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Conference Paper

Standardization in technology adoption: A comparison of broadcast TV cases

19th Biennial Conference of the International Telecommunications Society (ITS): "Moving Forward with Future Technologies: Opening a Platform for All", Bangkok, Thailand, 18th-21th November 2012

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Kim, Heejung (2012) : Standardization in technology adoption: A comparison of broadcast TV cases, 19th Biennial Conference of the International Telecommunications Society (ITS): "Moving Forward with Future Technologies: Opening a Platform for All", Bangkok, Thailand, 18th-21th November 2012, International Telecommunications Society (ITS), Calgary

This Version is available at:

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The 19th ITS Biennial Conference 2012

“Moving Forward with Future Technologies: Opening a Platform for All”

18 - 21 November 2012, Thailand

STANDARDIZATION IN TECHNOLOGY ADOPTION: A COMPARISON OF BROADCAST TV CASES

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ABSTRACT

Based on developments in the U.S. television, this study illustrates the choice of technical standards by the government. Broadcasting in the U.S. has been largely affected by the adoption of new technology. Technology adoptions have impacted economy, society, industry, and government policies of the U.S. broadcasting. The purpose of this study is to examine standard-setting development and policies for major technology adoptions in broadcasting: color TV adoption and digital TV adoption.

INTRODUCTION

Technologies change the way people watch broadcast TV. Color TV and digital TV are major technological advances that brought in innovations for TV industries and consumers. When technology standards for innovations are incompatible with preexisting systems, consumers have to purchase new equipment to receive signals. Standard-setting in innovation adoption is important because the process of standard-setting reflects the interests of the industries, consumers, and the regulatory authorities. The purpose of this study is to examine the standard-setting and related policies in the cases of color TV adoption and digital TV adoption: the two major technological innovations in broadcasting. This paper discusses the different aspects of developing and implementing the standards for color TV and digital TV and the implications from these experiences.

LITERATURE REVIEW

Standard-setting is essential for the adoption of new technologies and networks' compatibility (Balto, 2000). A network's success depends upon its users' expectations of the likely behavior of other users of the network. Standardization reduces consumers' avoidance of investing in an innovation and also assures consumers that their purchase will not become technologically obsolete. Consumer acceptance is critical to technology adoption in network industries because adoption becomes more valuable as the number of adopters increases. In addition, compatibility allows different systems to communicate or interface with competing suppliers of complementary products. As a core function of innovative products, compatibility plays an important role in the adoption process. For example, digital TV sets and receivers should share compatible standards for the digital TV transition to succeed

(FCC, 2009).

Varian (2004) presents three types of competition related to standard-setting, describing the process for standard establishment. The three types of competition are standard war, standard negotiation, and standard leader. A standard war refers to a situation where all firms compete to determine the industry standard. A standard negotiation occurs when firms compete within a standard, but prefers the features of their own standard. A standard leader is typically a large, established firm that wants to maintain its proprietary standard, so other firms may want to interoperate with the existing standard (Varian, 2004).

As to how to develop standards, three types of standard-setting methods are widely known (Gandel, 2002; Hemphill & Vonortas, 2005). First, an *ex-post* or *de facto* standard is determined in the market. The PC operating system industry is a good example of *de facto* standards; Microsoft has established *de facto* standards in software applications such as operating systems and word processors (Lee & Mendelson, 2007). Second, an *ex-ante* or *de jure* standard, also known as industry standard, are developed and approved by key participants, such as industry groups and professional organizations in a market that seek consensus on standard-setting. For example, a group of DVD manufacturers led by Warner and Columbia worked together for a single standard, and developed the open DVD standard. Third, a mandatory standard is established by national standards regulators or international standards organizations. Although a mandatory standard often makes reference to a *de jure* standard, a mandatory standard is distinguished from a *de jure* standard by its compulsory nature, as required by legislation (Hemphill & Vonortas, 2005). On the other hand, a *de facto* standard and a *de jure* standard are market-mediated. A *de facto* standard is usually selected at a later stage of technology development (Koski & Kretschmer, 2005), although a mandated standard has an advantage in that it generally takes less time to be established as a standard.

