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Standard-setting Strategy balancing between 'De Facto' and 'De Jure' in a Latecomer Country: The case of ICT industry in China

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Standard-setting Strategy balancing between 'De Facto' and 'De Jure' in a Latecomer Country: The case of ICT industry in China

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Abstract

The main objective of this study is to gain insights into the complexities of the standard-setting process involving a latecomer country. Standards are identified into two categories: market (de facto) standards arising from market interactions and formal standards (de jure) arising from mandatory specifications by public authorities. The study focused on two research questions: (i) What are the different factors that influence the outcome (success or failure) of a proposed standard by a latecomer country? (ii) How does a latecomer country navigate between de facto standard and de jure standard? It analyzed two cases (WAPI - a failure and TD-SCDMA - a success) to examine the extent of government support for a standard-setting that needs to balance between the de facto standard and de jure standard. The study found that standard competition is a complicated interplay between technology, markets, politics and institutions. The experience of two cases suggest that a proposed standard should partly be a 'de jure standard' which aims to protect national interests and achieve a national goal, and partly embody the 'de facto standard' to meet the technology trend, market demand, as well as the end users' welfare. The other factors found to influence the success or failure of a standard proposed by a latecomer country include: compatible and interoperable technology, the strength of opponents, industry alliance, and industry foundation.

The paper makes two major contributions: (i) it adds case studies from a latecomer country to the standard-setting literature; (ii) it contributes towards standard strategy plan in China as well as other latecomer developing countries.

Keywords: Standardization; Latecomer country; Latecomer catch-up; De Facto standards; De June standards; ICT Industry.

1. Introduction

The Chinese economy cannot sustain high speed development by relying on demographic advantage and resource intensive industry alone. Technology innovation is the alternative. In the recent policy statement, the Chinese government has emphasized the significance of innovation (People's Daily, 2014). Mastering and controlling technology standards are considered as commanding heights of technology innovation. Technical standards are not any more the preserve of only the developed countries. Increasingly some newly industrializing and developing countries such as Korea and China have also begun to get involved in designing of technical standards. The Korean government has been actively promoting and supporting standard-setting by synergizing research resources from the universities, public institutes, and the Korean MNCs. The standards proposed by Korea are mainly focusing on electronics, IT and telecommunications. The Korean standards are targeted at both international and domestic markets. Similar to Korea, the Chinese standard-setting is also concentrated on telecommunications, electronics and IT industries. China only started to realize the importance of standard-setting very late. China is a latecomer in the field of global standard-setting. However, in the last ten years, its involvement has been increasing. This is particularly evident in the field of ICT. Apart from the case of WAPI and TD-SCDMA covered in this study, there are other standard-setting cases from China such as the DVD.

Over the years, there have been number of studies focusing on standards (e.g. Cargill, 1989; Weiss, 1991; Greenstein, 1992 etc.). But none of these studies provide an analysis of industry standard-setting from the perspective of anticipatory standard to explore the balance of interest between de facto standard and de jure standard (i.e. standards arising from market interactions and formal standards arising from mandatory specifications by public authorities). Unlike developed countries, absence of well developed multinational corporations (MNCs) makes it more difficult for developing countries to propose an international standard. Therefore the proposed standard must receive sufficient support from the government. However an excessive government support may harm the development of the industry. Therefore this paper selected two representative cases (WAPI - a failure and TD-SCDMA - a success) to examine the extent of government support towards a standard-setting that needs to balance between the de facto standard and de jure standard. These two cases are the most important standard cases in the ICT industry in China and they were proposed in the 1990s before the last century. The two standards involved similar stakeholders including industry alliance, domestic company led innovation and government support. But at the end while one failed and the other was a success story. Therefore, it will be interesting to analyze what proved the difference between the two making one a failure and the other a success.

Standards are identified into two categories: market (de facto) standards arising from market interactions and formal standards (de jure) arising from mandatory specifications by public authorities. The study focused on two research questions: 1. What are the different factors that influence the outcome (success or failure) of a proposed standard by a latecomer country? 2. How does a latecomer country navigate between de facto standard and de jure standard and control the balance between different vested interest groups? The main research objective is to gain insights into the complexities of the standard-setting process involving a latecomer country. This paper makes important contributions in two ways: (i) it adds to the standard-setting literature by presenting two detailed case studies from a latecomer country; (ii) it contributes towards standard strategy plan in China as well as other latecomer developing countries that are in largely similar developmental stage.

The paper is structured into eight sections: Section two reviews the literature and discusses the issues related to standardization and the concepts of de facto and de jure in standardization. Section three briefly discusses the research methodology. Next, the paper reviews the background of ICT industry in China and the attempts of standard-setting. In the following three sections, the cases of WAPI and TD-SCDMA are analysed and compared to identify what factors made one a success and the other a failure. Section seven provides overall discussions and analyses by comparing both case studies. Final section summarises the findings, draws some conclusions and presents the potential policy implications.

2. Literature review

Gerschenkron (1952) has recognized how latecomers learn from foreign technology and speed up the catch up process. Others carried this logic to explain how firms in the developing countries acquire technology and grow. Freeman (1987) and Lall (1987) established the precursor on learning from the acquisition of foreign technology with the experience of Japan and India respectively. Amsden (1989), Ernst (1990) and Kim (1997) recognized how Korean and Taiwanese firms adapted foreign technologies and used to progress in the technology ladder towards catch-up. In a recent work, Lee (2013) analyzed latecomer catch-up process pursued by South Korea and Taiwan and concluded that successful catch-up involves targeting of specific sectors based on short-cycle technologies. Hobday (1998:50) identified two major barriers to entry for latecomers: (a) technological disadvantages; and (b) market disadvantages". It is through learning from existing technologies that latecomer firms appropriate the benefits accruing to latecomers, including the potential for skipping and leaping sequential steps in the technology trajectory. Shan and Jolly (2011) examined four latecomer Telecommunication equipment manufacturers in China and concluded that the innovation capability and self-developed technologies have been the key to leading domestic firms in catching-up with the foreign MNCs. It is clear that the latecomer literature focuses on how latecomer countries catch-up in specific industrial sectors or technologies. However, there are not may studies in the literature focusing on the standard-setting by the latecomer countries from catch-up perspective.

Standardization is one of the crucial factors in the context technology development and economic development. According to Farrell and Saloner (1986) "standardization" is a coordination process resulting in the production of goods that are interchangeable or compatible. Standards in ICT industry play a central role in maintaining service quality (David and Steinmueller 1996). Network effects indicate that the utility derived by a consumer is affected by the total number of consumers subscribing to the same network. The adoption of a certain system will be partially dependent on the number of other consumers purchasing similar systems. A large installed base is associated with higher rates of adoption for a specific technology (Katz and Shapiro, 1985). It follows that the higher the switching costs, the more difficult it may be for a company to attract customers from rivals, which results in a more loyal customer base. From a path-dependency perspective, a company's ability and incentive to adopt a newer technology largely depend on its level of related experience with prior technologies (Lyytinen and Robey, 1999). Standards compatibility is vital for ICT where equipment must match the network. The highest priority of standard-setting is interoperability (Katz and Shapiro, 1985; Libowitz and Margolis, 1994). According to Tushman and Rosenkopf (1992), a standard is typically the result of a complex interplay between technological factors and user demands as well as among political, social and economic factors. Different technological designs backed by different sponsors compete for the position of dominant design in a process wherein economic, technological, and socio-political factors are intertwined. A complex system must focus on interfaces and negotiations with different users and producers of complementary products, through which it evolves from simple technological artefacts to more complex ones.

