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Sony's redemption: the Blu-ray *vs.* HD-DVD standards war

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This paper examines the factors that affect market dominance in a standards competition by comparing the VHS–Beta war in the 1980s with that between Blu-ray and HD-DVD in the 2000s. We first look at the changing home video market in terms of technological development. Then we move on to discuss three main strategies in a standards war: first-mover advantage, indirect network effects and software provision, and strategic alliances of hardware firms. We find that technological innovation is essential. Being a first mover is helpful, but not sufficient, in building a dominant position in the market. Historical evidence shows that Sony created a network of complementary firms for Blu-ray. Consequently, an effective strategy to become a winner in a standards competition appears to be building a network of complementary products and subsequently an installed base.

Introduction

This paper examines the factors that affect market dominance in a standards war by comparing the competition between VHS and Betamax in the 1980s with that between Blu-ray and HD-DVD in the 2000s. As Figure 1 shows, the high-definition home entertainment industry is a huge, evolving industry with rental and sales revenues exceeding US$20 billion in 2009. In industries where standards are important, a firm's ability to establish its technology as the *de facto* standard is a critical determinant of its long-term competitive position and success (Hill, 1997). However, technological prowess alone is not enough to guarantee success in a standards war. What matters most may be the firm's strategy in the timing of entry, alliances with other firms, and aggressive marketing and sales to pre-empt a competitor's installed base.

In the paper, we pay attention to the motives and financial position of the key player in the standards war, namely the Sony Corporation. Sony is not just another Japanese company; it is an icon – creator of the Walkman, PlayStation and the MiniDisc player. Sony is one of the best known Japanese brands and was made in the image of co-founder Akio Morita (Nathan, 1999). It is a multi-faceted firm with 53% of its revenue coming from consumer electronics (TV, home audio/video, digital imaging, mobile products, games), 15% of its revenue from professional services and semiconductors, 15% from pictures and music, and 11% from financial services (Sony, 2012). Its 2011 revenues amounted to US$88.8 billion. And yet, Sony has been under increasing pressure over the past decade to regain its lost luster in the

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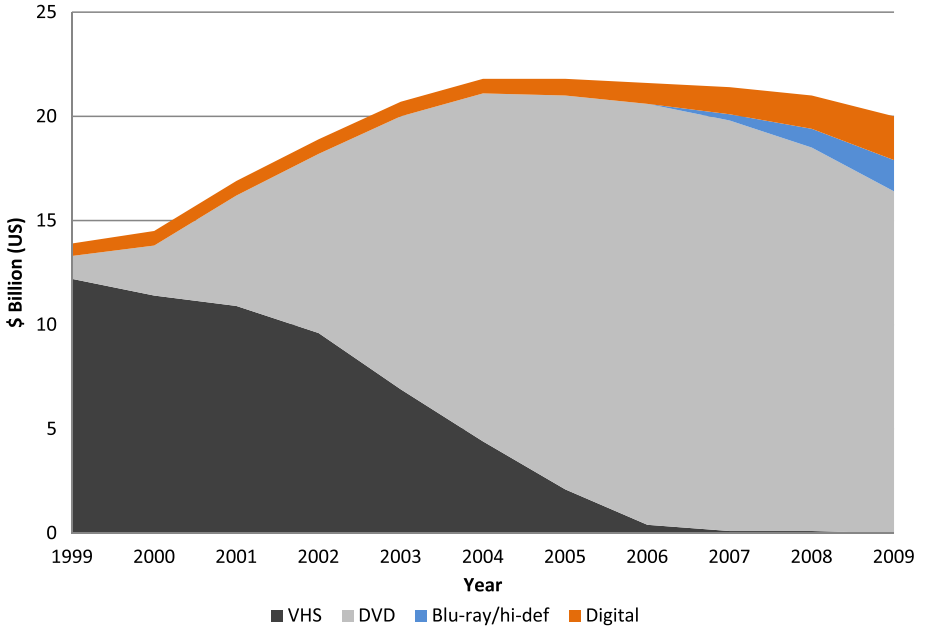

Figure 1. US home entertainment rental and sales revenue by type (US$billion)
Source: Digital Entertainment Group (2008). (Available in color online).

consumer electronics industry (Kunii, 2002; Burt, 2003). Kunii (2002), put it succinctly: 'The company, in short, is caught between a past that no longer works and a future that hasn't arrived'.

