Institutional and Economic Factors Affecting the Development of the Chinese Cloud Computing Industry and Market

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Abstract:

Due to the Chinese government′s mobilization of massive resources and entrepreneurial activities of foreign and local firms, the Chinese cloud computing industry and market are growing rapidly. A number of contradictory, conflicting, and paradoxical forces are shaping the Chinese cloud computing industry and market. This paper seeks to analyze these forces. It examines the importance of various economic linkages as well as formal and informal institutions in the development and utilization of the cloud in China and the emergence of country′s cloud providers as global players.

Keywords: Cloud computing | Cloud service providers | China | Institutions | Externalities | Cyber-control

Article:

1. Introduction

China′s cloud computing (hereinafter: cloud) market is a result of a number of contradictory and conflicting forces. On the one hand, the Chinese government has viewed the cloud as a strategic industry and mobilized massive resources to develop the country′s cloud industry and market (Johnson, 2014).

The 12th Five-Year Plan (2011–2015) targeted to spend US$ 308 billion for the telecommunications infrastructures. There are tax, subsidies and other incentives for investments in the cloud industry (Hille, 2010). A key issue, in light of China′s strict censorship policies, is whether the Chinese government is willing to loosen some of the cyber-control mechanisms in order to encourage the development of the cloud industry and market. On this front, some encouraging signs have emerged. For instance, in 2011, China announced an investment of US$154 million to develop a cloud center for high-tech and start-up firms in Chongqing. It was

announced that the cloud computing Special Administrative Region (SAR) would be free from censorship (Russell, 2011).

On the downside, thanks to strong cyber-control measures, most foreign cloud service providers (CSPs) have located their servers in neighboring countries. Requiring foreign-originated traffic to pass through China′s firewall often leads to long loading times for Chinese businesses and consumers. A study of the content delivery network provider, CDNetworks indicated that China′s firewall leads to an increase in the load time by 450 ms or more for an object hosted on a server outside China. For a typical website hosted in Asian cities such as Hong Kong, Singapore, or Tokyo, the firewall adds 10–15 s. The average time to load an object from a Hong Kong data center is 50% longer than in China. Websites hosted in the U.S. take 20–40 s to load (Kim, 2013). Thus, accessing cloud services provided by foreign CSPs such as Google Docs and Dropbox, is difficult or impossible. An upshot of the slow Internet speed is also that it has discouraged the relocation of foreign talents in China (Denyer, 2015). Foreign businesses often complain that their workers waste substantial amount of time just clicking to access email (Clover, 2015). Moreover, if a CSP′s contents are on a server that also hosts contents that are objectionable to the Chinese government, they might be blocked (Kshetri, 2014; MacKinnon, 2012).

In the Asia Cloud Computing Association′s (2014) (ACCI) Cloud Readiness Index 2014, China ranked 11th out of the 15 economies analyzed. According to the ACCI, while factors such as increased telecommunications spending during the 12th Five Year Plan and the establishment of the Chongqing cloud computing special zone have been major positive steps, data sovereignty, stability and quality of power grid and green energy and freedom of information access have been issues of major concern for the cloud′s development (Johnson, 2014).

In addition to the apparently paradoxical policy position of the Chinese government, the development of the Chinese cloud industry and market also needs to be looked in the context of contradictory economic dynamics. For instance, in 2013, China overtook Japan to become the world′s second largest IT market (Thibodeau, 2013), which suggests a strong demand of cloud services in the country. Despite the potential attractiveness of China′s cloud market, Chinese firms have exhibited a lower propensity to adopt the cloud compared to their counterparts in industrialized countries. For instance, according to the market research firm, International Data Corporation (IDC), only about 4% of companies in China were using the cloud in 2009 compared with 16% in Singapore (Arnold, 2010). Likewise, by 2013, only 5% of Chinese SMEs had used hosted servers (Yu, 2013). In the same vein, according to a July 2014 report of the McKinsey Global Institute (MGI), only about a fifth of Chinese firms were using the cloud, compared to three-fifths in the U.S. The report also noted that Chinese businesses in the average spend only 2% of revenues on IT, which is half as much as the global average (economist.com, 2014). Slow and unstable broadband network speeds and poor customer services have also hindered the diffusion of the cloud in China. For instance, whereas download speeds averaged 17.4 megabits per second (Mbps) in developed countries in 2013, it was only 4 Mbps in China (Carlson, 2013).

Firms in the Chinese ICT industry are expected to accomplish multiple goals on the political, economic and social fronts (Xia, 2012). A key goal of the Chinese Communist Party (CCP) is to

maintain the party′s power monopoly. The CCP is thus interested in using the cloud as a tool for maintaining its political dominance and preventing the opposition from challenging the dominance. It is also important to note that the base of the CCP′s legitimacy has shifted from Marx-Leninism to economic growth and prosperity (Zhao, 2000). The economic and commercial success of Chinese firms, especially state-owned enterprises (SOEs), is likely to support the CCP′s political ideology (Kshetri, 2007; Xia, 2012).

In order to understand the above dynamics, it is important to consider the relevant institutional and economic factors. Institutional theorists have emphasized the importance of formal and informal institutions in shaping the developmental patterns industries and markets (e.g., North, 1990; Scott, 1995). The idea here is that various policies, rules, laws (formal institutions), as well as cloud providers′ and cloud users′ norms of behavior, mental maps and codes of conduct (informal institutions) are tightly linked to the diffusion pattern of the cloud. Moreover, prior researchers have suggested that the developmental pattern of an industry is tightly linked to the forward linkages (demand), backward linkages (supply) and horizontal or inter-sectoral linkages (Markusen & Venables, 1999). This means that cloud industries and markets are embedded in the broader economy and thus their development should not be viewed as a self-contained phenomenon with self-contained solutions.

In light of the above observations, the goal of this paper is modest and simply aimed at deepening our understanding of the contradictory, conflicting, and paradoxical forces that are shaping the Chinese cloud computing industry and market. To achieve this goal, the importance of economic linkages as well as formal and informal institutions in the development and utilization of the cloud in China and the emergence of country′s cloud providers as global players are examined.