Standards may develop through market mechanisms, organizations that combine market participants, and government legislation (Greenstein, 1992). The literature also divides standard into two categories: market (de facto) standards arising from market interactions and formal standards (de jure) arising from mandatory specifications by public authorities (Farrell and Saloner, 1986). The challenge for regulator is to set standards balancing between de jure and de facto variants. In other words, in setting new standards, regulators strike a balance between official made and market driven (Joh Whasun, 2007). In the case of de facto standards, standard is adopted widely by an industry and its customers, when a critical mass likes the standard well enough to collectively use it. Firms follow the prevailing standard to avoid market penalties which may happen when an industry standard set by a dominant incumbent fails to deliver compatible products, thus being excluded from the market. A market-determined standard, by contract, may result in fragmented standards. The market decides which one of the available incompatible technologies will be adopted as a standard. There are no regulating institutional arrangements influencing the process (Eisenhardt and Schoonhoven, 1996). In order to hedge the risk of battle alone in the market, alliances composed by industrial consortia or vendors emerge to support the competition between different potential standards (Warner, 2003).

The de jure standards are set by public authorities mandatorily or imposed by law. The authorities ratify standard through official procedures and give the standard approval. The standard would require companies entering into specific markets and codifying the characteristics of new products. Political forces influence standard-setting; they are complicated and difficult to predict. The official made standards could avoid high social costs of incompatibility but it also may prove to be unreasonable owing to the vested interested of public authorities (Grindley, 1995). David and Steinmueller (1996) observed that government regulatory bodies may have an interest in standard-setting, because some government agencies hold the authority to regulate the industry’s players and they also perceive that the results of standardization activities affect important national goals such as protecting domestic employment or maintaining defence capabilities. Furthermore, government intervention also tends to accentuate identifiable “vested” interests. They pointed out that governments have incentives both to promote and to discourage the adoption of inter-operable compatibility standards in the ICT industry.

Governments mandate standards, especially when early market entry is considered an essential part of a national economic strategy (Tassey, 2000). The incentives to promote standards arise when compatible and inter-operable standards will contribute to user welfare, while having either positive or negligible adverse effects on domestic producers. When governments must weigh the promotion of inter-operable compatibility standards against the demise of a domestic producer or the compromise of other perceived national interest, common international standards or inter-operable compatibility standards are likely to be neglected. One way to preserve a domestic market position is to mandate or promote the use of compatibility standards to achieve inter-connectivity rather than inter-operability. Inter-connectivity assures that two devices may be connected through a converter or bridge that renders them mutually compatible. A government policy favouring inter-connectivity is most likely to provide more opportunities for domestic production. David and Steinmueller (1996) warned that such protection should be weighed against the possibilities of retaliation and more importantly, major consumer welfare losses arising from promoting an “inferior” standard.

Most of the time, formal standards are developed by standardization bodies, like ISO and IEEE. They can serve as a forum for discussion, development and dissemination of information about standards. Recently these organizations choose to develop anticipatory standards, which are standards developed prior to the existence of markets for compatible products (Cargill, 1989; Weiss, 1991). Examples of such standardization initiatives include Symbian 2[1] and SyncML 3[2]. Research on this hybrid model of standardization through alliances is relatively scarce (Keil 2002). These candidates are then introduced into the market that decides about their adoption thus leading to a de-facto standard. As ICT standards become far more complex and traditional industry leaders lose their historical influences (Weiss and Cargill, 1992), these organizations are involved more with anticipating technical change in standards and guiding their design (Greenstein, 1992). Anticipatory standards are characterized by guidance for future compatibility or interoperability, international and national institutional contexts, and proprietary or public domain agreements which can be influenced through institutional process (Lyytinen and King, 2006). Developing anticipatory standards in advance of the market increases market stability and benefits during the life-cycle of product (Weiss, 1993).

3. Research Methodology

The research is based on an exploratory qualitative methodological approach, as it employs a case study method which gives importance to qualitative interpretations than quantitative measurements. The data were gathered both from secondary and

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[1] Symbian was a closed-source mobile operating system (OS) and computing platform designed for smartphones and currently maintained by Accenture.

[2] SyncML (Synchronization Markup Language) is a platform-independent information synchronization standard.

primary sources. The secondary data were collected from archives including government documents, regulations, media reports, company statements and research publications. It is essential to select appropriate interviewees and secure reliable information sources. The selection of interviewees relied on the researchers' expertise in the field of telecommunications. Primary data were collected through semi structured interviews of important persons involved in both of the cases (Eisenhardt, 1989; Glaser and Strauss, 1967; Strauss and Corbin 2008; Yin, 1989).

In each interview, we prepared a concise key research question based on the interviewee's expertize and background. Then more sub-questions were developed one tier at a time and the selected theories also guided every question raised to the interviewees. Full and accurate notes were recorded since tape recording was not allowed by the interviewees. Then we skipped those non-relevant discussions from the large quantity of interview information, and outlined the answers to our research questions. To make sure that we get what we expected from the interviews, for each interview the research question was referred back to and an answer to each question extracted based on the interview contents. Then the information of the interviews was integrated and reflected in different parts of our analysis. Through these interviews and discussions, a first-hand industry development was elaborated and a deep industry insights were developed.

The interviews are based on a PhD research and other related projects. Most of the interviews were taken in coffee room of those companies/organization, or in a light working lunch. Some discussions were happened during conferences and seminars. The interviewees were from different areas of the telecom industry along with the industry chain. It is very critical to select appropriate interviewees in order to ensure reliable sources. The interviews varied from one hour to two hours. The selection criteria for the interviewees were relevant industry experience; continual contribution to ongoing projects in their field; ability to provide industry insights. In the Table 1, listed all the interviews related to this project. There are only 3 discussed about WAPI and most of them discussed about TD-SCDMA. Since WAPI was not successful, engineers and researchers are no longer in this field, interviewees can only recall the story of WAPI by their memories. However TD-SDMA is still an on-going standardization in China, we can find a number of experts to decode the history.

Table 1: the list of interviewees:

Company	*Name*	*Position*
Datang	Mr. Li J	Engineer
Eastcom	Mr. Zhao S	Senior Manager
Huawei	Mr. Chu Q	VP
Huawei	Mr. Lu X	R&D
Local S&T Bureau	Mr. Bo J	Director
Motorola	Mrs. Ren Q	Manager
Motorola	Mr. Xu Z	Engineer
Nokia	Mr. Shen Z	Regional GM
University	Dr. Yin X	Professor
University	Dr. Gao X	Professor
ZTE	Mrs. Ni L	Assistant to VP
ZTE	Mr. Shu H	Manager

Source: Compiled by authors

The contribution made by these interviews with people involved in different areas of the telecommunications industry has played a significant part in the overall study. The authors interviewed three officials in three different cities in Beijing and Shanghai, 18 industry professionals, five Chinese academics, three members of staff of industrial organizations and several ad hoc interviewees (for example during breaks at conferences) in Beijing, Shanghai and Hangzhou. The interviews (not including ad hoc interviews) varied from one hour to three hours in different locations including company offices, coffee bars or interviewee's home. The interviews were conducted in a semi-organized way. The selection criteria for interviewees were as follows: 1) Relevant industry experience; 2) Continual contribution to ongoing projects in their field; 3) Ability to provide industry insights.

