Prepared statement of Mark Brinda for the U.S.-China Economic and Security Review Commission

Hearing on China's Pursuit of Next Frontier Tech: Computing, Robotics, and Biotechnology

Panel I: Computing: focus on Cloud Computing

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The emergence of cloud computing is one of the most significant forces reshaping the technology industry and will play out over a multi-decade timeframe. We will explore the precise definition of the term *cloud computing*, but in simple language, the term refers to the pooling of technology resources for the purpose of enabling businesses or consumers to use as much or as little as they need, on demand, anywhere, anytime.

The shift from making fixed investments in technology resources that are owned and managed by the customer to the use of cloud resources that can be made available instantly and scaled up or down instantly is unlocking enormous innovation and efficiency within the global economy. Imagine if companies like Uber, Netflix or Instagram had to buy, install and manage all of the technology resources that deliver their service to customers. In order to support the rapid growth that they ultimately experienced, they would have needed to spend huge sums of money on technology before the business models were proven. Investors would have been far less likely to take a chance on a company with this profile. Instead, these companies were able to use cloud resources and spend virtually nothing on IT in the early days, and then let spend on IT grow in line with demand. Cloud dramatically lowers the bar for entrepreneurs to start a digitally-enabled business, and hence has unlocked a wave of innovation over the past decade.

Because of the broad economic importance of cloud, the Chinese government has made it a significant focus of the 13th Five Year Plan[1] and has launched initiatives like Internet Plus[2]. In this testimony, I will compare and contrast U.S. and Chinese technological capabilities in cloud computing, explore what steps the Chinese government has taken to support domestic firms, and lay out the broader implications of these policies for U.S. technological innovation.

This testimony is organized as follows:

1. Definition of cloud computing and segments of the market for cloud solutions
2. Overview of China's cloud landscape
3. Comparison of cloud in China and U.S.
4. Implications and recommendations

1. Definition of cloud computing and segments of the market for cloud solutions

"Cloud computing" is an overused and overhyped term that has lost some of its meaning over the past economic cycle. Companies associated with cloud have seen dramatic valuation growth, hence every company wants to jump on the bandwagon, regardless of the degree to which their offerings actually leverage or enable a true cloud architecture.

The National Institute of Standards and Technology outlines a specific and practical set of requirements for any technology environment to be accurately labeled "cloud"[3]:

- **On-demand self-service:** A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider
- **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations)
- **Resource pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth
- **Rapid elasticity:** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time
- **Measured service:** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

There are many computing models that share some of these characteristics and have been around for decades. In fact, cloud is not a dramatic new innovation but a breakthrough that emerged from a steady evolution of computing models. Utility computing, grid computing, virtualization, IT outsourcing and other technologies and delivery models have been enabling businesses to do some of these five elements, just not all of them as part of a single solution. Consequently, many legacy technology companies that have built a business in one or another of these predecessor computing models are now labeling everything they do "cloud", which has confused the market and made it difficult for customers and industry participants to distinguish true cloud solutions.

The NIST goes on to outline three cloud service models (Software as a Service, Platform as a Service, and Infrastructure as a Service) and four cloud deployment models (Private Cloud, Community Cloud, Public Cloud, and Hybrid cloud). For the purposes of this discussion, I will focus on four discrete intersections of these service and deployment models which collectively comprise the relevant cloud market segments:

Infrastructure and Platform as a service (IaaS/PaaS): cloud-delivered servers, storage, information management software and application development/operations tools sourced from a shared, 3rd party-owned data center environment

- Leading cloud players: Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform, IBM Bluemix, Force.com, Aliyun (Note: AWS is the global market leader with ~40% share, followed by Microsoft with just ~5% share)
- Leading traditional computing players: Dell, EMC, Cisco, IBM, HP, Microsoft, Oracle, VMWare, Huawei, Lenovo
- 2016 global market size: ~$20B[4]
- 2015-20 market growth rate: ~25-30%[4]

Software as a service (SaaS): cloud-delivered application software (e.g. office productivity, customer relationship management, enterprise resource planning, human resource management) sourced from a shared, 3rd party-owned data center environment

- Leading cloud players: Salesforce.com, Workday, ServiceNow, Microsoft, SAP, Oracle
- Leading traditional computing players: Microsoft, Oracle, SAP
- 2016 global market size: ~$55B[4]
- 2015-20 market growth rate: ~15-20%[4]