Before proceeding, some clarifying definitions are offered. Cloud computing involves hosting applications on servers and delivering software and services via the Internet. In the cloud computing model, companies can access computing power and resources on the “cloud” and pay for services based on usage. Cloud industry is defined as the set of sellers/providers of cloud related products and services. Cloud providers deliver value to users through offerings such as software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS). SaaS is a software distribution model, in which applications are hosted by a vendor and made available to customers over a network. It is the most mature type of cloud computing. In addition to global cloud players, local companies such as the online merchant, Alibaba offer SaaS-based solutions. In PaaS, applications are developed and executed through platforms provided by vendors. Some PaaS vendors include global CSPs such as Salesforce.com (Force.com) and Microsoft (Windows Azure platform) as well as local companies such as the search engine provider, Baidu. For instance, as is the case of the Apple Store, Baidu Yi platform allows third-party developers to create and sell apps. IaaS consists of, inter-alia, server, operating system, disk storage and database. Global CSPs such as IBM, Vmware and HP and local companies such as Huawei offer IaaS.

The paper is structured as follows. It proceeds by first providing a review of cloud diffusion in China and related entrepreneurial activities. Next, the facilitators and inhibitors of the cloud

industry in China are analyzed. It is followed by a section on discussion and implications. The final section provides concluding comments.

2. A review of cloud computing diffusion and associated entrepreneurial activities

Before proceeding further, a brief discussion of data and statistics used in this paper is provided, which are from secondary sources. Major constraints related to the use of any international secondary data include accuracy, age, reliability, lumping and comparability (Kotabe, 2002). Regarding accuracy, which is defined as a measured quantity′s systematic tendency to differ from the true value, it is worth noting that most of the data used in this article represent actions (e.g., cloud spending) rather than attitude, feeling, or intention (e.g., attitudes towards cloud and intention to use), and have straightforward operationalization. Accuracy thus is less of a problem. In order to address concerns related to age, attempts have been made to use the latest available data and statistics.

Regarding reliability, data and statistics related to the Chinese cloud industry and market have been obtained from a number of sources that are considered to be reputable and used in past scholarly papers. When it is possible, data triangulation from alternative sources has been used. While data related to different components of the Chinese cloud industry and market are lumped together in most available sources, attempts have been made to find data related to specific components (e.g., public cloud market). Attempts have been made to ensure comparability by using the data from the same sources when the sizes of various components of the Chinese cloud industry and market are compared with those other economies (e.g., the world) (Table 1).

Table 1. A comparison of China′s and the world′s public cloud services markets.

	China	World	China′s share (%)
2011 (Forrester Research)	US$ 297 million (Qing, 2013)	US$ 25.5 billion (Columbus, 2012)	1.16
2014 (IDC)[a]	US$ 717 million	US$ 56.6 billion	1.27
2015 (IDC)[a]	US$ 1 billion	US$ 72.9 billion	1.37
2018 (IDC)[a]	US$ 2.051 billion	US$ 127 Billion	1.62

a Forecasts.

While China lagged significantly behind industrialized economies during the early years of cloud computing development, it is now catching up rapidly (Sampler, 2015). According to China Information Industry Net (CNII) of the Ministry of Industry and IT, China′s public cloud market was estimated to worth US$561.6 million in 2012 (Kan, 2014a). As Table 1 shows, China′s public cloud services market is growing, and expected to grow, faster than the world average. Looking at the broader impact, the China Software Industry Association estimated that the country′s overall cloud-computing value chain will exceed US$122 billion by 2015 (Larson, 2013).

Some sample examples are considered to illustrate the cloud′s impact on Chinese businesses and consumers in Table 2. It is clear that the cloud could have important favorable impacts in economic, environmental, social and educational dimensions. There are also plans to use loud-based applications in areas such as a food safety to monitor food growers (cncworld.tv, 2012).

Looking at the deployment of clouds by Beijing municipal government, the city of Ningbo, Alibaba, Baidu and other organizations presented in Table 2, it is clear that the cloud is being combined with big data to create and capture value. This relationship is important because big data and the cloud, each drives and feeds off the advancement of the other.

Table 2. Cloud computing applications and their impacts in China: a sample of examples.

Cloud application	Example	Explanation
Enhancing efficiency with e-commerce/e-business	Alibaba	• Attracted vendors to its e-commerce websites Taobao and Tmall.com by promoting its big data- and cloud-based advertising and other services, which provide deep insights into shoppers′ preferences (Lorenzetti, 2014).
Development of new or improved products/services	The city of Ningbo	• Is working with IBM to develop a cloud-based Smart Logistics Center to streamline the port′s supply chain. The system will allow the 5000 logistics companies to share data. Connecting every shipping vehicle with a GPS tracker has led to the reduction of the idle times of trucks. A trucking company reported an 80% decline in idle time (Shu, 2014).
Extending market reach	Baidu	• Uses cloud-based artificial intelligence in advertising system to identify qualities of an ad that make people click (Nan, 2015).
e-health	Ningbo Cloud Hospital	• March 2015: The first Cloud-based virtual hospital in China started operations. its healthcare coordination platform included 100 primary medical institutions and 226 specialists and family physicians had signed contracts. It has four cloud-based clinics for hypertension, diabetes, psychological counseling and family medicine (wantchinatimes.com, 2015).
	Baidu	• Introduced Jiankangyun health cloud in July 2014, which uses the cloud and big data to offer pre-diagnosis assessments. a cloud-computing platform collects, stores and analyzes data obtained from smart devices such as weighing scales and blood pressure monitors to provide consultancy services to remain healthy and make use of healthcare technologies (Morris, 2014).
e-education	Supercomputer power/access to educational resources	• Analyze data on disease spread pattern and climate changes • Chinese universities are among educational institutions worldwide participating in the IBM Cloud Academy, which allows access to a range of educational resources.
e-environment	Beijing municipal government	• July 2014: the Beijing municipal government and IBM signed a deal to use the latter′s advanced weather forecasting and cloud technologies to solve the city′s pollution problem. IBM′s technologies will make optimizations and adjustments to make a better utilization of renewable energy sources. In a project implemented in Zhangbei in Hebei Province, the deployment of IBM′s supply and demand management system led to a reduction of energy waste from 30% to 20% (chinatechnews.com, 2014).