The standards for color TV and digital TV are both mandatory standard developed and administered by the standard organizations. However, the two standards took different paths in implementing innovations. Farrell and Shapiro (1991) suggest the mere comparisons of color TV adoption and digital TV adoption are limited by nature, because the broadcasting environments surrounding the two adoptions would be different. In spite of this limitation, examining the two will help understand how standardization and innovation adoption are interrelated, and what factors may be involved in this process. During the sixty years prior to the digital TV transition, the standards for U.S. television had not dramatically changed. The next section will discuss each case to better explain the processes by which the U.S. chose in adopting TV innovations.

COLOR TV ADOPTION

DEVELOPMENT OF COLOR TV: THE CBS SYSTEM

The U.S. color TV had a long history of vying for an approved standard for its system. In 1929, Bell Labs demonstrated mechanically scanned color TV superimposed the primary-color images, which were red, green, and blue for one-color image. Color

television had started in full-scale in the late 1940s, alongside black and white television. It was not a commercially viable until the early 1950s. The first color TV appeared in 1940, when RCA showed a color TV set using a sequential color system to the FCC members at the RCA factory. It was NBC, a subsidiary of RCA, that started the first field test of color TV in 1941, and CBS also did its daily field test in the same year. After the World War II, the development of color TV was led by three systems seeking for the FCC approval. CBS's field sequential system was incompatible with existing TV sets, while RCA's dot sequential system was compatible.

With an increasing interest in color TV in the industry, the FCC held a series of hearings on introducing color TV and did field tests in 1949-1950. The FCC approved the CBS system as the U.S. color TV standard, on the ground that the RCA system was more expensive, involved in technical problems and poor color performance. In its report on color TV in 1950, the FCC formally approved the CBS system. RCA responded by suing against the FCC to prevent the CBS color broadcasting from starting. Even though CBS was the winner of this lawsuit, the initiation of CBS system was postponed, since black and white TV sets which were incompatible with the CBS system kept selling in the market.

STANDARD-SETTING IN COLOR TV ADOPTION: THE RCA SYSTEM

The color TV adoption is an example of interplay between government-driven and market-driven standardization (Shapiro & Varian, 1999). In FCC's 1941 report, the Commission acknowledged the benefits of the CBS color system, confirming the NTSC (National Television System Committee) standard. Over the color TV standard, CBS and RCA (the owner of NBC) competed with each other. The CBS color standard had a high scanning rate, which was incompatible with the existing black and white TV sets. The FCC adopted the CBS system as an industry standard in 1950. As a result, monochrome TV sets could not be used without a special attachment. The FCC's endorsement of the CBS system did not actually promote the development of the color TV industry using the standard. CBS discontinued color broadcasts due to the limited numbers of color receivers in 1951.

In 1953, the FCC reversed its earlier decision and adopted compatible RCA system as the color TV standard (Shapiro et al., 1999). In order to promote the adoption of digital TV in the market, RCA shared a great deal of color TV technology after the NTSC color standard was selected. Also, NBC (RCA's subsidiary) was one of the major providers of prime-time color programming (Farrell, Shapiro, Nelson, & Noll, 1999). After the color standard was set in 1953, broadcasting stations upgraded their facilities to offer more color programming.

The color TV broadcasting became more popular; RCA invested \$130 million in developing color TV by 1959 and NBC showed 4,000 hours of color programming by 1965. CBS offered 800 hours of color, and ABC showed 600 by 1965 (Shapiro et al., 1999). ABC and CBS were likely to have less incentive to broadcast in color, since NBC's parent company RCA pioneered new color TV standard. During the early 1960s, color television grew at an amazing pace, especially on NBC, culminating in the color revolution of 1965. While NBC increased its color programming to help RCA sell color TV receivers, other TV networks were not as supportive of the adoption of color TV. In addition, network affiliates did not adopt color TV

immediately since the initial CBS system was not successful. Figure 1 illustrates the adoption of color TV broadcasting by network affiliates in terms of yearly hours.