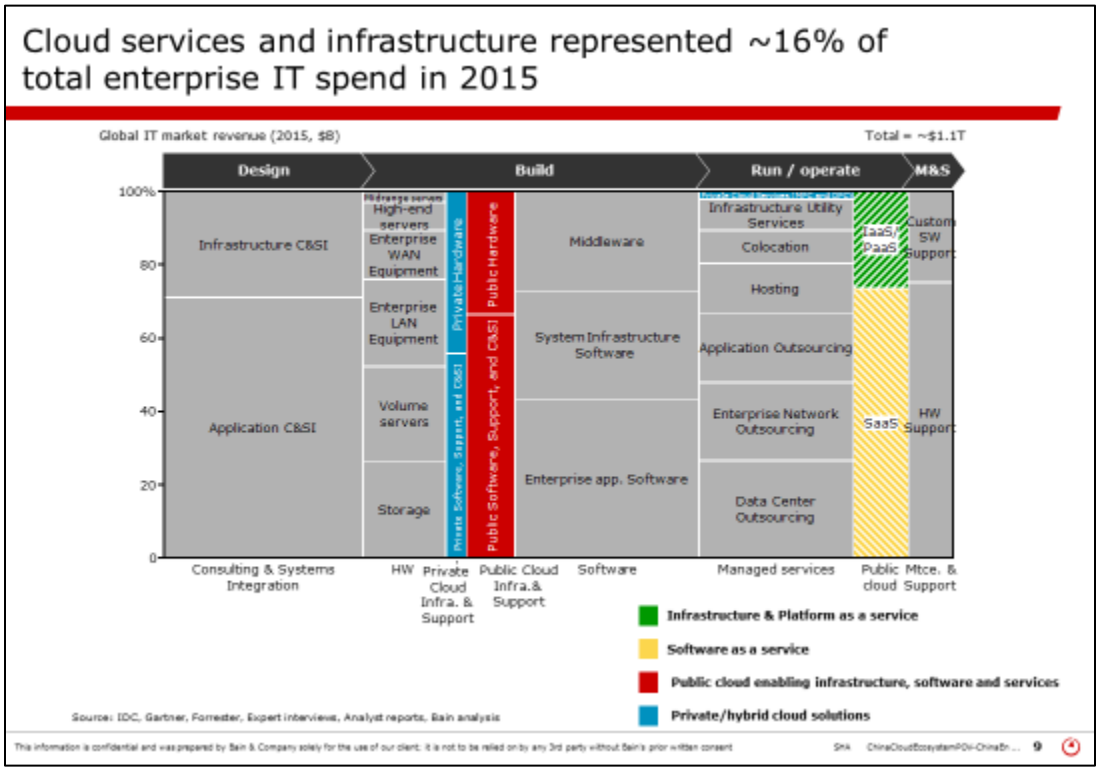
Public cloud enabling infrastructure, software and services: components, software and services required to build a cloud environment, including processors, servers, storage, networking equipment, infrastructure software, data center power and cooling equipment, and related services

- Leading cloud players: Intel, Dell, HP, EMC, Cisco, Pegatron, Compal, Wistron, Quanta
- Leading traditional computing players: same leaders
- 2016 global market size: ~$70B[4]
- 2015-20 market growth rate: ~12-15%[4]

Private and hybrid cloud solutions: cloud infrastructure and platform environment that is partially or entirely dedicated to a single company or customer; can be built and run by an enterprise for its own consumption or owned/managed by a 3rd party operator

- Leading traditional computing players: Dell, EMC, Cisco, IBM, HP, Microsoft, Oracle, VMWare, Huawei, Lenovo
- Leading cloud players: IBM, Microsoft, VMWare, Rackspace
- 2016 global market size: ~$7-20B[4]
- 2015-20 market growth rate: ~25-35%[4]

For context, these markets collectively represent ~$180B of the $1.1T global market for enterprise IT. They will drive roughly 60% of the total growth in the technology market from 2015-2020.[4] Thus, while it is important to keep in mind the enormous volume of technology spend that is not yet driven by the cloud, the technology industry and governments of countries with a large tech sector recognize the role that cloud will play in future growth and are appropriately focused on creating an environment where domestic firms can flourish.

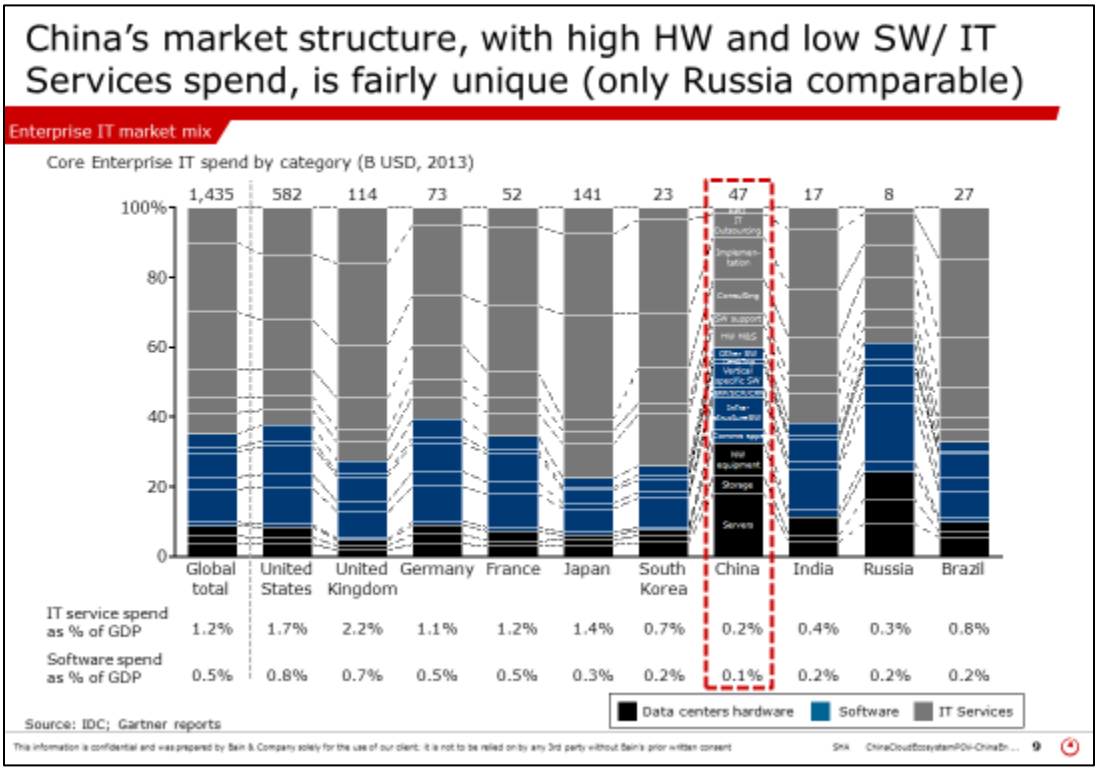


2. Overview of China's cloud landscape

To understand the current state of cloud computing in China, it is essential to start with an understanding of the broader technology market in China. Specifically, a) What types of IT offerings do Chinese companies buy? b) What firms spend that money?, and c) What has been the Chinese government's posture toward both domestic and U.S. technology providers?

