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From concept to implementation: The development of the emerging cloud computing industry in China

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ABSTRACT

Cloud computing has emerged as an important ICT (information and communication technology) innovation that could potentially revolutionize the way computing resources are consumed and provided. In emerging economies, such innovation is regarded as the new way to provide information infrastructure that has the potential for further economic upgrading. In this paper, we investigate the initiation and growth process of the cloud computing industry in China, based on an in-depth case study. We discover that the development of China's cloud computing industry that emerged from an initial concept involves the co-evolution of technological and institutional infrastructure leading to a preliminary cloud ecosystem. We also find that such a process involves a wide range of different actors, from the government side to the business side, the interaction among which, in pursuing their own interests, drive the development of the cloud computing industry into being. Finally, situated in the institutional context of China, the government–business relationship is witnessed to have changed and evolved along development of such an emerging industry, demonstrating the important and unique roles of both sides in industrial (or even national) wide diffusion of the ICT innovation.

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1. Introduction

In recent years, fast economic development in emerging countries has intensified further the considerable need for information technologies and services. These emerging countries leverage different strategies to link the domestic information and communication technology (ICT) industry development with the rest of the world. As pointed out by [Avgerou \(2008\)](#), one important means of understanding the future of ICT industry lies in emerging economies, which are playing an increasingly significant role within the global economy. Compared with developed countries, emerging economies have some unique characteristics, such as immature capital markets, lack of resources necessary for innovation development, poor legal framework to protect property rights, and weak pools of vertical intermediaries ([Back, Parboteeah, & Nam, 2014](#); [Mahmood & Mitchell, 2004](#)). Furthermore, emerging economies present a more dynamic and uncertain environment where changes are constant and complicated, both in terms of government regulations and market settings ([Back, Parboteeah, & Nam, 2014](#); [Fang & Zou, 2010](#); [Mahmood, Chung, & Mitchell, 2012](#)). Finally, the contexts of emerging economies are quite

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different in terms of cultural background and political environment, which have profound implications for understanding certain ICT related phenomenon (Xiao, Califf, Sarker, & Sarker, 2013).

In this paper, we focus our attention on one of the emerging economies – China. The world has witnessed the tremendous economic growth of China in recent decades, which has been given impetus by a series of changes in various aspects of the social and regulative systems, since the “reform and openness” policy implemented in the late 1970s. Parallel with such economic growth, we have also seen the impressive development of the ICT industry in China, which has been one of the major forces to transform China into a “knowledge-based” society. In recent decades, the development of the ICT sector has been given highest priority by the Chinese government in an effort to modernize the country (Amiri, Campbell, & Ruan, 2013; Zhu, 2006). As Martinsons (2005) puts it, “more than any other country, China is being transformed by the application of IT, from a poor and isolated society to major force in the global economy.” Such efforts have led to a series of revolutions in the ICT sector, including industry-level deregulation to decrease monopoly and introduce competition, internationalization and standardization (Gao & Lyytinen, 2000; Xia, 2012; Zhang & Cheng, 2011; Zhu, 2006). For instance, the gradual transformation of the telecommunication sector over the years resulted in controlled liberalization and limited competition (Gao & Lyytinen, 2000). This once again emphasizes the importance of contextualization in understanding technological progress in emerging economies (Li, Gao, & Mao, 2014).

In this study, we focus on the emerging cloud computing industry in China, examining the process of its evolution and investigating the role of various actors in driving such evolution. Cloud computing represents a convergence of two major trends in information technology, which are IT efficiency and business agility (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi 2011). Since 2007, the advent and spread of cloud computing, which represents a fundamental change in the way IT services are developed, deployed, scaled, updated, maintained and paid for, has been gradually changing the traditional ICT landscape in China. The market of China cloud computing services grew quickly and the overall cloud computing value chain is expected to grow to \$122 billion by 2015 (Larson, 2013).

The focus on cloud computing follows the call by Xiao et al. (2013) for more studies to consider emerging technologies, as previous ICT-related research in the context of emerging economies mostly focused on the adoption of well-established technologies such as various information systems and the Internet. These types of technological innovations are evolving in parallel with more socio-technical uncertainties than well-established ones both in emerging and advanced economies, and the applicability and use of such technologies are somewhat incomplete and unstable (Morris, 2009; Rosenberg, 1994).

By exploring the process through which the cloud computing industry has developed, we aim to provide insights into the underlying mechanisms of the large-scale diffusion, deployment, and adoption process of emerging ICT innovations – cloud computing in this case – in China. To do so, a longitudinal study is conducted to investigate the evolution process of the cloud computing industry in China. Taking such a “bottom-up” approach to analyze the phenomenon will allow us to generate context-specific insights and understand how the particular social and political environment in China has influenced or shaped such a process (Walsham, 2001).

The rest of the paper is organized as follows: first, we discuss previous literature and present relevant theoretical background for our analysis. This is followed by a brief discussion of the methodology employed in this study, and our interpretation of the data with respect to the development of China’s cloud computing industry. We discuss our findings and then offer our conclusions.

2. Cloud computing

Cloud computing is defined by the *National Institution of Standards and Technology* (NIST) as “a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction” (Owens, 2010). This new paradigm is regarded as an important solution for reducing IT investment costs, minimizing management effort, and improving business process (Armbrust et al., 2010).

According to NIST, cloud computing services are usually provided in three models: SaaS (software as a service),¹ PaaS (platform as a service),² and IaaS (infrastructure as a service)³ (Owens, 2010). The cloud-based IT deployment model differs from traditional IT service models in several aspects. First and foremost, with minimal initial capital investment, it has significantly lowered the entry cost of IT deployment, especially for smaller firms (Marston et al., 2011). This is complemented by the “pay-as-you-go” payment mode, which essentially transformed IT resources as measured service or another type of utility (Yang & Tate, 2012). Secondly, cloud computing utilizes on-demand network access as a means to connect users to a shared pool of IT resources, meaning that the amount of IT resources that can be accessed by almost everyone is unlimited (Marston et al., 2011). Furthermore, the level of elasticity associated with cloud computing is much higher than traditional IT solutions, making it easy for the users to scale up and down the deployment (Yang & Tate, 2012).

¹ Software as a Service (SaaS) is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet (Owens, 2010).

² Platform as a Service (PaaS) is a way to rent hardware, operating systems, storage and network capacity over the Internet (Owens, 2010).

³ Infrastructure as a Service (IaaS) is a provision model in which an organization outsources the equipment used to support operations, including storage, hardware, servers, and networking components (Owens, 2010).

Finally, apart from reduction in costs and skilled labor, cloud computing also lowers the barriers to and opens up opportunities for innovation, an advantage that separates cloud computing from commoditized outsourcing, due to lowered transaction costs related to innovation afforded by the flexibility and elasticity of cloud-based IT solutions (Marston et al., 2011; Venters & Whitley, 2012).

Cloud computing not only represents, at the micro-level, a new mode of IT delivery and consumption, but also implies, at the macro-level, a new business model that leads to different industrial dynamics (Marston et al., 2011; Subramanian, Abdulrahman, & Zhou, 2014). New players (cloud only providers such as Salesforce.com) have emerged to challenge the incumbents, while the traditional IT vendors scramble to adapt to the new landscape by modifying and transforming their existing business model (Cusumano, 2010; Iyer & Henderson, 2010). From an even broader perspective, industrial experts have suggested that cloud computing would provide emerging economies an opportunity to leapfrog developed markets, given the advantages offered in terms of obtaining computing resources (as discussed above), and also in light of potential changes in industrial dynamics due to the rise of new players (Uretsky, 2014).

