

Understanding key features of the TD-SCDMA adoption process in China

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ABSTRACT: With China Mobile's official adoption of the TD-SCDMA standard in January 2009, it's argued that this standard will play an important role in the 3G mobile telecommunications in China, and likely in the world. However, the development of the TD-SCDMA standard in China has been extremely difficult. In this paper we try to understand this complicated process of technology standard adoption.

1 Introduction

The successful development and adoption of a communications technology standard is of critical importance for a firm's performance and even a country's economic development (Funk, 1998; Funk & Methe, 2001). The proposing of TD-SCDMA in 1998 to the ITU by the China Wireless Telecommunication Standard Group (CWTS) as a candidate for 3G mobile communications and its acceptance as one of the three international standards by ITU in May 2000 and 3GPP in March 2001, offers a rare opportunity for Datang to be an important firm in the telecom equipment industry, and for China to become a leader from a follower in this industry.

However, it takes more than 10 years for China Mobile to officially adopt TD-SCDMA. Why this adoption process takes so long a time? This is a question not easy to answer given Datang has all the incentives to promote TD-SCDMA, and many people argue that the Chinese government is willing to support indigenous technological innovation (Lee and Oh, 2006; Chen, Fan, and Lu, 2002). In this paper I try to develop a preliminary understanding about this puzzle. More specifically, I aim to develop some understanding about the following two questions: (1) why it is so difficult to adopt TD-SCDMA; and (2) why TD-SCDMA is finally adopted?

The rich literature on technology standard setting offers important guidance for studying the two questions. For example, it's helpful to examine the roles played by key firms such as dominant sellers or buyers in the market, inter-firm consortia, professional organizations such as ITU and IEEE, or the government; it's also important to look at the timing of setting a standard, the openness of a standard, and the prices of the products supporting the standard (Funk, 1998; Funk & Methe; Greenstein, 1992).

However, it's not appropriate to fully rely on the existing literature to find answers to the two questions this paper is trying to address, because the adoption process of the TD-SCDMA standard has its unique features as I'll discuss in the following. Because of the uniqueness of the TD-SCDMA case and the exploratory nature of this paper, I use a case study method (Yin, 1989) and focus on identifying the key factors driving the behavior of the key players related to the adoption of the TD-SCDMA standard.

The findings of this paper provide new insights into the analysis of the roles played by different players in the process of technology standard adoption in China. For example, 30 years' reform and development in China has resulted in diverse understandings about the appropriate approaches of economic development and enterprise management. This implies that it is not easy for the government to coordinate a lot of firms with different interest and mandate a technology standard such as TD-SCDMA, even if the government wants to take this responsibility. However, the central government is still very powerful, and government policy, especially the policy of promoting indigenous innovation, is the dominant factor contributing to the adoption of the TD-SCDMA standard. The findings of this paper also suggest that informal decision making system could play a crucial role in helping the government make informed decisions such as supporting the TD-SCDMA standard.

The paper is organized as follows: I first review the literature on technology standard setting, especially telecommunications standard setting. After explaining the research methodology and the data collection process, I report the preliminary answers to the two questions this paper is trying to analyze. I will conclude by discussing the contributions and limitations of the paper, and directions for further research.

2. The literature

The existing literature has identified a lot of factors affecting the setting and diffusion of technology standards. For example, the number of firms in a market influences the

arising of a standard in that market (Greenstein, 1992). When there are many buyers and many sellers, there exists “coordination problems” and too few standards emerge, or these standards emerge too late (Farrell and Saloner, 1986). In this situation, there exists the effect of “bandwagons” and early adopters play important and disproportionate roles (David, 1987; Farrell and Saloner, 1985). The developing and diffusion process of the TD-SCDMA standard is different. It’s accepted by ITU and 3GPP, not emerged in a market with a lot of players supporting their own standards. Of course, ITU and 3GPP have no legal authority to enforce a technology standard, and it’s necessary for Datang, the key developer of this standard, or other organizations such as the government, to attract other companies to support this standard.

Technology standards can also be sponsored by dominant buyers or sellers (Greenstein, 1992). Microsoft, Intel, and Cisco are some examples (Gawer & Cusumano, 2002). Qualcomm is also a well-known example in the telecom industry (Mock, 2005). The developing and diffusion process of the TD-SCDMA standard is also different. Datang, the key developer of this standard, does not have as strong influence as the key sponsors of WCDMA and CDMA2000. In fact, Datang faces a lot of “latecomer disadvantages” (Gao, et al, 2007).

