platform cover verticals such as healthcare, marketing and finance.
- **Baidu TianXiang:** Intelligent Multimedia Cloud that offers video, image and document processing services (including AI-based technologies), such as live streaming and video-on-demand.
- **Baidu TianGong:** Intelligent IoT (Internet of Things) Service offers full-stack, one-stop and smart IoT services for users in industries such as energy, logistics, automotive and retail.

Baidu also announced on July 5, 2017 that it will implement Xilinx FPGA-based circuits for application acceleration in its public cloud. The new Kintex tools and software will be dedicated to the development and deployment for hardware-accelerated data center applications such as ML and data security. Baidu's FPGA Cloud server will provide a complete hardware and software development environment with code examples, helping developers achieve rapid development and migration. According to Baidu Cloud's manager, Liu Yang, FPGA-based solutions provide a powerful performance for deep learning, inference and other high-speed data center applications.

**b) Baidu Brain** serves as the core engine of Baidu AI and has facilitated the development of many Baidu technologies including voice and image recognition, natural language processing and user profiling (for more details on the Baidu Brain, see *China, Technology: Internet: Big is better – raising target prices, still bullish; Alibaba CL-Buy*, October 24, 2016).

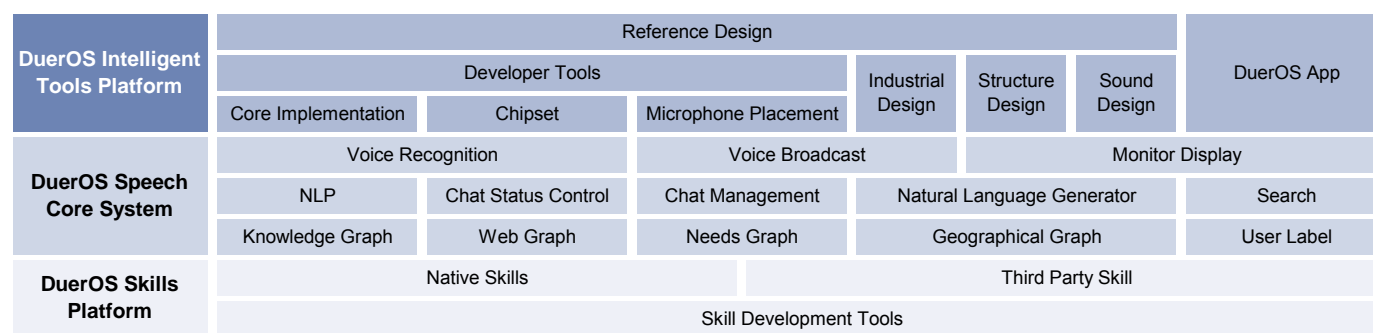
**c) DuerOS** is an AI conversational platform that empowers voice interface in various smart devices both at home and on the go (e.g., phones, smart speakers, robots, TVs, cars, wearables, etc.). Baidu partners with many consumer electronics and appliances brands in product design, and DuerOS's technology is also open to developers.

As illustrated by Dr. Lu in Baidu Create 2017, the key elements of DuerOS that enable human device interaction are:

- **Accurate listening**, which is of crucial importance as the first step of the interaction. DuerOS is equipped with the Deep Speech 2 speech recognition system. Ranked as one of the Top 10 Breakthrough Technologies in 2016 by MIT, Deep Speech 2 incorporates noise reduction technology and has achieved 97% recognition accuracy.
- **Understanding** the "freestyle" of user comments has been the goal of DuerOS. Baidu aims to provide seamless user experiences in which buzzwords and trendy slang can also be used in commands, not just an interactive system that can only understand certain predefined words. Baidu's skill in this area is supported by its large data assets as well as its market-leading technologies including Natural Language Processing and search (keyword queries, voice queries, etc.).
- **Fulfilling** customer needs with the technical ability that offers comprehensive content and services. Baidu houses 10 general categories of use cases of interactive conversations including entertainment, information inquiry, chat and leisure, O2O, smart home, travel/transportation, utility tools, phone instructions, personal assistant, and education. There are 100+ sub-categories, and the content and services DuerOS provides also grow rapidly on a daily basis.

DuerOS, as an open-sourced software, also significantly reduces the development cycle and debugging time when compared to other options. For instance, an Alexa-equipped Raspberry Pi system (from the Raspberry Pi Foundation) only needs one minute to migrate to DuerOS as demonstrated by Baidu during Create 2017. A similar process as this, according to the company, would normally require 5 people to develop and 3-6 months to debug. This brings great opportunities for developers/product manufacturers targeting the Chinese market. As an example of the product's flexibility and easy access, Baidu Create 2017, the inaugural AI Developer conference, showcased a software engineer who uses a DuerOS chip to turn a LEGO robot into a toy that can talk to his nephew.

#### Exhibit 18: DuerOS infrastructure



Source: Company data.

#### d) Apollo: Security, reliability and real-time control

Baidu's open innovation ecosystem has been extended to autonomous driving, with the launch of project **Apollo** at the Shanghai Auto Fair in April 2017. According to Baidu, Apollo will launch an open, complete and reliable software platform for unmanned driving and the auto industry (Apollo 1.0 is already on GitHub). Baidu expects sharing resources to accelerate industry innovation, empower business partners, and hence achieve mutual benefits. Together with the project, the company plans to **introduce fully autonomous driving capabilities on highways and urban roads by 2020**.

#### Exhibit 19: Baidu targets highway and open road autonomous driving capability by 2020

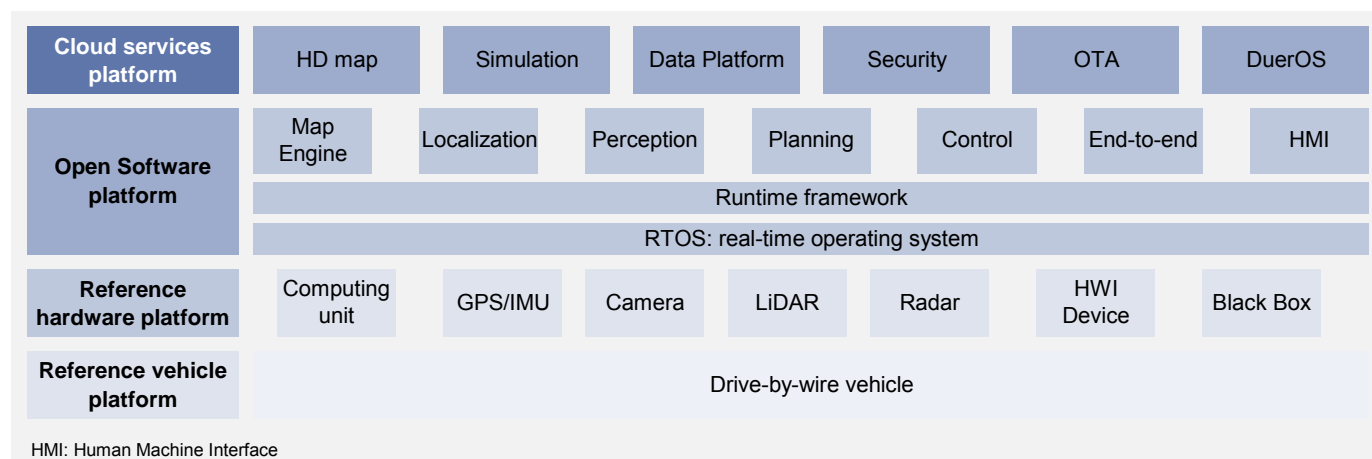


Source: Company data.



As the initial release of the platform, Apollo 1.0 has a highly extensible and high performance framework, and an off-the-shelf, ready-to-use reference vehicle and hardware that support closed venue autonomous driving. The whole Apollo architecture has many other elements as illustrated in Exhibit 20, and Baidu will gradually open-source its technologies over time.

**Exhibit 20: Apollo architecture**



Source: Company data.

#### Highlights of Apollo components:

- **Rout planning and navigation** is based on real-time data (such as traffic conditions and speed limit) and AI decisions. The feature adopts experienced drivers as deep learning references and practices defensive driving.
- **Open data platform** provides a 3D point cloud to detect and classify obstacles as pedestrians, motor vehicles, non-motor vehicles and others. A traffic light, for example, is detected through different weather at 1080P.

**Exhibit 21: Detection efficiency achieved by Apollo technology**

	Recognition rate	Accuracy rate
Lane line	95.72%	96.59%
Guard rail	97.48%	99.03%
Road side	98.87%	99.01%
Traffic sings	96.04%	93.35%

Source: Company data.

- **DuerOS** provides a comprehensive voice-based in-vehicle interaction solution including navigation, virtual Q&A assistant, personalized audio content recommendations, etc.
- **Localization** combines GPS, IMU and high definition map with a variety of AI-imbedded sensors. Based on different usage scenarios, the integrated product can be customized with software and hardware while minimizing costs and having adjustable precision. The first phase of Apollo will provide waypoint autonomous driving capability with control accuracy that can reach down to 10cm.
- **Security** safeguards network, OS, and cloud so that each component is secure. For instance, there is on-vehicle firewall to prevent hacking and defends from

untrustworthy commands, and over-the-air functionality to guard against hacking during updates.

- **Simulation** leverages Apollo's vast collection of data to simulate real world traffic and driving scenarios. This feature allows millions of kilometers of virtual driving on a daily basis, which accelerates tests, validations, updates and optimizations, shortening the whole R&D cycle of autonomous driving.

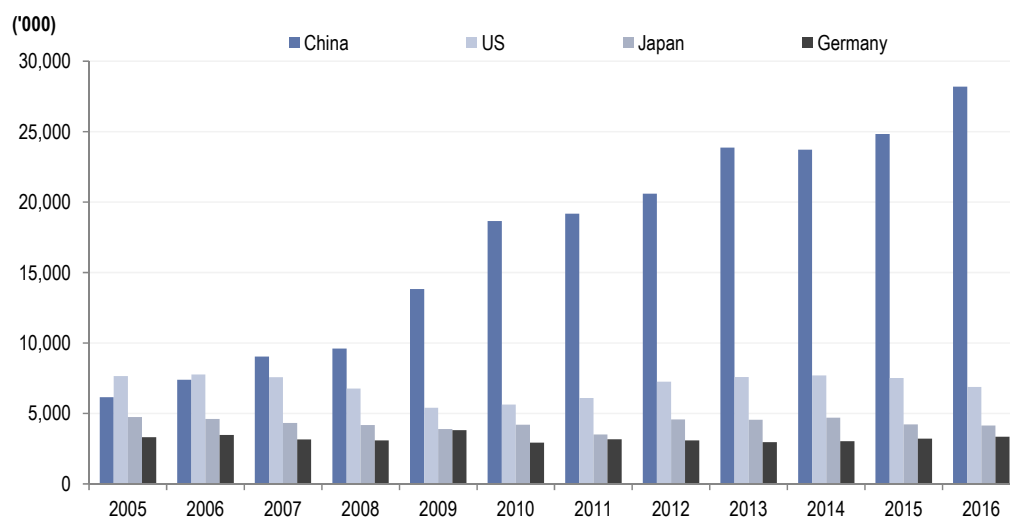
**On monetization path** for Apollo, we think it could be similar to that of Android for Google, via incremental revenue from four distinct areas:

- 1) Advertising, from revenue captured by Baidu's own apps including search and video. In our base case these are captured in our estimates for Baidu, and impact the multiple we assign to the business in 2020.
- 2) App download, and app related recurring fee. Though contribution is likely to be minimal by 2020, this could be a significant revenue source for the platform in the 2020-2025 period. Apple for instance in China charges 30% of the total revenue generated on the platform, which has made China its largest app platform.
- 3) High definition mapping services, which we estimate is a US\$1bn and US\$2.5bn revenue opportunity by 2020 and 2025, respectively.
- 4) Camera vision software, a US\$370mn and US\$1.6bn revenue opportunity in 2020 and 2025.

We expect Apollo to facilitate innovations in autonomous driving around Baidu's collaborative ecosystem, and we believe the platform is of importance to the high entry barrier autonomous driving industry. Under Apollo, car manufacturers will be able to run with different intelligent driving scenarios, potentially shifting manufacturing as the center for the auto industry to data and algorithms.

**Exhibit 22: China has the largest auto market globally, and Dr. Lu expects China to achieve a leading position globally in autonomous driving in three to five years**

New passenger car sales volume



Source: Wind, OICA

**Exhibit 23: Apollo is building its ecosystem with 50+ partners**

The partners include OEMs, component providers, research institutes, local governments, etc.



Source: Company data.

Apollo competes with the other AV ecosystems including Google's Waymo (which was formed seven years ago and counts Chrysler as its partner), Uber, BMW and GM.

**Baidu valued at US\$326 by 2020E**

Our 12-month SOTP-based valuation for Baidu is US\$240. We apply a 15X multiple to its core search segment, which we forecast will grow at 20% per year. We model search revenue growth based on AI use in processing search results, with results that are the most relevant based on big data and the user's search history for higher-paid traffic growth. All else being equal, removing the holding company discount yields an implied value of US\$326 per share valuation by 2020E.

**Exhibit 24: Our 12-month SOTP valuation for Baidu is at US\$240**

Based on 45% operating margin and 15X average 2018/19 NOPAT for the core search business

#	Segment (US\$mn)	Average 18/19 Rev	NOPAT	PE (x)	Val.	Baidu's stake	To Baidu	\$/share	Value split	Comment
1	<b>Core Search</b>	<b>11,244</b>	<b>4,048</b>	<b>15</b>	<b>60,716</b>	<b>100%</b>	<b>60,716</b>	<b>170</b>	<b>64%</b>	At 45% op margin, 20% tax rate, 15x PE
2	O2O- Nuomi, food delivery	1,328			2,534		1,574	4	2%	0.15x GMV
3	Video - iQiyi				11,554	81%	9,301	26	10%	3x revenue
4	Travel - Ctrip				30,204	21%	6,343	18	7%	At market cap
	Net cash						15,501	44	16%	Average 2018/19E Net Cash
	<b>NAV</b>						<b>95,009</b>	<b>267</b>	<b>100%</b>	
	less holdco discount					10%	9,501	27	-	Capital allocation, uncertainty risk lower
	<b>Total (US\$mn)</b>			<b>21.1</b>			<b>85,508</b>	<b>240</b>		
	#s of diluted shares						356			ave. 2018E/19E

Note: Key risks include slower recovery in search business; weaker macro.

Source: Company data, Goldman Sachs Global Investment Research.