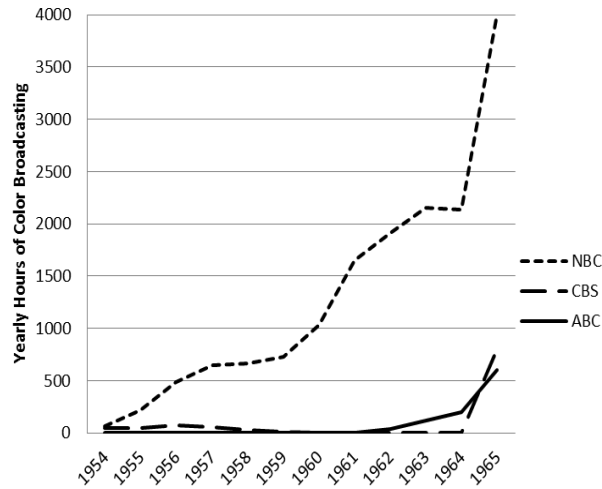


Figure 1. Yearly Hours of Color Broadcasting in Three Major Networks

NBC was the leader in color TV adoption, airing color broadcasts during primetime in 1966. Other networks followed by becoming all-color networks during primetime by 1967. However, the number of black and white TV sets sold in the U.S. still exceeded color TV sales until 1972. Thus, it appeared to take a long time for the U.S. households to have color TV as a household fixture even after the color TV standard was established. Table 2 shows the penetration of color TV sets in 1960-1999. In 1970, the penetration rate of color TV was only 35.7%, but color TV households increased continuously. In 1999, the penetration rate reached 98%, corresponding to 23,218 sales units.

Year	Sales Units (Unit:Thousand)	Average Price	Penetration
1960	120	\$392	0.7%
1965	2,694	\$356	4.9%
1970	5,320	\$317	35.7%
1975	6,485	\$341	68.4%
1980	10,897	\$367	83%
1985	16,995	\$325	91%
1990	20,384	\$304	96%
1995	23,231	\$293	97%
1999	23,218	\$267	98%

Table 1. Sales and Penetration Rate of Color TV: 1960-1999

(Source) “Lessons from History: The Adoption of Color TV”. Available at <http://www.edn.com>

DIGITAL TV ADOPTION

OVERVIEW OF DIGITAL TV ADOPTION

The digital TV transition has been hailed as one of the most fundamental changes in the U.S. broadcasting industry. The digital TV transition was initiated as a way to sustain the U.S. economy through maintaining competitiveness in the global electronics markets. The transition came out of the decision to improve the performance of the U.S. consumer electronics industry which competed with firms based in Europe and Asia. The motivation for the transition came from the need to consolidate U.S. dominance in the high-tech and consumer electronics industries (Brinkley, 1997). The digital TV transition had a technological goal of advancing broadcast TV into the digital age and a policy goal of making the transition as smooth as possible without disrupting viewers (FCC, 2009). The transition enabled the government to receive federal earnings through reallocating spectrum. Consumers also benefited from implementing the digital TV transition by receiving expanded programming in improved picture resolution and enhanced audio.

DEVELOPMENT OF DIGITAL TV

Discussions of digital TV go back as early as the 1970s when the U.S. Department of Defense developed digital resolution systems during the Cold War (Bates, 2007). The interest in developing digital TV originated from global competition to establish an international standard for HDTV. Carrying out research under the leadership of individual governments, Europe and Japan were ahead of the U.S. in developing HDTV. The analog-based MUSE system for HDTV first developed by Japan's NHK used 1,125 lines of resolution (Brinkley, 1997). In the U.S., HDTV was first demonstrated in the U.S. in 1981 (Dupagne & Seel, 1997). Later in 1983, CBS developed analog HDTV systems compatible with the NTSC system (Noll, 2001). As a reaction to HDTV initiatives from Europe and Japan in the 1980s, the U.S. established the development of digital TV as national agenda to stimulate the electronics and equipment manufacturing industry.