Although there exists a lot of debates, telecommunications standards could also be set by the governments and be very successful. The strong competitiveness of EU firms in GSM illustrates the importance of government support, and the relative weak

position of CDMA indicates the impact of free market based standard setting approach (Funk, 1998; Funk and Methe, 2001). The international success of South Korea companies in CDMA also shows the importance of government support (Jho, 2007).

The role played by the Chinese government in the process of developing and diffusing the TD-SCDMA standard is mixed as I will analyze in the following. This is one of the key reasons leading to the slow adoption of the TD-SCDMA standard. Then the question is why the Chinese government has inconsistent policies?

The literature also finds that many factors and players simultaneously influence the setting and diffusion of technology standards (Fuentelsaz, Maicas, and Polo, 2008; Jho, 2007; Tushman and Rosenkopf, 1992; Utterback, 1994). For example, Tushman and colleagues point out that dominant designs (standards) for simple products mainly emerge based on technical factors, and dominant designs of complex products and systems emerge based on not only technical factors but also social, political and cultural factors.

In this paper I find that the adoption of the TD-SCDMA standard is also influenced by many factors and players simultaneously. In the following I'll analyze these factors and players in detail.

3. Research methodology and data collection

Case study method

The adoption process of the TD-SCDMA standard has its unique features. For example, contrasting to the other two 3G mobile communications standards, namely, WCDMA and CDMA2000, the development of many of the key technologies supporting the TD-SCDMA standard started after, not before TD-SCDMA was accepted as a 3G mobile communications standard. This also means that the TD-SCDMA standard became mature relatively late than the other two 3G mobile communications standards. It's also true that the key developer of the TD-SCDMA, namely Datang (more accurately, Datang Mobile, a subsidiary of Datang), is a small firm compared with the key supporters of WCDMA and CDMA2000. The uniqueness of the adoption process of the TD-SCDMA standard indicates that a case study method is appropriate (Yin, 1989).

Data collection

I collected the data for case analysis through comprehensive reviewing the publicly available materials such as published papers and newspaper articles, and interviewing people familiar with the development of the TD-SCDMA standard, with doing interview as the key method. People interviewed are from many organizations and government agencies, including key equipment firms such as Datang, ZTE, Huawei, and Potevio; Handset makers such as Lenovo, Hisense, TCL, and ZTE; IC suppliers

such as T3G, Spreadtrum Communications, CYIT; service providers such as China Mobile, China Telecom, and China Unicom; multinational firms such as SKT, Ericsson, Qualcomm, LG, and Samsung; TD-SCDMA Alliance, TD-SCDMA Forum; government agencies such as the Ministry of Industry and Information Technology (MIIT), the Ministry of Science and Technology (MOST), and the National Development and Reform Commission (NDRC). I also interviewed noted telecom technology experts such as Dr. Li, Shihe, Professor Li, Jinliang, Dr. Li, Xiaoming, et al. More than 60 people are interviewed.

4. Understanding the delay in adopting TD-SCDMA

The data indicate that the delay in adopting TD-SCDMA has both direct reasons and indirect reasons. The direct reasons include a lot of ambiguities of support from the players along the TD-SCDMA value chain. The indirect reasons include a lot of uncertainties in technology, market, policy, and the complexities in managing the transformation from 2G to 3G. In the following I first discuss the various ambiguities, followed by the analysis of the uncertainties and complexities.

4.1 Direct reasons for the delay: Ambiguities of value chain support

The literature has found that support from firms along the whole value chain is important for the development of a technology standard. However, the reality is that this kind of support includes a lot of ambiguities, and many firms had been taking a wait-and-see attitude before China Mobile's official adoption of the TD-SCDMA

standard in January 2009.

4.1.1 The service providers

The data suggest that the telecom service providers were very active in supporting TD-SCDMA to become accepted by ITU and 3GPP as an international 3G mobile communications standard, partially asked by the government. However, the attitudes of these firms changed a lot after TD-SCDMA was accepted as an international standard, especially after the trials of TD-SCDMA in 2005 and 2006 were successful, and one or more service providers had to be chosen to adopt this standard.

For example, among the 6 telecom service providers before the restructuring in 2008, namely, China Mobile, China Telecom, China Unicom, China Netcom, China Tietong, China Satcom, only two firms, China Tietong and China Netcom once showed interest in adopting the TD-SCDMA standard. One reason for the active support of the TD-SCDMA standard by China Tietong and China Netcom is that the two firms were not in the mobile communications business and they were trying to enter this business.