**Exhibit 25: Baidu 2020, SOTP HK\$326 – assuming AI drives Baidu to attain traffic growth of 15%**

Based on 45% operating margin and 15X average 2020 NOPAT for the core search business, Paid Clicks and CPC 2017-2020E CAGR of 17%/1% respectively, excluding holding company discount

#	Segment (US\$mn)	2020	NOPAT	PE (x)	Val.	Baidu's stake	To Baidu	\$/share	Value split	Comment
1	<b>Core Search</b>	<b>14,106</b>	<b>5,078</b>	<b>15</b>	<b>76,172</b>	<b>100%</b>	<b>76,172</b>	<b>213</b>	<b>98%</b>	At 45% op margin, 20% tax rate, 15x PE
2	O2O- Nuomi, food delivery	1,703			1,065		665	2	1%	0.05 2020E GMV
3	Video - iQiyi				12,769	81%	10,279	29	13%	2.5x 2020E revenue
4	Travel - Ctrip				30,204	21%	6,343	18	8%	At market cap
	Net cash						22,762	64	29%	2020E net cash
	<b>NAV</b>						<b>116,884</b>	<b>326</b>	<b>150%</b>	
	less holdco discount					0%	-	-	0%	Capital allocation, uncertainty risk lower
	<b>Total (US\$mn)</b>			<b>19.5</b>			<b>116,884</b>	<b>326</b>		
	#s of diluted shares						358			2020E

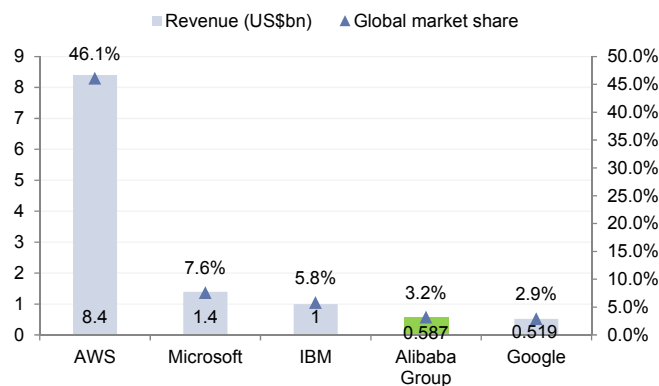
Source: Company data, Goldman Sachs Global Investment Research.

## Alibaba (BABA): A world-leading use case for AI

Alibaba's gigantic ecommerce business size (US\$547bn GMV in FY17, 175k transactions/second at the peak during the 2016 Singles' Day shopping festival) imposes high standards for real-time security, processing capacity as well as system stability and reliability, making the company one of the largest use cases for AI globally.

**Exhibit 26: AliCloud ranked 4<sup>th</sup> in the world**

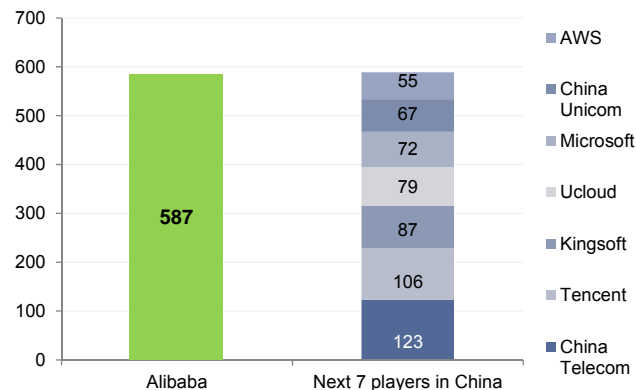
By revenue in the Global Cloud market of IaaS



Source: IDC Tracker 2016H1/H2.

**Exhibit 27: AliCloud's IaaS revenue is equivalent to the next seven players in China at a 40.7% market share**

In US\$mn



Source: IDC Tracker 2016H1/H2.

AliCloud had 1mn paying customers at June 2017 across a wide range of industries such as media, internet, finance, government, energy, e-commerce, manufacturing, healthcare, gaming and retail. With 15 data centers across the world, the company provides over 186 cloud solutions (as of end-May 2017), catering to various verticals' needs. According to the company, 1/3 of the top 500 companies and 2/3 of the unicorn companies in China are on AliCloud. The retention rate of the top paying customers of AliCloud in FY17 vs. FY16 was 96.7%, indicating its premium services quality.

### Apsara: AliCloud's independently developed super computational system

Apsara is the cornerstone of Alibaba's technology innovations with its core competence in data processing and computing. The technology's value proposition is to lower costs significantly and make enterprises more responsive by improving enterprise IT system responsiveness. Apsara enables business transformation, operation optimization, employee empowerment, and user experience improvement. It services enterprises in more than 200 countries and regions.

The processing platform developed on Apsara supports hundreds of thousands of concurrent transactions per second with high scalability, and offers safe, convenient and personalized shopping experiences to hundreds of millions of customers. During the 2016 Singles' Day event, AliCloud processed a total of 175k/120k (+25%/40% yoy) transactions/payment per second at the peak.

For AliCloud's external clients such as Sinopec Group, AliCloud helped the client to launch China's first e-commerce platform for the petrochemicals sector, epec.com. In a one-year pilot period before its official launch in April 2016, the platform recorded total transactional value of US\$2.1bn, across its 25,647 suppliers, 1,615 buyers and 93k registered users, and 152k goods.

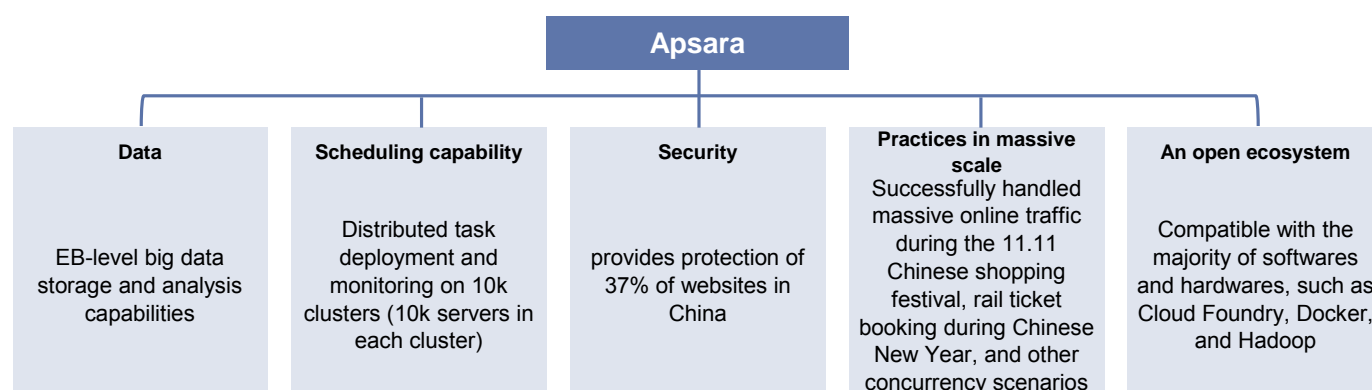


**Exhibit 28: Apsara, Aliware – the cornerstone of Alibaba's technology innovations**

Enabling Platform		Apsara Platform
Shared Services	Aliware Enterprise-Class Internet Architecture Platform	Virtualization, big data computing, security, etc.
User center	EDAS: Enterprise Distributed Application Service	IDC1
Commodity center	MQ: Message Queue	IDC2
Transaction center	DRDS: Distributed Relational Database Service	IDC3
Evaluation center	ARMS: Application Real-Time Monitoring Service	IDC4
Store center	CSB: Cloud Service Bus	
Search center		...
Marketing center		IDCn
...		

*Note: IDC stands for Internet Data Center.*

Source: AliCloud, MIT Technology Review.

**Exhibit 29: Apsara: The super computational system of Alibaba**

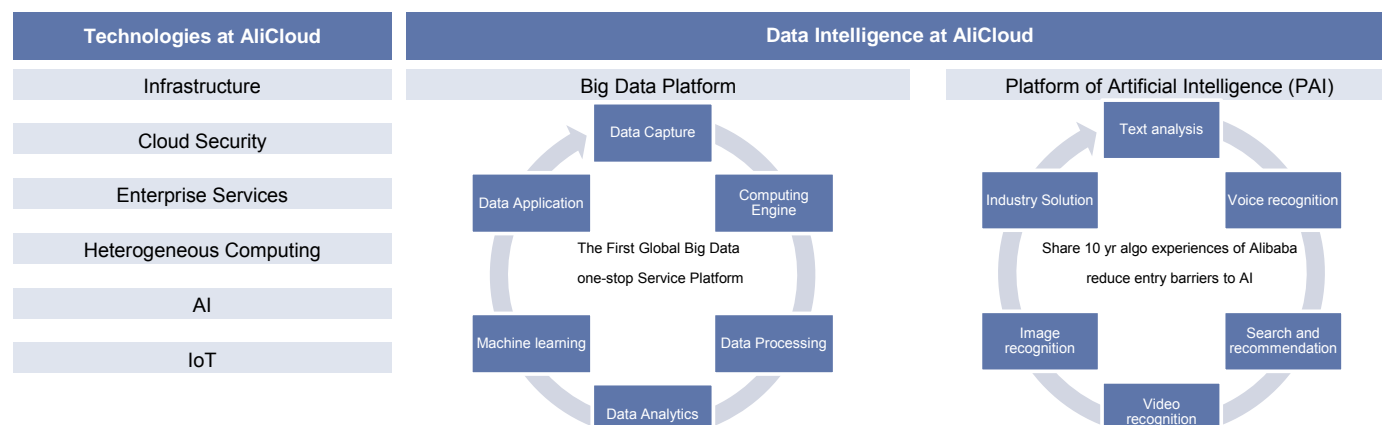
Source: Company data.

Some Intelligent products by AliCloud include:

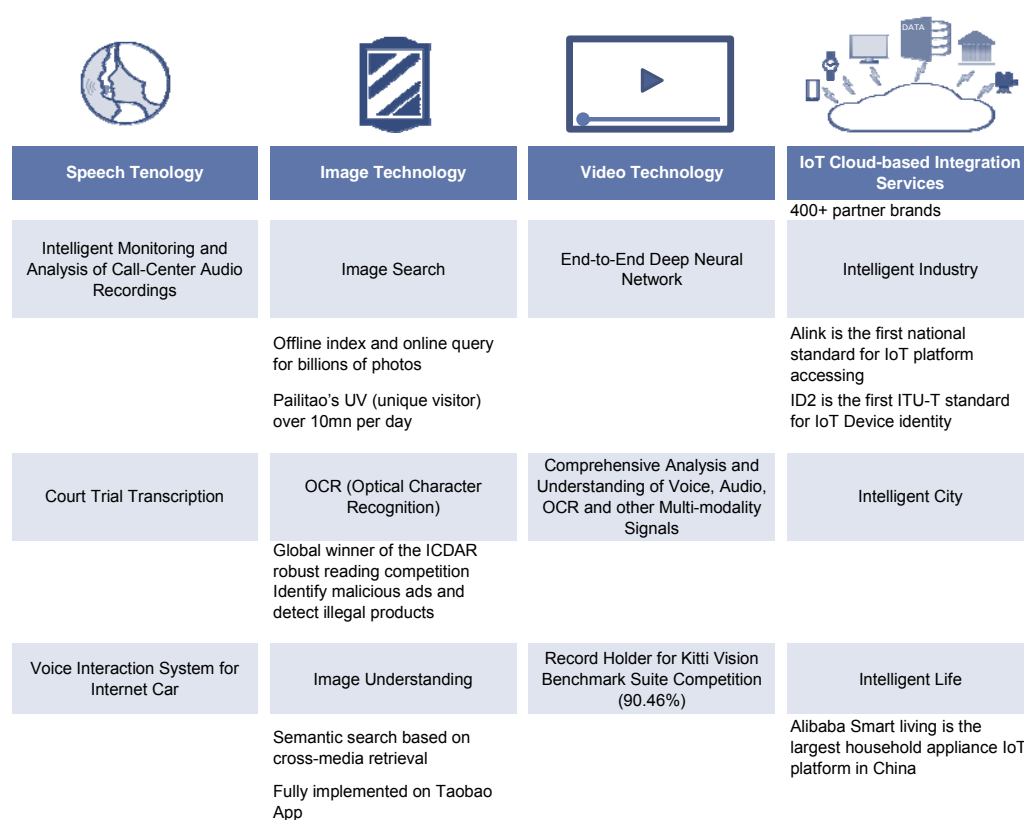
- **City's Intelligent Eye:** The accuracy rate of vehicle detection of City's Intelligent Eye reached 90.46%, breaking the world record for visual ML algorithm on platform KITTI.
- **ET City Brain for Hangzhou:** It now takes an average of 15 minutes for police to respond to traffic collisions, contributing to ~30% of traffic congestion; with Alibaba's City Brain, it only takes 3 minutes for police to arrive on site.
- **ET industrial brain** for XCMG, a Chinese multinational government-owned heavy machinery manufacturing company in China.
- **ET Medical brain:** Alibaba worked with Zhejiang University to improve the accuracy rate of thyroid nodular diagnosis with ~15% higher accuracy achieved by computers vs. human doctors.
- **ET Environment Brain (ETEB):** AliCloud launched ETEB, a technical solution for the global environment. Currently, ETEB can intelligently monitor pollution of water, air, and soil in Jiangsu Province. ETEB has provided 131 warnings to local governments at 93% accuracy, and helped them manage over 25k enterprises. Backed by AliCloud Apsara's computing power and rich AI algorithms, ETEB is expected to be helpful in disaster forecasting, extreme weather warning, and environmental protection.

**Exhibit 30: Technologies and data intelligence at AliCloud**

Data Intelligence has been the most important strategy for AliCloud since last year



Source: Company data.

**Exhibit 31: AI-related technology at AliCloud**

Source: Company data.

## Data at Alibaba

**Alibaba's technology is built on data.** The amount of data processed daily at Alibaba is equivalent to the size of 20mn HD movies, and it has as much as 8.27bn daily internal data access calls at the peak. The scale of online marketing revenue of Alibaba also suggests that the world's largest retailer on GMV is a data company. The company's networks cover almost 80% of the Chinese internet users, and customers use Alibaba's service at a high degree of frequency - 25min daily time spent and 7.2X daily launch of Taobao mobile app per active user on average. As a result, Alibaba is able to collect 500mn+ real demographic information and differentiate users with 8,000+ purchase intentions and location-based attributes.

Alibaba provides targeted marketing for merchants, personalized shopping experience for users and improved efficiency for its logistics partners. Alibaba combines its large database with strong capabilities in data mining and cloud computing. For instance, if a user searches for golf clubs on the platform, his actions on the search product list (e.g., what price range of the golf club he chooses or the brand he clicks the most into) also decides what he will see on the next list; and all those personalized lists are created within seconds.

In addition to valuable data generated from its own business lines, Alibaba also strengthens its network with its strategic partners. As the company recently extended its footprint into India, Korea, and all of ASEAN (Exhibit 32, or see more in *The Asia Stock Collection (Alibaba): The Power of Personalization*, published on February 27, 2017), we believe Ant Financial, BABA's finance arm, is on track to be **the world's largest fintech company**. The payment data of the company is substantiated by 717mn shoppers (454mn active online buyers in China, 83mn outside China on Lazada/Alibaba, and 180mn Paytm users in India as of end-March 2017), and a total of 3.2bn population in coverage (1.4bn in China, 1.3bn in India, and 560mn in ASEAN).

Alibaba's ecommerce associates globally are following the same model that its parent/principal shareholder has followed back in China. Lazada is hiring a team of data scientists, while Paytm's scientists are based at Paytm Labs in Toronto from where the technology driving the fastest-growing paying app is being managed.