The Chinese market for enterprise IT looks quite different from other large economies. First, the total amount spent on IT is significantly lower as a share of GDP. In 2013, the US market for IT was equal to 2.8% of GDP, the U.K. market was 3.0% of GDP and the China market only 0.5%. This is not just an emerging market phenomenon. The Brazilian IT market, for example, was equal to 1.2% of GDP.[5]

The reason China spends so little is simple: the market for software and services are disproportionately small relative to the market for hardware. Software piracy has long been a common practice for Chinese enterprises and the use of 3rd parties to outsource the build, operation and maintenance of IT is still not standard practice, particularly with State Owned Enterprise.



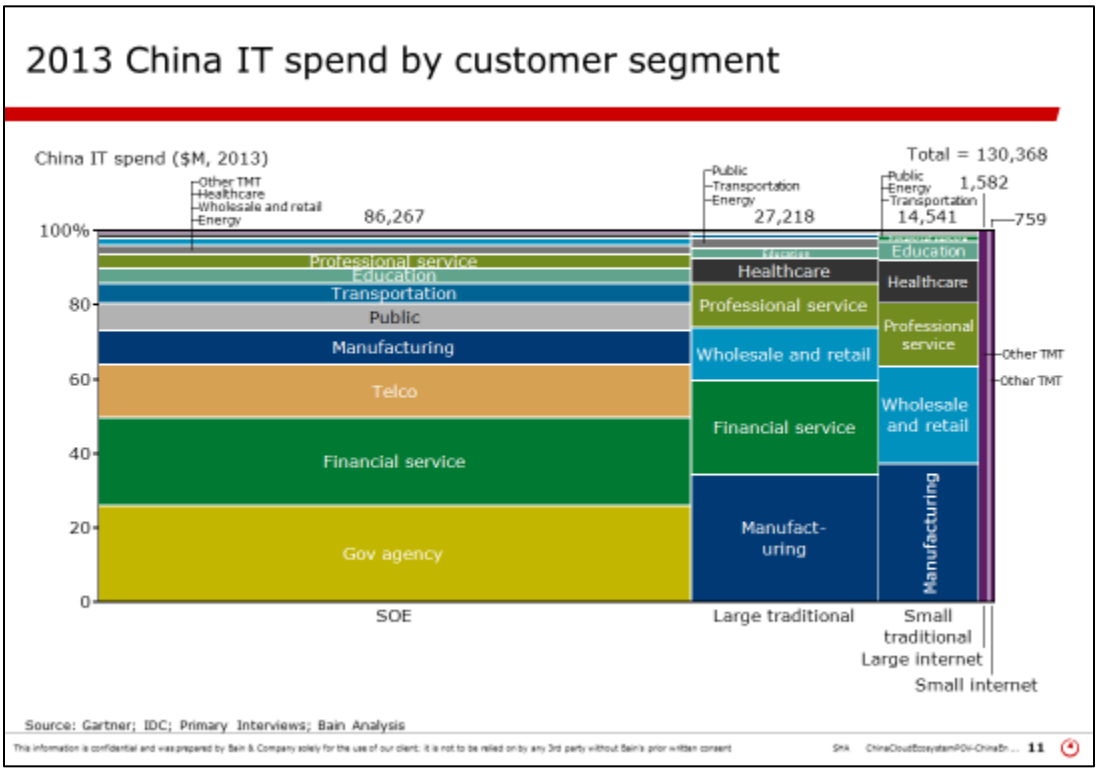
To the second question on who buys IT in China, the answer is that state owned enterprise (SOEs) drive an enormous share of spend. Two-thirds of total IT spend is driven by SOEs, a share so large that the posture of this segment toward the cloud will effectively determine the course and speed of cloud evolution in China.

Historically, SOEs have been very slow to adopt cloud solutions. There are several factors at play here. First, they are large, legacy organizations with a mature IT environments that are both costly and risky to move into a cloud. This fact will not change, regardless of the government posture toward cloud. With few exceptions, legacy systems that run mission critical applications have not moved to the cloud in any economy.

The second factor at play is the business mix of the SOEs. They are over-represented in financial services and telecom, and also include government agencies. All of these sectors of the economy tend to have IT decision makers with more conservative attitudes toward adoption of new technologies, regardless of geography. This is due to data sensitivity, systems rigidity and the mission critical nature of services provided.