In 1982, the Advanced Television Systems Committee (ATSC) was formed to coordinate the development of ATV standards to substitute the NTSC standard, the analog TV system used in the U.S. The original ATSC membership included representatives from the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), the Society for Motion Pictures and Television Engineers (SMPTE), broadcast, equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries (ATSC.org, 2011). In July 1987, the FCC formed the Advisory Committee on Advanced Television Service (ACATS) supervised by former FCC Chairman Richard Wiley. The purpose of the ACATS was to offer recommendations for ATV standard (FCC, 1987). The ACATS were represented by the members from broadcast, cable, electronics and equipment industries, government, and academics (Hart, 2004). On November 17, 1987, at the request of 58 U.S. broadcasters, the FCC started rulemaking on advanced television (ATV) services by the ACATS. The ACATS evaluated the feasibility of switching to

digital TV and competing systems and recommended that the ATSC review proposals on digital TV standards. The opinions from the ATSC argued that previous proposals on digital TV were not appropriate. The ATSC's conclusion on previous proposals on standardization encouraged ATV competitors to form the Grand Alliance for developing a new technical standard. The Grand Alliance was created in 1993, consisting of seven digital TV proponents involved in developing the digital TV system, including AT&T, General Instruments, MIT, Phillips, RCA, Thompson, and Zenith. In 1996, the FCC formally adopted the Grand Alliance standard recommended by the ACATS. Instead of approving one single standard as a final standard for a scanning format, the FCC allowed broadcasters to use the format that best satisfied their needs. This multi-standard decision resulted from a disagreement over the scanning format between the consumer electronics industry and broadcasting industry, and the computer industry.

The computer industry did not participate in the early stage of developing digital TV standards. As the computer industry realized the importance of digital TV standardization, major companies such as Microsoft, Compaq, Apple, and Intel formed the CICATS (Computer Industry Coalition on Advanced Television Service) to participate in the process of standard-setting (Van Tassel, 2001). The computer industry expected the FCC to approve a minimum standard based exclusively on progressive scanning, which would achieve a greater compatibility with computer screens and improved performance for displaying texts and still images. On the contrary, the broadcast industry supported interlaced scanning that used less bandwidth and was suitable for displaying moving images. As a compromise to mitigate the conflicting interests of different industries, the FCC approved a number of standards, including both interlaced scanning and progressive scanning (FCC, 1996).

STANDARD-SETTING IN DIGITAL TV ADOPTION

Digital TV provides better quality video and audio than an analog system. Digital TV offers accuracy and efficiency for the same amount of bandwidth to broadcast stations, and interoperability with other electronic media. When the need for the transition to digital was examined, there was a question about whether the FCC would administer the choice of technical standards or leave the outcome to the market (Carter, et al., 1992). The standard-setting for digital TV shows that the digital TV transition was a process affected by both government-mandates and market-based decisions. Although the digital TV standard was mandated, broadcast stations had the latitude to choose among 18 different scanning formats. This section reviews what specific digital TV formats were approved by the FCC and what formats are currently employed by broadcasters.

In 1996, the FCC chose the ATSC (Advanced Television Systems Committee) standard based on the technology developed by the Grand Alliance. The ATSC standard has 18 different scanning formats, but the formats primarily employed by broadcast stations were 480p, 720p, and 1080i scanning formats. The 'p' and 'i' respectively stand for progressive and interlaced scanning, which differ in terms of the lines that make up each frame of TV video. Offering progressively scanned digital images, 480p is the economical method for digital broadcasting. Broadcasters that provide multicasting choose 480p as their digital TV format (Hart, 2010). 480p is

allotted for SDTV while higher resolution formats of 720p and 1080i are designated for HDTV (Carter et al., 2008). 720p provides a higher quality image than 480p and possibly as high image quality as 1080i because it is progressive. ABC, NBC, and their affiliates employed 720p and made major investments in production facilities for broadcasting in this format. 1080i uses interlaced scanning which provides a high quality pictures over the formats using progressive scanning. CBS and their affiliates choose 1080i, which is costly to produce and display pictures (Hart, 2010). While broadcast stations receive a majority of primetime programming from networks, syndicators and advertisers also supply TV programming for stations. Therefore, broadcast stations should be able to receive programming of any digital format from these different programming sources to convert it to their transmission standard. Table 1 shows commonly employed digital TV formats by broadcast TV stations and networks.