### Exhibit 32: Alibaba/Ant Financials global footprint in payment

#### Paytm, India

India is an ecommerce market that will change significantly in a year or two. Alibaba is not only interested in the small ecommerce market, but also the larger Indian retail market which is forecasted to reach US\$1.3 trillion by 2020.

#### Mynt Financial, Philippines

Ant Financial along with Ayala Group jointly acquired 45% of Mynt in Philippines while Globe Telecom, which has 58.6mn mobile subscribers as of 1Q17, owns 55% – SingTel is Globe's largest shareholder with 47% holding. Mynt is currently the biggest mobile money base in the Philippines with 3mn+ customers and P1 bn in weekly transactions. Mynt operates GCash and Fuse Lending:

GCash is a micropayment service used to load on a prepaid mobile SIM, pay bills, send money or shop online.

Fuse Lending offers personal and business loans to the underserved Filipinos using smartphones, alternative data, and an innovative credit scoring methods.

#### Kakao Pay, Korea

Ant Financial invested US\$200mn in Kakao Pay, which is owned by Kakao, Korea's dominant messaging service. Kakao Talk has 42mn users in Korea and 7mn users outside of Korea (as of 1Q17), and 99.2% of people aged 6 or above use Kakao Talk in Korea. Kakao could assist BABA expand its Korean coverage, and Kakao Pay – which allows over-the-counter payments, peer-to-peer transactions, bill payment, web banking and more – will move to offer financial services such as loans and financing.

Ascend Money in **Thailand**, a part of the Charoen Pokphand Group, and M-DAQ in **Singapore** are Ant's other investments in ASEAN.

ANT has reached an agreement to acquire US payments firm MoneyGram for US\$1.2bn, amid negative feedback from political figures in the U.S. (as per CNN, Apr 17, 2017). Both parties anticipate that the deal will be complete within the second half of the year. MoneyGram is the world's 2<sup>nd</sup> largest money transfer company with 1Q17 revenue of US\$386mn, where non-US is 44%, US outbound 43% and US domestic transfers 13%. The company earns adjusted EBITDA margins of 17.2% in 1Q17. The company operates via 33k ATMs/kiosks and 350k agent locations, and has a presence in 200 countries.

Source: Company data, Sina news reports.

**Exhibit 33: Ant Financial on track to be a Fintech global leader**

Stats below for Alipay do not factor in Paytm

Payment		Wealth Management		Financing		Insurance		Credit System	
Alipay	Paypal	ANT Fortune	Charles Schwab	ANT Check Later	China Merchants Bank	ANT Insurance Service	Ping An Group	Sesame Credit	FICO US Credit Account
520mn	203mn	300mn	10.2mn	100mn	46mn	392mn	131mn	257mn	180mn
Annual Active Users	Active Accounts	Cumulative Users	Active Accounts	Annual Active Users	Credit Cards in Circulation	Annual Active Users	Active Users	Annual Active Users	Number of Accounts
+15% YoY growth		+17% YoY AUM growth per active user		73% use Ant Credit Pay 6+ yearly		+43% YoY premium growth per user		+95% YoY growth	

Note: Ant Financial and Paypal data are as of Mar 31, 2017; the rest are as of Dec 31, 2016. Ant Check Later, or Huabei, provides consumer credit loans.

Source: Company data.

**Exhibit 34: Our 12-month SOTP valuation for Alibaba is US\$208**

in US\$ mn	Description	FY19E rev.	NOPAT	PE	Value To BABA	Value to BABA	US\$/sh	% of NAV	Comment
<b>A. CORE</b>									
1	China commerce	35,959	15,822	25	395,550	100.0%	395,550	149.9	72%
2	International commerce	4,903			34,967	98.2%	34,349	13.0	6%
	Lazada	1,770			3,638	83.0%	3,019	1.1	1%
	Others	3,133	1,253	25	31,329	100.0%	31,329	11.9	6%
3	Youku Tudou	3,280			10,498	100.0%	10,498	4.0	2%
4	Cloud Computing, other	6,580			76,103	100.0%	76,103	28.8	14%
	Cloud Computing	4,578			64,090	100.0%	64,090	24.3	12%
	Other (incl. UC Web, Autonavi)	2,002			12,013	100.0%	12,013	4.6	2%
<b>Total, Core</b>							<b>516,499</b>	<b>195.7</b>	<b>94%</b>
<b>B. Associate/investments</b>									
1	Ant Financial				68,568	33.0%	22,627	8.6	4%
	SME lending			100%	19,917	33.0%	6,573	2.5	1%
	Payment			100%	22,771	33.0%	7,514	2.8	1%
	Other financial products			100%	8,538	33.0%	3,522	1.3	1%
	Koubei			50%	8,000	16.4%	1,309	0.5	0%
	Ele.me			7.8%	4,513	2.6%	116	0.0	0%
	PayTM			20.0%	4,830	6.6%	319	0.1	0%
2	Koubei				8,000	49.6%	3,968	1.5	1%
3	Cainiao				6,189	47.0%	2,909	1.1	1%
4	YTO				7,756	11.1%	860	0.3	0%
5	Didi Chuxing	13,160			50,000	8.5%	4,250	1.6	1%
6	Weibo				20,497	31.0%	6,354	2.4	1%
7	Alibaba Health				3,976	38.0%	1,511	0.6	0%
8	Alibaba Pictures				4,315	49.5%	2,136	0.8	0%
9	Intime Retail				4,060	73.7%	2,993	1.1	1%
10	Suning				16,772	20.0%	3,353	1.3	1%
11	Ele.me				4,513	19.9%	900	0.3	0%
12	Evergrande Football Club	920	(622)	(4.7)	2,920	37.8%	1,104	0.4	0%
13	Singapore Post	1,810	45	47.1	2,111	14.4%	304	0.1	0%
14	Meizu				3,933	15.0%	590	0.2	0%
15	Magic Leap				5,827	1.7%	100	0.0	0%
16	PayTM				4,830	20.0%	966	0.4	0%
17	Momo				8,812	4.3%	382	0.1	0%
18	Shiji Technology				3,823	13.1%	500	0.2	0%
19	Sanjiang				1,480	9.3%	138	0.1	0%
<b>Total Assoc./Inv.</b>					<b>228,382</b>		<b>55,945</b>	<b>21.2</b>	<b>10%</b>
<b>C. Net cash</b>									
							37,524	14.2	7%
<b>Total</b>							<b>609,968</b>	<b>231.1</b>	<b>111%</b>
<b>D. Less holdco discount</b>									
							60,997	23.1	11%
<b>NAV</b>							<b>548,971</b>	<b>208.0</b>	<b>100%</b>
#s of diluted shares							2,639		

Note: Key risks include slower GMV growth, lower monetization, competition.

Source: Company data, Goldman Sachs Global Investment Research.

**"Fully loaded 2020 valuation"**

Alibaba has been able to convincingly decouple GMV and China retail revenue growth by changing the search product listing algorithm in September 2016. As a result, customer management revenue (previously online marketing) yoy growth reaccelerated to 65% in 2Q17, vs. 46%/54% a quarter/year ago. We believe that if Alibaba were to continue improving its algorithms to drive better search results for customers and higher ROI ad placement for merchants, the effective take rate for China retail (China retail revenue / China retail GMV) could reach 5%. Without a holdco discount, the SOTP-based implied value on FY21 estimates would rise to US\$352.



**Exhibit 35: Alibaba, 2020; AI driven, fully "loaded", no holdco discount, 2020 SOTP implied value at US\$352**

in US\$ mn	Description	FY21E rev.	NOPAT	EV / Rev.	PE	Value	To BABA	Value to BABA	US\$/sh	% of NAV	Comment
<b>A. CORE</b>											
1	China commerce	Taobao, Tmall	59,629	26,237	8.8	20	524,738	100.0%	524,738	195.4	56% 55% op margin, 20% tax rate, 20x P/E
2	International commerce	Lazada	8,101		6.2		50,398	98.4%	49,569	18.5	5%
		ASEAN ecomm.	2,411		2.0		4,878	83.0%	4,049	1.5	0% DCF
		Others	5,690	2,276	8.0	20	45,520	100.0%	45,520	16.9	5% 40% net margin, 20x P/E
3	Youku Tudou	Online video	4,447		3.4		14,991	100.0%	14,991	5.6	2% DCF
4	Cloud Computing, other		18,519		10.9		202,205	100.0%	202,205	75.3	21%
	Cloud Computing	Aliyun	11,387		12.0		159,411	100.0%	159,411	59.4	17% 12x revenue
	Other (incl. UC Web, Autonavi)		7,132		5.0		42,794	100.0%	42,794	15.9	5% 5x revenue
	<b>Total, Core</b>							<b>791,503</b>	<b>294.7</b>	<b>84%</b>	
<b>B. Associate/investments</b>											
	<b>Total Assoc./Inv.</b>						<b>233,543</b>		<b>55,982</b>	<b>20.8</b>	<b>6%</b> As in base case
<b>C. Net cash</b>											
									<b>97,781</b>	<b>36.4</b>	<b>10%</b>
<b>D. Less holdco discount</b>											
	<b>NAV</b>								<b>945,267</b>	<b>352.0</b>	<b>100%</b>
	Spot								<b>472,163</b>	<b>175.8</b>	<b>49.9%</b>
	#s of diluted shares								<b>2,686</b>		

Source: Company data, Goldman Sachs Global Investment Research.

**Exhibit 36: Alibaba's valuation sensitivity to take rate**

	CY18-19 ave.	FY21			
	Current	Base case	Potential	Bull case 1	Bull case 2
Monetization rate sensitivity					
Take rate		4.2%	5.0%	6.0%	8.0%
China retail revenue		326,311	387,676	465,211	620,281
China wholesale		11,841	11,841	11,841	11,841
Other		178,354	178,354	178,354	178,354
Total rev		516,505	577,870	655,405	810,476
Operating profit, non-GAAP		226,805	263,624	310,145	403,187
Other income		7,909	7,909	7,909	7,909
Pretax		234,713	271,532	318,053	411,096
Tax		(51,662)	(59,766)	(70,005)	(90,484)
MI, Other		(229)	(229)	(229)	(229)
Net profit, non-GAAP		182,822	219,641	266,162	359,205
EPS		68.1	81.8	99.1	133.7
EPS (US\$)		10.16	12.21	14.79	19.96
# of shares		2,686	2,686	2,686	2,686
Valuation					
1 China Commerce					
Multiple x	25	20	20	20	20
Tax rate	20%	20%	20%	20%	20%
OPMG	55%	55%	55%	55%	55%
Valuation	395,550	444,140	524,738	626,576	830,250
2 International					
	34,349	49,569	49,569	49,569	49,569
3 Youku					
	10,498	14,991	14,991	14,991	14,991
4 Cloud, other					
	76,103	202,205	202,205	202,205	202,205
Core	516,499	710,905	791,503	893,340	1,097,015
5 Assoc./Investment					
	55,982	55,982	55,982	55,982	55,982
EV	572,482	766,887	847,486	949,323	1,152,997
6 Net Cash					
	37,524	97,781	97,781	97,781	97,781
EQ value	610,005	864,668	945,267	1,047,104	1,250,778
Less holdco discount	61,001	86,467	94,527	104,710	125,078
Valuation	549,005	778,201	850,740	942,393	1,125,700
Per share	208	289.7	316.8	350.9	419.1
Per share (ex holdco disc)	231	321.9	352.0	389.9	465.7
# of shares	2,639	2,686	2,686	2,686	2,686
PE		28.5	26.0	23.7	21.0

Source: Goldman Sachs Global Investment Research.

## Tencent (0700.HK): AI significant potential to monetize portfolio

Tencent is the dominant mobile platform in China based on user time spent across its multiple social/media assets. Though a relative latecomer in terms of AI among BAT, Tencent incorporates AI into its products to personalize user experiences for its consumers and optimize monetization for its enterprise-related business. In Aug 2017, the company also formed alliances with multiple industry experts to support self-driving research and the manufacturing of related products in the future. The members of the alliance include Sebastian Thrun, a Stanford University computer science professor known as “the father of Google’s self-driving car”; Xu Heyi, BAIC chairman; Li Bin, founder and chairman of Chinese electric carmaker Nio; Stefan Greiner, director of Audi China’s autonomous driving and chassis development; and Li Jun, an academican of the Chinese Academy of Engineering.

According to Tencent’s President & Executive Director Martin Lau in August 2017, AI is an essential capability that allows the company to enhance the user experience and capture new opportunities to grow its businesses for the future. Management is confident that its existing strength in computing power, data, technologies and use cases, coupled with its focus on AI talent, will give Tencent a favorable position in this strategic initiative.

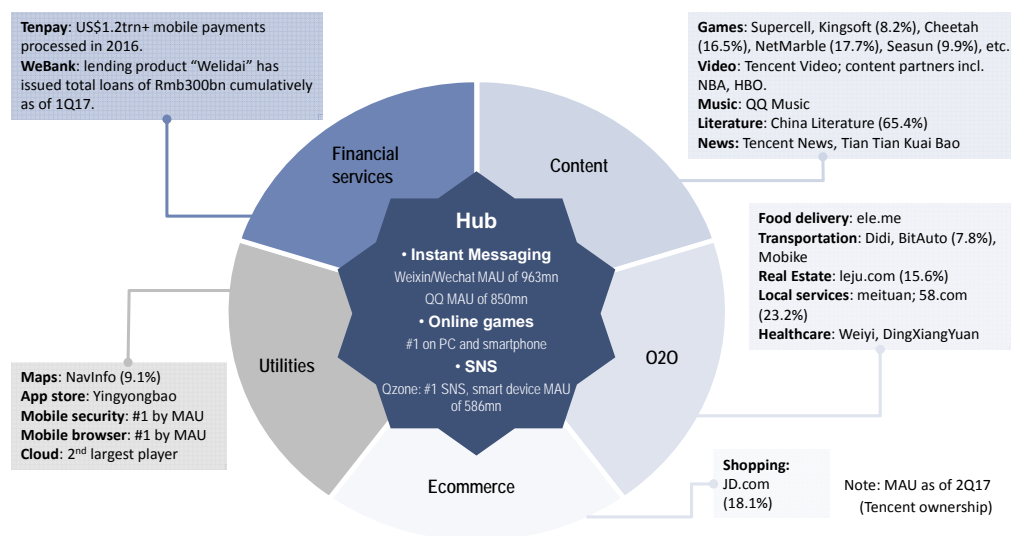
### AI research at Tencent

Tencent opened a research lab in Seattle in April 2017, in addition to its AI lab (Tencent Artificial Intelligence Laboratory) launched in April 2016. The Tencent AI lab is missioned to “Make AI everywhere”, with four areas of focus - computer vision, voice recognition, natural language process and ML. In December 2016, the company announced to open source its third-generation AI platform, Angel, in 2017 (now on Github).

Dr. Zhang Tong, former head of Baidu’s Big Data Lab (BDL) and professor at Rutgers University, leads a team of 50+ world-class scientists and 200+ AI software engineers at this lab. In 2016-17, the team published research that was presented at leading conferences such as CVPR (IEEE Conference on Computer Vision and Pattern Recognition), ACL (Meetings of the Association for Computational Linguistics) and ICML (International Conference on Machine learning).