In fact, even China Mobile, which officially adopted the TD-SCDMA standard in January 2009, had been very reluctant to choose this standard, although Ms Li, Mofang, the former chief engineer of China Mobile, once said that China Mobile might use both TD-SCDMA and WCDMA as these two systems could complement each other. However, the dominant opinion of China Mobile had been that it would be

a better choice to adopt WCDMA because it would be easier for China Mobile to evolve from its GSM/GPRS system to WCDMA, and the WCDMA value chain is more mature.

4.1.2 The equipment makers

Compared with other firms along the value chain, the equipment makers are much more active in supporting the TD-SCDMA standard. One reason is that Datang, the key sponsor of the TD-SCDMA standard, shared its knowledge and technology with these firms, and made it easier for them to start their R&D activities on TD-SCDMA. The second reason is that these firms are at the upstream of the value chain and realized earlier than downstream firms that the TD-SCDMA standard is an advanced standard. The third reason is that some of these firms, especially ZTE and Huawei, have very strong technological capabilities and it is not very difficult for them to leverage their technical knowledge in WCDMA and CDMA to support TD-SCDMA.

However, the active support is relative to other firms along the value chain. The data indicate that the support from the equipment makers in the early days of the development of the TD-SCDMA standard was weak. The input was limited and technology and product development was slow.

4.1.3 The handset firms

Domestic handset makers are clear about the opportunities offered by the TD-SCDMA standard. For example, in interviewing one very famous domestic

company, a senior manager pointed out that they are able to produce as high quality handsets as a MNE but are not able to charge as high price and capture as big market share as this MNE, and the direct reason is that their brand name is not as strong as that of this MNE, and the indirect reason is that this MNE started to make handsets earlier using CDMA technology. This domestic firm argued that by being one of the leaders in making TD-SCDMA based handsets, they will be able to enhance their brand name and compete more effectively in the market.

However, right before China Mobile's official adoption of the TD-SCDMA standard, the handset makers were very reluctant to offer strong support. This is true for the domestic company discussed above, which see a lot opportunities offered by TD-SCDMA. In fact, even today it's argued that the smaller number of styles of TD-SCDMA handsets indicates the immaturity of this standard compared with the other two 3G mobile communications standards.

4.1.4 The IC firms

The situation of the IC firms is similar to that of the handset makers. More accurately, the ambiguity of IC firm support was more obvious than the ambiguity of handset firm support, because the majority of the TD-SCDMA handset IC makers are joint ventures, and were more venerable than the handset firms, which are mainly large multi-business companies such as Hisense, Lenovo, and TCL, as well as leading equipment makers such as ZTE and Huawei.

4.2 Indirect reasons for the delay: The impact of uncertainties in technology, market and policy

The data suggest that underlying the direct reasons for the delay of the adoption of the TD-SCDMA standard are indirect reasons such as technology uncertainty, market uncertainty, and policy uncertainty. In this part I analyze the impact of these uncertainties on the adoption of the TD-SCDMA standard.

4.2.1 Technology uncertainty

Theoretically the TD-SCDMA standard is as advanced as WCDMA and CDMA2000. In fact, in many areas, the TD-SCDMA standard is more advanced than the other two standards (Li, 2009). For example, TD-SCDMA has intelligent antenna, which makes it possible for service providers to optimize their TD-SCDMA network through software. TD-SCDMA also has much higher spectrum usage efficiency. In order to transmit traffic at the rate of 2Mbit/s, TD-SCDMA requires one 1.6m band, while both WCDMA and CDMA2000 need to use two 5M bands.

However, when TD-SCDMA was accepted as one of the 3 international standards for 3G mobile communications, many people in China felt that there are many technology uncertainties, because many of the key technologies supporting this standard had not been developed, and there were strong doubts about whether or not these key technologies could be developed ultimately. The fact that Datang is transformed from a government supported research institute into a state owned firm further increased the doubts.

For a long time, people also did not believe that TD-SCDMA could be as good as WCDMA and CDMA2000, even after noted experts like professor Li, Jinliang, the former chief engineer of the 7th Research Institute of the China Electronics Science and Technology Group, and Editor in Chief of Mobile Communications, have conducted detailed comparison among TD-SCDMA, CDMA2000 and WCDMA, and concluded that TD-SCDMA is more advanced than the other two standards in terms of technology effectiveness and cost effectiveness.