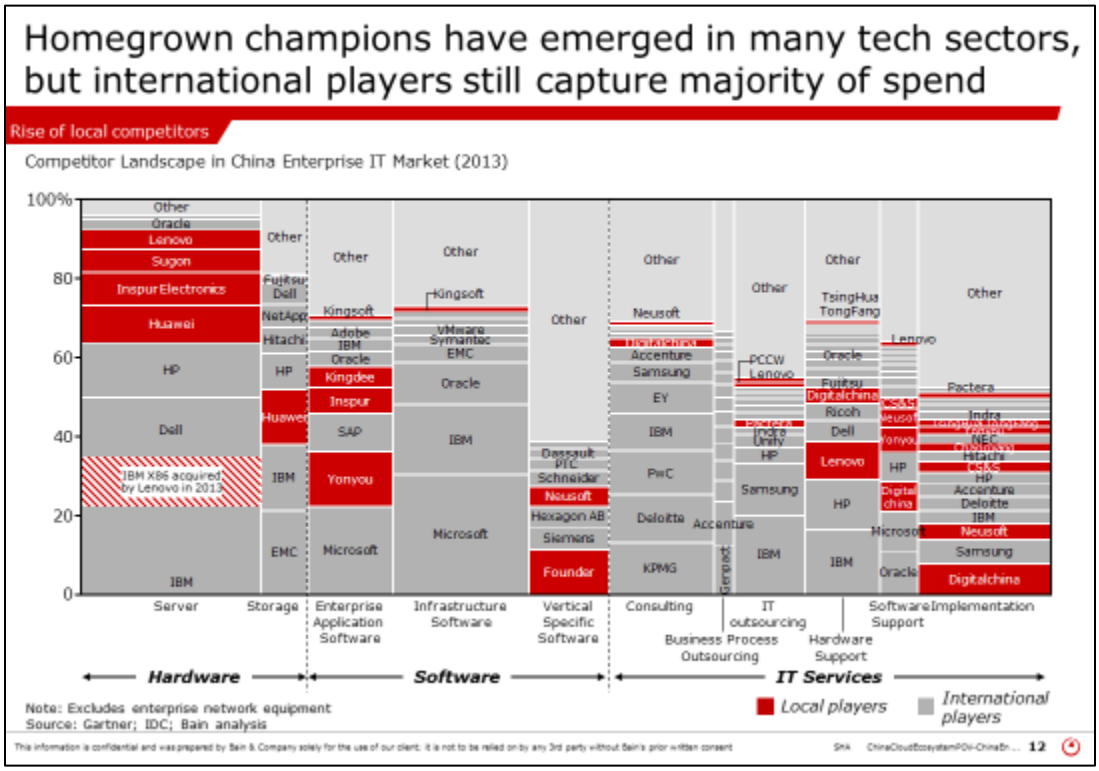
The third factor at play is the role that the government plays in setting the IT agenda at SOEs. In 2014, when Bain conducted extensive primary research into the attitudes toward cloud of different customer segments, SOEs had the lowest share of spend on cloud and the vast majority of that spend was on company-owned/managed private clouds. This is the factor that the government has started to change and is the wildcard in the Chinese cloud market.

Since 2014, the government has made clear the importance of digitization and investment in cloud technology through initiatives like Internet Plus and the 13th Five Year Plan. While the literal translation of these programs are vague, they have quite clearly begun to impact the posture that SOEs have toward cloud, and public cloud in particular. While there has not been a dramatic shift of investment from traditional IT to the cloud at SOEs because of the other factors cited, there has been an increase use of public cloud for new applications, in eCommerce, online customer engagement, and big data, for example.



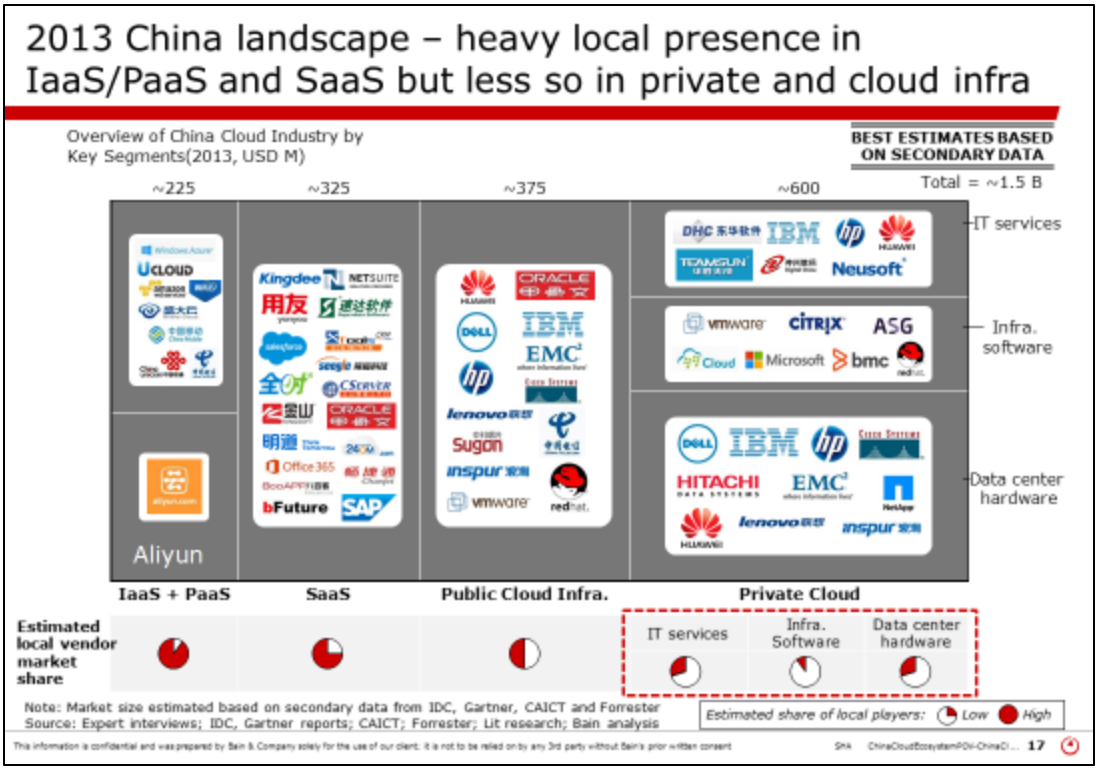
The final issue to understand with respect to the IT environment in China is around the government's treatment of domestic players vis-à-vis U.S. and other international technology companies.