When it comes to cloud computing related research, it is suggested that the field is still in its nascent stage with most studies concentrating on initial adoption of the technology (Schneider & Sunyaev, 2014; Winkler, Goebel, Benlian, Bidault, & Günther, 2011). Existing studies have tackled issues including whether companies or industries should move to cloud and what drives the adoption intention (e.g., Brust & Sarnikar, 2011; Hsu, Ray, & Li-Hsieh, 2014; Sarkar & Young, 2011; Sarkar & Young, 2011); the benefits and risks of adopting cloud-based IT solutions (e.g., Janssen & Joha, 2011; Lampe, Wenge, Müller, & Schaarschmidt, 2012); procedures and guidelines on cloud adoption (e.g., Abokhodair, Taylor, Hasegawa, & Mowery, 2012; Lee, Tang, & Sugumaran, 2012; Wind, Repschlaeger, & Zarnekow, 2012). Most of this research is done at the organizational level, aiming to shed light on the practitioners who are at the crossroad of adopting such a new business model of IT deployment. Some studies take an industrial level viewpoint by evaluating the potential of cloud computing with a focus on a certain industry (e.g., Lampe et al., 2012; Oliveira, Thomas, & Espadanal, 2014). However, very few studies approach the phenomenon on a societal or country level, not to mention in the context of emerging economies.

Our study investigates the cloud computing phenomenon at the macro-level. More specifically, we examine the process by which an industry has developed around this emerging ICT innovation in the context of China. Hence, we are interested in exploring the local uniqueness of China when it comes to cloud computing development, by identifying the relative actors (who have been included), structure (who hands off to whom), and governance (who influences the rules). More importantly, we examine how the policy evolves along the business practice as the industry progresses toward maturity (Tang et al., 2014).

3. Institutional environment of China's ICT sector

Given that the cloud computing industry belongs to the broad area of ICT, it is important to look at the institutional environment of the ICT sector in China when investigating the evolution process of the cloud computing industry. First and foremost, the government still plays a central role in launching major development programs, building national innovation systems, and further improving the ICT infrastructure (Luoma & Nyberg, 2011). For instance, in the case of cloud computing, different central ministries including MIIT (Ministry Of Information And Industry Technology) and NDRC (National Development and Reform Commission) have worked together to promote this emerging sector in China. Though China has experienced the so-called "opening up" reform attempting to transform into a market economy, control by central government is still substantial, especially when it comes to policy making and strategy planning (Zhu, 2006).

The implementation of ICT strategies is a "top-down" approach with central government providing guidelines and targeted goals (like the "National Five-Year Plan"), and different levels of local governments (including ministry-level government, provincial government, and municipal government) developing localized implementation plan and strategies according to their own situations and needs (Zhu, 2006). In this respect, the local government plays a critical role in ICT development, as it actually instigates various policies and programs. For instance, in the case of science and technology parks, a governmental initiative aimed at boosting China's technological capabilities, central government issued policy support (e.g., the Touch Program, Yuan, Gao, Xiang, Tian, & Zhang 1992), while various levels of local government established the huge number of local technology parks that facilitated scientific collaboration and knowledge transfer among local business, foreign companies, and high-education institutes (Hu, 2007; Nag, Corley & Gioia, 2007). However, it is worth noting that such an administrative system in China is still plan-oriented and usually managed by people who lack subject knowledge background, leading to situations where the quality of the developing initiatives and projects are not always guaranteed (Suttmeier & Yao, 2004). As noted by Gao & Lytinen (2000), who studied the transformation of the telecommunication sector, China has progressed slowly from the socialist planning system, a system that favors state control and prevents economic laws, which can lead to failure and lack of efficiency when it comes to ICT development.

Moreover, the recent governmental long-term plan of technology and science (the fifteen-year plan announced in 2006⁴) emphasizes the importance of indigenous research and innovation driven by technology (Li, 2007; Luoma, & Nyberg, 2011). China's ICT development strategy presents a typical dilemma of many developing countries: on the one hand, globalization

⁴ Website of the fifteen-year plan: http://www.gov.cn/english/2006-02/09/content_183426.htm. Accessed July, 2013

is a trend that should be utilized not avoided, while, on the other hand, globalization cannot be allowed to dominate fully the domestic market and hence seek technological autonomy and minimize dependence on foreign countries (Muchie & Baskaran, 2006). Along similar lines, other scholars like Suttmeier and Yao (2004) and Wang, Kwak, and Lee (2014) define the technological strategies of China as “neo-techno-nationalism,” where 1) national interests are pursued by leveraging globalization, 2) technological innovations are led by both private initiatives and government–business partnerships, and 3) the market is open to foreign investment under certain conditions. Such “neo-techno-nationalism” policy that promotes indigenous innovation can sometimes create inconformity between central government and local government, as it constrains the activities of foreign direct investment that plays an important role in economic development in certain regions (Chen & Ku, 2014; Lee, Chan & Oh, 2009; Wang et al., 2014).

Additionally, foreign enterprises have been playing a crucial role in China's economic growth and this is especially the case in the ICT industry (Whalley & Xin, 2010). For instance, after analyzing the revolution in the telecommunication sector in China, Yoo (2004) concluded that foreign influence is one of the three forces that drove the reform, together with market forces and state concerns. However, as discussed above, China's attitudes toward foreign investment or foreign enterprises are complex: on the one hand, Chinese ICT industry longs for domestic development fostered by technological innovations; on the other hand, the gap between China and advanced economies in ICT capabilities is still immense, which means that it still needs to rely on foreign enterprises to acquire the newest technology (Song & Wang, 2012). In this respect, the government efforts in coordinating various interests and managing relationships between domestic players and foreign players are of utmost importance in some of the ICT initiatives (Kwak, Lee, & Fomin, 2011; Whalley & Xin, 2010).

Finally, China has long been perceived as having a poor legal and regulatory environment (Gao & Damsgaard, 2007), which is very relevant in the case of cloud computing. As pointed out by Kshetri (2013), compared with the technological development, cloud-related legal systems and enforcement mechanisms are evolving more slowly, potentially hindering the maturation of the market. In China, there is currently no specific legislation that directly addresses cloud computing services. However, since cloud services are based on a real-time network (i.e., the Internet), regulations and rules for telecommunications will apply here to regulate cloud services. The majority of cloud services are likely to be categorized as value added telecommunication services under the “Telecommunications Regulations,” implying that special licenses are required to provide such services. Hence, if a foreign company intends to operate in the market of cloud computing, it must establish a foreign invested telecommunication enterprise, in accordance with the relevant requirements set forth in the “Foreign Investment Catalog,” “Provisions on Administration of Foreign-Invested Telecommunications Enterprises”, and other related rules.⁵ Therefore, foreign companies that wish to enter China's cloud computing market are required to establish joint cooperative arrangements with domestic partners.

4. Theoretical lens: actor-network theory

We adopt the actor-network theory for analysis and interpretation. Actor-network theory aims to examine the motivations and actions of actors who form alliances with and/or enroll other actors to form heterogeneous networks of aligned interests (Callon & Latour, 1981; Sarker, Sarker, & Sidorova, 2006; Walsham & Sahay, 1999). A core idea of ANT is that any object (of study) can be viewed as “a product or an effect of a network of heterogeneous materials” (Law, 1992; p. 381), and any network can consist of actors of different nature (human or non-human), and of different scale (micro or macro), which should be granted analytical equality (Callon, 1990; Latour, 2005). To form successful networks, a sufficient body of actors needs to be enrolled, and the interests of these actors need to be aligned and weaved into the network (Law, 1992; Walsham & Sahay, 1999).