For a long time, many people also had the following argument and believes: TD-SCDMA could not be used independently to build up a nation-wide telecom network, believing that TD-SCDMA has to be used as a complement to WCDMA; TD-SCDMA was a closed standard as Japan's PDC system in 2G and would not be able to survive in the era of globalization, ignoring that TD-SCDMA is an international standard and is an open system; TD-SCDMA was not as cost effective as WCDMA, believing that GSM could smoothly be upgraded to WCDMA.

The technology uncertainty has huge impact on the firms along the TD-SCDMA value chain. For example, one handset maker pointed out, "When we were asked to join the TD-SCDMA Alliance, we found that we would have to do a lot of research and develop some of the technologies rather than apply mature technologies in product development. This is a big departure from our previous work, which was mainly applying mature technology".

4.2.2 Market uncertainty

Firms along the TD-SCDMA value chain also felt a lot of uncertainty in the market, and it was not clear if they could benefit from supporting the TD-SCDMA standard. For example, most of the TD-SCDMA equipment suppliers have been producing WCDMA and CDMA2000 machines. In fact, in 2002 when they joined the TD-SCDMA Alliance, ZTE was (and still is) the leader in CDMA2000 in China, and Huawei was (and still is) the leader in WCDMA. In addition, both WCDMA and CDMA2000 started earlier than TD-SCDMA, and were (and still are) more influential in other countries. When there was no clear signal that TD-SCDMA would dominate the market at least in China, there was no strong reason for ZTE and Huawei to allocate more resources to the development of TD-SCDMA based machines. Allocating more resources to WCDMA and CDMA2000 seemed to be a more rational decision.

It's important to point out that there was a long period of market uncertainty. For example, in December 2008 the TD-SCDMA Alliance and the Tsinghua University RCTI invited the key handset makers and the key IC makers along the TD-SCDMA value chain to have a workshop. The majority of these firms felt that they would have to cut their investment in TD-SCDMA, because the market signal was too weak. This is one month before China Mobile's official adoption of the TD-SCDMA standard in January 2009.

4.2.3 Policy uncertainty

The data indicate there were huge policy uncertainties regarding the TD-SCDMA standard. It's true that the Chinese government offered very strong support to make TD-SCDMA one of the three international standards for 3G mobile communications, and many government agencies and government officials in many circumstances claimed that TD-SCDMA would be supported. For example, the Minister of the former MII, Mr. Wang, Xudong, pointed out several times at the end of 2005 and early 2006 that it was time to make a decision on TD-SCDMA's commercialization, and the commercialization would be led by a strong enough service provider.

However, for firms along the TD-SCDMA value chain, this is not a clear enough and strong enough policy signal. For example, there was once a rumor that China Mobile would be the adopter of the TD-SCDMA standard, and China Mobile made it clear many times that it preferred WCDMA rather than TD-SCDMA. Another rumor was that China Telecom would be the adopter of the TD-SCDMA standard, and China Telecom also made it clear many times that it preferred WCDMA or CDMA2000, not TD-SCDMA. Put it differently, before China Mobile's official adoption of the TD-SCDMA standard in January 2009, the Chinese government never made it clear that the TD-SCDMA standard must be adopted in China, and it was never clear which service provider(s) would be the key adopter(s).

In fact, even after China Mobile became the adopter of the TD-SCDMA standard in China, MIIT still insisted that China Mobile's market share be reduced in order to

make China Telecom and China Unicom be able to compete with China Mobile, and even asked and forced China Mobile to give RMB 50b to China Telecom to support China Telecom's development.

This policy uncertainty had created huge negative impact on all firms along the TD-SCDMA value chain, making them very cautious in allocating human and financial resources to the development of the TD-SCDMA standard. The negative impact had been more significant on the handset makers and the IC firms. As mentioned earlier, the majority of the handset makers and the IC firms felt that they would have to cut their investment in TD-SCDMA, one month before China Mobile's official adoption of the TD-SCDMA standard in January 2009.

4.3 Indirect reasons for the delay: complexity in the transformation of 2G to 3G

The data also suggest that the complexity in the transformation of 2G to 3G is another indirect factor contributed to the delay of adopting the TD-SCDMA standard in China. The complexity includes many dimensions, and one dimension is the relationship between 2G, 3G, LTE, and 4G. Specifically, is it a right choice to replace 2G with 3G, or 2G and 3G will co-exist for a long time? Will LTE and 4G come very soon or 3G will be used for a long time? These questions are not easy to answer. For example, there are a lot of people at China Mobile believe that LTE will come soon, and it is not a good choice to build a TD-SCDMA network to cover the whole country. Rather, using TD-SCDMA to cover big cities is a better choice, complemented with the current GSM network.