4. ICT industry in China - Background

Historically, the Chinese industries have been suffering from small number of patents and lack of core technologies, which resulted in high dependency on foreign technology and low margin in production. For example, before the year 2000, the Chinese Digital Versatile Disc (DVD) manufactures paid RMB 3 billion as patent fee to the foreign companies every year, which was higher than the total annual profit of the top ten Chinese DVD manufactures. Intel used its monopoly market position to earn RMB 5.7 billion income, which was higher than the total profit of the top ten Chinese IT companies. Microsoft earned over RMB 2 billion license fee in the Chinese market, which was also higher than the total annual income of the top ten

Chinese software companies. Among the 16,000 international standards, 99.8% were proposed by foreign companies. The Chinese companies only participated in less than 0.2% (Pan and Fu, 2004). The international production networks employed technical standards which were set by foreign MNCs. Usually, the Chinese manufacturers imported key parts of the software and hardware from developed countries to be used for production by the local Chinese labour force. The Chinese manufactures had to pay patent fees for each mobile terminal they produced, which was about 8 to 15% of the sales price for each terminal. The more they sold, the more they had to pay in patent fee.

The Chinese industries have also suffered from mandatory standard in exporting. The China made products were required to be sent to designated certification organizations and these products were not allowed to be exported if they failed these certifications. Thus, standard admittance became a legal trade barrier. For the importing countries, the purpose of the standard admittance is to prevent foreign made products from entering into domestic market, thereby protecting the interests of local producers. Since 2002, more than 70% Chinese manufactures encountered various technology barriers. For example in 2003, EU implemented two directives on Waste Electronic and Electric Equipment and Restriction of Hazardous Substance. This increased the cost of Chinese exported color TV by 10 to 15 US$. After 2004, the barriers became more wide-ranging and more particular. In 2004, the green barrier alone affected the Chinese exported products to the tune of US$ 7 billion (Pan and Fu, 2004).

Therefore, the Chinese government became concerned about the excessive dependence on foreign technology and standards. In addition, there were increasing concerns about the distribution of benefits within the international division of labour, the relative gains flowing towards the standard setters in international production networks (Suttmeier and Xiangkui, 2004). These concerns drove China to seek its own standards in order to reduce its dependence on foreign technology and standards and also further facilitate the development of its national innovation system to a higher level. After the year 2000, China got more and more involved in the international standard setting arena. For example, in 2004, China created a standard called Enhanced Versatile Disc (EVD) to compete with the foreign standard DVD. In the following year, China published the Intelligent Grouping and Resource Sharing standard to compete with the overseas standards developed by the Digital Home Working Group (DHWG). China has worked on its own Audio and Video Coding Standard (AVS) to compete with the international Moving Pictures Expert Group (MPEG) standard. In the computer science area, China has developed its Linux-based office applications to substitute the use of Microsoft system in government. In ICT area, there were two main initiatives. One was WAPI for wireless communication, and another was TD-SCDMA for 3G telecommunications. The two initiatives were the most significant developments in the industry. That is why they were selected as the cases for this research. The following sections analyses how these two standards were developed and why one failed and the other succeeded.

5. The background and birth of WAPI

After entering into the World Trade Organization (WTO), the Chinese import tariff could no longer support the emerging domestic hi-tech industries. The Chinese government attempted to find new measures that could be more effective in supporting domestic firms while also complying with the provisions of WTO. Building a series of standardization systems became imperative for China to sustain an innovative economy. Since the year 2000, the Chinese wireless network market increased dramatically. The continuous technology innovation and diversity of application provided a solid market foundation for WLAN industry chain[3]. The Asia-Pacific market has become the second largest Wireless-Fidelity (Wi-Fi) market by 2003, and the value of the Chinese market reached RMB 600 million and it was the fastest growing market in the world (Pan and Fu, 2004). However, the Chinese WLAN industry chain had not yet been established and the upper level of the industry chain of WLAN was controlled by the foreign companies.

Compared to the wired network, WLAN has become the main trend in application of network transmission due to no restriction on cable and space, just like mobile phone compared to fixed line. In general, WLAN standards had inadequacies in confidentiality, identity, data integrity and privacy. Data transmitted through wireless network was vulnerable to interception or can be changed by other unauthorized parties. It was a very risky to transmit national or business confidential information. In addition, due to lack of a protective barrier, network hackers and virus could easily attack the network and can cause its collapse. The frequency of attacks on WLAN would be far greater than the existing wired network. Because of security concerns, WLAN was not used in the 2004 Athens games (Pan and Fu, 2004). Safety concern created a bottleneck restricting further development of WLAN. Hence, solving the security problem of WLAN became the industry consensus then. It was not rare to solve such bottleneck through formulation of national or industry standards.

As early as 2000, the European Telecommunications Standards Institute (ETSI) started working on the development of the Hiper LAN standard. From 2003, 126 Japanese companies including NEC started working on developing more secure WLAN Japan standard (Pan and Fu, 2004). In October 2002, the Wi-Fi Alliance announced Wi-Fi Protected Access (WPA) as an interim response to the security protocol of Institute of Electrical and Electronics Engineers (IEEE) 802.11i. (Lee and Oh, 2006). It was well known that Wi-Fi had security holes (Cam-Winget et

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[3] WLAN means wireless local area networks. Both WAPI and WIFI are two of the standardizations of WLAN.

al., 2003; Housley and Arbaugh, 2003). The Wi-Fi alliance tried all means to overcome security difficulties, but because the solution proposed was too cumbersome, slow, complex, expensive, and suffered from poor confidentiality and operability, the solution did not win recognition by the industry as whole. Therefore, it was supposed to be a good opportunity to propose WAPI standard. It would guarantee national security demands and it would constitute legal barriers externally. Most importantly, China could set up WAPI as a standard for domestic market and speed up its own WLAN industry chain under the umbrella of this standard. In August 2001, after the Ministry of Information Industry (MII) issued the task to draft the national standard of WLAN, Xidian Jietong[4] initiated the Chinese broadband wireless IP standard working group and completed the drafting of the standard in three months. It was formally promulgated in 2003 May, called as GB15629.11. It was the only accepted protocol in this area proposed by China. The standard contained a new WAPI security mechanism, WLAN authentication and privacy infrastructure. The relevant departments declared WAPI as the mandatory national standard with effect from 1st December 2003 and the implementation deadline was set as 1st June 2004 (Pan and Fu, 2004).

That meant that WLAN products without this mandatory certification could not be manufactured, imported and sold. The news immediately caused a great disturbance in the industry. Especially those companies who mastered core technologies of WLAN protested strongly. They pointed out that the WAPI protocol was formulated by the Chinese government in order to protect the domestic high-tech enterprises. At that time, the 802.11 Wi-Fi standard, developed by IEEE, was the internationally and commonly used security protocol for wireless equipment. WAPI was not compatible with chips based on Wi-Fi (Fordahl, 2004).

Mandatory compliance with the WAPI standard was required for both domestically produced and imported wireless devices and equipment (Suttmeier and Yao, 2004). Foreign chipmakers were required to pay a per-chip royalty for WAPI if they wanted to market their products in China. Intel openly criticized WAPI and declared that it would not accept China's June 1st deadline for adhering to WAPI (Flynn, 2004). If WAPI had been enforced, all Intel's Centrino notebooks could not be sold in China. Therefore, Intel has strongly opposed this plan. "After a considerable amount of analysis we have decided not to support WAPI or produce any product that supports WAPI. We have concerns about its deployment and performance and the quality of user experience." (Li, 2005). Intel also pointed out that WAPI was more than a generation behind current technologies (Foremski, 2004). Thus, WAPI plan was strongly resisted by Wi-Fi interest groups, and they pressed the Chinese government through their dominant market power.