“Inscription” and “translation” are among the key concepts for understanding the interest alignment to form an actor-network. An inscription is a form of anticipated characteristics which actors, in one way or another, try to build into an artifact (Callon, 1990). Translation implies that an actor reinterprets or appropriates the interests of other human actors and the interests embedded in non-human actors according to one's own, and has these interests represented in the inscription (Sarker, Sarker, & Sidorova 2006). It is discussed in the literature that translation involves phases: problemization where the focal actor frames the problem; interessement where the focal actor convinces other actors to accept its own interests; and enrollment where other actors accept the interests defined by the focal actor and involve themselves in the network (Callon, 1986; Sarker et al., 2006).

As a powerful analytic tool, ANT has been adopted in a wide range of disciplines, including sociology, anthropology, economics, organization studies, and information systems studies (Law & Hassard, 1999). Particularly, in the area of information systems, which is at the intersection of the social and the technical, ANT has helped the progression of intellectual agenda. This is enabled by ANT's characteristics of encouraging the researchers to examine closely the dynamic interplays among complex socio technical systems, and to understand the social and political issues surrounding the development, adoption, and implementation of various information technologies (e.g., Hanseth & Monteiro, 1997; Sarker et al., 2006, Walsham & Sahay, 1999).

⁵ Currently, the proportion of foreign capital investment in FITEs providing BTS should not exceed 49% and for VATS-type FITEs should not exceed 50% in total.

We regard ANT as an appropriate tool for analyzing the development of the cloud computing industry in China. To begin with, ANT allows treating the evolution of the cloud computing landscape in China as a process of how a stable network of aligned interests has been built and maintained. In other words, the process can be described from the network building perspective, and the interactions among actors can be described as actions related to translation, enrollment, and inscription that facilitate or inhibit the stabilization of the network. Furthermore, as discussed above, the institutional environment of the ICT industry in China is characterized by the presence of multiple players from both the business sector and the government sector (Li, Shen, Ma, and Zhang, 2015). ANT would allow determining the interests of these actors, and analyzing how such interests are aligned and weaved into the network. Therefore, the theoretical lens of ANT would provide not only a holistic view of the cloud computing industry, in order to investigate how such a network comes into being (e.g., MacKenzie, 2009; Sarker et al., 2006), but also focus on each of the major actors and examine their interests, behaviors, and interactions, which facilitate or inhibit the development of the network (e.g., Walsham & Sahay, 1999).

To sum up, in this study, we analyze the process of which an actor-network is developed, shaped, and stabilized. The focus is on the interplay among various actors throughout the process, which results in or attempts to achieve “a black-boxed relationship” (Cordella, 2010). More importantly, the institutional environment of the ICT sector in general and the cloud computing industry specifically is an important piece of the puzzle for a holistic view of how the industry has developed. Hence, in our analysis, we not only focus on the various actors involved and their actions, but also scrutinize the influence of the broader social context in driving the interests of different actors and in shaping the behavior related to translation and inscription (Gao & Damsgaard, 2007).

5. Research methodology

Walsham (2001) advocates that scholars should take a “glocalization” approach when addressing issues in emerging economies. This implies a more “bottom-up” method that takes into consideration the local uniqueness of a certain emerging economy. Following such a call, we conduct a longitudinal case study to examine inductively the evolution process of China’s cloud computing innovation, while being sensitized to the context (Walsham, 1995; 2006; Yin, 2003). We adopt the ontology of “internal realism.” The reality – the development process of the cloud computing industry in China – we try to construct is not independent from our interpretation, but rather an “inter-subjective” construction of a shared understanding of the phenomenon between the participants involved in the process and the researchers (Archer, 1988; Walsham, 1995). Carrying out a longitudinal study on the evolution process of China’s emerging cloud computing industry requires capturing changes in information technology and the market, analyzing the dynamic contexts within which the evolution takes place, and exploring key actors’ role in the process.

5.1. Data collection

The authors of this paper first engaged in field observations (Yin, 2003). Two of the authors work in a national public institute directly involved in the policy formation of China’s ICT industry, allowing first-hand experience and observation of the development of the emerging industry. This also granted us access to major participants in the process. We conducted pilot interviews at China’s cloud computing conference, which attracted the main domestic and international firms to publicize new concepts, build connections, and promote new products. Several experts in leading companies were interviewed during the conference to analyze the industry’s development patterns. This helped us identify key players in the field, whom we were able to interview later. In the end, 35 semi-structured interviews were conducted with representatives of the main players including five foreign IT MNCs (multinational companies), seven government agencies, five internet firms, two industrial associations, three domestic system vendors, and three telecommunication operators, from the period of March 2012 to January 2014. Third, we also relied on archival documents, such as news reports, public speeches of ministers and industrial leaders, and the annual reports of cloud computing development in China.

5.2. Data analysis

As the first step of the data analysis, we identified and chronologically organized the key milestone events since the early appearance of the cloud computing concept in China. Such a process mainly involved content analysis of archival documents as well as interview data. Table 1 presents and describes these key milestones.

Secondly, we inductively analyzed the data through the theoretical lens of ANT. This round of data analysis was focused on identifying key actors involved in the development process, their interests, their actions, and the interactions between them. The key milestones presented in Table 1 helped us map out the formation of the network (in this case the cloud computing industry) and the influence of various actors throughout the process. The examination of the milestones through the lens of ANT allowed us to discern three distinct phases of the evolution process of China’s cloud computing industry to date, namely, *Initiating from the Concept*, *Building Cloud Infrastructure*, and *Developing Cloud Ecosystem*. These three phases marked different stages of the formation of the network, each of which was led by different focal actors and characterized by different problems. It is noted that the identification of the three phases was an iterative process that involved constant comparison between the data pattern and the theoretical concepts (Yin, 2003).

Table 1

Milestones of cloud computing development in China. Source: Collected by the authors from various reports and verified by the interviewees.

Time	Events
Feb. 2008	IBM announced the establishment of China's first Cloud Computing Center. This center provided emerging Chinese software companies with a virtual computing environment.
Jan. 2009	Alibaba established the first "Electronic Business Cloud Computing Center" in Nanjing, Jiangsu province.
Jul. 2009	Sinochem group established China's first cloud computing platform at the firm level.
Sept. 2009	Aliyun, the cloud computing subsidiary of Alibaba, was launched.
Nov. 2009	China Mobile launched "Big Cloud Project" to establish a large-scale cloud computing platform.
Jan. 2010	China Cloud Computing Technology and Industry Alliance (CCCTIA) was founded in Beijing.
Oct.2010	Chinese government announced its twelfth <i>Five-Year Development Plan</i> and highlighted Cloud Computing as one of the key investment areas.
Oct. 2010	MIIT and NDRC announced that five cities – Beijing, Shanghai, Shenzhen, Hangzhou, and Wuxi – would conduct a cloud computing trial service.
Aug. 2011	China Cloud Computing Promotion and Policy Forum (3CPP) was established as the collaboration platform for government and industry.
Aug. 2011	China Telecom announced its Cloud Computing Strategy
Oct. 2011	Chinese government developed subsidiaries of cloud R&D for domestic technology companies including Alibaba and Baidu.
To the end of 2012	Nearly 30 metropolitan governments announced large cloud computing and data center investments and projects
March 2012	China Telecom established dedicated cloud computing corporation
Aug. 2012	The National Broadband China Strategy was announced
Sept. 2012	Twelfth Five-year Special Plan for Cloud Computing Technology Development was announced
May 2013	Trusted Cloud Service Assessment program was launched
Aug. 2013	MIIT released 18 national standard plans including national standards for cloud-based e-government public platforms
July. 2013	IBM announced a strategic collaboration with Capital Online Data Service, the local partner, for deploying the public cloud service
Dec.2013	IBM and Microsoft announced the provision of cloud computing service in China with the collaboration of local partners
Jan. 2014	3CPP promulgated the first 20 certificated service providers offering cloud hosting, database, and storage services. The listed companies included <i>Alibaba, Baidu, Tencent, China Telecom, and China Mobile</i> , among others.