Another dimension of complexity relates to differences between management strategies in 2G and that in 3G. For example, it is well recognized that data services would be much more important in 3G than in 2G. This implies that the relationships in 3G between the service providers and other firms along the value chain would be different from that in 2G, and the service providers would have to take more responsibility to coordinate the whole value chain.

However, it has proved difficult for the service providers to realize this change and take effective actions. For example, in 2008 it was almost certain that China Mobile would be the TD-SCDMA adopter, but China Mobile was very reluctant to take proactive actions to lead the firms along the value chain and prefer to have these firms act independently. Partially for this reason, many contents providers (CPs) and service providers (SPs) expect to have stronger bargaining powers, while the service providers are unwilling to lose the powers they once had. This also constrains the development of the whole value chain.

5. Understanding the final adoption of TD-SCDMA

Although the process took a long time, TD-SCDMA was finally adopted in January 2009 by China Mobile, the strongest mobile operator in China. In fact, this adoption was not fully voluntary, and government intervention played a very important role. Why the Chinese government finally made the decision to give strong support to the TD-SCDMA standard? The data suggest that at least three factors are of crucial importance: the importance of indigenous innovation had become clear and

indigenous innovation became a national strategy in 2006, and the importance of indigenous innovation was further recognized during the economic crisis in 2008; the key technologies of the TD-SCDMA standard gradually proved to be effective; and Datang has been effective in associating the TD-SCDMA standard with indigenous innovation.

5.1 Indigenous innovation as a national strategy and the economic crisis

Technology transfer has been the most important channel of technology sourcing for local firms in China since the economic reform in 1978. This practice contributed to the rapid development of the Chinese economy and the telecom industry (Editing Committee, 2008). However, this policy began to face a lot of challenges from the late 1990s, especially after China's joining the WTO in 2001 (Gao, 2007).

Specifically, the key challenges facing the policy of relying mainly on technology transfer include the following: (1) more and more local firms relying mainly on transferring technology have begun to lose competitiveness; (2) more and more MNEs have become more and more reluctant to transfer technology, worrying about local firms' becoming their strong competitors, or finding it more attractive to use their technology in an open market in China; (3) more and more local firms have begun to realize that in many cases transferring technology is unlikely to help them develop innovation capabilities, and it is possible to develop core technologies internally.

For example, local firms in the TV set industry started from buying assembly lines and key components from firms such as Sony, Hitachi and Toshiba, and have developed strong manufacturing capabilities. On the other hand, all of them have difficulty in developing innovation capabilities and proprietary technologies. The result is that these local firms began to lose their advantages with China's joining the WTO and their disadvantage in technology has becoming increasingly obvious. In fact, these local firms are facing increasing challenges from Multinational enterprises (MNEs), which are localizing their businesses in China.

Surprisingly, the experience of some local firms that have been following a different path, that is, focusing on developing key technology internally when they are very young, have made impressive progress. For example, leading local firms in the telecom equipment industry in China were unable to compete with MNEs at the high-end market in the 1980s, because they did not have proprietary core technology, and did not have the opportunity to buy core technology from MNEs (Zhang, 2000). The situation began to change in the early 1990s, and local firms have made rapid progress in proprietary technology development. For example, Great Dragon, the first local firm that developed large-scale digital switches, invented breakthrough technologies such as "hierarchical distributed control system" and "completely decentralized T mode exchange network". ZTE and Huawei developed their large scale digital switches in 1994 and 1995, respectively. Based on their strong technological capabilities, Huawei and ZTE have become major players in the world market, with more than 70% of their sales coming from overseas market. In the SDR

(software defined radio) market, ZTE is now the leader in the world.

The automobile industry is another example. Most of the old and large domestic automobile firms have been relying heavily on having joint ventures (JVs) with MNEs, and once enjoyed obvious advantages over other local firms. However, with the development of indigenous innovation capabilities by local firms such as Chery, JVs are facing more and more challenges, making people reflecting on and doubting the effectiveness of JVs.

It's under this situation that the Chinese government began to rethink about the technology policy from the late 1990s, and finally made the decision in 2006 to make "indigenous innovation a national strategy" and "build an innovation oriented country". The importance of this policy change was further recognized in 2008 in the economic crisis when many local firms went bankrupt, especially in Guangdong, Zhejiang, and Jiangsu, where a lot of firms rely heavily on export and on buying technology rather than developing proprietary technology.