A look at the market share of local vs. international players across the IT landscape reveals that international players make up a significant majority of the market.[5] Despite local participants in almost every category, Chinese companies, including SOEs, have widely used U.S. technology. While there are factors at play in the market for cloud that will drive higher share for Chinese firms in some market segments, international players will continue to play a major role in the Chinese IT market, particularly in categories like CPUs, infrastructure software and IT outsourcing where no commercially viable, scale local alternatives exist. Players in these categories will all capture share of the Chinese cloud market as well.



With that backdrop, we can now look at the current state of the cloud market in China and the role that the government has played in accelerating investment and growth.

In 2013, the total Chinese market for cloud solutions across the four key categories was $1.5B. This represented just ~1-2% of the total global cloud market.[5] While Bain expects the Chinese market to rise to between 2.5-4% of the total global cloud market by 2020 and grow to a total of $13B-19B[6], the market will remain relatively small for the near-to-medium term. The factors outlined above are at the root of both why the market is relatively small and why it is growing more rapidly.



If we look at the four key segments of the market, the one that is most dynamic and where local players have the greatest share is the IaaS/PaaS market. This is a service that does not face significant language or culture barriers upon export and where there are fewer entrenched legacy players in many markets. Consequently, firms in this space have high hopes for international expansion.[7]

The Chinese cloud company that gets by far the most attention is Aliyun, an IaaS/PaaS provider owned by Alibaba that is considered "the Amazon Web Services of China". Aliyun is growing at >150% per year on a base of ~$800M-1B revenue in 2016. Wall Street estimates expect the business to reach $8B-$9B[8] by 2020. Aliyun has >50% market share in China now, up from ~40% in 2013.[6]

There are numerous reasons for its local dominance. Part of the story is similar to the one we have seen in Chinese consumer web services (e.g. WeChat, TenCent, RenRen, Baidu) where early government protections allowed a local player to achieve scale and meaningfully differentiate vs international competitors. When barriers are lowered, the local firm is able to survive foreign competition. In IaaS/PaaS, this protection came in the form of onerous rules about foreign entry that require international competitors to apply for a license to compete and take on a local partner with a majority stake.[9] While Microsoft Azure and AWS are both present in China, neither has been able to achieve the share position they have globally or in the US.

In terms of technology features and functionality, Aliyun is still not at full parity with AWS and Azure, but is close on most core services like compute, storage, and database. What Aliyun has done very successfully is win with the two most critical segments of the cloud market: SOEs and local tech-centric start-ups.

With SOEs, the story is straightforward: when a public IaaS/PaaS solution is appropriate for a given IT workload, there is a clear preference for local firms and Aliyun in particular. The fact that SOEs are leveraging the public cloud more, in line with government directives, including Internet Plus and the 13th Five Year Plan, is a direct boon for Aliyun. In Bain conversations with SOE buyers, they express a clear preference for Aliyun whenever there isn't an obvious reason why a more full featured solution from a larger global player is required.

With tech-centric start-ups, the story is more about a true advantage that Aliyun has created. The company has developed a comprehensive suite of offerings that a small web business would want, inclusive of business financing, turnkey eCommerce, marketing automation, and business productivity software. These offerings go well beyond what AWS or Azure can offer in China and leverage the local dominance of the Alibaba marketplace.

Looking at the SaaS market in China, we see that it is subscale relative to the global SaaS market – it is ~1.5x the size of IaaS/PaaS while the global SaaS market is ~3x the size.[4] [5] This is due to the fact that Chinese firms are unaccustomed to paying for software. In other markets, SaaS spend is capturing share from traditional application software while in China, it is typically net-new spend for a company.

A wide range of local players have emerged in the Chinese SaaS market, in large part because global software players have been slow to invest in creating offerings with local language requirements and that are tuned for the Chinese economy. Those international firms that have made a play are often following multinational corporations that have built or acquired Chinese businesses. The flip side of this story, however, is that Chinese SaaS players are very unlikely to succeed beyond the local market and potentially other geographies of significant Chinese influence.

The private cloud and public cloud infrastructure markets in China look much more like the markets for traditional IT infrastructure hardware and software. U.S. players have much stronger solutions and have deep incumbent relationships with local players. Aliyun, for example, uses a significant amount of gear from HP, Dell and other branded equipment manufacturers.

That is not to say that local firms are not taking share and growing rapidly; they certainly are. There are two flavors of Chinese players in the markets for cloud infrastructure: a) local "branded" infrastructure makers like Huawei and Lenovo that sell a specific set of pre-designed infrastructure solutions which are built specifically for clouds and b) local "white box" manufacturers (Original Design Manufacturers or ODMs) that do not design equipment but will build any configuration that a customer wants at razor thin margins, so long as the volume is sufficient to justify the order.

Chinese branded equipment makers are still not at parity with the global leaders like Dell, HP, IBM, and EMC and while they have closed the gap, the bar keeps getting higher and the leaders are spending huge sums to maintain a sizeable lead. The gap is really around the embedded software and surrounding support that U.S. leaders provide, both areas where China is not stocked with the local talent required to catch up. In some circumstances, Huawei and Lenovo win contracts for private cloud deployments within SOEs, but there is still a gap with global vendors. The gap is closing, however, driven in part by SOE preference for local vendors.