To ensure the consistency of our findings, we performed triangulation between and among different data sources (Yin, 2003). The use of the timeline to map out critical events also allowed us to construct a coherent story that linked the data together. Furthermore, the first-hand knowledge and experience obtained by two of the authors in the field enabled corroboration of actors, actions, and milestone events through dialogically reasoning between the authors from the perspective of both an outsider and someone who possesses deep contextual insights of China. Finally, we were able to validate the analysis results by presenting the general patterns discovered to some of the interviewees through phone calls or emails.

6. Evolution of China's cloud computing industry

In this section, we discuss the key events in each of the three phases identified and consider the roles of various actors, both from the government side and the business side.

6.1. Phase 1. Initiating from the concept: early 2008–Oct. 2010

In early 2008, some leading foreign firms like IBM and Microsoft began to introduce the concept of cloud computing to China's industries and government agencies at different meetings, conferences, workshops, presentations, and training sessions. These MNCs, which have always played an "educator" role when it comes to new technology (Whalley & Xin, 2010), hoped that by disseminating ideas related to cloud computing, they could establish a market in China and create initial demands for cloud-based services (Shen, Yang, & Keskin, 2014). For example, IBM announced the establishment of its first *Cloud Computing Center* in China in February 2008, which provides domestic software companies with a demonstration computing environment⁶. A senior business development director of IBM China we interviewed recalled:

"At first, many of China's IT executives and officials thought the cloud computing is just a novel concept and have a long way to come into operation. We then frequently present to the local interested parties about the great innovative opportunity of cloud by highlighting its merits like apparent cost-reduction or business flexibility. More important, the successful cloud computing business cases in the US help to convince China's government and local firms to perceive the possible advantages by buying computing service instead of buying computer equipment."

⁶ IBM to Build First Cloud Computing Center in China, Virtualization News, <http://www.sys-con.com/node/494628>

It can be interpreted that the activities of foreign MNCs at this stage were to frame the problem as the need to develop a cloud computing industry in China (problemization). This reflected their interest in expanding their cloud-related business to China by stimulating the demands of such a market first (as suggested by the IBM director above), and then convincing other actors (e.g., domestic IT firms and Chinese government) of the importance of such a problem (interessement). Due to these efforts by foreign MNCs, the business and administration circles in China gradually realized that emerging cloud computing was becoming an important global trend which could serve as China's future IT infrastructure at the national, regional, and organizational levels. As a result, these actors, from both business and government, were enrolled in the initial network developed for cloud computing.

From the business side, domestic IT vendors initiated various cloud related projects to explore the opportunities and possibilities of this emerging technology. For instance, in January 2009, *Alibaba* announced the launch of the first E-business Cloud Computing Center. In November 2009, *China Mobile* launched Big Cloud Project to establish a large-scale cloud trial platform in the telecommunication sector. The development of cloud-related projects among local players can be interpreted as an inscription effort to claim first-mover position in the emerging market. It is worth noting that some of the domestic IT firms in China were already providing some SaaS services, such as software outsourcing and off shoring service, which were not described as cloud computing. However, these early efforts at engagement with cloud computing or related technology were scattered and not organized around a specific market. It was not until more systematic development, for example, the initiation of the abovementioned project, that cloud computing became an important phenomenon attracting the attention of local business in China.

From the government side, in October 2010, State Council announced Circular 32 document – “Decisions of State Council on Accelerating the Cultivation and Development of Emerging Strategic Industries” – which designated cloud computing as a component of *Next-Generation IT* in the “Twelfth Five-Year Plan”.⁷ This has triggered a series of governmental initiatives to push the industry forward (as presented below in the discussions of Phase 2). The inclusion of cloud computing development in the State's “Five-Year Plan” signaled official enrollment of the Chinese government in the network created around cloud computing, and can be interpreted as an effort to inscribe the interests of the government in the network – facilitating the development of a strategic industry – in the form of governmental planning.

In January 2010, *China Cloud Computing Technology and Industry Alliance* (CCCTIA) was launched in Beijing. With such an inter-organizational community concerned with innovation, the foundation of CCCTIA may be viewed as the initiation of the cloud computing industry in China. At the end of Phase 1, the development of the cloud computing industry achieved its initial institutional legitimacy with a common vision for both business and government. On the one hand, the central government envisioned the development of a cloud computing industry as another means to pursue its long-term strategy of promoting “indigenous innovation;” while, on the other hand, domestic IT vendors envisioned their efforts in pushing the industry forward as a way to make the transition to the new IT. It is worth noting that this common vision of cloud computing industry shared by Chinese government and domestic players deviated from MNCs' plan to develop through creating demand, as the focus shifted toward building a domestic industry and nurturing domestic vendors. This was inevitable considering the involvement of central government, as well as the policy issue we discussed earlier regarding MNCs not being able to engage directly in the cloud computing business without local collaboration. This common vision of the development of China's own cloud computing industry also signaled the shift in focus of actors who would facilitate the further development of the network, as discussed in the following section.

6.2. Phase 2. Building cloud infrastructure: October 2010–September 2012

Following the strategic orientation by central government to include cloud computing development in the “Five-Year Plan”, in October, 2010, the MIIT and NDRC released “Nationwide Pilot demonstration program for cloud computing” to support the cloud service experiment in five cities: Beijing, Shanghai, Shenzhen, Hangzhou and Wuxi. These cities, it was anticipated, would implement a trial operation of cloud computing in healthcare, education, and other public services sectors. The policy support from central government triggered some strong initiatives by local governments, and the goal of leveraging cloud services to support regional economic upgrading.

This pilot program subsequently prompted fierce competition to build a cloud infrastructure, in the form of an Internet datacenter (IDC), among the trial cities (and others) with two important groups of actors involved: local governments and public telecommunication operators. By the end of 2012, nearly 30 metropolitan governments, such as Beijing, Chongqing, Shandong, and Shanghai, among others, announced different investment projects in cloud computing and Internet data centers. These local governments were hoping that the development of cloud computing would stimulate local economic growth in the future, which reflected their main interests as a result of the intersegment efforts by the MNCs during the first phase. The problem framed at this stage by regional government was to operationalize the idea of cloud computing and develop supporting projects at the local level. Their main efforts included establishing collaborations with large state-owned organizations, in this case telecommunication operators and some system vendors, and enrolling these players in the

⁷ Website of China's central government, http://www.gov.cn/zwqk/2010-10/18/content_1724848.htm, accessed March 16, 2014. The central government in China guides the direction of social and economic development by issuing so-called “Five-Year Plans.” Cloud computing has been included in the latest “Five-Year Plan,” demonstrating the support from central government in pursuing the development of this industry.

network. The collaboration with state-owned organizations is desired by local governments to gain further policy support from central government, according to one senior official of local government, who was interviewed:

“We tend to cooperate with these large state-owned operators or vendors as they can attract more policy supports and investment from the central government. You know, we must compete with other large cities in China in such ‘emerging industries’ like ‘cloud computing’ to stimulate the quick growth of other local industries.”

On the other hand, leading telecommunication operators were actively engaged in the cloud infrastructure building with focus on expanding their datacenter landscape. In March 2012, *China Telecom* established its own dedicated cloud computing subsidiary to promote service actively, particularly for the public market. This specific subsidiary would allow *China Telecom* to accommodate more comprehensive cloud computing services ranging from the original server hosting to data storage and processing, and to support various Internet and e-commerce businesses. One senior director of *China Telecom* we interviewed recalled:

“As a state-owned telecommunication operator, with widespread network and data centers, we have captured many cloud contracts mainly from the public sectors like e-government and e-education-related cloud services by our comprehensive cloud computing services. In these markets, those private Internet firms couldn’t compete with us.”

