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Balancing Between 'De Facto' and 'De Jure' in Standard-setting Strategy by 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 analysed 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 judiciously combine partly a 'de jure standard' which aims to protect national interests and achieve a national goal, and partly the 'de facto standard' to meet the technology trend, market demand, as well as the end users' welfare.
Keywords: Standardization, Latecomer country, Latecomer catch-up, De Facto standards, De June standards, ICT Industry

1. Introduction

Increasingly, 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 multinational corporations (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 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. 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. Both involved similar stakeholders including industry alliance, domestic company led innovation and government support. But at the end while one failed and the other emerged as a success story. Therefore, it will be interesting to analyze what proved the difference between these two cases.

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 in depth case studies from a latecomer country; (ii) it contributes towards standard setting strategy in China as well as other latecomer developing countries that are at relatively similar developmental stage.

The paper is structured into eight sections: Section two presents the literature review. Section three discusses the research methodology. Section four outlines the background of ICT industry in China. In the next 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 the 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) 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 leap frogging 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 factors 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 many 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 of 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 total number of consumers subscribing to the same network affects the utility derived by a consumer. 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.

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 driven 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.

Generally, standardization bodies, like ISO and IEEE, develop formal standards. They serve as a forum for discussion, development and dissemination of information about standards. Increasingly, 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 a product (Weiss, 1993).

Kwak et al. (2011) used five case studies of ICT industry from China and South Korea to understand the standardization process of the latecomer countries. They revealed that coordination with foreign players is more important than coordination with domestic players to determine the path of standardization. Therefore, Government role is crucial to mitigate international conflicts in the process of standard setting. WAPI as a standard of mobile industry in China failed to make it as an international standard setting as China has not disclosed WAPI security algorithm to the international community (Lee and Oh, 2006).

Studies related to standard setting mostly used the secondary sources to know the process of standard setting. This study uses interviews of relevant personals to understand the process of standardization in depth and will add rich empirical insights to the growing standard setting literature.

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 (Strauss and Corbin 2008; Yin, 1989). The data were gathered both from secondary and primary sources. The secondary data were collected from archives including government documents, regulations, media reports, company statements and research publications. Primary data were collected through semi-structured interviews of important persons involved in both cases. The interviewees included 3 officials, 18 industry professionals, 5 academic experts, 3 members of staff of industrial organizations and several ad hoc interviewees (for example at conferences). The list of selected interviewees is provided in Appendix I (excluding those who wanted anonymity). The selection criteria for interviewees were as follows: 1) Relevant industry experience; 2) Continual contribution to on going projects in their field; 3) Ability to provide industry insights. The interviews were conducted mainly in Beijing, Shanghai and Hangzhou. The duration varied from one hour to three hours.

Since WAPI was not successful, engineers and researchers originally involved are no longer in this field,

[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.

and interviewees can only recall the events related to WAPI from their memories. As TD-SDMA is still an on-going standardization in China, we could find a number of experts to decode the history.

As no prior institutional ethics committee approval was required for the project, general data protection and confidentiality guidelines were followed[1.] There was no written consent required to participate in this study, as the respondents were not keen on formal written consent and preferred informal voice consent. Moreover, written consent would be too formal and the respondents felt constrained from sharing information freely. Participants consent was registered using voice recorder when a respondent did not insist on anonymity, and by manual recording when the respondent insisted on anonymity. There was no need to obtain prior ethics approval for this procedure, as only general data protection and confidentiality guidelines were to be followed.

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. About 99.8% of over 16,000 international standards were proposed by foreign companies. The Chinese companies only participated in less than 0.2% of these standards (Fang, 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 locally. 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. As the industry grew rapidly, the firms sold more which meant they had to pay more in patent fee. Mr. Chu from Huawei commented: "The Chinese ICT industry experienced the most rapid development than other industries. One of the reasons is the short life cycle of ICT technology. Emerging companies have more opportunity to catch up. Another drive is the huge domestic market."

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$. After 2004, the barriers became more wide-ranging. In 2004, the green barrier alone affected the Chinese exported products to the tune of US$ 7 billion (Fang, 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.