### Data at Tencent

**Exhibit 37: Tencent’s ecosystem**



Source: Company data, Better Than Cash Alliance.

Overall, given the relatively low levels of monetization of Tencent's assets, we expect AI to be manifested across the company's social/messaging apps and gaming business. Tencent's social/messaging app and user ID collects 600+ of data points on each of its users. However, we believe Tencent management would prefer to under-monetize their assets, rather than risk compromising user experience at any time.

### Use case of AI at Tencent

- On performance ads, Tencent adopts AI throughout the process of ad placement (understanding user preferences, contextualizing ad content, ranking the bidding price, optimizing the display formats, and matching the most appropriate advertisers) to enhance ROI for advertisers and the reading experience for users.
- On information-based services (e.g., news apps, video, music and app store), AI helps the company to better understand users interests, which results in more relevant and customized recommendations.
- On Internet finance businesses (e.g., mobile payment, wealth management and micro loans), AI enables Tencent to have greater insights into user behaviors and thus higher predictability on their financial activities. Users are provided with more suitable products, and meanwhile Tencent minimizes the risks.
- The facial recognition technology at Tencent Youtu has an average accuracy of 95% in gender detection, and age detection error is less than five years. The technology also scored excellent results with a world-leading face detection dataset and benchmark, Fddb. The technology is implemented in Tencent's photo editing app, Pitu, as well as its financial services for complete ID identification.
- Tencent has recently released its first medical imaging AI product, MIAIS, for early screening of esophageal cancer in August 2017. According to 36Kr.com, the detection rate of early esophageal cancer is <10% in China currently, while the product's accuracy rate for detection is as high as 90%, and the screening takes less than four seconds.
- Tencent's chess AI Jueyi (Fine Art) had its first champion from the 10<sup>th</sup> Computer Go UEC Cup (an annual worldwide computer Go tournament), defeating DeepZenGo from Japan and Crazy Stone from France within less than a year of development.
- According to Tencent's Vice President Yao Xing, AI in Tencent has extended from chess to other gaming areas. We note that DeepMind and Blizzard have started collaboration in November 2016 to open up StarCraft II AI research, and we also expect Tencent to leverage its gaming assets within the ecosystem to further advances its AI research.

In addition to Tencent's own AI team, the company also extends its AI capabilities via various investments in the areas such as Cloud, healthcare, enterprise solutions and open source platforms (Exhibit 9). We note that Tencent is also the largest shareholder of Sogou with a 45% stake (as of December 31, 2016).

**Exhibit 38: Our 12-month SOTP valuation for Tencent is US\$369**

Gaming at 25X 2018/19, advertising at 30X, 10% holdco discount

		% owned	Valuation US\$m	Val. Rmb mn	To Tencent (Rmb mn)	Rmb/sh.	HK\$/sh.	% of Val	Val. Multiples (x) 18/19E ave.			17-19E Rev CAGR	Comment
SUM OF PARTS									Rev	OP	PE		
A	Tencent's core business												
1	Gaming	99%	254,572	1,705,631	1,695,031	176	205.3	55.7%	11.5	20.7	25.0	19%	@ 25.0x PE, vs. Activision Blizzard's 28x/23x 17/18e
2	Advertising (ex video)	100%	122,214	818,832	818,832	85	99.2	26.9%	14.4	24.8	30.0	38%	@ 30.0x PE, FB 28x 18e - GS TP @34x
3	Video	100%	12,999	87,090	87,090	9	10.5	2.9%	3.7			39%	@ DCF (12% WACC, 3% g)
4	Payment	100%	29,607	198,364	198,364	21	24.0	6.5%	2.6	23.0	20.4	62%	@ 27.0x PE (Visa, MasterCard's 17e avg)
5	Cloud	100%	19,290	129,246	129,246	13	15.7	4.2%	12.0	332.6	617	76%	@ 12.0x rev, vs. Allicloud's 14.0x, AWS 14x
6	Others	100%	2,644	17,713	17,713	2	2.1	0.6%	0.5			8%	@ 0.5x rev
CORE			441,325	2,956,876	2,946,275	307	356.9	96.8%	9.5	29.3	36.7		
B	Investments												
1	Online games	Supercell	38.5%	10,200	68,340	26,277	2.7	3.2	0.9%				@ Last transaction value
		Kingsoft	8.2%	3,444	23,077	1,892	0.2	0.2	0.1%				@ Market cap
		Cheetah	16.5%	1,613	10,807	1,783	0.2	0.2	0.1%				@ Market cap
		Douyu	20.0%	2,000	13,400	2,680	0.3	0.3	0.1%				@ Last transaction value
		Shunwang	3.8%	2,188	14,657	558	0.1	0.1	0.0%				@ Market cap
		iDreamSky	26.9%	646	4,331	1,165	0.1	0.1	0.0%				@ Last transaction value
		Glumobile	20.9%	421	2,821	590	0.1	0.1	0.0%				@ Market cap
		NetMarble	22.0%	10,191	68,277	15,021	1.6	1.8	0.5%				@ Market cap
		Activision Blizzard	5.0%	47,099	315,563	15,747	1.6	1.9	0.5%				@ Market cap
		Season	9.9%	1,440	9,651	955	0.1	0.1	0.0%				@ Last transaction value
2	Ecommerce and O2O	MeituanDianping	15.0%	18,000	120,600	18,090	1.9	2.2	0.6%				@ Last transaction value
		DidiChuxing	4.5%	50,000	335,000	15,075	1.6	1.8	0.5%				@ Last transaction value
		NavInfo	11.0%	3,346	22,416	2,459	0.3	0.3	0.1%				@ Market cap
		58.com	26.3%	6,949	46,555	12,244	1.3	1.5	0.4%				@ GS Target valuation
		eLong	26.5%	677	4,538	1,203	0.1	0.1	0.0%				@ Last transaction value
		Ly.com	15.0%	2,985	20,000	3,000	0.3	0.4	0.1%				@ Last transaction value
		JD.com	18.1%	79,670	533,792	96,616	10.1	11.7	3.2%				@ GS Target valuation
		BitAuto	7.8%	2,613	17,507	1,366	0.1	0.2	0.0%				@ Market cap
		Leju	15.6%	240	1,608	251	0.0	0.0	0.0%				@ Market cap
3	Others	Huayi Brothers	8.0%	3,679	24,630	1,978	0.2	0.2	0.1%				@ GS Target valuation
		WeBank	30.0%	5,500	36,850	11,055	1.2	1.3	0.4%				@ Last transaction value
		Koolearn.com	12.3%	478	3,200	393	0.0	0.0	0.0%				@ Last transaction value
		Tesla	5.0%	32,426	217,253	10,863	1.1	1.3	0.4%				@ GS Target valuation
Investment total			289,605	1,940,333	251,444	26	30.5	8.3%					
Net CASH					184,247	19	22	6.1%					
TOTAL					3,381,967	352	410						
Less holdco discount		-10%			(338,197)	(35)	-41	-11.1%					
NAV					3,043,770	317	369						
Total shares outstanding (mn)					9,612								

Note: Key risks include slower online gaming growth, fiercer competition in P4P ad.

Source: Company data, Goldman Sachs Global Investment Research.

**Implications of AI on Tencent's business**

**Targeted advertising** should benefit from superior customer profiling, based on a plethora of customer social data. According to Tencent, advertisers can get access to location, basic demographics, interests, recent activity and purchasing power information of users, all of which together allows localized and precise marketing. The greater the relevancy of customer advertising, the higher the click-through ratio and the greater the volumes. In turn, click-through-rate tends to be higher, for superior conversion rates and higher monetization without compromising the user experience.

The targeting of WeChat users could also benefit Tencent's portfolio of companies and partners, including JD.com, and potentially Meituan and WUBA. Tencent in return may witness higher adspend on its major P4P assets. For JD.com (18% owned by Tencent, and also Tencent's largest advertising customer), targeting the 900mn+ WeChat customers could result in:

- 1) The order per customer improving. JD.com last disclosed at ~6 per year per customer, around a tenth of Alibaba's.
- 2) JD's customer number expanding. JD.com last reported 220mn customers, less than half that of Alibaba.
- 3) A 10% improvement in both orders per customer and shoppers would raise GMV by over 20%, all else being equal.

**Games: Improving the gaming experience & raising the paying ratio:**

In our view, AI could be used in games to

- 1) Narrate a story based on player choice, rather than the traditional branching path in games.

- 2) Test games via algorithms in advance lowers churn rates after launch.
- 3) Revolutionize the way player avatars animate in real time in the game environment which results in the avatars behaving more like humans, for a wider range of more realistic movement and an overall improvement in the gaming experience. This is attained via machine learning, which determines the move based on each distinct part of the body, generating the user movements based on the specific game conditions and environment, rather than playing a clip based on a database where movement is overlaid onto the environment.

Eventually AI may even change the way games are developed.

Last, the monetization of games via the freemium model results in only a small percentage of gamers who buy these virtual items – for PC games the paying ratio is around 10%-30% and for mobile games it is 5%-15%. AI could boost targeting of skin sales, for instance, to improve monetization, all else being equal.

The attractiveness of freemium games is that they are among the least expensive forms of entertainment in the world, and they have represented the preferred model for gaming companies in China. These games are monetized via their reach and the sale of virtual items. Across both PC and mobile games, Tencent's strategy has been to ensure the user experience, to keep friction low and build engagement and grow the customer base. The monetization push commences after a full year of game launch in some instances, as we observed with Honor of Kings being the world's largest game.

Tencent owes its success as much to its unique product mix of gaming and social assets, unparalleled execution, and a laser focus on user experience, to the extent that the user experience has seldom been compromised for commercial reasons. Also, the barriers to entry for building a social network comparable to Tencent's in particular are among the highest in the global internet.

### Fully loaded valuation on Tencent

Tencent management recognizes that AI offers them the opportunity to better monetize their assets without compromising the user experience. If Tencent were to proceed down this path, we believe the upside could be significant. In Exhibit 39, we present a scenario where AI drives the monetization of gaming/advertising with 50%/87% higher revenue vs. our base case in 2020. Without a holdco discount, the SOTP implied value under this scenario rises to HK\$688.

#### Exhibit 39: Tencent 2020; AI driven, fully "loaded", no holdco discount, 2020 SOTP at HK\$688

Gaming at 20X earnings, advertising at 25X, payments at 20X, video on a DCF, and 0% holdco discount

SUM OF PARTS		% owned	Valuation US\$mn	Val. Rmb mn	To Tencent (Rmb mn)	Rmb/ sh.	HK\$/ sh.	% of val	Valuation (x)			Comment
									Rev	OP	PE	
A	Tencent's core business											
1	Gaming	99%	321,934	2,156,957	2,143,970	219	255	37.1%	14.5	26.2	20.0	@ 20x 2020E PE
2	Advertising (ex video)	100%	335,785	2,249,756	2,249,756	230	268	38.9%	12	21	25.0	
3	Video	100%	16,607	111,264	111,264	11	13	1.9%	3			@ DCF (12% WACC, 3% g) in 2020E
4	Payment	100%	49,473	331,469	331,469	34	39	5.7%	1.9			@ 20x 2020E profit after tax
5	Cloud	100%	35,177	235,684	235,684	24	28	4.1%	8.0			@ 8.0x 2020E revenue
6	Others	100%	2,644	17,713	17,713	2	2	0.3%	0.5			@ 0.5x 2020E revenue
CORE			761,618	5,102,842	5,089,856	520	606	88.0%	7.0		25.1	
B	Investments											
Investment total			290,402	1,945,291	251,988	26	30	12.6%				As in base case
Net CASH					443,389	45	53	13.7%				
TOTAL					5,785,233	591	688	100.0%	7.9		28.6	
Less holdco discount			0%		-	-	-	0.0%				
NAV					5,785,233	602	688		7.9		28.6	
Total shares outstanding (mn)					9,785							

Source: Company data, Goldman Sachs Global Investment Research.



**Exhibit 40: 2020E bull case advertising revenue factored in our fully loaded valuation**

	2016	2017E	2018E	2019E	2020E	2020-Bull case
<b>1 Media advertising</b>	<b>11,365</b>	<b>15,989</b>	<b>21,520</b>	<b>28,219</b>	<b>36,125</b>	<b>37,931</b>
% yoy		41%	35%	31%	28%	
% vs. 2020E base case						5%
<b>2 Social and others advertising</b>	<b>15,605</b>	<b>24,555</b>	<b>34,201</b>	<b>45,429</b>	<b>54,723</b>	<b>146,343</b>
% yoy		57%	52%	46%	42%	
% vs. 2020E base case						167%
ad load/day		1.0	1.2	1.5	1.7	5.0
% yoy			22%	21%	12%	
% vs. 2020E base case						203%
total ads		347,133	460,473	582,527	668,283	2,030,860
% yoy			33%	27%	15%	
CPM/CPC		0.07	0.07	0.08	0.08	0.07
% vs. 2020E base case						-12%
<b>TOTAL</b>	<b>26,970</b>	<b>40,544</b>	<b>55,720</b>	<b>73,648</b>	<b>90,848</b>	<b>184,274</b>
% vs. 2020E base case		50%	37%	32%	23%	103%
<b>Gross advertising revenue</b>	<b>29,475</b>	<b>44,310</b>	<b>60,897</b>	<b>80,490</b>	<b>99,287</b>	<b>199,937</b>
% yoy growth	54%	50%	37%	32%	23%	
% vs. 2020E base case						101%

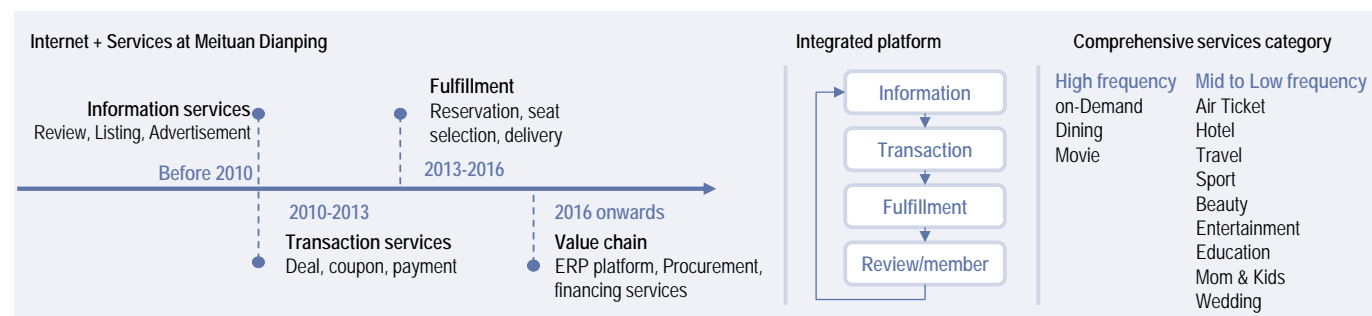
Source: Company data, Goldman Sachs Global Investment Research.