Such localized collaboration between regional governments and telecommunication operators was a process of translating their interests to align with the network of the cloud computing industry. The joint projects that aimed at building facilities to support a cloud-based infrastructure ultimately pushed the development of the industry further. Additionally, the collaboration resulted in the establishment of IDCs across China, an effort that involved both parties in the network. In other words, the objectives of local government and telecommunication operators in developing the cloud computing industry in China were realized through the joint efforts of building these IDCs.

It should also be noted that several ICT related initiatives of central government during this period facilitated the development process, by providing further subsidies to domestic IT vendors as well as telecommunication operators in cloud-related projects. In August 2012, the State Council announced the “Broadband China” strategy and implementation plan which outlined the target and timetable for China to become a leader in international broadband accessibility. China intends to increase urban and rural household broadband speeds to 20 Mbps and 4 Mbps respectively, according to a blueprint issued by the State Council (Li, 2013). The nation broadband penetration rate will greatly increase by 2015, when fixed broadband coverage of households is expected to reach 50%, while mobile broadband coverage must surpass 32.5%, according to targets set by the State Council (China Daily, 2013). This strategy also develops e-commerce, digital music, mobile payment, location-based services, electronic books, and an App store, among others. It supports business innovation in mobile internet, cloud computing, internet of things and the convergence of telecommunication, Internet, and broadcasting networks to drive the development of the broadband network by application. The domestic telecommunication operators and system vendors actively leveraged this broadband investment surge to enhance their competitive positions in the cloud computing sector. Subsequently, these state-owned companies acquired most e-government services contracts from local governments (Zhu & Shao, 2014). For example, *China Telecom* partnered with many local governments to build and operate e-government programs on the cloud platforms.

As the scale of cloud computing deployment continued to grow, increasingly complex efforts were needed to encourage and guide the development of the cloud computing industry. In August 2011, under the support of three ministries – MIIT, NDRC, and MOST – China Cloud Computing Promotion and Policy Forum (3CPP), an industrial association, was launched with 17 founding members including two public institutes and 15 local cloud firms. The previous minister in MIIT acts as the honorary chairman, the president of CATR (the national communication institute) acts as the chairperson, and the senior executives from the member firms act as the vice chairpersons. Later, MNCs, such as Microsoft, Intel, Oracle, and Dell, also joined the forum. The key objectives of 3CPP forum include promoting communication between government and industry in terms of the standards, policies, plans, and laws in the cloud computing area. Since its inception, the forum has actively worked on a set of best practices as well as operation specifications and cloud vendor certifications to address client concerns.

The launch of 3CPP signaled that the cloud computing industry in China had entered the next phase of more disciplined growth, after the rather “chaotic” period of infrastructure building. The interests of the Chinese government in establishing a well-functioning domestic industry of cloud computing were inscribed in the forum, and the fact that ministers acted as chairperson reflected the government’s intention to maintain control over the development process. Finally, the 3CPP forum acted as the obligatory passage point of the network as regards the cloud computing industry, and in which all the actors had to participate (Callon, 1986).

6.3. Phase 3. Developing cloud ecosystem: September 2012–present

In September 2012, the “12th Five-Year Special Plan (2012–2017) for Cloud Computing Technology Development” was announced. It was the first time that China proactively developed a clear “Cloud Strategy” to facilitate the growth of the cloud computing industry and hence the enhancement of domestic technological capabilities for new service applications.

The initial market for China's cloud computing is small but expanding rapidly. The market value of China public cloud services in 2012 increased by 73% compared with 2011⁸, and this value reached 4.76 billion in 2013.⁹

The growth in the number of data centers slowed down at the beginning of 2013. By July 2013, 173 data centers had come into operation with 82 under construction (MIIT, 2014). At the same time, the service mode of time-based or usage-based payment was increasingly accepted by more IT users. The demands of the cloud market were quickly growing, especially in the areas of e-business, healthcare, and education, and more Chinese SMEs (small and medium enterprises) gradually adopted solutions from the domestic cloud vendors such as *Aliyun* and *UCloud*.

However, despite the growth of the cloud computing market, some important challenges still remain, including the complexity of the regulatory environment, concerns about information security, lack of confidence among potential customers, and unclear operation specifications. All of these challenges have negatively affected the perceived sustainability of the cloud computing industry.

It is no secret that regulation and security-related concerns have been at the center of the debate on cloud computing since its emergence (e.g., Marston et al., 2011, Owens, 2010). The nature of cloud computing means that data (more importantly, sensitive data) are often held by cloud providers, who constantly send this information via the Internet to be retrieved by customers. Therefore, issues regarding the ownership and privacy of the data are of great concern for cloud users (Marston et al., 2011). Lack of regulations and standardizations in this area is often cited as one of the key factors that could cause lack of adoption on the customer side (e.g., Ackermann, Widjaja, Benlian, & Buxmann 2012). In the case of China, similar concerns regarding security and regulation exist in the newly emerging cloud industry. Furthermore, while the infrastructure building at the second phase established the foundations, specific operations of how cloud services should be provided were unclear, which added more uncertainties to the market. In other words, while the technological infrastructure is in place, the institutional infrastructure (concerning the operation of the market, and establishment of standards and regulations) is still missing, which hinders further development in the industry.

It was under such circumstances that the standardization activities around cloud computing were initiated. The nature of cloud computing makes standardization (lack of standardization) an important issue in terms of how service quality and vendor responsibility are specified; this problem, it has been pointed out by scholars, should be tackled on the national level (Marston et al., 2011). Hence, the initiatives taken by the Chinese government in this phase can be seen as an attempt to provide the institutional infrastructure with the intention to solve the challenges mentioned above. As a director of MIIT who is in charge of cloud computing development commented:

"After large number of data centers has been constructed, the security concern, quality standardization, and privacy issues were emerged. However, these challenges couldn't be solved by government only. We find building effective institutional architecture for the cloud adoption maybe more important. The close collaboration between government and industry will be critical when we try to establish the certification mechanism and standardization framework for the cloud service market."

In other words, the problem of central government in this phase is to find ways to develop further the cloud computing industry through standardizing the market. And such interests (the need for standardization) were translated to business players by seeking collaboration with the industry through various programs and projects. For instance, in September 2012, China's National Information Technology Standards Technical Committee (NITS) launched *China's Cloud Computing Standards Working Group*,¹⁰ which would be in charge of technological specifications.

On the other hand, the central government also issued several regulations and standards of data security and privacy, especially concerning cloud use in the public sector. This signaled its interest in, for example, ensuring data security and further standardizing and controlling the market. In July 2012, the "Basic Security Requirements for Government Department Cloud Computing Service Providers", drafted by China National Information Security Standards Technical Committee (TC260), proposed security standards for providing cloud services to the public agencies. In December 2012, the National People's Congress published a resolution, "Strengthening the Protection of Information on the Internet", which applied to the collection and processing of electronic personal information and introduced some basic privacy and security principles.¹¹

As the largest industrial association, the 3CPP Forum launched "Trusted Cloud Service Assessment" program in May 2013. Some major cloud providers (who were among the first batch of certified firms) also joined force to draft the business procedures and specification requirements. In January 2014, the 3CPP and MIIT introduced the first round of 20 certificated service providers offering cloud hosting, database and storage services. The certification structures the rights and duties of service providers and cloud users during the process of cloud service delivery and consumption. The listed companies include *Alibaba*, *Baidu*, *Tencent*, *China Telecom*, and *China Mobile*, among others. Such progress has ensured a trusting

⁸ See the article titled *The Message Conveyed by the Investigation Report on the Development of China Public Cloud Computing Services* (《中国公共云服务发展调查报告(2012年)》) issued by the China Academy for Telecommunication Research of the MIIT, <http://www.chinacloud.cn/show.aspx?id=12508&cid=18>

⁹ White Paper on Cloud Computing, 2014, by China Academy of Telecommunication Research.