Cloud-related offerings of Chinese firms are presented in Table 3. As Table 3 has shown, Chinese CSPs have developed cloud offerings to meet the diverse needs of consumers. Chinese

CSPs have developed cloud services to consumers, SMEs, and larger firms. Major Chinese CSPs already serve a large number of customers. As of the early 2015, Alibaba Group′s cloud subsidiary, Aliyun had more than 1.4 million clients (Erickson, 2015). Likewise, as of the mid-2015, Baidu cloud had 200 million users (Nan, 2015). Specialized services have been developed to meet the unique needs of banking, petrochemical and other industries.

Table 3. Patterns and drivers of cloud-related entrepreneurship of local firms in China: a sample of examples.

Example	Explanation
Offering for SMEs	
• Aliyun	• Most of the clients are SMEs. Aliyun had a revenue of US$205 million in the FY 2014, up 64% from the FY2013 (Darrow, 2015).
Offerings for large enterprises or specialized business needs	
• Aliyun	• Provides cloud services to enterprises and financial institutions such as banks, hedge funds (Nan, 2015). • April 2015: Reported to help Sinopec, which is Asia′s biggest oil refiner, build cloud-based business system. Aliyun′s cloud big data analytics solutions cover Sinopec′s entire production chain (reuters.com, 2015).
Offerings for foreign markets	
• Aliyun	• March 2015: Opened a data center in the Silicon Valley (Kan 2015). • Mid-2015: Teamed up with Dubai′s Meraas to serve governments in the Middle East and North Africa.
• Tencent	• 2014: Opened data center in Hong Kong • April 2015: announced a plan to open a data center in Canada.
Offerings for individual consumers	
• Tencent	• 2014: Offered 10 TB of free storage to users, which is arguably 100 times bigger than Dropbox, Box, Microsoft SkyDrive, Google Drive, and Mega combined together (Elliott, 2014).
• Xiaomi	• As of May 2015, the users of the Chinese phone maker, Xiaomi uploaded an average of about 300 terabytes (TB) of data on Xiaomi clouds every day, compared with 258 TB in 2014 and 61 TB in 2013 (Wan, 2015).
• Baidu	• Announced the development of unmanned bicycles called "smartbike", which will use advanced intelligent sensors and cloud-based big data analytics. The bicycle will know the owner′s requirements and health index and will be able to drive by itself. As of 2013, China had 551 million bicycles, of which 81 million were electric (ECNS, 2014). • Applying cloud-based artificial intelligence to a self-driving car (Nan, 2015).

Especially impressive is Chinese CSPs′ internationalization activities. For instance, Aliyun opened a data center in the U.S. in March 2015 (Kan, 2015). In the mid-2015, it also signed a deal with Dubai′s Meraas to provide cloud services for governments in the Middle East and North Africa (Nan, 2015). Likewise, in July 2014, the social network provider, Tencent opened a data center in Hong Kong and in April 2015, it announced plans to open another data center near Toronto in Canada (Luo & Judge, 2015).

The rapid growth in the Chinese cloud computing market can be attributed to the initiatives taken by the public as well as the private sectors (Sampler, 2015). First, many large companies such as Alibaba, Baidu, Tencent and telecommunications providers such as China Mobile, China Unicom and China Telecom have invested heavily in Internet data centers (IDCs). In 2014, Lenovo Group announced an investment of US$ 48.7 million to build 50 cloud centers (bmiresearch.com, 2014). Aliyun and Tencent′s Qcloud are already driving the market for enterprise cloud services. Analysts have predicted that future strategies of other Chinese companies, which have invested heavily in building IDCs for their own use, are likely to involve supplying cloud services (Lohr, 2014). For instance, Amazon and Google followed such a strategy.

Chinese ICT firms are also likely to benefit from competence in related areas. For instance, Baidu′s Minwa supercomputer outperformed those from Google and Microsoft in an annual image recognition challenge (Nan, 2015). Baidu has also made heavy investment in artificial intelligence. Likewise, in 2014, Alibaba′s Open Data Processing Service (ODPS) had capability to process 100 million high-definition movies′ worth of data in six hours (Li, 2014).

In the public sector, a massive investment has been made in the cloud industry. Facilitating the development of the cloud industry and market was a key priority of the 12th Five-Year Plan released in 2011. In 2011 alone, US$286 million was spent on cloud computing infrastructure (Huang, 2012). By 2013, there were more than 40 public cloud projects as a key component of the plan. The city of Beijing alone had received more than US$8 billion to support projects in constructing servers and other infrastructure (Larson, 2013). In addition, local governments have also announced cloud computing parks to support the IDCs (Atkinson, 2014).

According to the guidelines issued by the State Council, China plans to spend over US$70 billion in 2015 and more than US$115 billion in 2016 and 2017 in Internet infrastructure. There are also plans to build high-speed broadband networks and improve Internet access in over 14,000 villages by the end of 2015 (bgr.in, 2015).

2.1. Standardization initiatives

A research report released by CCID Consulting in 2010 emphasized the importance of cloud standards emphasizing that this together with cloud security are among the most urgent issues facing China′s cloud computing industry that should be dealt with by the government and other relevant actors (reuters.com, 2010). In the State Council′s policy announcement to promote cloud computing, the establishment of an industrial cloud standardization system has been identified as a key priority (gov.cn, 2015).