This policy change has created a much more favorable environment for TD-SCDMA. In fact, TD-SCDMA has been cited as one of the most important and most successful stories of indigenous innovation by many government agencies many times. More specifically, TD-SCDMA began to get more and more support from late 2005, including the following:

- In late 2005 top leaders of the central government clearly asked related

government agencies to study the importance of TD-SCDMA, and the policies to support it, after three noted scientists wrote a letter to the top leaders of the central government, requesting government support to TD-SCDMA;

- In 2006 telecom service providers were asked to support TD-SCDMA trials in “3+2” cities to test the key technologies and the network;
- In 2007 telecom service providers were asked to support TD-SCDMA pre-commercialization trials in 10 cities, including Beijing and Shanghai;
- In April 2008 China Mobile was asked to offer TD-SCDMA service based on its pre-commercialization network, especially TD-SCDMA service in Beijing during the Olympic Games;
- In January 2009 China Mobile, the strongest mobile service provider in China, was given the TD-SCDMA license.

5.2 Focusing on making TD-SCDMA mature

As discussed earlier, for a long time people have had a lot of doubts about the TD-SCDMA technology and Datang’s capability. To deal with these doubts Datang has developed a lot of strategies. One strategy is focusing. After Datang’s TD-SCDMA was accepted as one of the three international standards for 3G mobile telecommunications, it decided to make TD-SCDMA a strategic business and gradually found that it had to focus its resources on the development of TD-SCDMA. For this reason, Datang has had to sacrifice its leadership in businesses such as ATM and backbone routers.

The second strategy is to stick to the principle of developing leading technologies and leading products. As discussed earlier, since the reform in 1978, the telecom industry has been growing at a much faster rate than the Chinese economy as a whole. The central government is interested in the sustainable development of this industry, and cares about the development of key supporting technologies. For this reason, in addition to the support of buying and absorbing of advanced technologies from MNEs, the central government also supports advanced indigenous technology development at local firms. For example, in 1998 the Chinese government initiated a research program called “C3G” to support study on 3G technologies. Because of TD-SCDMA’s technology advantage, it became an important research area along with WCDMA and CDMA2000. This program not only provided some financial support to the development of TD-SCDMA technology but also created a lot of opportunities for more people to have a better understanding about TD-SCDMA and compare it with other technologies such as WCDMA and CDMA2000.

The third strategy is to attract other firms to develop the TD-SCDMA value chain. One practice is to create the TD-SCDMA Alliance in 2002 with the support of government agencies such as NDRC, MIIT, and MOST, and share its key technologies within the TD-SCDMA Alliance. In addition to the TD-SCDMA Alliance, Datang also created the TD-SCDMA Technology Forum with the support of the central government, aiming to attract as many companies as possible, including MNEs, to join the TD-SCDMA value chain.

The creation of the TD-SCDMA Alliance has played an important role in making the TD-SCDMA standard mature. For example, within the Alliance, member firms such as ZTE and Huawei, who are Datang's direct competitors, are able to access to Datang's patented technologies by paying very low fees, and are able to get technical support from Datang. In this process, these firms have developed deep understanding about TD-SCDMA technology, and this is also very helpful to increase the credibility of TD-SCDMA and Datang.

Datang not only collaborated with local firms but also MNEs. For example, Siemens began to collaborate with Datang closely on TD-SCDMA in 1997 because Datang is the leader in several important technology areas such as smart antenna, software radio and joint detection. Although the collaboration stopped later on because of differences in the two companies' strategies, the willingness of Siemens to collaborate with Datang indicated that TD-SCDMA is an important and advanced technology.

Datang's strategies have proved to be very effective. One result is that in 2005 three Ministries organized a trial and TD-SCDMA was proved to be able to set up large scale telecom networks independently. After this trial, more and more people, especially technology experts began to show their confidence about TD-SCDMA.

5.3 Associate TD-SCDMA with national strategy

The data suggest that the increasing importance of indigenous innovation and the maturity of technology are only necessary conditions in order for the central

government to offer strong support to the TD-SCDMA standard. It is critical for the central government, especially the top leaders, to be familiar with this standard and its importance for indigenous innovation. Datang effectively solves this issue by building an “informal social network”. Specifically, it has been able to unite non-customer stakeholders such as noted scholars, government officials (including retired ones), and people in the media, to help with TD-SCDMA.