¹⁰ Website of Chinabyte, <http://info.chinabyte.com/443/12433443.shtml>. Accessed September 6, 2013.

¹¹ Website of China's central government, www.gov.cn/jrzq/2012-12/28/content_2301231.htm. Accessed August 18, 2013.

relationship between the involved participants and further stimulated the diffusion of cloud service within China. The vice president of 3CPP Forum commented during the interview:

“Now China's many cloud users still consider the potential risks when they intend to buy computing service instead of buying computer equipment as before. Therefore, the Trusted Cloud Service Certification mechanisms become critical especially for the service procurement. As the leading industrial association, we have the responsibility to launch such certification program to establish the trust among the service providers and the service users. Our program has gotten the firm support from the government and many domestic and foreign firms actively join us for the mechanism discussion and the specification drafting.”

The certification mechanism stimulated businesses to develop further cloud-based service. Some certificated Internet firms started to promote aggressively the comprehensive cloud computing solutions to local firms and public agencies. For instance, *Aliyun*, established in September 2009, with R&D and operational facilities in Hangzhou, Beijing, and Silicon Valley, now provides elastic computing, database services, and storage and computing services, as well as web-hosting to its hundreds of thousands of customers including website hosts and e-commerce companies, banks, game developers, and others. In 2013, *Aliyun's* business revenue from cloud computing and Internet infrastructure service reached RMB 650 million.¹² As a senior director of *Aliyun* recalled, further growth of their cloud services as well as the overall cloud ecosystem depended on collaboration with various players, based on the assessment program:

“As Alibaba is managing one of the largest online e-business in the world, it gives us the ideal platform to ramp up a strong cloud customer base. We collaborate with the different independent software developers and business solution providers to support our SME users to grow up. As we have passed the Trusted Cloud Service Assessment, we will work closely with system vendors, network operators, and government agency to keep cloud ecosystem growing quickly.”

Though facing strong regulatory obstacles (e.g., special licenses are needed to operate cloud services), foreign MNCs such as *Amazon* and *Microsoft* still strive for penetration into the Chinese market with their global-scaled cloud infrastructure.¹³ In December 2012, *Amazon* partnered with *21Vianet*, a leading Internet firm, to build a joint venture. In July 2013, *IBM* announced collaboration with another local partner to provide its public cloud service in China. With the enhanced computing power and scalability, the IaaS and SaaS based solutions provided by these joint ventures also launched in the Chinese market, which triggered fierce competition. Arguably, MNCs engaged in such partnerships with local firms to re-enroll themselves in the network and to fulfill their objective of becoming established in the emerging market of cloud computing.

Throughout this phase, we observed that a cloud computing ecosystem, one that is centered around the 3CPP forum, is gradually emerging as the result of a series of joint efforts on both the government side and the business side. A forum was established to facilitate communication and collaborations within and among various groups of players. A policy mechanism was developed to regulate and standardize the market; the cloud business models around service delivery and deployment became more mature together with the growing cloud market. As stated by the senior director of *Aliyun*, such an ecosystem involves parties like cloud providers, network operators, and government agencies, as well as cloud users. In this respect, the network of the cloud computing industry is stabilized with various actors aligning their interests with the network.

Table 2 summarizes the development of the cloud computing industry in each of the three phases we have identified.

7. Discussion

As an indispensable part of China's systematic effort to integrate with the global economy and achieve selective liberalization of the domestic market, the ICT sector bears the responsibility to “informationalize” the economy and transform it from a traditional model to one that is “knowledge-based” (Zhu, 2006). The industrial-wide effort to adopt the concept of cloud computing represents one of the many endeavors of the ICT sector to pursue indigenous innovation and nurture a domestic market, with the support from and collaboration with the government. The development process of China's cloud computing industry involves the development of both physical infrastructure (e.g., Internet data center) and institutional infrastructure (e.g., the 3CPP forum) via dynamic interactions among various actors motivated by their respective interests. If we look at the pattern by which the cloud computing industry in China has evolved, we can discern its own uniqueness which we discuss from the following three perspectives.

7.1. The evolving role of various actors

First and foremost, the development of China's cloud computing has witnessed the participation of various actors both from the government side and the business side. These actors have played different roles across different phases in

¹² The Registration statement of Alibaba Group <http://www.sec.gov/Archives/edgar/data/1577552/000119312514184994/d709111df1.htmto>. Accessed July 17, 2014.

¹³ Website of Shanghai government, <http://www.shanghai.gov.cn/shanghai/node2314/node2315/node15343/u21ai676727.html> Accessed May 12, 2014.

Table 2
Description of the three phases.

Phase	Main actors involved and their interests	Main activities among the actors	Business–government relationship dynamics
1. Cognition and initiation	<ul style="list-style-type: none"> MNCs – exploiting the emerging market of cloud computing in China; further expanding business; Chinese government – strategic development of emerging industry Domestic IT vendors – seizing first-mover advantage in the emerging industry 	<ul style="list-style-type: none"> Problemization by MNCs; Interessement by MNCs (to government and domestic players); Enrollment of government and business; Some inscription in the form of building cloud computing centers and development of strategic plans 	<ul style="list-style-type: none"> Scattered efforts by business and government. Educational effort by foreign business as regards the concept. Inclusion of cloud computing in strategic plan by government.
2. Infrastructure building	<ul style="list-style-type: none"> Local government – local development; political achievements; seeking support from central government Telecommunication operators – expanding existing networks; first-mover in cloud computing industry 	<ul style="list-style-type: none"> Problemization by local government; Interests translation between local government and telecommunication operators; Interests inscription in government program, IDCs, and 3CPP forum; 3CPP as the obligatory passing point 	<ul style="list-style-type: none"> Localized collaboration between government and business to build IDC. 3CPP forum was established as the collaboration point.
3. Institutionalization	<ul style="list-style-type: none"> Domestic IT vendors – establishing viable business model; revenue seeking from the cloud market Cloud users – obtaining high quality cloud-based IT service Central government – information security; stimulate and support domestic IT players; nurturing domestic players MNCs – penetrating the cloud computing market 	<ul style="list-style-type: none"> Problemization by central government; Enrollment of more domestic IT vendors and cloud clients; Re-enrollment of MNCs; Interests inscription in regulations and standardizations 	<ul style="list-style-type: none"> The business–government relationship was further enabled through 3CPP forum. Industrial-wide collaboration between business and government in regulation and standardization

facilitating the development process of the cloud computing industry by inscribing their own interests in the emerging industry (Latour, 2005). For instance, at the initiation stage, when the concept of cloud computing was first introduced in China and recognized as a future global trend, foreign MNCs acted as focal players. Based on their successful experience with cloud computing in their home markets, foreign MNCs were aware of the huge market potential of China in terms of providing cloud-based IT services. Motivated by further expansion of their businesses in China and achieving more value, these MNCs were eager to publicize cloud computing among the local parties to explore the market potential. As discussed above, MNCs had to seek collaboration with local parties to penetrate the market, given the tight regulations governing the Chinese Internet infrastructure. In this sense, MNCs' efforts in educating local parties was an attempt to enroll them into the network, by making them aware that cloud computing was the next generation of IT technology worth pursuing (Callon, 1986; Sarker et al., 2006).