Particularly in the ICT industry the perception is: "third class companies are doing product, second class companies doing technology, first class companies doing brand, and the top class companies doing standard"[2]. Therefore, since 2000, China made increasing effort in the international standard setting arena. In 2004, China created a standard called Enhanced Versatile Disc (EVD) to compete with the foreign standard DVD. In 2005, 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, it developed Linux-based office applications to substitute the 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.

The following sections analyses how these two standards were developed and why one failed and the other

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[1] Yan Hui, the principal researcher, conducted all the actual interviewees in China. She was part of the Aalborg University, Denmark, when the first phase of the research was completed. Subsequently, she moved to the Shanghai University, China, and completed the final phase of the research. There was no requirement to obtain prior approval from ethics committee in both universities, especially in this area of research.

[2] According to Mr. Li, a former R&D manager from Datang.

succeeded.

5. The Case of WAPI

After joining the World Trade Organization (WTO), the Chinese import tariff could no longer support the emerging domestic hi-tech industries. The 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 2001, the Chinese wireless network market increased dramatically. The continuous technology innovation and diversity of application provided a solid market foundation for WLAN industry chain[1.] The Asia-Pacific market has become the second largest Wireless-Fidelity (Wi-Fi) market by 2003, and the value of the Chinese market reached USD 600 million it was the fastest growing market in the world (Fang, Pan and Fu, 2004). However, the Chinese WLAN industry chain was yet to be established and the foreign companies controlled the upper industry chain of WLAN.

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 (Fang, 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 (Fang, 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 al., 2003; Housley and Arbaugh, 2003). The Wi-Fi alliance tried all means to overcome security deficiencies, 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. 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[2] initiated the Chinese broadband wireless IP standard working group and completed the drafting of the standard in three months. It was formally promulgated in May 2003, 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 (Fang, Pan and Fu, 2004).

That meant the WLAN products without this mandatory certification could not be manufactured, imported and sold. This measure immediately caused great disturbance in the industry. Especially those companies who mastered core technologies of WLAN protested strongly. They pointed out that the Chinese government formulated the WAPI protocol 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 1st June 2004 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 and declared: "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

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

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

they put pressure on the Chinese government through their dominant market power.

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. He argued that the WAPI implementation would be contrary to the principle of bilateral trade relations and it contravenes China's WTO commitments. On 22nd April 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, 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. The Chinese standard was proposed in July 2004, but it was announced as unilateral by JTC1 secretary in August 2004. In November 2004, the US embassy in Beijing refused to issue visas to the Chinese technical experts for SC6 Orlando meeting, which delayed 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 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 and decided that "1N7506 does not exist", "the meeting shall not discuss 1N7506". It 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 were 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 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 led to failure to gather support from the voting members of ISO (Yi, 2006).

Before the final vote in the ISO on 9th January 2006 the government took initiative to form the "WAPI industry alliance" that included four telecom operators who had the capabilities to implement the standard in the market. Although their participation 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 Case 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 leap frogged. From 1987 to 1993 the annual growth rate of subscribers was about 200%. By August 2001, the subscribers of mobile communication reached 120 million and overtook the US as the number one mobile market in the world (Beijing Chenbao, 2004).This made it possible for the Chinese market on its own to sustain an independently developed technology. On the other hand, 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 it was required to meet 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 July 1997, the 3G wireless technology assessment coordination team was officially registered by ITU, which included Chinese wireless communications experts. Different factions from Europe, Japan, and the US working in the coordination team started courting the Chinese delegation because of China's huge market. 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).