The Ministry of Industry and Information Technology (MIIT) has been guiding the cloud standardization initiatives. A senior MIIT official noted that “an open attitude” will be adopted in standardization related actions. The official also stated that Chinese companies will actively take part in the formulation of international cloud standards in order to raise China′s concerns (Yuankai, 2014). China has participated in various international level initiatives. For instance, China Life and the government-owned telecommunications company, China Unicom are represented in the Intel-backed cloud standards organization—the Open Data Center Alliance

(Thibodeau, 2011). Likewise, in July 2012, the Distributed Management Task Force (DMTF), and the China Electronics Standardization Institute (CESI) announced that they formed a partnership to drive adoption of DMTF cloud management standards in China (dmtf.org, 2012). According to the agreement, the DMTF will work to make its standards meet requirements outlined by CESI. The CESI, on the other hand, will encourage Chinese companies, universities and non-profit organizations to adopt DMTF standards which include the Cloud Infrastructure Management Interface (CIMI), the Open Virtualization Format (OVF) as well as future DMTF standards for cloud auditing and software license management.

3. Facilitators and inhibitors of the cloud industry and market in China

In order to gain better knowledge about diffusion and impact of the cloud in China and factors that are driving the entrepreneurial activities, our proposed model focuses on institutional and economic factors (Fig. 1). Table 4 provides reasoning and justification for the relationships presented in Fig. 1.

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Fig. 1. A proposed framework for understanding the diffusion and development of the cloud in China.

Table 4. Drivers of the cloud industry and market in China.

Factors	Explanation
Institutional factors	
Regulative	
State′s mobilization of resources in the cloud and related sectors	• The state′s investment has been a major driver of the cloud industry.
Data security, privacy and cyber-control laws and policies	• Lack of strong privacy and data protection laws. • Using the cloud to pursue cyber-control measures: inability of businesses and consumers to realize the cloud′s potential.
Normative	
Special interest groups and non-government entities	• Loosely organized. • Trade associations notably absent.
Implicit social pressure to use clouds	• Pressure from customers, suppliers and the broader social context.
Cognitive	
Price sensitivity of SMEs	• SMEs prefer low cost models.
Large SOEs′ reluctance to outsource	• Since the cloud model involves outsourcing, it may act as a barrier.

Economic factors	
Forward linkage	
Cloud adoption propensity of organizations and industries	• Huge market size a driving force. • Some industries with high propensity to adopt the cloud: online gaming. • Governments agencies adoption of cloud: especially of domestic CSPs.
SMEs′ technology adoption	• SMEs′ access to technologies they cannot otherwise afford.
Backward linkage	
Local skill and technological base	• Domestic and foreign firms′ engagement in R&D activities related to the cloud.
Supercomputing industry and economies of agglomeration	• Data centers are built next to regional supercomputing sites.
Horizontal linkage	
ICT penetration	• High cellular penetration and increasing proportion of cloud ready mobile phones (e.g., smart phones). • Rural–urban disparity in ICT penetration.
Bandwidth availability	• Slower Internet speeds than in most industrialized countries • Rural–urban disparity in bandwidth availability.

3.1. Institutional factors affecting the development of the cloud industry and market

First, the roles of institutions are analyzed. As noted above, institutionalists have emphasized the importance of formal and informal institutions in shaping the developmental pattern of an industry (North, 1990; Scott, 1995). Institutions are the “rules of the game” (North, 1990, p. 27) and include “formal constraints (rules, laws, constitutions), informal constraints (norms of behavior, conventions, and self-imposed codes of conduct), and their enforcement characteristics” (North, 1996, p. 344). Some specific examples of institutions identified in the prior literature include government regulations, trade policy, the roles of non-governmental organizations such as trade associations and consumer preferences (Kshetri, 2013a; Kshetri, Palvia, & Dai, 2011). Scott (1995) proposed three institutional pillars: (i) regulative; (ii) normative and (iii) cognitive. These pillars relate to “legally sanctioned”, “morally governed” and “recognizable, taken-for-granted” behaviors respectively (Scott, Ruef, Mendel, & Caronna, 2000, p. 238).

It is important to emphasize that there are some problems associated with differentiating cognitive and normative institutions. Some institutionalists argue that the distinction between normative and cognitive institutions is blurred (Campbell, 2004) and it is unclear when taken-for-grantedness of social norms becomes high enough to become part of cognitive institutions (Clemens & Cook, 1999). Other have pointed out that there is a poor specification of

mechanisms by which normative and cognitive structures affect behaviors of various actors (Hirsch, 1997).

Scott′s normative and cognitive pillars can be mapped to what North′s (1990) informal institutions and Galtung′s (1958) informal constraints or norms. This paper follows Galtung′s (1958, p. 127) approach, which distinguishes two types of informal constraints or norms facing a person (P): Institutionalized norms are "norms from other members from the social system to P" and internalized norms are "norms from P to himself." This emphasis on institutionalized and internalized norms is also reflected in Scott′s writings. He observes the existence of external and internal dimensions in institutions by stating that values and norms "… are both internalized and imposed by others" (1995, p. 40). This paper′s approach is based on the distinction proposed by Galtung and Scott. Norms imposed from the external social system is considered to be normative institutions and internalized norms are considered to be cognitive institutions.

3.1.1. Regulative institutions

Prior researchers have noted that laws and regulations are among the major factors influencing the diffusion of clouds (Noam, 2014). They can be considered to be parts of regulative institutions, which consist of "explicit regulative processes: rule setting, monitoring, and sanctioning activities" (Scott, 1995, p. 35).

3.1.1.1. State′s mobilization of resources in the cloud industry

The cloud has become a key policy priority in China. According to the National Development and Reform Commission (NDRC), the government has viewed cloud computing as a strategic industry (Johnson, 2014). In January 2015, the State Council offered its opinion on the role and importance of the cloud. Among the developmental goals included the adopting of the cloud in "key areas" by 2017; and providing international standard cloud services and establishing local enterprises in this sector which demonstrate global competitiveness by 2020 (gov.cn, 2015, paras 3–4).