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[4] A Chinese company established in 2000, focusing on internet security development. More information please refer to the homepage www.iwncomm.cn

On 2nd March 2004, Colin Powell (the then US Secretary of State) sent a letter to the two Chinese Vice Premiers Wu Yi and Zeng Peiyan criticizing the technology and demanding the abandonment of WAPI plan. He argued that the WAPI implementation would be contrary to the principle of bilateral trade relations and contravene China's WTO commitments. On April 22nd of 2004, the Chairman of the IEEE 802 Local and Metropolitan Area Networks Standards Committee wrote a letter to the SAC and the Ministry of Information and Industry, stating that the compulsory WAPI standard in China would divide the global WLAN market into two parts and diminish the scope of consumer choices, as well as increase the production costs of WLAN goods (Lee and Oh, 2008). It would also prevent the business development of IEEE802.11 based WLAN products in Chinese market (Li 2005). Under these pressures, after the 15th meeting of Sino US Joint Commission on Commerce and Trade in April 2004, the Chinese government announced that the date of standards enforcement would be postponed indefinitely.

Li Shihe (2005) claimed that the Chinese proposal was treated unfairly in the application process of international standard. The Chinese standard was proposed in July 2004, but it was announced as unilateral by JTC1 secretary in 2004 August. In November 2004, the US embassy in Beijing refused to issue visas to all the Chinese technical experts for SC6 Orlando meeting, and it resulted in the delay of the proceeding. On 21st February 2005, the Chinese delegation attended ISO/IEC JTC1 SC6 WG1 special working meeting held by International Organization for Standardization (ISO) in Frankfurt. The main purpose of the meeting was to discuss the two competing proposals of ISO/IEC 8802.11 security supplement. The Chinese WAPI standard adopted JTC 1N7506 proposal, and Wi-Fi used 802.11i of IEEE, the JTC 1N7537 proposal. The Frankfurt meeting overturned the resolution of the Orlando meeting. It also decided that "1N7506 does not exist", "the meeting shall not discuss 1N7506". The Frankfurt meeting suggested that "the Chinese delegation should re-submit international proposal", "Chinese national group shall join the IEEE operation". These suggestions were strongly opposed by the Chinese delegation (Li, 2005). On 13th March 2006, ISO overwhelmingly rejected the proposal for WAPI to become an international standard, and IEEE802.1li naturally became the international standard (Zheng et al., 2006).

But this failure was not an accident. Although WAPI working group claimed that IEEE802.11i had hidden weaknesses, WAPI standard also had its own serious drawbacks. Since 802.11 series of Wi-Fi posed safety concerns, WAPI and 802.11i were originally presented as the updated version of ISO/IEC8802-11 standard, which are designed to protect the information security. In other words, the Chinese WAPI technology and IEEE802.11i technology were safety supplement proposals of the WLAN technology at that time, and that meant that WAPI was not an independent technology on its own right. In addition, WAPI standard was not compatible with 802.11i standard which was a fatal flaw of WAPI. Finally, the development of WAPI was a closed process, and the algorithm was not open. These technology constraints of WAPI resulted in failure to gather support from the voting members of ISO (Yi, 2006).

Before the final vote in the ISO on 9th January 2006 initiated by the government, "WAPI industry alliance" included the four telecom operators who had the capabilities to implement the standard in the market. Although the four operators' participation in the "WAPI industry alliance" appeared to be strong, they did not give genuine support to the alliance. For them, only 3G was of key interest. They were not sure of the necessity or relevance of WAPI after the launching of 3G. Furthermore, although equipment producers repeatedly claimed that they made huge investment in R&D, there was not a single successful commercial product in the market with client experience. There was no market promotion of WAPI. On the contrary, Centrino product represented Wi-Fi technology and performed very well in the market (Yi, 2006).

6. The background and birth of TD-SCDMA

The background of the design of TD-SCDMA is similar to that of WAPI. After China introduced the first mobile telephone system in 1987 and opened the GSM system in 1994, the number of mobile subscribers has leaped massively every year. From 1987 to 1993 the annual growth rate of subscribers was about 200%. By August 2001, the subscribers of mobile communication in China reached 120 million and overtook the US as the number one mobile market in the world (Beijing Chenbao, 2004).That made it possible for the Chinese market on its own to sustain an independently developed technology. On the other hand, for a long while, China's participation in the global economy was characterized by low–tech, which was due to the constraints faced by its industry and the international production networks established by foreign MNCs. In the international production hierarchy, the Chinese manufacturing industry was at the low-end. The Chinese manufacturers could only share limited profit margin of the fast-developing market. Both during the time of 1G and 2G, almost all the networks and equipment were provided by the foreign MNCs. The Chinese government decided to change this situation and improve the domestic manufacturers' position in the global network through the independently developed technology TD-SCDMA.

In order to support the domestic firms to develop internal capability with technology advantages, from the mid-1990s, the Chinese government started coordinating the development of the next generation of mobile technologies as part of a national plan (Zhang, 2008; Marukawa, 2010). At that time, the smart antenna was a very advanced technology in terms of subscriber capacity, coverage distance, and cost savings. Chinese engineers developed another core technology called uplink synchronization, and the resulting technology was named SCDMA (later referred to as Synchronous CDMA) (Lu 2006). The technology was recommended to the Ministry of Post and Telecommunications (MPT), and MPT decided to develop the application of SCDMA technology in China. Thus, in 1995, a Joint Venture was established to focus on the development of smart antennas and synchronous up linking of SCDMA wireless access to the core technology system (Zheng and Tao 2006). Then, SCDMA project was granted funding of RMB 15 million under the “9th Five-Year” research programs. The SCDMA thus became the prototype of TD-SCDMA (Lu 2005).

In April 1997, the International Telecommunications Union (ITU) called for 3G standard applications and the Chinese government started considering whether to promote SCDMA to the international standard. But the government was hesitant to join the application process due to short time frame and lack of experience (Lu 2006). The deadline for application was 30th June 1998 and the application needs to meet the basic requirements of International Mobile Telecom System-2000 (IMT-2000) standard and follow the Radio Transmission Technology (RTT) IMT-2000 timetable and steps. But eventually, the government decided to join the application process and set up a task group. In the end of July 1997, the 3G wireless technology assessment coordination team was officially registered by ITU and the Chinese wireless communications experts became part of them. Different factions from Europe, Japan, and the US working in the coordination team started courting the Chinese delegation considering the huge market in China. Each rival faction tried to co-opt China. This situation convinced China that it can develop its own standard-setting strategy (Lu 2006 and Dong, Zhang and Duan, 2006).

In July 1997, MPT formed the 3G Transmission Technology Assessment and Coordination Group (TTACG) and its preliminary task was to develop one of the important parts in 3G standards: signal transmission solution. After evaluating and comparing the technologies from Ericsson, Nokia and Siemens, the technology from Siemens was selected. Siemens has been developing the TD duplex signal transmission method, but it failed to proceed to a 3G standard proposal. This enabled to forge cooperation between the Chinese 3G developer and Siemens (Marukawa, 2010; Tsai and Wang, 2011; Yan, 2007).