For example, scholars become important non-customer stakeholders of TD-SCDMA, because they feel they have the responsibility to tell the public “the truth” (their research results and their understanding) about the relative advantages and disadvantage of different technologies, mainly because there exist huge differences among scholars. Another reason is that the decision of adopting a specific 3G technology standard will have important impact on a lot of scholars’ career development.

One important role played by scholars is that their discussion and debate help the central government to make better decisions, which have turned out to favor TD-SCDMA and help Datang. For example, in early 2005, a very famous economist at one of the most prestigious universities in China published a report, arguing that China was lagging behind in the development of 3G business and the government should issue 3G licenses as soon as possible. He also criticized that the government refused to issue 3G licenses because the government was captured by special interest groups, including Datang, whose technology was not as mature as WCDMA and

CDMA2000.

This led to a round of intense debate, and several very famous telecommunications technology experts criticized the economist, pointing out that the data he used was highly biased, his calculation was inaccurate, and his technological knowledge in making technical judgment is highly limited. This debate had an important impact on the central government's decision of further delaying the issuing of 3G licenses.

Another example is the debate on the relative advantages and disadvantages of different 3G standards. For a long time, most people believed that WCDMA and CDMA2000 had more advantages than TD-SCDMA. However, more and more experts in the wireless telecommunications technology area have very different opinion. Professor Jinliang Li at the 7th Research Institute of the China Electronics Technology Group Corporation is a typical example. Professor Li has done a lot research and written many articles to compare the relative advantages and disadvantages of TD-SCDMA, CDMA2000 and WCDMA. One of Professor Li's key conclusions is that TD-SCDMA enjoys big, not small, technology advantages over WCDMA and CDMA2000. For example, TD-SCDMA is suitable for providing asymmetrical data services, because it is able to dynamically adjust data transmission rates. TD-SCDMA is also better positioned than the other two standards to evolve into more advanced stages and support new applications such as PTT. Professor Li also argues that TD-SCDMA's obvious technology advantage will lead to low cost advantage.

Because of Professor Li's reputation as a highly respected expert in wireless telecommunications, his study and publications have directly helped the government to build up its confidence in supporting TD-SCDMA. In fact, Professor Li and his friends have written many letters to the top leaders of the central government to share their understandings about TD-SCDMA and request support of this standard.

6. Discussion and conclusion

The above analysis indicates that the key to understand the puzzle raised at the beginning of the paper is the decision making mechanism of the Chinese central government, although other factors are also important. Specifically, it's crucial to understand: (1) The strong impact of government policy in China; (2) The importance of indigenous innovation; (3) how policy change and the role of "informal social network" in policy change.

6.1 The strong impact of government policy in China

The strong impact of government policy in China could be illustrated by the behavioral change of China Mobile. As discussed earlier, generally speaking, for a long time, China Mobile, as China Telecom and China Unicom, was not willing to adopt TD-SCDMA. This is understandable, because WCDMA and CDMA2000 have been adopted in many countries. However, the central government was able to ask China Mobile to adopt TD-SCDMA in January 2009, and after the adoption China Mobile has changed its behavior dramatically and become very active in promoting TD-SCDMA. The following are some examples.

- In February, 2009, China Mobile started a “TD-SCDMA network quality improvement campaign”, with more than 100,000 people participated, and has made impressive progress. For example, up to early June, the success rate of switching between the TD-SCDMA network and the GSM network reached 96%, from 64% during the Olympic games in 2008 (<http://www.sasac.gov.cn/n1180/n6130640/n6192763/n6201274/n6226661/6468419.html>).
- On 13 March, 2009, China Mobile decided to spend RMB 600M to support TD-SCDMA handset and IC firms, and on 17 May, 2009, China Mobile selected 9 handset makers and 3 IC firms to work with. This is the first time for a service provider to directly support handset and IC firms along the value chain in China.
- In accepting an interview in July, 2007, by Ms Ma, Xiaofang, a reporter from CHINA BUSINESS NEWS, Mr. Wang, Jianzhou, CEO of China Mobile, made the following argument: “TD-SCDMA offers the first opportunity for Chinese firms in the telecom industry to be world leaders, rather than followers”. (http://www.chinamobile.com/aboutus/news/200908/t20090813_12447.htm)

Given the big influence of government policy in China in the telecom sector, it’s important to understand the sources of this influence. An obvious reason is that the key share holder of the 3 dominant service providers is the Chinese central government, although all of them are listed companies. The firms might want to adopt other technologies, but they have to listen to the government.