The one exception where Chinese branded infrastructure players have managed to build a significant global presence is in telecommunications equipment (the gear that telcos install to build wireless networks) where Huawei and ZTE to a lesser extent have taken significant share. While this is not directly a part of the cloud market, it is work noting because Huawei in particular has leveraged this business into a smaller position in networking equipment (i.e. Cisco's core business) and an even smaller position in servers and storage. They are trying to build a cloud infrastructure business and even an IaaS/PaaS business but have had limited success outside of China to date. Huawei, however, is the biggest threat to U.S. branded equipment makers. Lenovo would be the second most significant following its acquisition of IBM's low-end server business, but is still less competitive in either the private cloud and public cloud infrastructure market.

The market for white box equipment is a very different story. Players like Inspur, Wistron, and Quanta, have built significant global businesses selling equipment to cloud providers. This market very directly leverages China's core strength in manufacturing, supply chain and logistics. This is really more of a manufacturing business than a technology business. There is virtually no IP included in the equipment that these vendors offer. They are simply a low cost way for companies like AWS, Facebook, and Google, as well as branded equipment makers like Dell, EMC and HP to build infrastructure that they have designed themselves. It is similar to the relationship between Foxconn and Apple.

While this is not a particularly attractive business, it is a vital one, not just to cloud but to the entire IT infrastructure market. There are no scale alternatives to outside of China and Taiwan. Should a trade war break out or some other global disruption occur that severs the link between U.S. cloud providers and these suppliers, there would be a significant and sustained disruption in the global IT market.

I will conclude comments on the state of cloud in China by summarizing the impact of government policies and plans on the Chinese cloud market and on the global competitiveness of both Chinese and U.S. cloud providers.

I do not profess to be an expert at deciphering the true meaning of Chinese government proclamations. The relevant comments around cloud computing in policy statements are often vague and not clearly indicative of action. What is clear to me is that Chinese policy is having the following major impacts:

- Select cities have been designated as cloud hubs, either by the center or by local leaders, in order to accelerate growth of the domestic digital business and IT vendors
- Funding for cloud-related infrastructure buildout is very readily available, to the point that this is not a constraint on growth
- Decision makers at SOEs have been steered to digitize their businesses and, where sensible, to leverage local public cloud solutions to do so
- International IaaS/PaaS players have been saddled with significant barriers to entry, which has created a protective bubble within which local firms have achieved scale

What policy has not impacted are the following fundamentals of the Chinese cloud market and technology business more broadly:

- Vast majority of technology profit pools are in sectors that the Chinese firms are fundamentally not positioned to compete in due to a lack of local talent: CPUs, infrastructure software, and services drive >70% of technology profits and Chinese firms are all virtually absent from these sectors, even in Chinax

- While local protections have enabled IP-driven cloud businesses to achieve scale locally (i.e. IaaS/PaaS, SaaS) they have had no success exporting their offerings to date and there are few examples of Chinese success in other attempts to export IP-driven technology
- Large, legacy businesses are slow to adopt cloud for structural reasons and two thirds of IT spend in China is driven by these kind of firms
- White box infrastructure, the cloud segment where China is globally competitive, is part of a broader segment of custom technology infrastructure manufacturing where China has long been a global leader

3. Comparison of cloud in U.S. and China

The U.S. is by far the global leader in the cloud market. U.S. companies lead every cloud category across IaaS/PaaS, SaaS, private/hybrid cloud and cloud enabling infrastructure and make up at least 4 of the top 5 providers in every cloud market. The one exception being SaaS where Germany's SAP has a #3 position but no other non-U.S. company is in the top 10 (and even SAP is headquartered in the US with an American CEO).

In this section, I will explore each cloud segment from the perspective of U.S. vendors to understand what they are doing to achieve a competitive advantage, how they are taking that to the Chinese market and what success they are having.

First, let's discuss the IaaS/PaaS market, where AWS is the largest global player with a $12B 2016 business that is larger than all of the Chinese cloud market. The business has a technology lead that is insurmountable in the near term. The AWS cost per unit is lower than any other player, enabling them to earn 20%+ EBITDA margins and reinvest in widening their lead on bringing innovative new services to market. They achieved this position by being first to market, hiring and retaining incredible talent, and continuously investing in growth. The untapped potential to capture demand currently served by traditional data center equipment is vast, many times the current size of the business. There are also many large adjacent markets, most notably SaaS, where AWS has yet to focus.

The #2 player in the IaaS/PaaS market is Microsoft Azure, now a $2B+ business growing >100% y/y, even faster than Amazon. Microsoft has the advantage of a huge base of developers and an enormous installed base of infrastructure software that it has managed to retain and begin transitioning to the cloud. Of the legacy infrastructure HW and SW providers, Microsoft is the lone success story. Hardware vendors, including Dell, HP and Cisco, as well as other infrastructure SW players, notably IBM, have struggled to take share or have failed altogether. By making the Microsoft cloud experience for developers comparable to that of its legacy offerings, but with the flexibility, self-service and other attributes of the cloud, they have become the de-facto cloud provider for the millions of "Microsoft shops" out there.

AWS and Microsoft are threatening to make the global IaaS/PaaS market a two horse race. Many large tech incumbents, including Dell, HP and Verizon, have thrown in the towel on this business after investing significantly. Others, including IBM, Google, and Oracle, are still investing but struggling to keep pace. There is a "long tail" of subscale players, both in the US and internationally who predominantly serve small and mid-size customers with

minimally complex needs. However, no international player outside of Aliyun is close to becoming a scale global player.