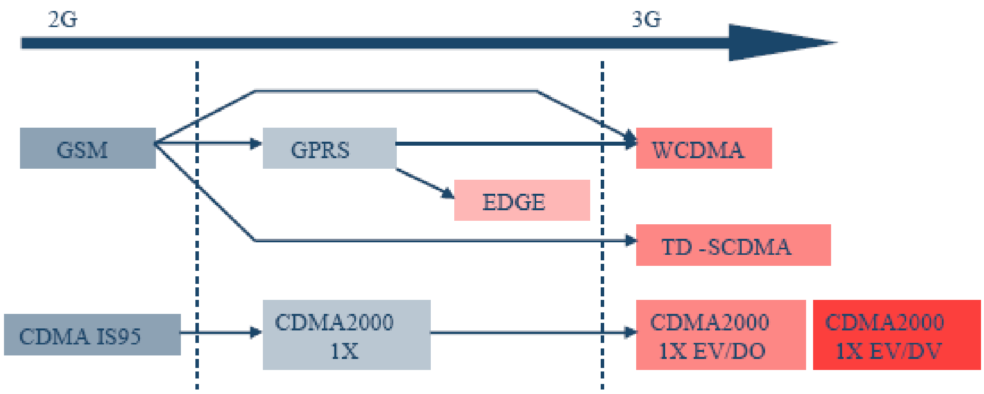
On 30th June 1998, on behalf of China, Datang submitted TD-SCDMA to the ITU. ITU-R received 16 3G standard proposals from the US, China, Japan, South Korea and some European countries. WCDMA and CDMA2000 were the main competitors. The European Telecommunications Standards Institute Special Mobile Unit (ETSI SMG) adopted WCDMA proposal as standard in January 1998. Behind CDMA2000 stood a number of leading companies including Qualcomm, SKT and other Korean companies (Lu, 2005)

However the gap between TD-SCDMA and other two competitors was considerable. The other two competitors had been developed over a long period and the technologies were more matured (Tang 2009). There were more than 100 companies with over 10,000 researchers conducting R&D for WCDMA, and some producers invested more than US$ 1 billion. In comparison, TD-SCDMA only involved about hundreds of researchers, and R&D investment was in the range of RMB 2 million annually (Tang 2009). It was clear that TD-SCDMA was not mature as it was only being developed by the Chinese engineers for few years, and it was still less stable and less reliable. The two other competing standards have relied on the global 2G network, which offered advantages in network effect compared to TD-SCDMA. On the other hand, the tough competition between WCDMA and CDMA2000 led to a rivalry between the two and opened up a window of opportunity for the third party, TD-SCDMA.

Technically, there were two advantages of TD-SCDMA. The first was the advantage of higher frequency spectrum utilization. TD-SCDMA only occupies one 1.6MHZ bandwidth, which means that the system capacity is several times larger than the other two. The Time Division Duplex (TDD) model only needs a single channel for bi-directional communication. A higher efficiency of frequency spectrum utilization means lower cost for users and operators. In addition, this technology is particularly efficient in high subscriber density areas. Second, the most important feature is that TD-SCDMA has been designed to provide compatibility with GSM and WCDMA core networks (Li et al., 2005).

Because of the technical advantages offered by TD-SCDMA, MII took a tough stand from the start. It declared: "Even foreign forces tried to block the Chinese standards to be adopted, the Chinese market has sufficient market to support their own standards, we are fully capable to develop and operate TD-SCDMA in China". Considering the importance of the Chinese market and the positive features TD-SCDMA, the large telecommunications manufacturers did not take more radical opposition stand. In May 2000, it was finally approved as one of the standards (Zheng and Tao 2006). In the end, there were three 3G standards implemented in China: TD-SCDMA, WCDMA, and CDMA2000.

Figure 1 illustrates the evolution of TD-SCDMA. Table 1 presents the chronology of WAPI and TD-SCDMA and Table 2 provides a comparison between WAPI and TD-SCDMA.



Source: China Electronics, 2008.

Figure 1: The Evolution of TD-SCDMA

Table 2: The Chronology of WAPI and TD-SCDMA

Year	WAPI	TD-SCDMA
1998	***TD-SCDMA***: Under direct instruction by the MII, China Academy of Telecommunication Technology (CATT) drafted TD-SCDMA proposal which was conformed to IMT-2000, based on SCDMA technology. It was submitted to ITU on 30th June and became the 15th candidate of IMT-2000.	
1999	***TD-SCDMA***: In November, the 18th meeting of ITU-TG8/1 in Helsinki, ITU reviewed all the evaluation results.	
2000	***TD-SCDMA***: In May, ITU-R meeting in Istanbul, TD-SCDMA was accepted as one of the CDMATDD designs.	
	TD-SCDMA: Datang Group presented the TD-SCDMA technology on behalf of the Chinese government. It was accepted as one of the 3G standardizations. This was the significant breakthrough in the Chinese telecom history.	
	TD-SCDMA: On 12th December, TD-SCDMA technology forum was established.	
2001	***WAPI***: On 1st August, after the Ministry of Information Industry issued the task to draft the national standard of WLAN, Xidian Jietong initiated the Chinese broadband wireless IP standard working group and completed the drafting of the standard in three months.	***TD-SCDMA***: On 16th March, TD-SCDMA was accepted by 3GPP (3G's partner project).
2002	***TD-SCDMA***: In January, committee was established in Shanghai jointly by Nokia, TI, LG, Petvio, DBtel and CATT. FTMS made the first dual direction MOC voice call.	
	TD-SCDMA: On 23rd October, MII allocated spectrum 155MHz （1880-1920MHz, 2010-2025MHz and 2300-2400MHz）	
	TD-SCDMA: On 30th October, TD-SCDMA industry alliance was established. Datang, Huawei, Holley, Lenovo, ZTE, Zhong CECT and Petvio became the first group members, and signed "Agreement of Initiator" to collectively promote TD-SCDMA enterprise for China. This response from industry was a significant breakthrough in the process of industrialization.	
	TD-SCDMA: In November Datang Mobile, Philips Semiconductor and Samsung signed an agreement to set up a joint venture. UT Star signed agreement with Datang Mobile in Beijing to jointly develop TD-SCDMA equipment.	
2003	***WAPI***: On 1st May, the Standardization of China (SAC) announced the promulgation of WAPI.	
	WAPI: On 23rd November, SAC announced that the implementation of WAPI standards would be effective from 1st December.	
	WAPI: In December, the US Embassy in China expressed their concern to the Chinese government and proposed bilateral discussion on this issue.	
	WAPI: In December, the Chairman of the IEEE 802 Local and Metropolitan Area Networks Standards Committee wrote a letter to the Chinese government.	
2004	***WAPI***: In January, the Chairman of the Wi-Fi Alliance announced that if the WAPI issue could not be resolved by 1st June 2004, the Wi-Fi Alliance might consider restricting the Wi-Fi products that could be exported to China.	
	WAPI: In January, Broadcom, the world's largest wireless network chips manufacturer expressed discontent over WAPI.	
	WAPI: In February, Texas Instruments announced that it would support WAPI, followed by some other chip makers.	
	WAPI: In February, Taiwan manufactures declared their support to WAPI.	
	WAPI: On 19th February, it was reported that the US was not planning to take the case to the WTO at this stage.	