Unsurprisingly China has mobilized massive resources in the development of the cloud and related industries. In October 2011, the NDRC, the MIIT and Ministry of Finance allocated US$236 million to support indigenous cloud computing (Atkinson, 2014). In addition to the massive spending in telecommunications infrastructures in the 12th Five-Year Plan, in 2013, the State Council released the "Broadband China" initiative, which aims to expand full broadband coverage across country by the end of this decade. By 2020, the speeds of urban and rural broadband accesses are expected to reach 50 Mbps and 12 Mbps respectively (Quigley, 2013). The broadband coverage in administrative villages is expected to reach 95% by 2015 and 98% by 2020. The government announced plans to spend US$326 billion on the Broadband China strategy (Johnson, 2014).

There are subsidies, tax and other fiscal incentives for the cloud sector. Many local governments, such as those of Chongqing, Ningxia, and Beijing have targeted cloud computing and IDCs and have provided subsidies to attract businesses in these areas (Atkinson, 2014). As noted earlier, China announced an investment to develop a cloud center for high-tech and start-up firms in

Chongqing (Russell, 2011). As of 2015, Chongqing Cloud Computing Zone was China′s largest cloud center (Yao, 2015). Major Chinese ICT companies such as Tencent and China Telecom, as well as foreign players such as the U.S. based software company, Microsoft, the Taiwanese PC maker, Acer, Hong Kong-based provider of managed data connectivity solutions, Pacnet and Japan′s IT and network technologies provider, NEC have established operations in the Chongqing Cloud Computing Zone.

Another planned high profile cloud project is the 100-hectare Jingbei Cloud Valley project at the Miaotan industrial park in the Zhangbei economic development zone of the Hebei Province. Planned facilities in the US$1.6 billion project include 20 large data centers, power supplying centers, operation and management centers and a big data center with 500,000 servers (wantchinatimes.com, 2014).

3.1.1.2. Laws and policies related to security, privacy and cyber-control

China′s strong state cuts both sides. The strategies toward ICTs have been to balance economic modernization and political control (Kalathil, 2003). While China′s supports to the development of the cloud industry are encouraging, it is also using the technology to pursue political goals. An obvious danger in an authoritarian regime concerns the possibility that the government may intensify further controls on citizens (Kshetri, 2011; Zittrain, 2009).

As noted earlier, the government′s cyber-control measures have led to an inability of businesses and consumers to realize the cloud′s potential. For instance, China′s filtering system makes it difficult or impossible to access services provided by foreign CSPs such as Google docs, and Dropbox and causes significant connectivity speed and capacity reduction (Getting to grips with cloud in China, 2011). In July 2014, it was reported that Microsoft′s OneDrive cloud storage service and Yahoo′s Flickr were inaccessible from China (Horwitz, 2014). A member of China-based anti-censorship site, GreatFire.org speculated that these blocks were due to concerns about photo sharing in demonstrations in Hong Kong (Reuters, 2014). The filtering system was reportedly upgraded in January 2015 to target the virtual private networks (VPNs), which were often used by individuals, research institutes and companies to access foreign contents. It was reported that banned sites such as Google mail, cloud, search and mapping service were no longer accessible (blogs.wsj.com, 2015).

Prior research has suggested that jurisdictional differences and national sovereignty issues are likely to persist in the cloud environment (Noam, 2014). There are also concerns related to perceived security (Forde & Doyle, 2013). These issues have been of particular concern in China′s case. For instance, China has imposed local data server requirements in order to ensure that national security-, currency control- and industrial policy-related concerns are addressed sufficiently (Business Roundtable, 2012). In response to these policy pressures, Apple has started storing personal data in Chinese servers. Its first iCloud data center in China was built in collaboration with China Telecom (toptechnews.com, 2014). Likewise, Amazon supplies the software and its Chinese partners provide data centers, bandwidth and content delivery (chinaeconomicreview.com, 2014). In the same vein, Microsoft Office365 is hosted by a Chinese company. Other foreign CSPs such as IBM and SAP have followed similar models (Atkinson, 2014).

3.1.2. Normative institutions

Normative institutions introduce “a prescriptive, evaluative, and obligatory dimension” (Scott, 1995, p. 37). As noted above, these are institutionalized norms imposed from the external social system. Professional and social obligations constitute major sources of pressure in this category.

3.1.2.1. Special interest groups and non-government organizations′ roles

Special interest groups and non-government entities are organized loosely and there is little room for these groups to influence national policymaking in China (Li, Lin, & Xia, 2004; Su & Yang, 2000). The China–India difference related to this is illustrated. Various ongoing efforts and activities initiated by National Association of Software and Services Companies (NASSCOM) and Data Security Council of India (DSCI) have played a key role in accelerating the cloud′s diffusion and addressing key security and privacy challenges in India (Kshetri, 2012, 2013a). Trade associations have been notably absent in the Chinese cloud landscape. In general, prior research has noted a declining influence of public opinions in the formulation and implementation of ICT policies (Xia, 2012). For example, despite the dissent and opposite viewpoints, the 2008 industry consolidation took place, in which seven telecommunications companies were merged into today′s three major national carriers.

3.1.2.2. Inter-organizational and societal influences

Proponents of dependency theory contend that organizations are embedded within larger inter-organizational and societal networks, which generate formal and informal pressures (Pfeffer, 1981). Value delivery networks such as suppliers and customers are among the key sources of such pressures (Maloni & Benton, 2000). Prior researchers have noted that trading relationship between two firms is a function of the degree of ‘fit′ between the technologies used by them, which is also referred to as a technological distance (Ford et al., 1998).

To put things in context, there has been a growing popularity and use of cloud services among individuals and enterprises in China (chinaeconomicreview.com, 2014). Due primarily to this, there is also an implicit societal expectation for Chinese firms to use the cloud in key organizational activities. For instance, SOEs such as Sinopec have been under pressure to make better use of cloud computing and big data in order to improve the way they track and manage supply, demand, emissions and other indicators (reuters.com, 2015).

3.1.3. Cognitive institutions

In the context of this paper, cognitive institutions constitute the frames through which firms and individuals make meaning and significance of cloud related decisions. These are built on the mental maps of decision makers (Huff, 1990). The basis of compliance in cognitive institutions is related to internalized norms (e.g., price sensitivity and propensity to outsource IT functions) and not social and professional obligations.