The main actors in the second phase were local governments and telecommunication operators who together pushed forward the evolution by building the infrastructure for cloud computing services. From the perspective of local governments, the pressure of internal competition was high; there was constant need to fight for institutional resources and national funds with other cities, regions or areas. Furthermore, it was essential for local leaders to demonstrate what achievements had been made as part of their political performance. Hence, in the infrastructure building phase, local governments played a central role. Due to the efforts of MNCs in the first phase, many local governments have come to believe that cloud computing is the new global trend in new IT infrastructure enabling the upgrading of whole local industries. The motivations behind local governments' investment in IDCs are threefold: 1) to compete with other local regions in developing the emerging industry; 2) to be part of the strategic plan to construct high-performing infrastructure for further economic growth; 3) to improve their political records (by building something tangible). Therefore, local governments inscribed their interests in the industry development process by building IDCs, which served as the foundation for further development of the cloud computing industry (Latour, 2005).

On the other hand, public telecommunication operators in China were actively involved in the investment growth in IDCs, as they saw this as an opportunity to expand further their existing network assets. Besides cheap land and electricity supply, they could also have cloud-based e-government contracts from local governments. Similarly, the telecommunication operators inscribed their interests in the process through IDC building, but their focus was mainly on increasing their existing network and becoming fully involved in the emerging cloud computing industry by providing network and datacenter infrastructure. It is worth noting that the heavy involvement of the telecommunication operators in the cloud computing development represents one important contextual characteristic of China: the dominant position of the three telecommunication operators within the ICT industry. This can be attributed to the fact that they are state-owned and hence enjoy various policy support from the government. As a result, they control the network and datacenters (which are extremely relevant in the case of cloud computing). Such a finding accords with the study of Shen et al. (2014), who

compared the cloud ecosystem of the U.S. and China, and revealed that the U.S. market is dominated by Internet firms, whereas the Chinese market is dominated by network providers (i.e., the telecommunication operators).

The role of the Chinese central government is also evident in the evolution process of the cloud computing industry. As discussed above, though we have witnessed the liberation of the Chinese telecommunication market over the last several decades, the ICT industrial system in China is still controlled and centralized. The central government targets the strategic industries by issuing so-called “Five-Year Plans.” Cloud computing has been included in the latest “Five-Year Plan,” demonstrating support at national level. By closely analyzing the endeavors of the government, we are able to trace the underlying motivations.

First, cloud computing has been regarded by central government as one of the key technological innovations that can be exploited to make the transformation to a knowledge-based society (Zhu, 2006), which explains the policy to set cloud computing development as a strategic priority. Second, the urgent need to stimulate and facilitate internal innovations saw huge support and investment from central government to help domestic cloud firms (e.g., *Alibaba* and *China Telecom*) establish the cloud computing industry. This observation may be related to so-called “neo-techno-nationalism” strategy toward technological development (Suttmeier & Yao, 2004). Finally, information security has long been a major concern for the Chinese government, and such concern has never been more serious than today given the dispute with Western countries over cyber security (Tiezzi, 2014). Due to this, the government considers it crucial to intervene and, to a certain degree, control some applications of the cloud computing service, especially when it comes to cloud-based platforms that are developed for government activities. Such security and privacy concerns can also explain the continuous support from central government for domestic cloud vendors.

Finally, the growth of China's cloud computing industry has certain unique characteristics, compared with that in developed countries. For instance, large-scale infrastructure building happened before the establishment of viable business models. After the MIIT and NDRC released “Nationwide Pilot demonstration program for cloud computing”, nearly 30 metropolitan governments announced different investment projects in cloud computing and Internet data centers by the end of 2012. Such progression is different from the application-driven models of the foreign cloud computing industry as, for example, in the case of Amazon and Google. Furthermore, in China's infrastructure-driven model, domestic cloud providers initially hesitated to devote their efforts to the industry before the emergence of viable business models. This helps to explain why domestic cloud providers did not play a central role until the third phase. To explain such patterns, we have to take into considerations the role of two major players: foreign MNCs and Chinese government. As discussed above, China has long relied on foreign MNCs to introduce the latest technologies (Song & Wang, 2012), and it was similarly the case with cloud computing. Consequently, domestic IT vendors had to go through the learning process first, just as the other actors and the public, before any sensible business model was generated. On the other hand, due to “Telecommunications Regulations” in China, foreign MNCs were not able to establish cloud-related business by themselves, and had to rely on collaborations with local companies. This meant that developing business models to stimulate the cloud computing market was not an option at the beginning.

The “top-down” approach of ICT-related development is again evident in this case; the Chinese government issued strategic plans at the beginning to support and nurture the cloud computing industry. Local governments, in collaboration with telecommunication operators, followed such strategies by focusing on the projects that would yield tangible results – Internet data centers – due to the institutional pressure in the political environment. In other words, the actors involved in the development of the cloud computing industry went through a period of learning and exploration. This happened before the central government further established the direction of development by launching the 3CPP forum and focusing on stimulating the growth in a more structured and standardized way.

With the formation of the 3CPP forum, the Chinese cloud providers became more aggressive in service development, as they realized that the supporting specifications and regulations would lead to a mature market where customers could have more confidence in service quality and information security.

The way the cloud computing industry in China has evolved to date has been the result of various translation and inscription efforts by various actors. We did not observe a single actor continuously playing a central role in shaping the process, but rather a dynamic interaction between all the pertinent actors driving the changes. However, it should be recognized that though the interest among various actors to participate in the process varied, they were aligned or not in conflict with that of the network (Gao & Damsgaard, 2007). This helps to explain the development of the cloud computing industry to date to a certain degree. Furthermore, the changes in focal actors along the process allowed for problemization at each phase, which again can be attributed to the loosely defined interests of the network. In other words, the fact that no focal actor led the process with specific and pre-defined goals at the beginning encouraged the flexible development of the network, which is characterized by problemization and problem solving in each phase.

What we have presented here is rather different from that in previous literature where a clear artifact was identified (e.g., a certain information system) (e.g., Sarker et al., 2006; Walsham & Sahay, 1999), or the interest of the network was specified at the beginning (e.g., Gao & Damsgaard, 2007; Hanseth & Monteiro, 1997). This might be explained by the fact that: 1) we are investigating the phenomenon at a macro level and focusing on general patterns (Hanseth & Monterio, 1997); 2) the cloud computing industry in China is still emerging with evolving business models, and hence the interests at stake are not substantial at this point. Therefore, it would be interesting to observe the dynamics of the network in the future as the market grows more and more mature.

7.2. Government–business relationship dynamics

As discussed above, various actors have been playing a role in the evolution process of China's cloud computing industry, motivated by their own interests. We can divide these actors into two large categories: the business, including foreign MNCs, telecommunication operators, domestic system vendors, and cloud providers, and the government, including the central government, local governments, and other public research institutes such as CATR. The development of the cloud computing industry in China over the last several years can also be seen as a dynamic process through which the business–government relationship evolved toward close collaboration (as elaborated in the rest of the section). Such collaboration has played an important role in facilitating the maturation of the industry and the emergence of a localized ecosystem of a new ICT innovation.

During the first phase, there was common belief on the side of business and the side of government that cloud computing technology was a promising ICT innovation which would change the way IT resources are delivered. In other words, it was clear to business and government that cloud computing was a key trend in the ICT sector, setting the foundation for future partnership between both sides.

During the second phase, a significant number of investment initiatives were taken by central and local government to construct the infrastructure (in this case, Internet data centers) and also to stimulate certain cloud application. The government–business relationship was more like a directive approach with central government targeting the future goals of high-growth industry, and local governments and vendors developing localized plans according to their own needs (Gershon & Kanayama, 1995; Zhu, 2006). Though the vision regarding the potential of cloud computing was shared between government and business, the relative business model was rather unclear at that time, resulting in only vague guidelines being issued to local governments. This led to a unique aspect of cloud computing development in China: the rapid growth of cloud computing infrastructure before the maturing of business models.