Another reason is that the telecom service industry is different from many industries, and there exist strong “network effects” and is a “natural monopoly”. For this reason, the Chinese government has been very active in restructuring this industry. For example, in April 1995, China Unicom was established to increase competition. On 2 June, 1999, the MII decided to set up a new firm to take over the mobile business of China Telecom, and on 20 April, 2000, China Mobile was established. In May, 2008, the 6 telecom service providers were re-organized into 3: the new China Mobile, the new China Telecom, and the new China Unicom.

The third reason relates to industrial policy. Specifically, the Chinese central government believes that China is a developing country and in some cases it’s necessary to use industrial policy to support economic development. As one of the most important industries, the telecom industry is on the radar of the Chinese central government. I discuss this in detail in the following section.

6.2. The importance of indigenous innovation

The impact of the perceived importance of indigenous innovation by the central government, especially the top leaders of the central government, on the adoption of the TD-SCDMA standard is also obvious. More specifically, when the perceived importance of indigenous innovation is not high, for example, before 2006, the government policy did not offer very strong support to TD-SCDMA; when the perceived importance of indigenous innovation is very high, for example, after 2006, the government policy began to offer very strong support to TD-SCDMA.

It's important to point out that it's necessary to take a historical perspective to understand the importance of indigenous innovation in China. Since the founding of the People's Republic, the Chinese central government has been exploring effective strategies of building a strong economy in China. This includes heavy industrialization in the Mao Zedong era, and the reform and open to the outside world era since 1978. As mentioned earlier, a key feature of the reform and open era is relying heavily on sourcing technology from MNEs. The positive side of this policy is that local firms could transfer mature technology and serve the market quickly. The problem is that this policy also has its negative side as discussed previously. When the government has developed deep enough understanding about the negative impact, policy change is inevitable.

For example, Professor Li, Jinliang wrote letters to Vice Premier Minister Wu, Bangguo and Premier Minister Zhu, Rongji in 2000 and 2001, respectively, hoping that the central government would put together and coordinate the four groups of people doing 3G studies in China to concentrate on developing and improving TD-SCDMA. Although Vice Premier Minister Wu, Bangguo asked the MII to study this proposal, and organized a meeting to discuss related issues, no big policy change occurred. The key reason is that the perceived importance of indigenous innovation is not very high.

However, with China's join the WTO, the negative impact of relying heavily on buying technology became clear, and high level consensus among top leaders began

to emerge. This led the National Science and Technology Meeting in January 2006. It's under this situation that top leaders ordered concrete action after three noted scholars (and also very high level government officials) wrote a letter to the top leaders) in late 2005 requesting support to TD-SCDMA. This is the turning point of the development of TD-SCDMA in China. This also implies that indigenous innovation is not a temporal policy but has become one of the most important policies in the future development of the Chinese economy.

6.3 Policy change and the role of “informal social network”

This paper also indicates the important role of “informal social network” in government policy change. It's not easy to change government policy even when it is necessary to make the change. One reason is that there exist risks. For example, one very high level government official said, “It was not clear if Datang would be successful in developing all the key technologies to make TD-SCDMA really be commercialized, especially in the early days; for this reason, it's not a cautious and sound choice to declare its adoption when it's not fully mature”.

Inertia also makes change difficult. Compared with other industries, the telecom industry in China have been able to keep a much higher growth rate based on technology transfer. This makes many government officials believe that technology transfer, rather than developing indigenous technology, is more effective and important for the development of the telecom industry.

This study suggests that an “informal social network” could facilitate change. In the telecom industry, firms such as Datang and people like Mr. Zhou, Huan, former Chairman of Datang, Dr. Li, Shihe, Professor Li, father of TD-SCDMA, Jin, Liang, Mr. Jin, Luzhong, a former government official at MOST, et al realized the necessity and possibility of transforming from relying mainly on buying technology to relying mainly on internal development of proprietary technology very early. These people are also well connected to the government, including to the top leaders. Because top leaders are more likely to make decisions with a global rather than a local perspective, it’s more likely for them to initiate changes, especially when local change is difficult.

This study also has limitations. For example, in some cases, there is not enough information about how a decision is made, especially when the decision is made by very high level government officials. Another limitation is that in this paper inter-government agency differences are not analyzed. This paper also does not directly look at the adoption of WCDMA and CDMA2000. Future research will try to address these limitations and new directions such as how the three different standards evolve with different initial conditions.

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