Format	Active Lines	Horizontal Pixels	Aspect Ratio
HDTV	1,080i	1,920	16:9
	720p	1,280	16:9
SDTV	480p	704	16:9 or 4:3
		640	4:3

Table 2. Digital TV Formats in the ATSC Standard

(Source) ATSC (2011).

For a network industry - where total network size is an important factor in the success of a network - standardization of technology, particularly inter-operability, is one of the important strategic decisions to gain competitive advantages and cost reduction (Varian, 2004). Standards could be determined by stakeholders such as government, industry alliances, the market, and industry leaders (Rosen, Schnaars, & Shani, 1988). Rosen et al. (1988) identify the benefits of standard-setting in terms of reducing the risks for consumers and firms, and also increasing competitiveness in international markets. Standard-setting becomes especially important when complementary products utilize the new technology. For example, TV programs should be produced in digital formats for broadcast stations to offer digital programming.

This situation can be characterized as the “chicken-and-egg” problem, caused by the interdependence between different service providers and producers (Gupta, Jain, & Sawhney, 1999). In the case of digital TV transition, the incentives for digital TV adoption are likely to be affected by the choices of other stakeholders. Broadcast stations are willing to adopt digital TV when more consumers have digital TV receivers and more studios produce digital programs. In turn, consumers may want to wait until the price of digital TV sets decreases, while studios are less willing to produce digital programming unless broadcast stations adopt digital TV. Similarly, studios are more willing to invest in digital programming when an established base of consumers and broadcast stations adopt digital TV and pay for the programming. In turn, consumers and broadcast stations are likely to wait until there is sufficient digital programming available so that they benefit from their adoption decision. In this respect, Congress and the FCC acknowledged that most importantly, the digital TV transition should stimulate consumer demand (Graham, 2003).

THE NATURE OF DIGITAL TV ADOPTION

The establishment of deadlines for moving to digital TV followed a similar multi-participant process. First, the U.S. digital TV transition is a government-mandated transition. Congress structured the transition through legislative actions, and the FCC made rules for the transition, such as timelines and digital TV standards. The timeline and the standard-setting are two components that formed the mandated nature of transition, subject to legislative and regulatory decisions by Congress and the FCC. Nevertheless, the mandated transition was implemented with discretion on the part of the stations, as they met the needs in the marketplace. In this respect, the process of the digital TV transition shows the interaction between technology, policy and industries. Both private and public entities participated in the process and the policymaking of the transition: the FCC, Congress, and the affected industries such as the broadcast, computer, and electronics manufacturing. The completion of the digital TV transition took more than a decade from its onset in 1996. Over the following years, the FCC had made rules and Congress had enacted legislation for the transition. Since the digital TV transition would affect the future of the broadcast industry and the development of new markets, the completion of the transition involved the interests of all stakeholders. Also, digital TV policy is a result of continued efforts to enforce the mandated transition by policymakers.

CONCLUSION

This study looked at the cases of technology adoptions in the U.S. broadcast TV, focusing on the different paths in standard-setting in color TV and digital TV adoption. The analysis suggests that the characteristics from each case explain and justify the disagreements and policies involving the two adoptions, focusing on the government-driven and market-driven nature of adoptions. A major difference between the adoption of color TV and digital TV is that digital TV was adopted according to the government mandate with predetermined schedule. In adopting digital TV, the government played a more decisive role in speeding up and completing the adoption than color TV adoption. On the other hand, the decision to adopt color TV for TV networks and households was more likely to be left to market under no specific timelines.

When it comes to the standard-setting, color TV adoption showed more interactions between government and market. The adoption of color TV is similar to that of digital TV in that color TV adoption had a technical standard determined by the government. However, the adoption of color TV did not require the replacement of existing TV sets for the reception of signals, and there were no signal cut-off unlike the case of digital TV. Therefore, TV households had less incentive to adopt color TV by purchasing a new set, since they were able to watch TV on their black and white sets.

It is expected that standardization issues, including compatibility and agreement between different stakeholders, become more important in order to coordinate different positions by relevant stakeholders. The U.S. chose committee-based and de facto standards for their major TV innovations, since this type of standard-setting method contributes to a fast rollout of new broadcast services. As such, standardization provides a basis for the development of innovations.

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