	WAPI: On 21st February, European Information and Communication Technology Association requested the European Community to take measures against WAPI.	
	WAPI: On 24th February, some of the US stakeholders planned to put pressure on the US government to take a tougher stand against China.	
	WAPI: On 2nd March, Colin Powell (the then US Secretary of State) sent a letter to the Chinese Vice Premier Wu Yi and Zeng Peiyan.	
	WAPI: On 10th March, Intel strongly criticized WAPI for its poor functionality	
	WAPI: Intel also announced that it had decided not to support WAPI or the related manufacturing of product using the WAPI standard because it had a number of concerns including its interoperability, performance, deployment and application support.	
	WAPI: On 17th March, the US put more pressure on China and declared that the Chinese government's initiative was intended to favor domestic manufactures which would adversely impact on US manufacturers' fair competition in the Chinese market. Therefore it will consider taking action according to the WTO regulations.	
	WAPI: On 29th April, the Chinese government announced standards enforcement date was postponed indefinitely.	
	WAPI: It was reported that negotiation was restarted to make WAPI compatible with existing 802.11x protocols.	
	WAPI: In November, the US embassy in Beijing refused to issue visas to the Chinese technical experts for SC6 Orlando meeting, and it again led to the delay of the proposal.	
	WAPI: In December, WAPI was listed as a formal proposal along with IEEE802.11i proposal at the 2004 annual meeting of ISO.	
2005	***WAPI***: In February, in the Frankfurt meeting, the Chinese delegation walked away from the ISO meeting, by claiming unfair treatment.	***TD-SCDMA***: 16th April 2005, another seven companies joined the alliance: UTstar, Bell Alcatel, Zhongyou, Shanghai DBTEL, Okwap, TYCC and ZCXC. The alliance had 21 members, including system vendors Datang, ZTE, chip manufactures like Spreadtrum, Commit, and terminal producers such as Lenovo, and DBTEL. The alliance also obtained cash support from MNCs like Motorola, Siemens, Samsung, Philips, Nokia, Texas Instruments and others.
2006	***WAPI***: In March, ISO overwhelmingly rejected the WAPI proposal to become an international standard and IEEE802.1li naturally became the international standard.	
2007	***TD-SCDMA***: In March, the TD-SCDMA network technology application tests have been carried out in a wider scope. TD-SCDMA trial networks were planned to be deployed in 10 major cities.	
	TD-SCDMA: In November, the Long Term Evolution, Time-Division Duplex (LTE TDD) fusion technology program was signed by 27 companies in 3GPP RAN151 meeting, and its frame structure was identified based on the frame structure of TD-SCDMA. It opened the door for TD-SCDMA to evolve towards TD-Long Term Evolution (TD-LTE) and 4G mainstream standards.	

Source: Compiled by authors

Table 3: A Comparison between WAPI and TD-SCDMA

Items	**WAPI**	**TD-SCDMA**
Background	Fastest development and large potential market (increasing growth of over 75% in 2003)	Rapid development and the largest potential market (growth of 200% from 1987 to 1993)
	Largely relied on MNCs such as Intel and Microsoft; an MNCs dominated product chain	Highly dependent on imported foreign equipment in 1G and 2G technologies
	Wi-Fi's bottleneck in security design	Low level of the technology in global production network
Purpose	To build an independent WAPI industry chain; to decrease the dependency on foreign standards; to avoid trade barriers.	To improve the domestic manufacturers' position in the international production network, to decrease the dependency on MNCs technologies through the development TD-SCDMA products.
Technology basis	In 2001 August, China initiated the development and completed the drafting of the standard in 3 months.	In mid-1990s (couple of years before the standard application) the Chinese government started to coordinate development of the technology through its research agency.
Government support	WAPI was declared as the mandatory national standard with effect from 1st December 2003 and the implementation deadline was set as 1st June 2004.	TD-SCDMA was submitted to the competition for international standard, but not announced as mandatory national standard. Strong support from the government was granted after the success of standard application, during the industrialization - commercialization of this technology.
Internal factors	Industry alliance was initiated by the government few months before the final vote. Although the four operators-industry alliance appeared strong, the firms did not give genuine support.	Industry alliance was established after the success of standard application.
	The government provided strong support from the start and took a lead role.	In the early stage, the government was hesitant to go ahead with the application due to lack of experience. Only a few months before the deadline, it decided to continue the application.
International cooperation	It was a closed development process and it lacked from compatibility with other	Siemens' TD duplex signal transmission method was selected as part of the Chinese 3G technology, as it failed to

	technologies.	continue as standard proposal and it was available. It was compatible with GSM and WCDMA core networks
International competition	The mandatory standard immediately caused a great disturbance in the industry.	In the11th international assessment team in July 1997, different coordination teams sponsoring different technologies courted China's opinion.
	Intel and Broadcom openly opposed WAPI. Texas Instruments and some Taiwan companies expressed support.	In the initial 3G R&D Team, Siemens was one of the three key members of research force together with CATT and Xinwei.
Political pressures	The US and European governments and associations exerted pressure on Chinese government to drop WAPI. US refused visa for Chinese experts to attend SC6 Orlando meeting.	
Technology characteristics	WAPI was a supplement proposal of WLAN technology and not independent technology on its own right. It was not compatible with 802.11i. WAPI's process and its algorithm was not open to foreign companies.	Independent technology on its own right; High efficiency of frequent usage; Compatibility between TD-SCDMA and other technologies
Competition	An overwhelming competition from Intel/Wi-Fi forum	Two strong competitors; Network effect and install base.

Source: Compiled by authors

7. Analysis of WAPI and TD-SCDMA: Factors behind Success or Failure

7.1 External factors

In the standard-setting process, the influence of political forces is inevitable and the involvement of political forces makes the structure of standard-setting more complicated and unpredictable. In the case of WAPI and TD-SCDMA, both of them gained strong government supports. Comparatively, the government support to WAPI was stronger than that to TD-SCDMA. Few months after the promulgation of WAPI, it was declared as a mandatory national standard by the government and it also set a deadline for implementation. However the over-bearing government support to WAPI provoked serious opposition from the foreign MNCs. The strategy of protecting the domestic industry even at the cost of damaging the support from most of the foreign industrial partners appeared to be unwise and unworkable. The challenge for the government was to navigate between de facto and de jure standard-setting and finally find a balance for safeguarding the interests for all or most of stakeholders. In other words, there needs a degree of government support for the ultimate goal of protecting the domestic industry, but at the same time the government should also consider the interests of other groups such as foreign companies in order to avoid large scale opposition which would make its effort to fail or counterproductive.

The government support to TD-SCDMA was not that stable or strong as in the case of WAPI. In the beginning, the technology was criticized heavily internally with insufficient confidence which created serious controversy. So, the government support to TD-SCDMA was indecisive, conservative and low-key. The application for standard was submitted only at the last minutes of the deadline. Gao (2014) even pointed out that the government support to TD-SCDMA was inadequate as they "say one thing and do another". Unlike the WAPI, the TD-SCDMA was not set as a mandatory standard in China, and government did not set a deadline for its implementation. As a result, this standard was proposed to co-exist with other foreign standards in China. In the commercialization process, the Chinese government gave strong support including spectrum allocation and policy preferences. These measures were taken after considering the long-term impact, and not taken from short-term perspective as in the case of WAPI.