## Meituan Dianping: World's largest O2O platform

*"Technology is the reason why Meituan Dianping exists today. Only with technology Meituan is able to disrupt the traditional services industry in China, providing a better life for its customers."*

--- Shaohui Chen, Senior Vice President of Meituan Dianping

### Exhibit 41: Meituan Dianping's business at a glance



Source: Company data.

Meituan Dianping (Meituan, not listed), the world's largest O2O platform with annual GMV of US\$35bn in 2016, has full coverage across a range of 200 ecommerce services and product categories with ~28mn POI (Point Of Interest) and 3.1mn active merchants, providing services including dining, on demand food/goods delivery, hotels, travel, beauty and leisure, in over 2,800 cities and counties in China. With 270mn annual buyers on Meituan as of July 2017, the platform generates 20mn orders/day (vs. 5mn a year ago), 18mn room nights in July (~1/3 of the total room nights in China), and food delivery orders on the platform are still growing at 200%+ yoy.

**Data:** Meituan generates 1.5PB (Peta Byte) of data on a daily basis, and the company has stored an aggregate 200PB of data. Big Data is the key of Meituan as the business model requires integration of online and offline data for O2O and omni-channel retailing. Data sourcing, data analytics, and data application capabilities together crucially determine the customer experiences the platform could offer.

**Technology Infrastructure:** Meituan's proprietary "O2O Real-Time Logistic Dispatch System", for example, provides a "Super Brain" engine for all those involved in the supply and delivery chain. The dispatch system uses big data analysis to generate the most efficient delivery route in less than 100 milliseconds across hundreds of millions of historical order data, billions of delivery routes traveled, and tens of millions of different kinds of customer and merchant data. Each order dispatched on Meituan usually requires calculations in the hundreds of millions to optimize the delivery route. The system allows Meituan to complete deliveries within 28min on average.

The company has dedicated research teams that adopt ML technologies in data processing and predictive modelling. In 2017, Meituan has also been recruiting AI talent to work on drones and autonomous driving units, targeting to address delivery needs in high population density areas.

## An Interview with Shaohui Chen, Senior Vice President at Meituan Dianping

*We interviewed Meituan Dianping Senior Vice President Shaohui Chen and his team about AI and technology.*

### What's the company's view on AI?

AI development at Meituan cannot leave specific scenarios as well as the scale of the activities, and it will not be a one-stop process but a long-term innovation for the company. The orders on the Meituan platform span across a variety of very fragmented SKUs, and are oftentimes of high frequency in nature. As a result, the order fulfillment in the services industry is a very complicated process vs. that of ecommerce, and only with technology + operations can the company scale up the business to better serve its customers.

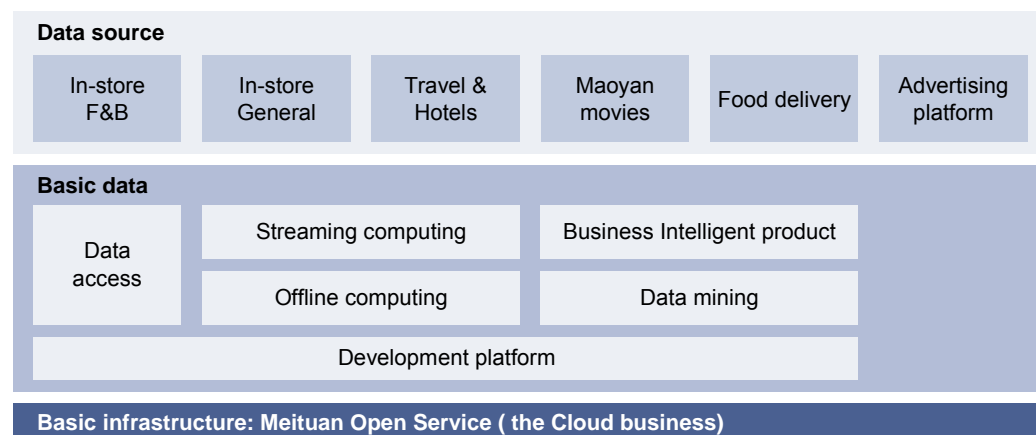
Online penetration for physical goods has reached the high teens in China, with relatively mature ecommerce business models. The services industry, on the other hand, is still at single-digit online penetration. With the underlying massive market opportunity, Meituan strives to leverage technology to re-define services in the digital age, and eventually to provide better life quality to its customers.

### How will AI help Meituan in its business innovations?

The importance of AI to Meituan's business manifests in three aspects:

- 1) for consumers, AI technology combined with data enables personalized shopping experiences on the platform, which in turn improves customer retention rate, purchase frequencies and incentivizes spending;
- 2) for merchants, Meituan does not only strive to push for digitalization of business operations in the traditional services industry, but also aims to provide AI-enabled one-stop intelligent solutions that could potentially open up new business opportunities for its merchants;
- 3) for the last mile services, algorithm and ML is of crucial importance to address matching problems among Meituan's merchants, consumers and riders. The operation/cost efficiency of the network is highly dependent on the company's technology capabilities to solve real-time matching problems.

### Exhibit 42: Meituan data structure



Source: Company data.

## Takeaways from discussions with Shaohui Chen, Senior Vice President at Meituan Dianping in May 2017

**Meituan Dianping (not listed) is the world's largest service-focused ecommerce platform.** China's local services market has been growing at ~10% per year, with online spending at less than 5% of a US\$1.5 trillion market. Assuming 25% online penetration, a 10% take rate and 25% operating margins, the profit pool potential is US\$10bn.

Meituan's platform strategy provides a one-stop solution for service-oriented verticals, both from a supply side and demand-side, i.e., for the consumer as well as the merchant. Consumers can search for services across 10 broad categories (dining, delivery, movie, hotels, leisure, transport, karaoke, tour, beauty, travel), avail a discount and complete transactions on the Meituan platform. The service offerings range from high frequency dining/delivery services to low-frequency wedding services – high frequency brings in customers and ensures retention while low frequency services are those with higher take rates.

Merchants, on the other hand, use the platform for marketing, to enhance efficiency and offer value-added services. For restaurants, Meituan offers a comprehensive range of solutions, from reviews, to payments, including reservation, CRM and queue management. The company's mission is to be the most popular brand in 'dining'.

### Key stats

- **Demand:** Meituan's services platform has 220mn MAUs as of April 2017 and 260mn annual buyers for the 12 months to April. The company defines MAUs based on users who purchase more than one time on Meituan in a year. On the supply side, Meituan is connected with 30mn merchants, of which 3mn active monthly merchants place deals and ads on its platform.
- **Frequency:** Meituan is focused on driving its higher frequency business, which brings in traffic and retains users. The platform caters to 19mn orders per day (+120% yoy), including 6mn food delivery orders supported by 300K active riders. Total GMV on the platform in 2016 was US\$35bn, while total orders were 3.4bn, i.e. an average order of US\$10.3. Average annual purchasing frequency is at 14 times per user (up to 30 times prior year cohort, excluding 2016 new users).
- **Take rates:** Meituan earned a 9% blended take rate in 1Q17, which management believes should cross 10% this year. Category wise, the food delivery take rate is 20%; hotel and travel is at 8-9%; restaurant 4-5%; and other long-tail businesses 9%. US\$2bn in revenue, an average 6% take rate.

### Market shares and key categories:

**Dining:** Meituan commands 70% (Feb 2017) market share in restaurant-to-store business and 75% market share in review/retention management/coupon/deals business.

**Food delivery:** In April, Meituan delivered 10mn daily food orders, and captured 58% market share from 41% a year ago. According to management, Ele.me has been giving three times more subsidies than Meituan, but they are still losing market share. China's food delivery market at 18mn orders per day is 9X the US market where GrubHub leads with a 20% mkt share.

**Hotels:** According to management, Meituan is dominant in the younger generation's travel demand and now covers c.200mn non-business travelers, and expects to drive gradual organic conversion from business travelers by ensuring good supply. Meituan has quickly emerged as #2 in the hotel market based on room nights with a 40% market share as of Feb 2017. ARR for Meituan's hotel business is at Rmb160 currently, up from Rmb130 a year ago. Monthly room nights for Meituan are 16mn per month. High-end hotels contributed 5% of Meituan's total room nights one year ago, increasing to 17% as of April 2016.

**Movies:** Meituan's market share in movies is at 75% in Feb 2017, and the online penetration rate for movies is at 75%.

**Other:** Meituan is the market leader in tour tickets with 40% market share at end-2016, and the dominant company in KTV with 90% share as of February 2017.

**Revenue outlook:** Meituan benefited from the proliferation of smartphones in the last five years. According to management, although the peak growth rate for smartphones may be behind us, Meituan's penetration is just 25%. This suggests Meituan could grow 2-3X. Non-meal category currently contributes 5% of total revenue, but is growing three times faster than average, and Meituan expects non-meal to contribute 20-30% of revenue in the next few years. The company is also pushing for long-tail categories within which some categories are generating positive cash flow. Chinese users' lifestyles give the company a unique value proposition to tap into, and develop full-value-chain online transaction platform. Examples include some restaurants restructuring their interior outlays by reducing in-dining seats and increasing kitchen spaces, designing the food to be easier for on-the-road delivery.

**Margin outlook:** Post merger, marketing expenditure for Meituan has decreased, and they achieved operating profit breakeven in April 2017. The company is leveraging its consolidated R&D and sales volume amid slowed momentum in new user growth.

**Tencent partnership:** Currently Meituan Dianping has two entry points on WeChat: food delivery and Dianping. In addition, there are 5-6 major partnership areas on traffic, map service, Internet + restaurant, WeChat Payment, and smart POS where the company utilizes WeChat Payment.

## DiDi Chuxing: 4,500TB of data processed daily

**DiDi Chuxing (not listed)**, co-invested by BAT, is the world's largest mobile transportation platform that processes over 4,500TB of data, receives 20bn+ route requests, and handles 20mn+ orders on average on a daily basis. Problems in general for transport in China are bigger given the size of its major cities, some of which are the equivalent of 5 cities in the other parts of the world. DiDi's scale is 5-6x that of its US competitor in its home market. Its products include taxi-hailing, ride-sharing, private car, designated driver, enterprise solutions and bus services.

**DiDi Research**, the company's research lab, is working on Deep Learning, human-machine interaction, computer vision, as well as intelligent driving technologies. Current uses include matching riders with drivers on routes that work favorably for the customer as well as the driver, better routing, and demand forecasts.

### Exhibit 43: DiDi operates on a system with a predictive mind in improving passenger travel experiences

DiDi Research is headed by Dr. He Xiaofei, former research scientist at Yahoo Research and a fellow of International Association of Pattern Recognition (IAPR)

#### DiDi Brain

##### Intelligent System

- Cloud computing
- Big Data
- Machine learning

#### Problem solving

##### Demand/supply forecasts

- The forecasts is based on billions of rides factoring weather conditions, type of cars, customer profile and destinations. DiDi has achieved **85%** of accuracy in forecasting transportation demand/supply 30min into the future.
- The accuracy allows DiDi to dispatch drivers in advance to meet potential demand, and thus improve efficiency of the network.

##### Route planning

###### Data

- DiDi platform data warehouse
- Transportation system
- Order history

###### Machine learning system

###### Map services e.g. Route planning, Estimated time of arrival (ETA)

##### Intelligent dispatching

- Intelligent car/driver dispatching and driver-rider matching on DiDi incorporates real-time analysis on information from multiple fronts, including supply/demand predictions, pricing adjustment, route planning, as well as customer services quality scores.
- Currently, it takes DiDi less than 1 millisecond on single trip route planning, with order match taking place every two seconds. Each successful order is based on 58bn CPU calculations on average.
- In a 2017 letter to employees, DiDi has announced the establishment of a "future transit team". Headed by Senior VP Zhang Wen Song, the team tasked with cooperating with local government to futurize transportation in cities in China.
- According to Zhang, optimizing DiDi's dispatching is 100x more complicated than chess.

#### Features in highlight

##### Pick-up point recommendations

As of Dec 2016, this function has included 30mn recommended pick-up points, reduced phone communications for pick-ups by 10%, and passenger waiting time by 1min on average; Over 30% of the pick-ups take place without phone communications.

On average, DiDi adds 80k pick-up point recommendations per day based on new trip data.

##### Guess where you are going ("猜你去哪")

This function collects/ analyze individual trips data, and provides trip destination suggestions. E.g. if you go to the same place for laundry on Saturday for a few times, same destination will be suggested for you on Saturday.

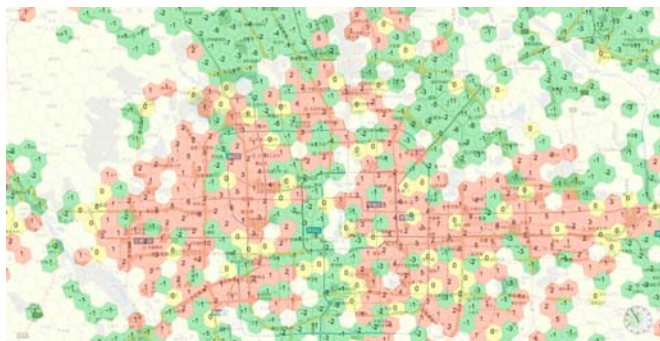
The destinations suggestions arrives within 2sec and has an accuracy rate of 90% on average.

Source: Company data, Sina/ NetEase news reports.

In July 2017, DiDi also launched its open source platform (<http://didi.github.io/>) and released its first open source software VirtualAPK. It is a plugin framework for Android, which seamlessly loads and runs an APK file as an installed application. According to DiDi, this independently-developed tool is more versatile in its functions, compatibility and interactive ability compared to its peer products.



**Exhibit 44: Data technology helps DiDi supply-demand balance in Asia's urban maze like Beijing**



Source: DiDi.

**Exhibit 45: DiDi's captures the changing density/pattern of urban transportation of 400+ cities from dusk to dawn in China**



Source: DiDi.

To attract talent and gain exposure to new technologies DiDi Labs opened offices in Mountain View, CA, in 1Q17. The research center will be led by Dr. Fengmin Gong and Zheng Bu. Fengmin Gong joined the center after AssureSec, which specializes in security, was acquired by DiDi in September 2016.

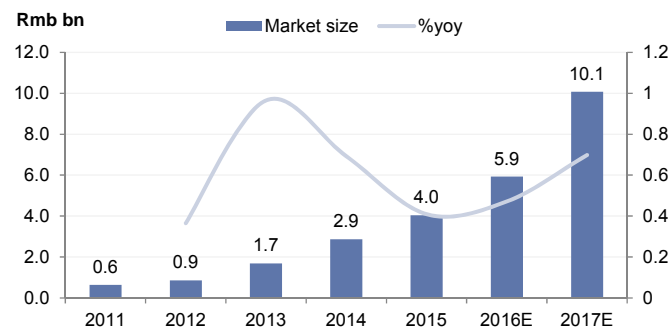
In April 2017, DiDi raised US\$5.5bn, which will be used among other areas to invest in artificial intelligence to bring breakthroughs in intelligent driving technologies and smart transportation architecture.

## iFLYTEK (002230.SZ): The leading player in China Intelligent Speech

iFLYTEK (Coverage Suspended) is an information technology company that focuses on speech and language recognition. The company has the largest market share in China's intelligent speech industry, and its products' vertical applications include education, public services/security, auto, customer services, healthcare and other consumer products.