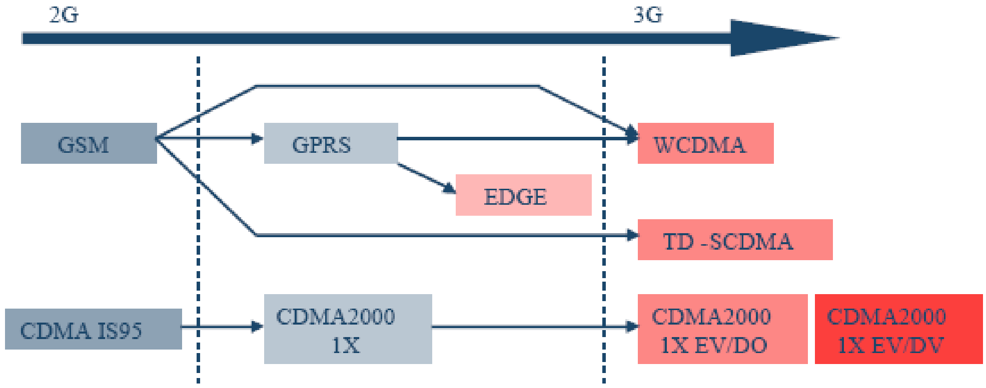
On 30th June 1998, on behalf of China, Datang submitted TD-SCDMA to the ITU. ITU-R received 16 3G standard proposals from the US, China, Japan, South Korea and some European countries. WCDMA and CDMA2000 were the main competitors. The European Telecommunications Standards Institute Special Mobile Unit (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)

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 and it was still less stable and less reliable, as it was under development for just few years. 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 an aggressive stand from the start and declared: "Even if foreign forces tried to block the Chinese standards… 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 a 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 1. The Chronology of WAPI and TD-SCDMA

<table>
<tr><th>Year</th><th>WAPI</th><th>TD-SCDMA</th></tr>
<tr><td>1998</td><td colspan="2">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.</td></tr>
<tr><td>1999</td><td colspan="2">TD-SCDMA: In November, the 18th meeting of ITU-TG8/1 in Helsinki, ITU reviewed all the evaluation results.</td></tr>
<tr><td>2000</td><td colspan="2">TD-SCDMA: In May, ITU-R meeting in Istanbul, TD-SCDMA was accepted as one of the CDMATDD designs.</td></tr>
<tr><td></td><td colspan="2">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></tr>
<tr><td></td><td colspan="2">TD-SCDMA: On 12th December, TD-SCDMA technology forum was established.</td></tr>
<tr><td>2001</td><td>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><td>TD-SCDMA: On 16th March, TD-SCDMA was accepted by 3GPP (3G's partner project).</td></tr>
<tr><td>2002</td><td colspan="2">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></tr>
<tr><td></td><td colspan="2">TD-SCDMA: On 23rd October, MII allocated spectrum 155MHz（1880-1920MHz, 2010-2025MHz and 2300-2400MHz）</td></tr>
<tr><td></td><td colspan="2">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></tr>
<tr><td></td><td colspan="2">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.</td></tr>
<tr><td>2003</td><td colspan="2">WAPI: On 1st May, the Standardization of China (SAC) announced the promulgation of WAPI.</td></tr>
<tr><td></td><td colspan="2">WAPI: On 23rd November, SAC announced that the implementation of WAPI standards would be effective from 1st December.</td></tr>
<tr><td></td><td colspan="2">WAPI: In December, the US Embassy in China expressed their concern to the Chinese government and proposed bilateral discussion on this issue.</td></tr>
<tr><td></td><td colspan="2">WAPI: In December, the Chairman of the IEEE 802 Local and Metropolitan Area Networks Standards Committee wrote a letter to the Chinese government.</td></tr>
<tr><td>2004</td><td colspan="2">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</td></tr>
</table>

Year	WAPI	TD-SCDMA
	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 2. 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 provide 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 technologies.	Siemens' TD duplex signal transmission method was selected as part of the Chinese 3G technology, as it failed to 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	Independent technology on its own right; High efficiency of frequent usage; Compatibility between TD-SCDMA and other technologies

Items	WAPI	TD-SCDMA
	and its algorithm was not open to foreign companies.	
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. Although both WAPI and TD-SCDMA gained strong government support, the support to WAPI was stronger than that to TD-SCDMA[1]. But the results were different. 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 the foreign industrial partners appeared to be unwise and unworkable. The challenge for the government was to navigate between the de facto and the de jure standard setting and finally find a balance for safeguarding the interests of 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 indecisive, conservative and low-key and not that strong compared to WAPI, as the technology was criticized heavily in the beginning, which created serious controversy. Gao (2014) even pointed out that the government support to TD-SCDMA was inadequate as they "say one thing and do another". According to Prof Gao, an expert of telecom industry: "In fact, to obtain government support was an arduous task. In addition, the government's support was unstable. Then the attitude has fundamentally changed after lobbying by a group from academic society." The application for standard was submitted only at the last minutes before the deadline.