The government support for standard setting could be seen as a contest between different vested interest groups. In fact, the anticipatory standard could be understood as a basically-qualified de facto standard which would be implemented by a de jure standard. In the two cases of this research, both standards could be understood as anticipatory standards, and the anticipatory standard is unlike to be successful if it leans too close towards "de jure" side while diverging to far from "de facto" side. This highlights the challenge for regulators as to how to navigate and strike a balance between the de facto and de jure standards. In the both cases in our study, the Chinese government tried to find a balance between these two poles. With respect to TD-SCDMA standard, the government considered more de facto factors, including market acceptance, install base, network effect, switching cost, consumer welfare and so on. In the case of WAPI, the government considered more de jure stakeholders, including the national goal, the protection of domestic industry interest, and the development of the domestic industry. In the case of TD-SCDMA standard, the government was finally able to strike a greater balance between the de facto and de jure because of the nature of technology base, compatibility with different technologies and cooperation from foreign MNCs.

Compatibility is the most important factor in standard-setting. However, government may end up promoting the adoption of either a compatible standard or incompatible standard after considering various factors and interests comprehensively. To promote an incompatible standard is contrary to the criteria or priorities of standard-setting.

This strategy may intend to promote a national goal and promote domestic industry, which may appear to be reasonable. But if it is too farfetched and forced on the industry and market, it may affect end users' welfare and could become counter-productive.

TD-SCDMA was proposed in 1998 and it became an international standard after two years. Eventually it co-existed with other two strong competitors. In contrast, WAPI experienced more frustrations along the way. It was developed in 2001 and proposed in 2003, revoked from international standard proposal in 2005. In 2006 the balloting was launched again but it ended in a failure. WAPI's rival was only IEEE802.11i Wi-Fi alliance led by Intel. The success of TD-SCDMA was partly attributed to the tough rivalry between the two strong competitors, WCDMA and CDMA2000. The intense rivalry between the two strong competitors gave TD-SDMA a window of opportunity. When the two main competitors were heavily preoccupied by each other, they appeared to have ignored the emerging of TD-SCDMA. When they realized the existence of TD-SCDMA as third player, both decided to co-opt it rather than oppose it totally. This created unique advantage for TD-SCDMA. The divergence between the US and Europe as well as the underestimation of the Chinese proposal inadvertently gave TD-SCDMA an advantage. In contrast, in the case of WAPI, the strong Intel and its Wi-Fi alliance was the only opponent, and Intel had enough time to confront and oppose WAPI strongly. WAPI appeared to be particularly weak in front of this strong alliance.

TD-SCDMA alliance was not established until it was accepted as an international standard. The alliance was developed and improved from few founding members like Datang and Huawei to a number of members including a number of domestic and international companies. TD-SCDMA industry alliance contributed a lot during the industrialization - commercialization process, from chipset to terminals to make it a successful standard. In contrast, the WAPI alliance was established before the final vote to accept the standard, at an earlier stage than that of TD-SCDMA. Although the alliance consisted of key mobile operators, these operators did not give wholehearted support to the alliance to make WAPI a success. The foreign companies were excluded because of the incompatibility of WAPI technology. In addition, the Wi-Fi camp opposing WAPI formed a powerful industry alliance with the companies covering the whole industry chain. Kwak et al., (2012) pointed out that once a technology becomes a standard, it will inevitably influence every part in the industry chain. The role of industry alliance in supporting a standard is critical in its success. From the comparison of the two cases, the research finds out that the industry alliance has its unique significance in the standard-setting process. But, the alliance should not be a simple collection of companies. The members of the alliance should share some common goals and interests, so that they can play constructive and proactive role towards promoting the proposed standard.

7.2 Internal factors

The reasons for the failure of WAPI appeared to be complicated. But one of the major reasons was the inherent flaw in the technology. Compatibility and interoperability are essential for successful implementation of standards, since different technologies should work with each other within a network. Compatibility and interoperability can contribute towards users' welfare, because they ensure full value of installed base and reduce the risk of switching cost. As the development WAPI was a closed procedure and it used three months to complete the preliminary design, it caused speculations about the reliability of the technology. WAPI was promulgated as the national mandatory standard while the algorithm of this technology was closed to the foreign companies. This also exacerbated the reliability of this technology. Furthermore, as WAPI was a safety supplement technology proposal, it was criticized as a non-independent technology with limited novelty.

The most fatal flaws in WAPI were incompatibility and in-operability. Because of the closed nature of its algorithm, WAPI had no interaction with the large product market of WALN. In fact, at that time Intel controlled a large market of WALN through its Centrino products. Therefore, the decision to introduce WAPI as mandatory standard by the government was a non-starter and was like a suicide. It appears that China took this 'doomed to failure' decision because it overlooked the importance of openness, incompatibility and in-operability of the technology and was just motivated overwhelmingly by its drive to protect domestic industry and ignored users' welfare. Furthermore, China chose an 'inferior standard' which was flawed and not totally an independent technology to win general acceptance. The need for a balanced decision was compromised due to perceived national interest. The need to develop a common international standard with compatibility and inter-operability was neglected in this case. It is understandable that for a government it is difficult to make a decision to choose a standard that may pose a challenge to the development of the domestic industry. In order to preserve the domestic industry another choice would have been to realize mutual compatibility through inter-connected device, but WAPI did not realize inter-connection. Without a solid and feasible technology to support, the goal of promoting domestic industry through of standard-setting is unlikely to succeed.

The technology of TD-SCDMA was based on MNCs' patent and the Chinese companies only held about 7% of the patent (Yan, 2007). It had two bright spots. The most crucial advantage was its compatibility. The deployment of GSM and CDMA already formed an install base as the available resource. Because of its compatibility, the switching cost of TD-SCDMA from GSM or CDMA market was not expensive. The second advantage was the high efficiency of frequency usage, which was an important advantage in telecom standard. Frequency is not a sustainable natural resource and the future technology must increase the efficiency of frequency to a higher and higher level. The TD-SCDMA met this requirement. In addition, it had no serious weakness that could be criticized by foreign competitors. The technology had its unique novelty and innovativeness. In addition, from the market point of view, the opportunity of TD-SCDMA was better than that of WAPI. The

GSM had fully opened the Chinese market and established distinct advantage in terms of install base and network effect. When WAPI was proposed, WALN's market had not been matured and therefore its install base was not as powerful as that of GSM.

The deficiency of WAPI technology was partly attributed to its closed development procedure. WAPI was solely developed by one Chinese company within a short time. Even in the later stage of technology development, the developer of WAPI still showed an insular attitude to foreign cooperation. Internationally, only few Taiwanese companies and Intel's rival TI expressed support to WAPI. In contrast, the development of TD-SCDMA technology was accumulated through a considerable time. During the development, the deficiency of TD-SCDMA was realized and cooperation with Siemens was initiated to address this and find a complementary solution. Eventually, TD-SCDMA emerged as a successful technology as the result of deep cooperation between Siemens and the Chinese companies. Furthermore, Siemens also offered strong support to TD-SCDMA in the later application process, and forged a common interest alliance. The two cases, WAPI and TD-SCDMA, demonstrated that in the standard-setting world a closed technology will failed to gain support in the industry value chain, while open and collaborative technology is likely to win broad support in the industry.