### Exhibit 46: Intelligent Speech - Rmb10bn market in China...

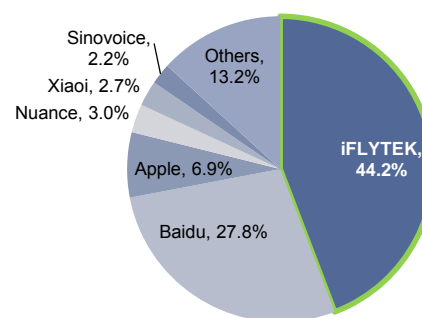
China intelligent speech market



Source: Speech Industry Alliance of China (SIAC).

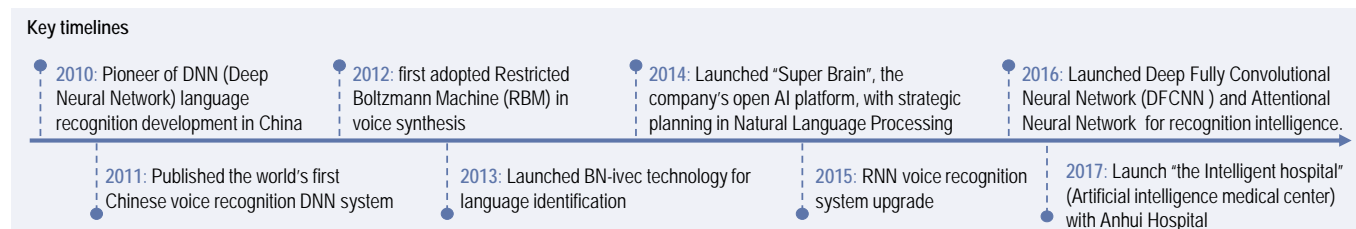
### Exhibit 47: ...with iFLYTEK being 44% of the market

China intelligent speech market share (2015)



Source: Speech Industry Alliance of China (SIAC).

### Exhibit 48: Deep learning at iFLYTEK



Source: Company data.

### Exhibit 49: iFLYTEK's recent achievement globally

Time	Event	Achievement
2016	NIST Text Analysis Conference (TAC) Knowledge Base Population	First place
2016 Sep	CHiME Challenge	iFLYTEK claimed 3 champions in the 4th CHiME (Computational Hearing in Multisource Environments). The 3 projects are single-channel speech separation and English recognition, double-channel speech separation and English recognition and six-channel speech separation and English recognition.
2016	Blizzard Challenge	iFLYTEK won Wins Blizzard Challenge again in 2016, topping other competitors in all the index comparisons including similarity, naturalness, intelligibility and paragraph articulation.
2017 Aug	Luna Test	IFLYTEK ranked first in the international medical imaging evaluation test (LUNA) on its average recall rate of 92.3% for the detection result, renewing the world record.
2017 Aug	SQuAD Test	IFLYTEK claimed first place on SQuAD (Stanford Question Answering) test, which was the latest machine reading/comprehension test held by Stanford University. The system model submitted by IFLYTEK won the title for the first time as a Chinese local research institution.

Source: Company data, news reports.

## Hikvision (002415.SZ): World leader in surveillance through AI lens

Over the past 16 years, Hikvision Digital Technology has grown into the No.1 surveillance company in the world and a global leader in AI surveillance products, from cameras to NVR to servers. Products have been adopted by Nanchang City's SkyNet project, among others, effectively improving the accuracy of identifying suspects. In the AI era, we believe Hikvision commands strong competitive advantage with unparalleled access to relevant data sets from its large customer base.

**Control center AI products** include server products with AI capabilities. Hikvision launched video structuring server "Falcon" and vehicle image structuring server "Blade" in 2015, both based on GPU and deep learning technology. In 2016, Hikvision launched intelligent traffic product group "Divine Captor" and facial analytics server "Hikface". Falcon, Blade, and Hikface are all used in the Nanchang Sky Net project. Over the next several years, we expect control center equipment to become the main revenue driver with its AI product suites, as the heavy lifting of data analysis will happen at the server side.

**Front-end AI products:** In 2016, Hikvision launched DeepInview camera series based on GPU/VPU and deep learning technology, enabling much more complicated facial, traffic, vehicle recognition and analysis. It is the first and only AI-enabled front-end product in the market. Going forward, we expect front-end products to continue to be a big revenue contributor for Hikvision.

**Back-end AI products:** In 2016, Hikvision launched DeepInmind NVR with embedded deep learning algorithms, enabling more accuracy in facial recognition and analysis.

Hikvision has 9,366 engineers in R&D, with dedicated teams in video image processing, video and audio codec, video content analysis, cloud computing, big data and deep learning. Hikvision dwarfs both global and local competitors by consistently allocating 7%-8% of its revenue to technology advancement over the past 10 years.

### Recent AI development

Hikvision's intelligent cameras have been installed at the subway entrance in the city of Nanchang. According to management, the cameras help to capture suspected criminals almost every day.

AI also helps to detect defects in manufacturing. For example, when assembling components onto PCBs, the traditional detecting practice is done manually by workers with the help of magnifiers as normal industrial cameras are incapable of such detailed detection. However, by embedding AI algorithms into traditional industrial cameras, machines can learn to achieve accurate defect detection.

### Investment view

We are Neutral-rated and have a 12-month target price of RMB28.00 (based on 20X 2018E EPS). Key risks: Fluctuations in government/public spending, changing competitive intensity

For more details, please see *Hikvision Digital Technology (002415.SZ): Takeaways from management meetings at TechNet*, published on May 29, 2017.

## AI companies in China - the others

In addition to BAT, hundreds of start-ups in China are also penetrating into the industry and establishing a services models in various AI segments and application areas. At present, the field of AI in China roughly covers:

- 1) Basic services such as data resources and computing platforms
- 2) Hardware products such as industrial robots and service robots
- 3) Intelligent services such as intelligent customer services and business intelligence
- 4) Technical capabilities such as visual recognition and ML.

In our view, key players at the forefront are:

### Speech and natural language

- **AISPEECH** - Artificial Intelligent Speech was founded in Cambridge U.K. in 2007 by Gao Shixing, who holds a Master of Philosophy degree on Technology Policy from Cambridge University. As a leading speech technology provider in China, the company's end-to-end spoken dialogue system offers intelligent hardware in three major areas - in-car devices, smart home and robots, with reported recognition accuracy of 99%, 98% and 93%, respectively.
- **Unisound** is one of the pioneer players in China that incorporate AI applications to voice technology. Founded in 2012, the Beijing-based company has over 200 employees, 20k+ strategic partners, providing services to 180mn+ users. As per Unisound, the company owns the largest independent third-party voice cloud platform in China, which covers 100mn devices in 470 cities. Unisound is also one of the fastest-growing AI start-ups in China, according to Forbes China.
- **Mobvoi** was founded by ex-Google scientist Zhifei Li in 2012, and the company became the strategic partner of Google Android Wear™ in voice search in 2015. The company has said its software partners include a wide range of internet companies such as Alipay, WeChat, DiDi and Sogou, and Mobvoi also has big international companies such as Ford and Bosch as their industrial application partners. The core team at Mobvoi consists of engineers and AI experts from global tech firms such as Google, Microsoft, IBM, Baidu and Tencent, as well as researchers from top institutes and universities such as Harvard, MIT, Cambridge and Tsinghua.

### Takeaway from company meetings hosted by Dr. Zhifei Li at Goldman Sachs

As a 4.5-year-old company, Mobvoi started by building up the voice tech on mobile phones, and then went on to explore a very specific area in voice interaction and to focus on designing consumer-facing end-products, such as wearables (smart watch like Ticwatch, which has 40% gross margin with ASP of around US\$200), automobile (in-vehicle robot Ticmirror) and home (smart speaker products to be launched). The company's in-house technologies cover voice recognition, Natural Language Processing, Dialogue management, gesture interactions, etc.

According to Dr. Li, the key bottleneck in voice technology nowadays is natural language understanding, which unfortunately has no short-term solution. More specifically, there is no generic algorithm that is suitable for all of the domains/scenarios of dialogue, e.g. if one wants a natural language system for buying a train ticket or ordering from a restaurant, all of it would need separate tuning.

On AI in China vs. in the US, Dr. Li noted that China is ahead in application with its fast-paced product cycles, while fundamental research is still lagging primarily due to talent.

## Computer Vision

- **SenseTime** is an innovative technology company focuses on computer vision and deep learning. The company achieved 99%+ accuracy on the Labeled Faces in the Wild (LFW) benchmark dataset, surpassing human face recognition capacity. Currently the research team of SenseTime has 50+ PhDs coming from top-tier universities such as MIT, Stanford and The University of Hong Kong, and together the team has published over 150 papers in the top three world-class computer vision conferences – CVPR (Computer Vision and Pattern Recognition), ICCV (International Conference on Computer Vision), ECCV (European Conference on Computer Vision), ranked the No.1 in Asia on this front.
- **Face++** (Megvii) offers computer vision technology in APIs (Application Programming Interfaces) and SDKs (Software Development Kit), including facial recognition, image recognition and Optical Character Recognition (OCR). The Paying with your face product from the company was listed as one of the 10 Breakthrough Technologies 2017 by MIT Technology Review, as the technology was “finally accurate enough to be widely used in financial transactions and other everyday applications”. Customers of Face++ include Lenovo, Alipay, Didi, Camera 360 and Meitu.
- **YITU Technology** engages in AI fundamental research in finding solutions for machine vision, listening and understanding with top-tier researchers previously from MIT, Google, Alibaba and other well-known institutions. By 2016, YITU has built a portrait system of 1.5bn+ people coverage which can deliver image-matching results within a second. In application, YITU's portrait comparison system is used by China Customs, China Immigration Inspection, and many other regional/local Public Security Bureaus.

## Chip and Hardware

- **DeePhi Tech** focuses on providing deep learning platforms. Founded by researchers on hardware acceleration from Tsinghua University and Stanford University, the company is equipped with core members from top companies including Baidu, 360, Siemens and Nokia. DeePhi technologies include deep compression, compiling toolchain, deep learning processing unit (DPU) design, FPFA development, and system-level optimization. The company has published multiple papers at top conferences across the world such as NIPS 2015, ICLR 2016, FPGA 2016, ISCA 2016, NIPS 2016 Workshop and FPGA 2017, and also received the Best Paper Award in ICLR 2016 together with Deep Mind and best paper honorable mention in NIPS 2016 Workshop on Efficient Method of Deep Neural Network (EMDNN).

## Intelligent machine

- **SIASUN Robot & Automation** mainly conducts research and development of industrial robot applications, automatic assembly & testing production lines, providing equipment to global companies such as DELPHI, WEBSTO, ZF, CONTINENTAL, etc. The company was listed on Forbes as one of Asia's 200 Best Under A Billion in 2015.
- **DJI (Da-Jiang Innovations Science and Technology)** manufactures unmanned aerial vehicles (UAV), or drones, for aerial photography and videography, gimbals, flight platforms, cameras, propulsion systems, camera stabilizers, and flight controllers. Founded in 2006, the company is referred to as “World's largest drone manufacturer” by Forbes, with over 6,000 employees globally, in the United States, Germany, the Netherlands, Japan, Beijing and Hong Kong.
- **Anhui EFORT Intelligent Equipment** designs and manufactures industrial automation equipment, with a specialty in general purpose robot R&D, spraying robots, high-end metal processing and automation auto equipment. The company designed the first 165kg heavy-load robot in China, which is written in the Chinese enterprises' innovation records and awarded with the silver medal at the China International Industry Fair in 2012. EFORT is the largest domestic manufacturer of industrial robots in terms of sales in China, as per the company.

## Healthcare

- **iCarbonX** focuses on building digital life ecosystem based on individual's biological, behavioral and psychological data. With holographic health data, it aims to study, guide and take care of individual health based on AI solutions. Mr. Wang Jun, CEO of iCarbonX, graduated from Peking University with a bachelor's degree in an AI-related major and a PhD in bioinformatics. Mr. Wang was formerly the executive director at BGI, and he was among Nature's "Ten people who mattered this year" in 2012.

## Agriculture

- **TT Aviation** is a UAV industry chain provider founded in 2008. As a member of the Chinese society of agricultural engineering aviation, the company is one of the first and largest players in the manufacturing of drones for agriculture use. According to the South China Morning Post (SCMP) in June 2016, TT Aviation holds 30%-40% of the drones for plantation service market in China, with its unit product price at Rmb30k-80k. According to TT Aviation, drones save 30%-40% of pesticide volume needed, and are particularly suited for China where parcels of land tend to be small.

## Intelligent Driving

- **Tusimple** provides computer vision and AI technologies, and specializes in autonomous driving applications. According to PRNewswire in October 2016, the company has broken 10 records in autonomous driving technology, was ranked No.1 in KITTI Vision Benchmark and Cityscapes Dataset's Benchmark, the most influential public leaderboard in autonomous driving worldwide. The company has two R&D centers in Beijing and San Diego with top scientists from China and the US.
- **Minieye** focuses on developing visual perception system for vehicles, and was the successor of a project on Advanced Driver Assistance Systems (ADAS) funded by the MDA of Singapore government. Minieye has R&D centers in Shenzhen and Nanjing, China, and the team has published over 80+ papers in top conferences and journals, which are cited in more than 6k papers. In a Minieye sharing session in December 2016, CEO Liu Guoqing published Minieye's first self-developed ADAS product, which is very close to outperforming Mobileye's model in four functions: Forward Collision Warning, Lane Departure Warning, Virtual Bumpers and Stop & Go. The product was based on a three-year R&D effort since the company was founded in 2013, vs. its Israeli rival Mobileye's 17 years of company history.

## Services robot

- **UBTECH** is the first company in China dedicated to commercializing humanoid robots, and is also known globally as the industry leader in humanoid robotics (e.g. Alpha 1S), as per the company. Its Alpha 2 (a humanoid robot designed for the family with practical household service and companionship) and Jimu Robot (an interactive, STEM-friendly robotic building block system) were named CES 2017 Innovation Awards Honorees.
- **Rokid** was named a 2016 CES innovation Awards Honoree in the home Audio/Video Components and Accessories category for its first product, *Alien*. The company's second product, Pebble, also won the Innovation Awards Honoree in 2017 CES. Pebble is a portable home companion featuring advanced AI and deep learning that enriches life by proactively delivering information, providing entertainment and performing tasks via voice and visual interactions. According to *Fortune* on March 17, 2017, Rokid is one of the 50 largest startups leading the AI revolution.



## An Interview with Rokid management

*We interviewed with Rokid management CFO Eric Wong and Director of Product Management Reynold Wu.*

### What is Rokid's view on the industry and how does Rokid position itself?

AI: AI has only become hot in recent years. Half a year ago, most of the services were targeting to business but not customers, and some of the companies are trying to present services AI in a toy industry. Rokid, on the other hand, introduces the product as an intelligent companion.

The early adopters of Rokid's products are those who are fascinated by the new tech/product, and targeted users in general are young people aged 18-35 who love new tech, and have the highest willingness to adapt to new things. It is also the trend that the elderly and kids in the family, those who look for companionship, are spending more time with Rokid's products.