Local governments were keen to deliver tangible projects to win further support from the central government (Walder, 1995), and hence chose to build data centers as deliverables. Moreover, local governments were not only directly involved in the infrastructure investments, but also provided development subsidies to boost business participation, which shaped the initial government–business partnership. The main businesses that became actively engaged in the partnership were three major telecommunication operators seeking such opportunities to leverage and exploit their network assets. At the same time, the limitations of network bandwidth for certain IDC projects were also solved. Though motivated by different interests, both parties (government and business) played important roles in the second phase and their collaboration resulted in the establishment of many IDCs, which served as the foundation for further cloud computing development. However, it should also be noted that the government–business relationship formed in the second phase was still on the project-level, instead of the system-level, meaning that the collaboration was limited to related projects and systematic efforts in driving forward the development of the cloud computing industry have not yet been seen.

The third phase witnessed a more systematic collaboration between the government side and the business side based on the 3CPP forum. Such evolution in the partnership was driven by the improved business models through which different cloud-based IT solutions could be provided to various users. From the business perspective, issues related to service quality, information security, and privacy diminish customers' confidence in cloud services, creating significant barriers to further market development. From the government perspective: first, governments are also cloud users and hence the above-mentioned issues need to be solved before widespread adoption of cloud services in the public sector; second, the central government realized that a more systematic approach was urgently needed to regulate and standardize the market and enhance the interoperability among different cloud services.

With the founding of the 3CPP forum in 2011, the government–business relationship entered a new era in which systematic collaboration is gradually established with a dialogue mechanism. On the one hand, the forum may enhance the capability of industrial bodies (the business side) to achieve consensus among more members. On the other hand, the public institutes like CATR are positioned at the center of the decision-making committees of the forum to influence the direction of the participating firms in accordance with the government's strategic goals, thus signaling its heavy involvement and control (Suttmeier & Yao, 2004; Zhu, 2006).

It is noted that foreign firms can also participate in the dialogue, but due to regulations discussed above, they have to enter into joint cooperative arrangements with Chinese domestic partners in order to penetrate the market.

7.3. The cloud computing ecosystem in China

It is rather early to speculate on the success of cloud computing in China, given its infancy. However, it is safe to say that a primitive cloud computing ecosystem has emerged. With the infrastructure building in the second phase and the certification system building in the third phase, the physical and institutional architectures for the cloud computing industry are growing more mature, setting the foundation for sustainable development and further innovation in the area.

Central to the ecosystem is the government–business partnership accompanied by the maturing cloud business model that involves collaboration between all the actors. The main vehicle of the government–business partnership is the *3CPP Forum*, which defines the responsibilities of service providers and the interests of service users. It has created a situation in which each party can benefit from such a partnership. First, the standardization and certification of cloud services at the

national level help regulate this infant market and enhance service trustworthiness (Marston et al., 2011). As a result, there is increasing adoption of cloud computing among Chinese users. Such clear guidelines regarding privacy and legal compliance for cloud vendors may assist them to cope with the challenges encountered in providing cloud services, such as the lack of transparency perceived by users. And, more importantly, the 3CPP forum helped to facilitate cooperation on the business side such as that between developers of equipment/solutions and service providers, or between service providers and service users.

On the other hand, through the 3CPP and its partnership with business, the Chinese government could mobilize foreign and domestic resources to scale local cloud computing service, and use domestic market potential as a bargaining power to achieve the strategic goal of cultivating the domestic cloud sector. In other words, by governing the 3CPP and collaborating with business, the central government is able to reinforce its technological strategy of nurturing domestic innovations (Suttmeier & Yao, 2004). Moreover, process standardization and vendor certification have stimulated public purchasing of cloud services; this benefits both central and local governments, which are themselves cloud users.

However, it must be noted that the ecosystem that has been built around the cloud computing industry involving various parties such as vendors, customers, governmental agencies, and regulators is still in its infancy. The market is still growing with the technology and associated new business model yet to be diffused more widely; the standardization efforts have just started with some initial results from the certification program. Hence, as the circumstances change, future research can study the further development of the industry with specific focus on the standardization process. Additionally, as the cloud market matures, it would be interesting to investigate the dynamics of the cloud ecosystem in China in greater detail by examining the architectural structure and governance mechanisms (Tiwana, Konsynski, & Bush, 2010).

8. Conclusion

Over the last few years, the cloud computing industry in China has evolved from just a concept initiated by few pioneering foreign companies, into a primitive ecosystem that involves a wide range of players. This is promoted by the systematic efforts directed by business participation with different levels of governmental involvement.

Our case study has revealed that the development process of China's cloud computing industry involves the co-development of physical and institutional architectures via dynamic interactions between various actors motivated by their respective interests. Such interactions serve as a systematic effort in pushing the industry forward through three distinct phases.

We have also observed, along the development process, a dynamic government–business partnership upgraded from project-level to system-level. First, the shared common vision for the cloud computing aligned the interests and incentives of both business and government sides. Then, the initial partnership scheme was shaped for infrastructure building at a lower level and across a narrower range. A more systematic approach was established around the 3CPP forum through which the interests of both sides were addressed, and, more importantly, a sustainable partnership framework was established central to the ecosystem of the cloud computing industry. Thus far, the evolution process of the cloud computing industry has demonstrated that, in a large developing country, the effective growth of an emerging ICT innovation needs a locally situated government–business partnership to explore the market demand and deal with the risks.

However, the cloud computing industry in China is still in its infancy with some important technical and institutional challenges. It will be of great interest to study the further development of the cloud computing industry, especially in light of the ever-maturing market with viable business models. Future research could also compare the cloud computing development in China with the process in developed countries, to investigate further contextual differences in the emergence of new markets and technological ecosystems.

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Appendix A

See the Tables A1 and A2.

Table A1

Public promotion programs on cloud computing.

Time	Program name	Details
Oct.2010	Chinese government announced 12th Five-Year Development Plan.	Cloud computing was highlighted as one of the key investment areas.
Oct.2010	State Council's decision on cultivating and developing strategic emerging industries.	Cloud computing was considered as an important part of China's new generation information technology industry
Oct.2010	Pilot program on cloud computing service innovation and development.	MIIT and NDRC announced five cities – Beijing, Shanghai, Shenzhen, Hangzhou, and Wuxi – for conducting cloud computing trial service.
Oct. 2011	Supporting program for cloud computing application initiated by NDRC.	Chinese government developed subsidiaries of cloud R&D for domestic technology companies including Alibaba and Baidu.
Dec.2011	The guidance on promoting development of national high technology industry.	Cloud computing service was considered as the key direction of the high technology industry.
Aug. 2012	National Broadband Strategy was announced.	Promoting the diffusion of cloud computing through enabling the broadband population in 2020.
Sept. 2012	Twelfth Five-year Special Plan for cloud computing technology development was announced.	The aim of the program was to establish technology and standard system, and promote the critical application of cloud computing.
May 2013	Trusted cloud service assessment program was launched.	The certification in the program structured the rights and duties of service providers and cloud users during the process of cloud service delivery and consumption.

Table A2

Interview protocol.

Background of the organization
Brief introduction about the company/organization.
Driving force of engagement in cloud computing.
Position and function of the organization in the cloud computing industry.
The industrial development dynamics
Initiation of the cloud computing industry in China.
Role of the government in China's cloud computing industry.
Relationship between government and business in the development of the cloud computing industry.
Dynamics of cloud computing infrastructure building.
Nurturing the business ecosystem
The role of the organization in the ecosystem evolved around the cloud computing industry
The partners/collaborators of the organization
The collaboration mechanism between the organization and its partners
The changing relationship between the organization and its ecosystem partners

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