The backgrounds of the two standards were similar: China was experiencing fast development, but also struggled to cope with and overcome the constraints imposed by the low technology. The lack of core advanced technology and independent IPR constrained further development of the Chinese companies. They could only follow the foreign standards and endure the Chinese market being dominated by the foreign companies. The Chinese government attempted to change the status of technical standards to help the Chinese companies to hold more initiatives both in the domestic and foreign markets. In the Chinese market, the mobile industry developed more rapidly than IT industry. The Chinese consumers also rely on mobile phone more than computers. The Chinese market has already emerged as the number one mobile market by 2001. Since 1990s, the flourishing mobile market also spawned a number of telecommunications companies including Huawei and ZTE. Gradually, these companies have established their presence in the domestic market and gained international reputation. The accumulation of technological capabilities by Huawei and ZTE formed the foundation of the Chinese telecom industry chain. This was one of the reasons that the later-established TD-SCDMA alliance was credible and solid. In contrast, the industry base of WAPI was weak as the WAPI market was not as matured as that of mobile at that time. Second, the leading Chinese companies in WLAN such as Lenovo were not strong enough to compete with foreign companies. This made WAPI's developer fight on alone and lost. Therefore, the reason for WAPI's closed development procedure might be attributable to the weak foundation of the industry chain. The weak industry foundation in turn made the companies in the industry chain not competitive enough to support the industry alliance. The result was that the alliance indeed existed only in name without real strength or cohesion.

8. Conclusions

The main objective of this study is to gain insights into the complexities of the standard-setting process involving a latecomer country. It focused on following two research questions: (i) what are the different factors that influence the outcome (success or failure) of a proposed standard by a latecomer country; (ii) how does a latecomer country navigates between de facto standard and de jure standard and control the balance between different vested interest groups. It analyzed two cases: WAPI (Failure) and TD-SCDMA (Success). The study found that similar to the Korean standard-setting experience, the Chinese standard-setting is also organized by the government initiatives, integrating the best resources in the domestic industry chain. However, the Chinese standard mainly focuses on the Chinese market. It is clear that for latecomer countries, a strong government support is vital to propose a new standard. Usually developing countries have fewer MNCs to compete with the MNCs from developed countries. Under this condition, the government is the real coordinator-in-general in the standard-setting practice. However, the cases of WAPI and TD-SCDMA demonstrated that it is unwise for a government to act with undue haste. They showed that an incompatible technology and mandatory standard may not offer new opportunity for the domestic industries, and instead may eventually provoke a strong opposition from its opponents. Such outcome is contrary to the original aim of standard-setting which is to promote the domestic industry and build a complete industry chain. To avoid such negative outcome, the latecomer countries must master the 'extent' to which government should support standard-setting. How to control the 'extent' of support by the government for a standard and how to find a balance between de jure standard and de facto standard in the design of anticipatory standard are critical in standard-setting. The findings from the two cases suggest that it should partly be a 'de jure standard' which aims to protect national interests and achieve a national goal, and also partly try to embody the 'de facto standard' to meet the technology trend, market demand, as well as the end users' welfare.

A market-determined or de-facto standard might result in fragmented standards, which would help catch up standard-setting strategy. As highlighted by the case studies, various factors in 'de facto' standards including install base, network effect and others have to be considered. There are different ways to solve these concerns including compatibility, inter-operability, and inter-connections. An incompatible technology standard proposed by a developing country is very difficult to succeed in market competition. So, for developing countries, the ambition to challenge international standard has to be realistic. The gradual process and co-existence in harmony are more suitable for developing countries' standard-setting strategy.

The other factors that play an important role in standard-setting include the strength of opponents, industry alliance, and industry foundation. They can influence the success or failure of a standard-setting by a developing country. The emphasis of the discussion in this paper is about government support and technology accumulation. For a latecomer catch-up country in standard-setting, the element of opponent is out of its control and the policy options are limited. The decision makers could only either avoid or challenge a strong competitor. For industry alliance, it is not only important to bring together big names in the industry value chain, it is vital to find common interest and common pursuit for these companies to make the alliance inherently strong and 'winnable' in a real sense. It is understandable that developing countries eager to launch their own standards to overcome the dependence on foreign technology. However, strong or weak foundation of the domestic industry determines the technology starting point in a standard-setting process. The proposal of technology standard should be based on a solid industry foundation and technology itself should be persuasive so that its commercialization in the later stage could be feasible. Another important factor is openness. Even though there is technological distance between developed and developing countries, a developing country can propose a technology standard and make it a success if it follows a 'openness' policy. If the catch-up country manages standard behind closed doors, the technology cannot gain essential improvement and cannot get support from voting members in standard organization. There, openness is an important factor determining success or failure when a catch up country design a standard-setting strategy.

Finally, the standard competition is far fiercer than the competition between different technologies in the market place. It is a complicated interplay between technology, markets, politics and institutions. It is a contest between national powers and national interests and it is raised to the level of national competition eventually. As discussed earlier in this paper, diplomatic correspondences between the leaders of different countries and China during the WAPI standard proposal demonstrate that standard-setting is part of international political affair affecting the whole country. Although standard-setting remains complex and unpredictable, it is likely more and more developing countries will get involved in standard-setting affairs in the future. The current world economic structure is undergoing profound changes. Many African countries are growing fast and BRICS countries are sharing the global economy with an increasing weight and ambition to catch up with advanced countries. However, for developing countries, considering their weak industry foundation, it will be futile to propose a standard which attempts only to preserve its own industry's interests and needs, and has no compatibility, inter-operability or inter-connection with other technologies. Therefore, it is imperative that when a latecomer country is implementing the interest of de jure standard, the elements of de facto must be considered and a balance between the two must be struck judiciously.

Although there are still few cases of developing countries participating in standard-setting, globalization trend is likely to bring more and more developing countries entering standard-setting and challenge the standard-setting order set by the developed countries. The experiences of these two standard-setting forerunners discussed in this paper will be particularly valuable for other latecomer countries.

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Abbreviations

1G, 2G and 3G: the First Generation, the Second Generation and the Third Generation of mobile communications
3GPP: 3G's partner project
CATT: China Academy of Telecommunication Technology
CDMA2000: Code Division Multiple Access
DHWG: Digital Home Working Group
DVD: Digital Versatile Disc
ETSI SMG: European Telecommunications Standards Institute Special Mobile Unit
ETSI: European Telecommunications Standards Institute
EVD: Enhanced Versatile Disc
GSM: 2G standardization, Global System of Mobile
ICT: Information and Communications Technology
IEEE: Institute of Electrical and Electronics Engineers
IMT-2000: International Mobile Telecom System-2000
ISO: International Organization for Standards
ITU: International Telecommunications Union
LTE TDD: Long Term Evolution, Time-Division Duplex
LTE TDD: Long Term Evolution, Time-Division Duplex
MII: The Chinese Ministry of Information Industry
MNC: Multinational Companies
MPEG: Moving Pictures Expert Group
MPT: The Chinese Ministry of Post and Telecommunications
RTT: Radio Transmission Technology
SAC: Standardization of China
SCDMA: Synchronous CDMA
TDD: Time Division Duplex
TD-LTE: TD-Long Term Evolution
TD-SCDMA: Time Division-Synchronous Code Division Multiple Access
TTACG: Transmission Technology Assessment and Coordination Group
WAPI: Wireless LAN Authentication and Privacy Infrastructure
WCDMA: Wideband Code Division Synchronous Address
Wi-Fi: Wireless-Fidelity
WLAN: Wireless Local Area Networks
WPA: Wi-Fi protected Access
AVS (Audio and Video Coding Standard)
Centrino: Intel's product
Datang: Chinese telecommunications company; the major developer of TD-SCDMA
Huawei: Leading Chinese telecommunications company for infrastructure and handset equipment, ranked No.2 in the world by 2013
ZTE: Leading Chinese telecommunications company for infrastructure and handset equipment, ranked No.4 in the world by 2013