3.1.3.1. Price sensitivity

Concerns for cost are reported to be among the major factors affecting the diffusion of clouds (Forde & Doyle, 2013). This concern may be even more pronounced in China. Compared to more mature economies, SMEs in China tend to be price sensitive. According to a 2014 report of the MGI, Chinese businesses in the average spend only 2% of revenues on IT, which is half as much as the global average (economist.com, 2014). A survey conducted among Chinese SMEs suggested that many believed that they were paying too much for telecoms services and 24% of the respondents were concerned about high prices (Castelli, 2008). It was reported that Chinese organizations primarily emphasize on process improvement, efficiency and savings, rather than on finding innovative ways to make use of the cloud′s enormous computing power, speed and flexibility (Alter, Yali, Lin & Jeanne, 2010). Due primarily to price sensitiveness, most Chinese organizations′ cloud adoption thus may involve simple, low cost, online presence.

3.1.3.2. Propensity to outsource IT functions

Put simply, the cloud entails outsourcing IT functions. Due to concerns related to data security and overall benefits, a large proportion of Chinese businesses are cautious in spending in cloud services (Atkinson, 2014). This is because the adoption of the cloud model results in losing control over these functions. China′s SOEs arguably consider the ability to control as important (Ko, 2011). China′s SOEs also exhibit a higher level of concern regarding data security and have a tendency to distrust CSPs (chinaeconomicreview.com, 2014). In this regard, a barrier facing the Chinese cloud industry is that large SOEs are reluctant to outsource IT needs and move to the cloud (Hille, 2010). Indeed, until not long ago, SOEs were not allowed to use outsourced data center services (chinaeconomicreview.com, 2014). It was reported that the cloud was diffusing faster among SMEs and more cost-sensitive start-ups than among larger companies and big SOEs in China (Arnold, 2010).

3.2. Linkages in the economy

As noted earlier, the developmental pattern of an industry is tightly linked to the forward linkages, backward linkages, and horizontal or inter-sectoral linkages (Markusen & Venables, 1999). This section thus examines upstream and downstream linkage effects as well as horizontal linkages.

3.2.1. Demand related factors

3.2.1.1. Cloud adoption propensity of organizations and industries

China has a number of industries and organizations that have been able to successfully apply the cloud in a number of key business functions. In the healthcare industry, for instance, while the investments in the past focused on hardware, a shift is occurring toward software and digital services with the increasing maturity of the industry (Kshetri, 2013b). A huge e-healthcare market has stimulated the demand for the cloud (Table 2). The online gaming industry, which generated about US$14 billion in 2013 (Millward, 2014) has also generated strong forward linkages. In order to capitalize on this opportunity, Alibaba launched cloud-based online gaming platform in 2014 (chinatechnews.com, 2014a, 2014b). In general, gaming companies are facing

intense pressure to transform processes and business models. The deployment of a cloud platform reportedly helped the gaming company, Shanda enhance the automatic management of game operation business and reduce data center costs by 80% (Intel Corporation, 2011).

3.2.1.2. The cloud′s potential to facilitate SMEs′ access to technologies that are otherwise unaffordable

Most Chinese SMEs have access to the Internet but do not use advanced tools related to communications, collaborations, and business applications. The cloud makes it possible for them to access these technologies, which are often unaffordable if they are acquired from other sources. As a component of its ambitious virtualization program, the Chinese government considers the cloud to be an opportunity to provide these services to SMEs in a cost-effective manner. According to a study released by Parallels in 2014, Chinese SMEs′ spending on cloud-based communication, collaboration, and business applications increased by 54% in 2013 (flanders-china.be, 2014).

3.2.2. Input (backward linkage)

The development of industries which supply various ingredients needed for the cloud offer strong backward linkages. In China, cloud R&D and the development of the supercomputing industry have provided backward linkages.

3.2.2.1. Development of supercomputing industry and economies of agglomeration

The idea in economies of agglomeration is that large number of firms in related industries benefit from positive externalities by clustering together. Factors such as the presence of multiple suppliers, knowledge spillovers, availability of intermediate inputs, and labor specialization lead to low costs of production. For instance, by locating close to other firms, they benefit from positive spillovers from investment and economic activities that are already in place. Several mechanisms associated with economies of agglomeration include technology spillovers, advantages of thick markets for specialized skills, and the backward and forward linkages (Marshall, 1920). Users and suppliers of intermediate inputs tend to cluster close to each other because a large market provides greater demand for goods and supply of inputs (Krugman, 1991).

IDCs and the supercomputer industry provide economies of agglomeration for the cloud industry. In addition to its heavy investment in IDCs, China is increasingly known for its supercomputer prowess. In the 2014 list of the world′s top 500 supercomputers, China′s Tianhe-2 supercomputer was ranked as the fastest and most powerful computer (Lee, 2014). Unsurprisingly China′s approach to the development of the cloud industry has been to build cloud centers next to regional supercomputing sites. For instance, Chengdu Cloud Computing Center, which was China′s first major commercially-operated Cloud Center launched in December 2009, was built by Chengdu Supercomputer Center and powered by the Dawning 5000 supercomputer. Likewise, the Shenzhen Cloud Computing Center, which completed testing in January 2012, is home to Nebulae supercomputer. In the same vein, Changsha Cloud

Computing Center opened in July 2011 is home to the Tianhe-1 supercomputer built by the Chinese National University of Defense Technology (NUDT) (Trader, 2012).

3.2.2.2. Local skill and technological base

Chinese firms have substantial cloud-related R&D activities. As early as in 2011, ZTE′s 10,000 m2 global cloud center in Nanjing had about 3000 R&D staff. In 2012, Huawei had more than 6000 people working on cloud computing R&D and other related projects (http://www.huawei.com/enapp/1209/hw-133186.htm). China Mobile launched cloud research program in 2007. In 2014, it set up an R&D center in Suzhou, which is expected to have a team of 3000–4000 people (ofweek.com, 2014).