In the first stage of development, Rokid has been focused on hardware and software development and has been introducing different scenarios over time. Content providers in the scenarios include music, weather, audio book, laundry shop, food ordering, taxi hailing, etc.

Rokid is now in the second stage of the development, where the company plans to open the voice interactive platform and provide it to external companies.

### How does Rokid differentiate itself?

Rokid focuses on scenario development, all employees including the CEO and developers need to communicate with angel customers on a daily basis for feedback and user experiences.

With an integrated hardware and software self-development model, Rokid also provides great flexibility and efficiency in product innovation, and this drives long-term benefits.

Rokid is a small company, vs. big companies with existing technology frameworks who might not have the flexibility to update so frequently for the current product lines; Rokid is more willing to take risks to test/verify new technology, concepts and user experiences. The R&D team at Rokid follows closely on most recent research updates in both academy and industrial world, and verified new algorithms and models will be pushed to production system directly to benefit users.

Talent-wise: within the 18 months of company history, Rokid has established a lab in Silicon Valley with ~10 PhDs from UC Berkeley, and also a team of PhDs in its AI lab in Beijing. As a small company, Rokid is more willing to give talented people space to lead projects and test new technologies/products. Rokid believes the company's vision and the existing talented R&D team will continue to attract other talented young people to join.

### How does Rokid think about competition in the industry?

Rokid does not regard the recent outburst of AI as a competition stage, and believes that the peers are all educating consumers from different angles. The market is still very immature, and the industry is blue ocean.

Moreover, Rokid is very open to encourage wider free adoption of its AI research technology to various industries (e.g., toys, entertainment, home appliances, etc.), allowing consumers to enjoy a happier life "powered by ROKID". In terms of business model, Rokid covers the whole chain of design and production, and thus provides larger room for innovation.

- **Cloudminds** (founded in 2015) focuses on building end-to-end ecosystems supporting cloud-connected smart machines. The company's founder & CEO, Bill Huang, was the President of China Mobile Research Institute, and co-founder and CTO of UTStarcom. Currently, Cloudmind is building secure, high-performance, low-latency private networks functioning as the "nerve transmission system" for its intelligent robots; the company aims to build family-friendly robots with a cloud communication infrastructure. Investors in the company include Foxconn, Walden International, KeyTone Ventures, etc.
- **Roobo** (Beijing Intelligent Steward Co., Ltd) was established in 2014 as a technology platform for intelligent hardware. The company is dedicated in designing new AI robots and other intelligent hardware for consumers by integrating AI systems, products and services. Currently Roobo's products include Pudding Robot series for children's learning purposes, three other robots (Jelly, Farnese, and Domgy) for home and other commercial services, and a voice chip based on ASIC. According to Roobo, the chip is China's first intelligent deep neural network processing voice chip, includes a Brain Network Processing Unit and is capable of supporting the structure of deep neural network.
- **Qihan Technology** (Shenzhen based) focuses on robotics, AI and video analysis. The company's core products include Sanbot (a humanoid robot), Qihan Cloud and CCTV surveillance equipment. Sanbot is an intelligent humanoid service robot connected to

the cloud with 60+ sensor chips that enable four senses - sight, hearing, smell and touch. It understands speech and interacts with humans by utilizing tons of data with a statistical model and patterns of human speech, and can also project video, stream calls and facilitate FaceTime.

- **Turing Robot** focuses on AI commercialization. Their major products include Turing Robot and Turing OS, and the latter is an AI-level Robot Operating System with thinking mode simulation and emotional recognition of humans, and thus provides natural and friendly multimode human-machine interaction methods. The company's strategic partners include Microsoft, IBM, Haier, Baidu, Samsung, HTC, and China Telecom.

### Other verticals

- **Jin Ri Tou Tiao** is a headline news APP powered by AI and Big Data Analytics. The app focuses on personalized news feeds (as user DNA is updated within 10s of each user action) that captures longer user time spent than traditional news app. With more than 700mn cumulative active users, average daily time spent on the app were reported at 76min in Oct 2016. The company has 800+ engineers, answering 6bn requests and handling 6.3PB data on a daily basis. Toutiao's revenue is advertising based, as the newsfeed is tailored to the customer's interests and preferences. Toutiao uses ML to determine user interests such that the clicks are maximized.

Toutiao's AI lab is headed by Lei Li, an ex-Baidu engineer with an academic background in fast algorithms for mining co-evolving time series. This team is working on ML based solutions that can improve targeting as well as develop new products, such as generating short stories based on results of a football game.

- **Noitom** focuses on motion capture, mapping the human body's movements and interaction with the environment. The company delivers sensor/motion capture solutions not only to film and gaming companies, but also to other industries such as education and medicine. The clients of Noitom include GARMIN, Lenovo, AltspaceVR.

## AI & the productivity challenge: An interview with Andrew Tilton



Andrew Tilton

*GS Asia head of TMI research analyst Piyush Mubayi sat down with our Chief Asia Pacific Economist Andrew Tilton to discuss the role AI & ML could play in the productivity challenge.*

**Piyush Mubayi: China growth has been about increased capital and labor? When does productivity become a key consideration for growth?**

**Andrew Tilton:** China's growth in the past three decades has been heavily input-driven, with both labor supply increases and capital stock growth driving the economy. Capital investment accounted for half or more of overall growth in the past few decades, with labor input also quite significant earlier but slowing down in recent years. That said, China has also seen gains in efficiency, or total factor productivity in economist-speak, which to a large extent have been enabled by those investments.

The government has emphasized the need to rebalance growth, focusing on raising domestic consumption and living standards. It has also emphasized "technological upgrading" in sectors such as manufacturing, as highlighted in policy documents such as the Made in China 2025 roadmap. However, driving productivity growth is easier said than done.

First, the gains to productivity from manufacturing sector growth and investment are likely slowing. China's manufacturing sector is very well developed with a large global market share. Upgrading can still drive productivity growth, but further improvements in economies of scale or scope may be more limited. The service sector will need to be a key focus for productivity improvement, but typically overall service-sector productivity growth is lower - partly because of measurement issues, but also perhaps because appropriately regulating service-sector industries is more challenging.

A second challenge for productivity growth is that private firms still have more limited access to capital; or put another way state firms still preferential access to resources and limited exit for inefficient firms. The upside is that private firms do typically exhibit faster productivity growth, so if China can level the playing field somewhat, there could be a boost to productivity.

Research on productivity growth at the sector level by McKinsey Global Institute suggests that two factors - technology and (smart) regulation - are key drivers of productivity growth. China is moving on both fronts, though to varying degrees.

**Mubayi: Is China then entering a similar phase of growth as the US entered in the 1990s, when productivity was accelerating?**

**Tilton:** A key part of the story of US productivity growth was about the progress in microprocessor technology (which led to higher measured productivity growth in computing) and its diffusion into other sectors of the economy, including labor-intensive areas such as wholesale and retail trade.

To the extent China is moving in the direction of a more level playing field for non-SOEs, trying to ease doing business (for example the recent focus on reducing unnecessary permits and fees), and encouraging technological upgrading, these could be helpful in driving faster productivity growth.

Productivity growth also has a cyclical element - filling existing capacity does not require more capital and usually not much more labor - so moving from decelerating growth to stable or slightly accelerating growth would help. This has been the case over the last couple of quarters, though our expectation is that growth will be lower a year or two from now.

**Mubayi: We've seen a lot of other technologies being developed in China over the past 10-15 years. Why hasn't there been a similar impact to productivity from technologies such as the smartphones, social networking, and cloud computing?**

**Tilton:** Measurement issues are probably a big part of it. In some cases, the benefits of technological progress may not be measured; in others, it may show up indirectly via higher productivity in other sectors of the economy that use the technology. Smartphones are a good example. In general, the hardware - specifically the microprocessor/memory technologies - does show high productivity growth, but the software typically does not, even though there is a huge proliferation of useful apps.

Mobile technologies surely have had positive productivity effects on downstream industries, for example by allowing delivery drivers to plan routes, access real-time maps, etc., but gains of this sort would be measured as productivity improvements in that sector and would not be specifically traceable to the telecom sector or electronics (smartphone) manufacturing. So my guess would be that mobile technologies have helped productivity, but that the gains are under-measured, and those that are measured are diffused among a lot of sectors that use the technology. Other new technologies also face measurement challenges, for example Internet-based services like social networking with advertising revenue models where users may pay nothing directly for the service.

**Mubayi: What kind of impact could the development of technologies like artificial intelligence and ML have on jobs, and overall productivity in China?**

**Tilton:** There are multiple effects. The effort to develop these technologies creates some very high-skilled jobs, but the number is likely to be very small relative to national employment. As the technologies are deployed in other industries, the initial effects might well be negative for employment.

A topical example is the potential combination of ride-hailing services and driverless vehicles, which could, in theory, eliminate a vast number of jobs in the transportation industry. To the extent these innovations reduce the cost of transportation, they could eventually free up income that people could spend on other goods or services—which could create jobs elsewhere in the economy.

Of course, those goods or services might not be provided by the same people, or as many people, and the new jobs would probably require different skills and be in different locations, so the process of transition could be socially disruptive. Even if overall employment is steady, people who are in mid-to late-career and have invested in developing skills for declining industries could see a major hit to their lifetime earnings.

A recent study by researchers at MIT and Boston University<sup>1</sup> found that in automotive and electronics industries, one robot replaced more than 5 workers, and automation overall had a small

depressive impact on wages. The researchers also noted that “perhaps surprisingly, we do not find positive and offsetting employment gains in any occupation or education groups.”

**Mubayi: Overall fixed investment in China is growing slower, and we have seen aggressive capex cut in China SOEs over the past few years with meaningful profitability improvement in 2016, which has led investors to expect better dividends policies in China. What is the role of productivity in this change?**

**Tilton:** In the short run, the change in dividends seems to be more a policy decision than a reflection of higher productivity growth. The reduction in capex in overcapacity industries reflects the lack of productivity of past investment. Favored access to credit and resources led to more investment in some sectors of the economy than would have been the case had market forces operated more freely. If the recent policy focus on “supply-side reform” succeeds in limiting excess investment in upstream industries and contributes to a more productive capital allocation, this should help boost companies’ capacity to pay dividends in the future.

**Mubayi: When we see gains in productivity historically, how do those typically impact corporate profits? Do costs simply move to another part of the income statement as companies seek competitive advantage or do we actually see sustainable increases in profitability?**

**Tilton:** In a rapidly growing and innovating industry, we can often see very high productivity growth, as we did in the computer hardware manufacturing sector for many years. At least some of the innovators tend to generate outsized profits — the economic signal for further investment in the sector. In the innovating sector, these productivity gains are often coming via top-line growth. In contrast, sectors that use the technology may see more of the

benefit on the cost side – coming back to the delivery example above, better real-time planning of routes with computers and mobile technologies might save on fuel and labor costs.

Economists tend to think that over long periods of time, these profit gains get competed away – the high profits attract new entrants to the sector. That said, in some high-tech sectors there can be forces (such as ‘network effects’) which increase the advantage of the leading player and lead to relatively concentrated market structure, which could support higher profit margins for an extended period, at least until the next disruptive technology is developed.

**Mubayi: In the 90s, we saw the market react positively to the productivity improvements in the US. To the extent that we see AI/ML and the broader technology driven improvements and efficiency, what impact do you tend to think that has on asset valuation?**

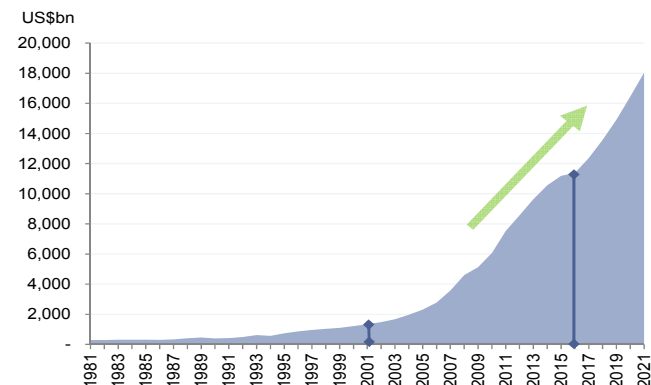
**Tilton:** Acceleration in economy-wide productivity would almost certainly be good for equities. Effectively, faster productivity growth is “the good without the bad” - more growth without more inflation that would in turn necessitate tighter monetary or fiscal policies. Assuming at least some of the benefit is captured by listed companies, this would probably lead to higher equity valuations. In particular, keeping all else the same, our US portfolio strategy team found that periods of faster productivity growth also mean periods of higher asset valuations. If we look at the US in the 1990s, we did see that. Of course, we also had an equity bubble that developed towards the end of that period with negative consequences.

<sup>1</sup>*Robots and Jobs: Evidence from US Labor Markets* by Daron Acemoglu, Pascual Restrepo, on March 17, 2017

## China's economy in 6 charts

### Exhibit 50: China GDP has grown 6x in the last decade to US\$11.4trn in 2016

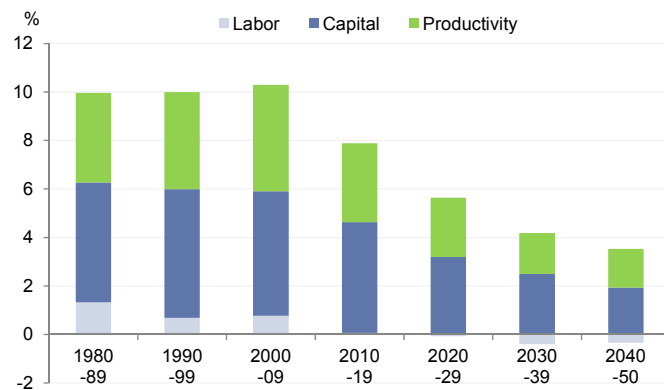
China GDP



Source: International Monetary Fund.

### Exhibit 52: China's GDP has been capital-driven in the past few decades; going forward productivity will play a bigger role

China GDP growth breakdown

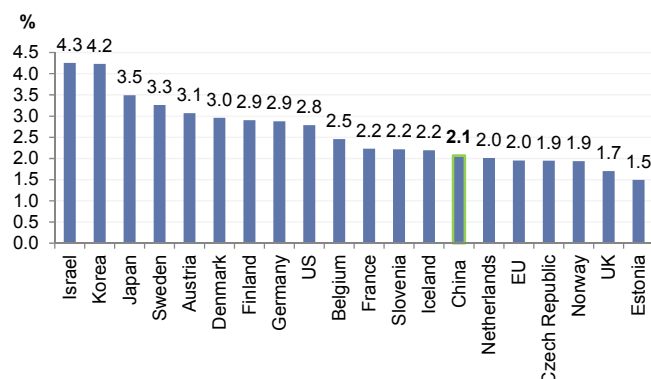


Note: 2010-2019 and beyond are GSe.

Source: NBS, Goldman Sachs Global Investment Research.