As previously discussed, Aliyun has achieved near-parity on some competitive dimensions and has actually differentiated on other dimensions that resonate with the Chinese market. While Aliyun has yet to make any significant headway internationally, the business certainly has ambitions to play in both the U.S. and other markets where Chinese technology firms have been successful. Jack Ma has reportedly met with President Trump and the company has considered U.S.-based M&A.[7] The U.S. market will be a challenge. There are no obvious scale acquisition targets and the likelihood is low that a new entrant from China will organically achieve scale in a mature market where the #1 barrier to purchase is data privacy and security.

The more likely scenario is that Aliyun will win in international markets where other Chinese companies have been successful: Southeast Asia, Africa, the Middle East, Eastern Europe. These markets are nascent, however, and total IT spend is minimal. It is likely that the domestic market will be the largest one for Aliyun for the foreseeable future

In the global market for SaaS, U.S. firms are also far ahead and hold a defensible long term position. There has been substantial consolidation in the SaaS market over the past decade, driven both by M&A activity of large software incumbents, particularly Oracle and SAP, and the transition of legacy software franchises to a cloud-based delivery model. Some scale new players have emerged, notably Salesforce.com and Workday, and many other smaller, fast growing competitors exist.

The U.S. has long had a lead in the market for software and the transition to cloud builds on and reinforces the factors that have made the U.S. a leader. A large, highly skilled developer ecosystem is the first essential criteria. Innovation hubs like Silicon Valley where developers, venture investors and acquirers are in close proximity are a second essential criterial. A large domestic market for software is a third criteria – without customers, it is hard to build a successful business.

On each of these dimensions, particularly the third, the U.S. holds a sizeable lead vs. China. The U.S. market for software is ~17x that of China's. The ratio of spend on SW to spend on infrastructure that it runs on is 5:1 in the U.S. and only 1.25:1 in China. It will take well over a decade for the software market in China to mature to scale that an economy of its size should support. When thinking about global competitiveness of Chinese SaaS firms, this difficult-to-influence factor will be a significant headwind. Beyond this, there is friction around adapting software to local language and processes that largely does not impact the Chinese hardware companies that have had international success. Finally, there are the same concerns about data privacy and security. For these reasons, I am skeptical that government declarations on innovation hubs and encouragement of developer education will lead to globally competitive Chinese SaaS firms that rival those in the U.S. anytime in the next decade.

The last two segments, private/hybrid cloud solutions and public cloud enabling solutions, are areas where U.S. firms are marginally more exposed, though even here the U.S. competitors have a sizable lead in most sub-categories. There are a number of sub-segments in these markets where the U.S. has no credible rival in China and Chinese demand will continue to be filled by U.S. firms. Broadly speaking, these are areas where the IP content of the offerings are high, e.g.: CPUs that go into cloud infrastructure, cloud

infrastructure software, “cloud in a box” systems (certain types of what are called converged systems in IT jargon).

These are markets where decades and hundreds of billions of dollars of accumulated demand give the U.S. firms in these categories a massive edge. For example, since 2006, the Chinese government has backed an alternative CPU architecture from the Jiāngnán Computing Lab. After more than a decade of sustained investment, there is no enterprise-ready CPU available from a Chinese manufacturer. Chinese clouds, just like those in the U.S., run on Intel x86 processors. The reason that all of this investment has not led to an alternative is that the entire enterprise IT ecosystem is designed to run on CPU architectures that only U.S. firms are capable of designing. Only in a completely closed system with entirely proprietary software and surrounding components could a home-grown alternative be viable, which is what we have seen in the supercomputer space where the Sunway TiahuLight has become the world’s fastest supercomputer leveraging a the CPU architecture from the Jiāngnán Computing Lab.

This is just one example of a market where there is significant IP content that an entire ecosystem has been built around and it is not enough to simply create an alternative. Moving an entire economy from one IT standard to another is far harder than building a prototype that works in a lab. We are still more than a decade away from a world where Chinese clouds can run entirely on home grown componentry instead of CPUs, software and hardware from the U.S.

The segment of this market where the U.S. is not only less competitive but *non*-competitive is that of manufacturing custom designed hardware at scale. This is a market where the Chinese and Taiwanese lead globally and U.S. firms have not attempted to compete. Profit margins in this business are razor thin and global supply chains for many of the heaviest components (e.g. server chassis, motherboards, SSDs) originate in Asia, advantaging Chinese firms relative to a potential U.S. entrant.

There are significant geo-political risks that the broader U.S. technology market is exposed to as a result of this dependency; cloud certainly shares that exposure. This is not a market where U.S. firms should play based on economic fundamentals alone. However, this exposure creates a point of strategic weakness that could be exposed in trade negotiations or other conflict with China, particularly if Taiwan is involved. The damage that the U.S. would incur from a shock to the IT hardware supply chain would be much larger than the shock that China would experience, creating a potential point of leverage.

4. Implications and recommendations

Against this backdrop, where U.S. cloud firms have a commanding lead globally, where there are significant challenge facing Chinese firms who would aim to compete on a global basis and where Chinese firms are still significantly dependent upon technology from U.S. firms to build and run cloud environments, I would offer the following recommendations:

1) Encourage aggressive use of cloud by government agencies – The U.S. Government represents a sizeable share of domestic IT spend, enough to impact the pace of innovation in some sectors of the cloud market. There are notable examples where the Government has embraced the cloud (e.g. the CIA use of AWS for select applications) but use has been slower than other industries. The stated rationale for

the slow pace of migration is around data privacy and security. However, this is a red herring.

The U.S. Government represents such significant spend and such an important reference for cloud providers that they will invest heavily to co-create solutions tuned for the unique needs of government. The AWS-CIA example is a perfect one. That solution was entirely custom built for the CIA, but by using it, AWS gained enormous credibility in the market and has substantially changed the perception that it is an offering just for startups on a budget.