Foreign multinationals have also located their cloud-related R&D activities in China. For instance, IBM′s Shanghai R&D facility has the cloud as a primary area. IBM is also working on a cloud research project, which involves statistical analyses to assess the effectiveness of traditional Chinese medicines (Kshetri, 2013b). Finally, the trend of increasing collaboration between Chinese and foreign scientists in cloud related R&D activities deserves mention. For instance, China Telecom and Cambridge University have teamed up to conduct research involving mobile health cloud (Kshetri, 2013b).

3.2.3. Structures of related industries (horizontal linkage)

An intersectoral linkage is said to exist between two economic sectors if events in one provide a stimulus to another. For instance, a higher ICT penetration rate and bandwidth availability may lead to higher demands of cloud related products and services. Conversely, ICT users are more likely to enjoy higher benefits from the cloud.

3.2.3.1. ICT penetration

The availability of web-connected computers, cellphones, or other devices is a prerequisite to benefit from the cloud. The role of the cloud is to change the delivery, pricing and consumption of the IT functionality (Ried, Holger, & Pascal, 2010). That is, the cloud can help leverage existing ICT investments, systems and infrastructures.

The high penetration rates for cellphones and the Internet provide strong horizontal linkages, especially due to the popularity of mobile clouds. In 2013, the number of smartphone users exceeded 700 million, and about 530 million accessed the Internet via mobile devices (Sampler, 2015). According to the MIIT, there were 1.29 billion mobile phone users in the country as of February 2015 (Woo, 2015). As of the early 2015, about three-quarters of mobile phones used were smartphones, which accounted for 90% of cellphone sales (Tejada & Dou, 2015).

Prior researchers have noted challenges such as the lack of basic coverage and capacity in rural areas (Forde & Doyle 2013). Such problems are significant in China as well. It was reported that the Internet penetration rates in urban areas were about four times as high as in rural areas (Andreasson, 2015).

3.2.3.2. Bandwidth availability

The basic idea in the cloud model is that computation and storage concentrate on the clouds and high performance machines are linked by high-bandwidth connections to manage resources (Hayes, 2008). High bandwidth is thus required for a better and effective utilization of cloud-based resources. According to International Telecommunication Union (ITU) (2011), the country′s fixed broadband penetration reached 12% in 2013. Low bandwidth has been among the most glaring shortcoming in China′s rural areas, which has hampered the cloud′s growth.

According the provider of content delivery network and cloud computing, ChinaCache, China′s average connection speed in 2013 was 3.45 Mbps. The average speed for Shanghai, which is the Chinese city with the fastest Internet connection speed, was only 5.4 Mbps (bmiresearch.com, 2014). Likewise, according to the cloud services provider, Akamai Technologies, in the second quarter of 2014, average Internet speeds in China was 3.7 Mbps compared to 11.4 Mbps in the U.S. (Kan, 2014b).

4. Discussion and implications

Observers have noted that the cloud′s biggest impacts on the country′s economy have not yet materialized (economist.com, 2014). However, with favorable policy interventions and the ongoing progress in key areas such as ICT penetration, bandwidth availability, positive agglomeration externalities derived from IDCs and the supercomputing industry and local R&D activities, the cloud would gain momentum and hold a promise to bridge the digital divide.

The above discussion shows that conflicting and contradictory institutional forces are in effect in the Chinese cloud computing industry and market. For instance, China′s SOEs have a tendency to distrust CSPs, leading to their lower tendency to use clouds. At the same time, they are facing pressures from value delivery networks and the society to make an increase use of the cloud. However, influences of trade and professional associations, which are major factors in firms′ cloud adoption decisions in other countries, are notably absent in the Chinese cloud landscape.

Likewise, the Chinese government′s desire to have cloud services of international standards in the country and establish globally competitive local enterprises in this sector has led to the massive mobilization of resources and support for the development of the cloud industry and market. On the other hand, due to cyber-control measures and other protectionist policies cloud services provided by some major foreign CSPs are unavailable in the country. China has expressed a high degree of suspicion and distrust toward foreign technology providers. Some foreign CSPs have been forced to store their data locally. Such measures may lead to higher costs of cloud services for end users since CSPs cannot enjoy economies of scale. Other unintended consequences include decreased competitiveness of local firms due to their isolation from the world′s innovative and efficient cloud services and strong computing power and harm to consumers due to denial of cloud services available around the world.

Regarding the cognitive institutions, compared to their counterparts in other countries, Chinese businesses and consumers are likely to subscribe to different beliefs and motivated by different goals, factors and considerations in their cloud-related activities. For instance, fear of losing

control over IT functions has been a major factor precluding widespread use of the cloud among SOEs. Likewise, the cloud′s cost-saving potential is likely to be a bigger motivator for Chinese firms compared to their counterparts in industrialized countries.

It is important to note the mutually interdependent nature of the various components of institutions, which often make it difficult to isolate them in the real world (Hayek, 1979; Kshetri, 2007). North (1994) observed that informal rules provide legitimacy to formal rules (North, 1994). Likewise, Axelrod (1997, p. 61) comments on the relationship between regulative and normative institutions: “Social norms and laws are often mutually supporting. This is true because social norms can become formalized into laws and because laws provide external validation of norms”. In the context of the Chinese cloud industry and market, compared to most other economies, regulative institutions related to the cloud have more dominant effects on other institutional components. For this reason, despite their reluctance to outsource and concern about the lack of control in the cloud environment (cognitive institutions), pressures from the government (regulative institutions) has been key in driving cloud use among SOEs. The government wants the SOEs to move IT applications and services to the cloud in order to reduce costs and improve efficiency (Sampler, 2015). Compared to economies such as India and the U.S., normative institutions such as trade and professional associations, on the other hand, are less dominant and exert less influence on other components of institutions.

The various factors presented in Fig. 1 are subject to different rates of change. In general, economic factors are likely to undergo more rapid changes compared to institutional factors. Policy intervention can play a role in overcoming some of the limitations related to economic factors presented in Fig. 1. For instance, as noted above, China′s plan is to increase Internet speeds in cities to 50 Mbps by 2020. The Chinese government is also taking initiatives to bridge the rural–urban divide in ICT penetration and bandwidth availability. Such initiatives are likely to stimulate cloud diffusion in the rural area. Moreover, with the availability of high-bandwidth connections to home and mobile devices, businesses and consumers are likely to derive a higher value from the cloud.