### Exhibit 54: China R&D intensity reached 2.1% in 2015, up from 1.1% a decade ago...

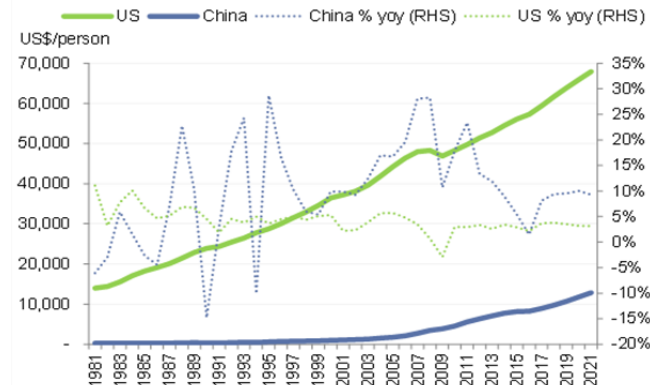
R&D expenditure as % of GDP in 2015



Source: OECD.

### Exhibit 51: ...yet GDP per capita is still 1/7 of that of the US

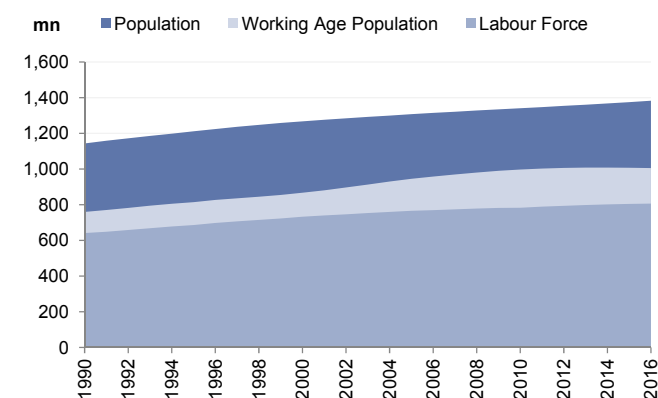
GDP per capita: China vs. the US



Source: International Monetary Fund.

### Exhibit 53: ...coupled with an aging population and a stabilized labor supply

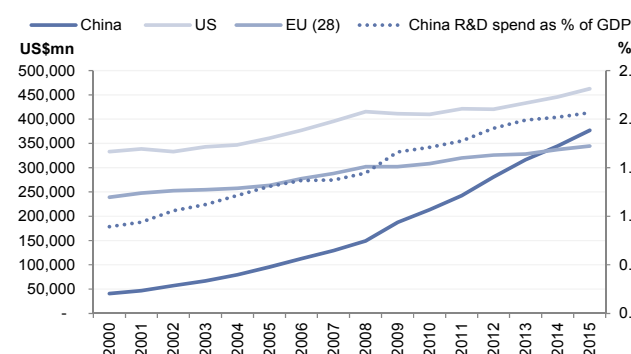
China's labor market



Source: NBS, United Nations, World Bank.

### Exhibit 55: ...with R&D expenditure surpassed that of EU in 2014, narrowing the gap vs. the US

R&D spend in US, China, and EU



Source: OECD.

## Appendix: What is artificial intelligence?

Artificial intelligence (AI) is the science of simulating intelligent behavior in computers. It entails enabling computers to exhibit human-like behavioral traits including knowledge, reasoning, common sense, learning, and decision-making.

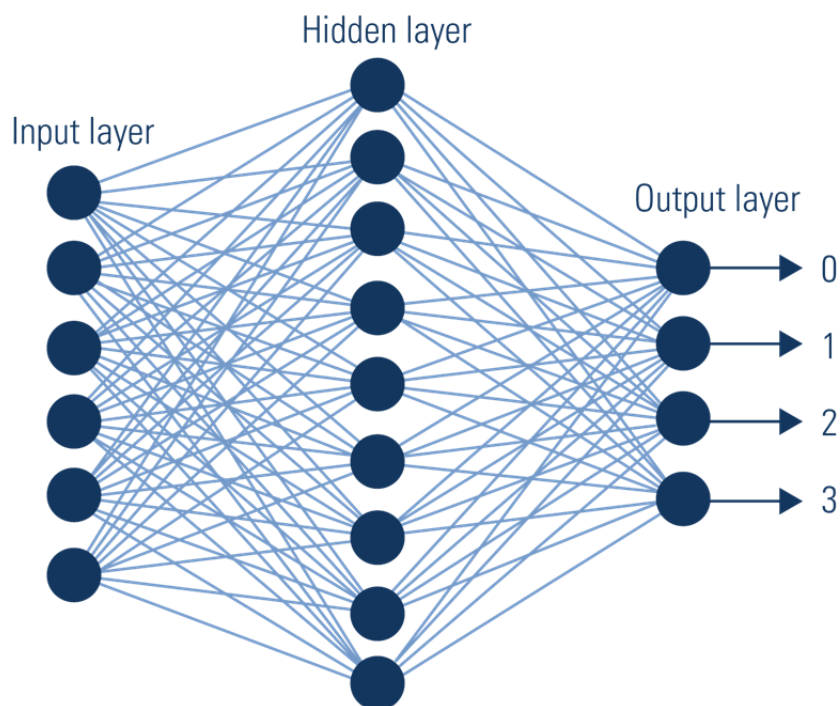
**What is machine learning?** Machine learning (ML) is a branch of AI and entails enabling computers to learn from data without being explicitly programmed. To provide simple context, a computer can be programmed to recognize trains in photos, but if it sees a photo of an object that only resembles a train (e.g., a museum built inside an old train, a toy train), it may falsely identify it as a train. In this scenario, ML would entail enabling the computer to learn from a large set of examples of trains and objects that only resemble trains, allowing it to better identify actual trains (thus achieving a level of AI).

There are many real-world applications of ML. For instance, Netflix has said it uses ML algorithms to generate personalized recommendations for users based on its massive volume of user behavior data and Zendesk uses customer interaction data to predict the likelihood of a customer being satisfied.

**What is a neural network?** A neural network in the context of AI/ML describes a type of computer architecture that simulates the structure of a human brain onto which AI/ML programs can be built. It consists of connected nodes in aggregate that can solve more complex problems and learn, like the neurons in a human brain.

### Exhibit 56: Neural network

Multiple hidden layers would be characteristic of deep learning



Source: Michael A. Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015, Goldman Sachs Global Investment Research

**What is deep learning?** Deep learning is a type of ML that entails training a hierarchy of "deep layers" of large neural networks, with each layer solving different aspects of a problem, allowing the system to solve more complex problems. Using the train example



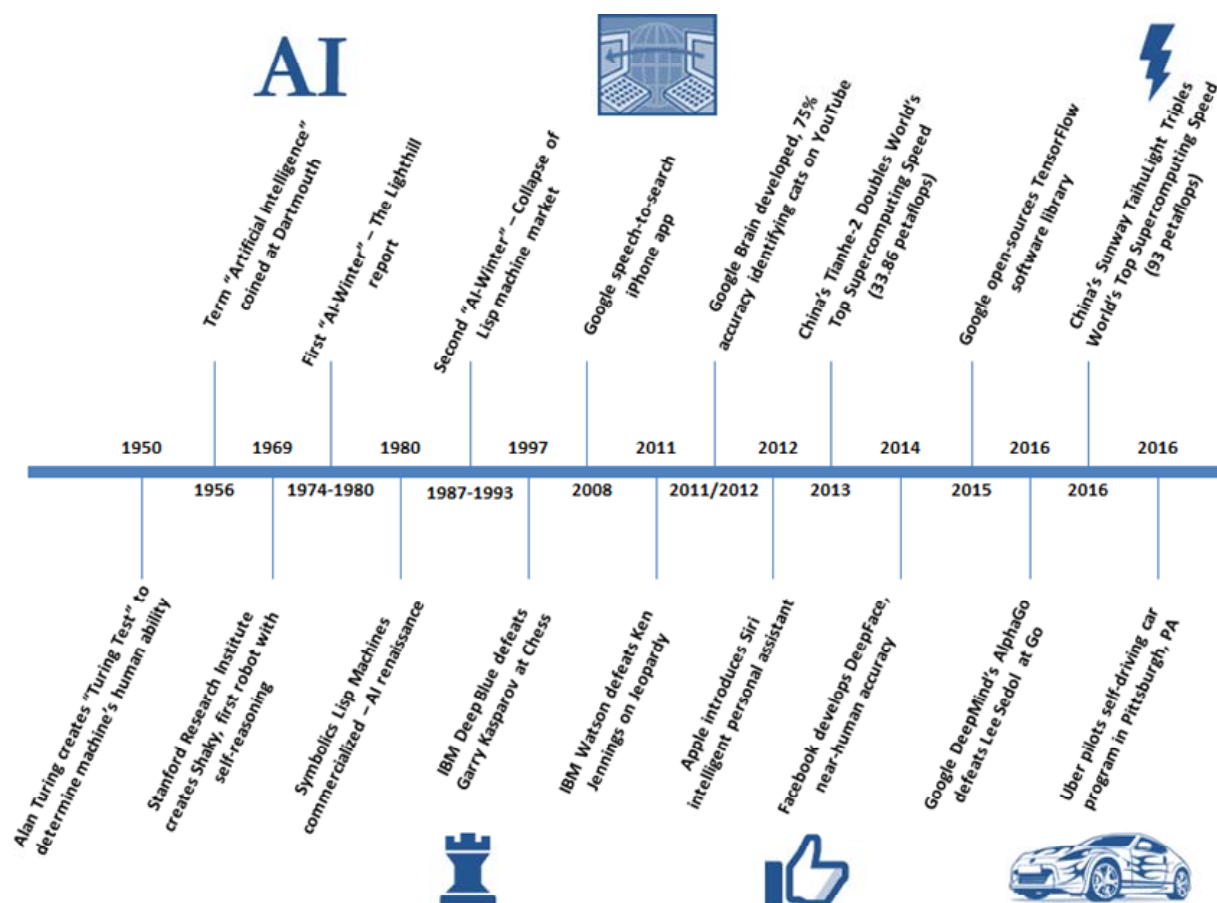
given above, a deep learning system would contain layers that each identifies a different trait of a train. For example, the bottom layer would identify whether the object has windows. If the answer is yes, the next layer would look for wheels. The next would look for rectangular cars, and so on and so forth, until the layers collectively identify the picture as a train or result in it being rejected. Deep learning has been gaining popularity as a method of enhancing ML capabilities as technological advancements began to allow for the training of large neural networks.

**What is supervised learning? Unsupervised learning?** Supervised and unsupervised learning are both types of ML. In supervised learning, the system is given a set of examples with “correct answers.” Based on these examples, the system would learn to correctly predict the output based on what it has learned from the correct answers. Real-world applications of supervised learning include spam detection (e.g., the system may be fed a set of emails labeled “spam” and learn to correctly identify spam emails) and handwriting recognition. In unsupervised learning, the system is not given correct answers, but unlabeled examples instead and left on its own to discover patterns. An example includes grouping customers into certain characteristics (e.g., purchasing frequency) based on patterns discovered from a large set of customer data.

#### **What are some types of ML?**

- **Classification.** Classifying emails as spam, identify fraud, facial recognition, voice recognition, etc.
- **Clustering.** Comparing images, text or voice find similar items; identifying clusters of unusual behavior.
- **Predictive.** Predicting the likelihood of customer or employee churn based on web activity and other metadata; predict health issues based on wearable data.

**What is General, Strong or True AI?** General, Strong, or True AI are terms used for machine intelligence that fully replicates human intelligence including independent learning and decision-making. While techniques like Whole Brain Emulation are being used to work toward the goal of General AI, the amount of computing power required is still considered far beyond current technologies, making General AI largely theoretical for the time being.

**Exhibit 57: Evolution of AI: 1950-Present**

Source: Goldman Sachs Global Investment Research

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# Mindcraft: Our Thematic Deep Dives

## Innovation & Disruption

Virtual Reality



Drones



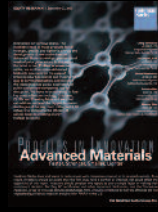
Factory of the Future



Precision Farming



Advanced Materials



Artificial Intelligence



Space



Store of the Future



OLED



## Rise of the Asian Consumer

Chinese Consumer



Chinese Millennials



China E+Commerce



## The Future of Finance

Future of Finance



China FinTech



Blockchain



Asia Digital Banking



## Old China Commodities

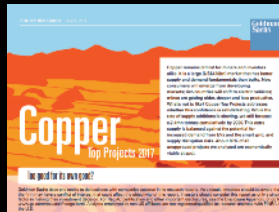
Top Oil & Gas Projects



Reforming China Energy



Copper: Too good for its own good?



## China Banks



## Japan Aging



## The Low Carbon Economy

Tech in the Driver's Seat



The Great Battery Race



China's Environment



China's Battery Challenge



Low Carbon China



## Music's Return to Growth

Opportunity



Risk



## Creating Tomorrow's Greater Bay



## Apple Suppliers' Dilemma



## Asian Quantamentals



## SUSTAIN

Quality problems, quality solutions



## Credit

Mapping Out China's Credit Market



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**Growth** is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

Financial Returns and Multiple use the Goldman Sachs analyst forecasts at the fiscal year-end at least three quarters in the future. Growth uses inputs for the fiscal year at least seven quarters in the future compared with the year at least three quarters in the future (on a per-share basis for all metrics). For a more detailed description of how we calculate the GS Factor Profile, please contact your GS representative.

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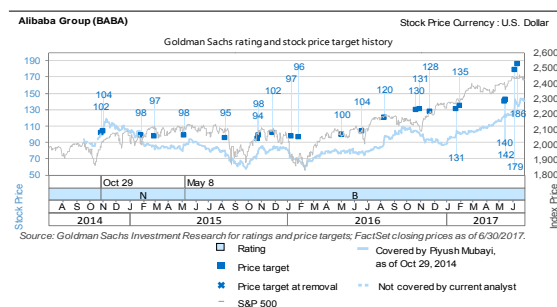
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	Rating Distribution		
	Buy	Hold	Sell
Global	32%	54%	14%

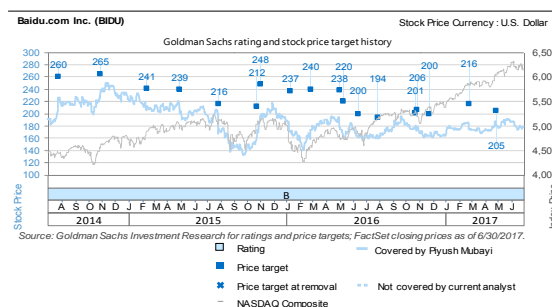
	Investment Banking Relationships		
	Buy	Hold	Sell
	65%	56%	49%

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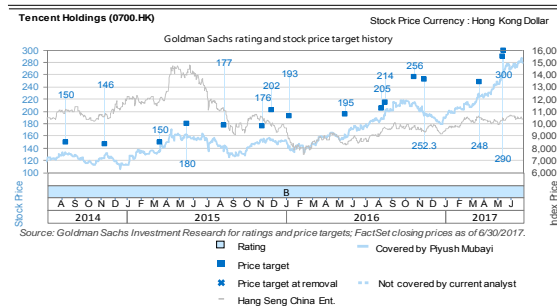
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