Another area where the government could impact innovation and adoption in the market is around private cloud. A multi-billion dollar investment in private clouds, which would enable government agencies to be far more agile on how they build and scale custom software, would go a long way toward addressing an innovation gap in this space. Enterprises want private cloud but for the right price. Today's private cloud solutions are still expensive and complex. But a scale investment in private cloud, coordinated across government agencies, would drive considerable investment in innovation that could then be taken to the private sector.

2) Collaborate with industry on a supply chain disruption mitigation plan – I have highlighted the structural risk stemming from dependency on Chinese and Taiwanese ODMs. There are many plausible scenarios where Taiwan the flashpoint in a U.S.-China conflict and the global IT hardware supply chain is severely disrupted. This is a risk that would certainly impact the broader technology ecosystem, so I would not be surprised if there is a mitigation strategy already in place. If there is not, the government and the largest ODM customers, which would include AWS, Facebook, Google, Apple and others beyond the legacy IT hardware players, should collaborate on a mitigation plan.

3) Maintain a very high bar on Chinese acquisition of U.S. cloud companies and on IP-sharing ventures between U.S. and Chinese companies – Chinese technology companies have access to investment and there are many U.S. cloud technology firms, some of which are small, that could be bought. Any potential acquisition should continue to face significant scrutiny, even if small in terms of revenue. Similarly, there should be significant scrutiny of IP sharing agreements between U.S. and Chinese cloud firms where there could be a short term boon for a U.S. company seeking access to the Chinese market.

4) Monitor anti-competitive activity by cloud leaders to ensure an environment where disruptors can continue to enter the market – In both the IaaS/PaaS and SaaS markets, competition is on the decline. AWS and Azure are the largest players in IaaS/PaaS and are gaining share. SaaS is not a monolithic market, but the aggregation of many application categories where SaaS has taken hold. Within these categories, software incumbents have taken share by aggressively acquiring independent SaaS players. Ensure that the FTC has appropriately defined the competitive landscape and is monitoring anti-competitive activity. This has not stifled innovation to date, as evidenced by start-ups like Docker and Digital Ocean that would like to unseat AWS, but could become an issue over time.

5) Evaluate and reset barriers to Chinese IT participation in U.S. markets to ensure equivalent impact vs. Chinese barriers to U.S. firms – U.S. firms have not played on a level playing field in the Chinese market and have lost share that they would have surely gained in an entirely open market. Trade regulators should have a view on what the economic impact of these policies has been on U.S. cloud providers and ensure that an equal response is in place to advantage U.S. firms domestically.

6) Grow the cloud-enabled talent pool in the short term through immigration policy and over the long term through sponsored training programs – There is a sizeable talent shortage when it comes to building and managing cloud environments. In a Bain study completed in 2016, cloud-enabled employees were cited by IT decision makers as the leading technology talent gap, ahead of data scientists, devops, or specialized programing language proficiency.

   Cutting off the supply of cloud-enabled talent from regions that have it would have a very negative near term impact. In fact, the door should be opened even wider to satisfy the short term demand for this talent.

   Over the longer term, cloud-enabled IT professionals can be home grown more rapidly through state sponsored education programs. In the 1990's, government-backed loans enabled rapid growth of Microsoft- and Cisco-certified professionals who were essential to the growth of the technology architecture of that era (client-server). We need the equivalent of that now around AWS and Azure-enabled professionals.

The U.S. cloud industry has flourished with limited government support or intervention. The "do no harm" principle is actually the most important one. Elected officials need to take appropriate caution when setting technology policy, for there can be far reaching implications that go well beyond the objectives of a piece of legislation. The cumulative impact of all these actions could be wiped out by one well-intentioned but poorly executed law around cybersecurity, net neutrality, or any number of broad-reaching technology issues that the Government has recently waded into.

[1] Full version of 13th FYP: Full version of the 13th FYP in Chinese can be accessed here (English version not yet available as of April 20th): http://news.xinhuanet.com/politics/2016lh/2016-03/17/c_1118366322.htm

[2] Summary of Internet Plus plan: http://english.gov.cn/policies/latest_releases/2015/07/04/content_281475140165588.htm

[3] National Institute of Standards and Technology definition of cloud computing: http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf

[4] 2016 "Bain Global Cloud Computing Point of View", which integrates primary and secondary data from the following sources: Gartner, IDC, Forrester, Bain & Company survey of IT decision markets, literature searches on publicly disclosed statements about cloud usage

[5] 2013 "Bain China Cloud Ecosystem Point of View", which integrates primary and secondary data from the following sources: Gartner, IDC, Forrester, Euromonitor, and expert interviews with industry participants

[6] 2016 "Bain China Cloud Ecosystem Point of View", which integrates primary and secondary data from the following sources: Gartner, IDC, Forrester, expert interviews with industry participants and a Bain & Company survey of IT decision makers in China

[7] Jack Ma, founder of Alibaba, meets with President Trump in January 2017 and discusses expansion, including cloud: http://www.reuters.com/article/us-usa-trump-alibaba-idUSKBN14T1ZA

[8] Multiple Wall Street analysts forecast Aliyun growth within the broader Alibaba portfolio, including Goldman Sachs (https://static.businessinsider.com/amazon-web-services-threat-alibaba-goldman-sachs-2016-8) and Morgan Stanley (http://unique.finance/3-reasons-why-alibaba-stock-is-a-good-buy-now/)

[9] Overview of ICP requirements for foreign firms in China: https://webdesign.tutsplus.com/articles/chinese-icp-licensing-what-why-and-how-to-get-hosted-in-china--cms-23193