Other countries should also learn from the drawbacks that the Chinese example has shown. For instance, in countries such as India and the U.S., trade and professional associations have addressed some of the concerns businesses and consumers have regarding the adoption of the cloud. The American Institute of Certified Public Accountants (AICPA) has facilitated cloud adoption among its members. It has endorsed different CSPs for payroll solutions, invoice management and payment, financial management and accounting, and tax automation. The AICPA′s endorsements are based on an extensive due diligence on the CSPs′ security practices. CSPs have also started pressuring policymakers for sensible regulations. IT companies such as Oracle, Cisco, SAP, Apple, Google, and Microsoft lobbied to streamline the European Union′s (EU) fragmented national data protection laws. Because of China′s strong state and a weak civil society, such initiatives and pressures are conspicuously absent in the country.

Economic and institutional factors presented in Fig. 1 would also help identify strategically attractive market segments for foreign and domestic CSPs, which vary considerably in capabilities and offerings and are perceived differently by different market segments. According to an analyst at Forrester Research in Beijing, key advantages of foreign CSPs concern the

richness of product offerings, quality and experience in servicing large scale clients. A Gartner analyst noted that most Chinese CSPs have capabilities to provide services to SMEs or startup companies, which tend to be price sensitive (cognitive institutions). Global players such as AWS, on the other hand, have offerings appropriate for large enterprises or SOEs (Jing, 2014). It should, however, be noted that, due to China′s security and cyber-control measures (regulative institutions), SOEs are often expected to sign deals with Chinese CSPs and thus are not potentially attractive for foreign CSPs.

An upshot of China′s security and cyber-control measures is that foreign companies should avoid hosting illegal contents (e.g., pornography and politically sensitive speech). They also need to be prepared to deal with the government′s overly forceful measures such as occasional “lockdown”. In some occasions, IT companies are not allowed to move hardware to or from IDCs. Such lockdown lasted for over three weeks in the early 2014, when a big political meeting was being held in Beijing (chinaeconomicreview.com, 2014).

As noted earlier, the CCP views Chinese firms′ economic and commercial success as closely tied to its political ideology (Kshetri, 2007; Xia, 2012). Local firms′ success can also help promote a sense of nationalism and burnish the country′s image abroad. It is important because the CCP bolsters its legitimacy through nationalism and patriotism (Barme, 1999; Hansen, 1999; Ong, 1997; Sautman, 2001). This means that domestic firms in technology sectors are likely to benefit more compared to foreign ones by the state′s massive mobilization of resources in the cloud industry. In addition to the data localization requirements discussed earlier, other mechanisms exist that are likely to work in favor of local companies. China′s policy and legal framework is characterized by vagueness and ambiguity (Myers, 1996), which often works in favor of local companies. For instance, while there is no specific “cloud computing” category in the license list of value-added services, the central government has classified cloud computing as a value added telecom service (VATS). Under the Chinese regulatory regime, and in accordance with China′s WTO commitments, foreign-company ownership is capped at 50% in VATS ventures and 49% for basic telecom services (Kahler & Li, 2010). This means that foreign CSPs are required to find Chinese partners in order to operate in the country.

Another mechanism by which the Chinese government could exert an effect on the Chinese cloud industry and market concerns the state′s deep entrenchment in the economy. For instance, one estimate suggested that the state accounts for at least 70% of the Chinese economy (Pei, 2006). Likewise, estimates suggest that mobile operators in China are 70% state-owned (Zhang & Prybutok, 2005). The government can influence SOEs to use services provided by local CSPs.

The Chinese government has also expressed a desire to see the cloud industry dominated by local companies. It was reported in May 2014, the NDRC, Ministry of Industry and Information Technology and Ministry of Finance rolled out a funding program designed to help Chinese companies with significant cloud projects meeting certain criteria (Johnson, 2014). It is encouraging state-run IT companies such as China Mobile to expand cloud services. It also wants Chinese companies to control a higher share of the global cloud market.

Foreign CSPs in China are required to operate within an extremely competitive and low cost environment. Chinese CSPs such as Huawei, Alibaba Group and ZTE have emerged as strong

challengers to global CSPs such as IBM, Amazon, and HP (Long, 2012). The entry of foreign CSPs has forced local firms to be even more competitive. For instance, just before Amazon′s announcement of entry into the Chinese market, Aliyun said that it would cut the price of its services by up to 35% (Jing, 2014). Chinese firms′ low cost strategy and experiences in serving the home market may allow them to develop value-creating strategies and realize significant share in the global cloud market, especially in the developing world. At the same time, while Chinese IT companies have undertaken successful entrepreneurial activities on the home front, they may face barriers in foreign countries. Cloud providers from China might experience a negative country-of-origin effect. As noted above, institutional environment in China cannot guarantee data security and privacy. These concerns further increase if one takes into consideration the possibility of government control of China-based CSPs.

5. Concluding remarks

Chinese policymakers have recognized the opportunity to tap the cloud to slip into a higher gear and made this technology a priority. This does not, however, mean that Chinese policies favor domestic and foreign CSPs equally. While government purchases of products and services are expected to drive cloud diffusion, they are likely to favor products that incorporate high levels of domestically developed technology.

Other developing economies are likely to benefit from the lesson and experience of the Chinese cloud industry. Chinese CSPs such as Huawei and Aliyun can easily adapt the business models used in China. Their capability to deliver value for money in the domestic market is likely to be an important source of competitive advantage to operate in other developing economies.

Economies of scales have undoubtedly played a major role in attracting global and local players in the Chinese cloud industry. The breadth and depth of cloud offerings thus would continue to expand. Smaller developing economies lack some of the favorable conditions enjoyed by China and are less attractive markets for CSPs, and thus may face more challenges in the development of the cloud industry.

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