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, TD-SCDMA 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. Both WAPI and TD-SCDMA are anticipatory standards. The anticipatory standard is unlikely to succeed if it leans too close towards "de jure" while diverging to far from "de facto". This highlights the challenge for regulators as to how to navigate and strike a balance between the de facto and de jure standards. In both cases, 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, unlike the case of WAPI. "The problem was that after WAPI was declared, there was nobody using it even though it was the mandatory standard. It had no foundation. It existed in name only. Soon it was forgotten".[2]

Compatibility is the most important factor in standard setting. However, it is likely that the government may end up promoting the adoption of either a compatible standard or incompatible standard on the basis various factors and interests. To promote an incompatible standard is contrary to the criteria or priorities of standard setting. The strategy may be to promote a national goal and promote domestic industry, which may appear 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. According to Mr Shen, the former regional manager of Nokia: "Without the compatibility, WAPI looked very powerful superficially. It was indeed very weak as there was no current product as potential client. It was not a wise standard."

TD-SCDMA was proposed in 1998 and it became an international standard after two years. Eventually it

[1] According to Mr. Zhao, a senior sales executive for more than 20 years.
[2] According to an Anonymous interviewee

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, but was 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 can be 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. The two main competitors were heavily preoccupied by each other and appeared to have ignored the potential competition from TD-SCDMA. When they realized the emergence 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, Intel and its Wi-Fi alliance was the only opponent, and Intel had enough time to confront and oppose WAPI strongly.

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 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. 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. Also, they 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 took 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. One of the university experts commented: "If you check web forum about telecom technologies, you can find that most people at the time were not optimistic about WAPI."

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 growth 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 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 installed 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 enable increasing 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 installed base and network effect. When WAPI was proposed, WALN's market had not been matured and therefore its installed base was not as powerful as that of GSM. As a telecom operator, Mr. Zhu understood these advantages and opined: "As an operator, we need to choose a technology that can earn money. These two advantages give TD lots of competitiveness. Operators can save cost and increase profit."

The main deficiency of WAPI technology was its closed development procedure. One Chinese company within a short time solely developed WAPI. Even during the later stage, 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 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 this deep cooperation between Siemens and the Chinese companies. Furthermore, Siemens offered strong support to TD-SCDMA in the later application stage, and helped to forge a common interest alliance. WAPI and TD-SCDMA cases demonstrated that in the standard-setting world a closed technology will fail to gain support, while open and collaborative technology is likely to win broad support.

Although the overall backgrounds of the two standards were similar, there were significant difference in their industrial foundation which led to either success or failure. 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 this through technical standards to help the Chinese companies to hold more initiatives both in the domestic and foreign markets. However, the mobile industry developed more rapidly than the IT industry, as the Chinese consumers use mobile phones more than computers. The Chinese market has 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 became 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 a lone battle and it lost. Therefore, the reason for WAPI's closed development procedure might be attributable to the weak foundation of the industry chain. This 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.

Despite the fact that WAPI failed while TD-SCDMA succeeded, the message was clear: China, a late comer in technology standard setting has emerged as a power to be reckoned with. In the words of Mr. Chu: "No matter WAPI or TD, these Chinese standards signaled the coming trend. But the success or failure depends on the micro factors of the specific industry sector."

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 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 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 judiciously combine partly a 'de jure standard' which aims to protect national interests and achieve a national goal, and also partly 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 installed 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 are 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 an '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. Therefore, 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 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. 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 dominated 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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