Several studies have examined the processes and outcomes of a standard-setting competition, including the standards war between VHS and Betamax formats in the late 1970s (Cusumano *et al.*, 1992; Ohashi, 2003; Park, 2004). The VHS format became the standard in the VCR market even though the Betamax format was introduced earlier and was considered technically superior. Recently, the high-definition DVD market was the battleground for an intensive standards war between Sony-led Blu-ray technology and Toshiba-led HD-DVD technology. While the environments were similar to those of the VHS–Betamax format competition, Sony's technology won the war in 2008.

We compare the VCR competition with the high-definition DVD competition in terms of a firm's strategy to establish its technology as a standard. Several options are discussed in the literature, and our study focuses on four main aspects: first-mover advantages, network effects with software companies, strategic alliances with hardware companies, and architectural innovation. The paper begins with a brief history of the development of the US home video market. It then recounts the evolution of the home video market from the 1970s to the present, and examines the factors that might have affected success in the standards competition.

Technological developments in the home video market

The US home video market has seen standard-based competitions over the course of three major product generations: VCR, DVD, and high-definition video. Firms in

each generation vigorously competed to establish their respective technologies as the standard. While the DVD standards competition ended with a cooperative outcome, the VCR and high-definition video competitions ended with clear winners. Below we summarize the three product generations and their respective standards wars.

First generation: VHS vs. Betamax format

The first generation standards war in the US home video market was the competition for the home video cassette recorder (VCR) between Matsushita's (Panasonic) VHS format and Sony's Betamax format. Though Ampex reel-to-reel machines had been used commercially by television stations to rebroadcast live shows, there was no product that recorded or played video for home use. The VCR was thus a new type of product. Consumers had increasingly demanded a machine that could record television shows or sports games and play them at home later (i.e. 'time-shifting'). With a huge potential market for the VCR, firms competed to introduce products as quickly as possible.

Sony was first to market with the introduction of the Betamax format to the US in February 1976, and Matsushita launched its incompatible VHS format in September 1977. While introduced later, the VHS format took the lead in the market in 1978, capturing nearly 90% of the total VCR market by 1985. One of the technological features that led to Matsushita's dominance was its longer playing time than Betamax's one-hour play time. Given consumers' preference for time shifting, machines with a longer recording time were preferred and many firms supported the VHS format. Though Sony introduced new features to the Betamax format and increased its recording time by the early 1980s, it could not catch up with VHS. It is argued that the format war between VHS and Betamax was already over by 1981–1982 (Ohashi, 2003).

The intense competition led to price reductions. The inflation-adjusted mean price of VCR players dropped dramatically from US$761 in 1978 to US$245 in 1986 (Ohashi, 2003). In addition, each firm also tried to establish alliances with movie companies and provided consumers with free program cassettes. In 1984, VHS sales rose dramatically relative to Betamax sales for the previous year, and many Betamax-producing companies left the market (Park, 2004). Sony announced in January 1988 that it would produce VHS machines instead of Betamax, ending the standards competition in the VCR market.

Second generation: DVD format

By 1990, nearly 70% of US households had VCRs, and several companies were competing to develop the next generation of video product to replace the VCR. Sony and Philips introduced a new technology, the multimedia compact disc (MMCD), in the early 1990s, while Toshiba and its allies pushed a rival standard called the super density disc (SD). The proposed MMCD with a single layer could hold 3.7GB of information, but the SD had a capacity of 9GB using both sides of the disc. The higher capacity of SD technology enabled longer recordings of films and other features, and most movie studios backed it. In 1995, hardware firms and movie studios agreed on a common format, the digital versatile disc (DVD), based on Toshiba's SD technology with a few features from the MMCD technology. The

longer playing time and the movie studios' support were the main factors that positioned SD technology as a potential common format.

In 1996, the DVD forum of hardware and software firms published DVD specifications, which included open format, forward compatibility, and a sound encoding process. The first DVD players were released in early 1997 with support from most movie studios. Competing with laser disc players and a new technology called DIVEX (digital video express), which entered the market in late 1998, DVD technology became the dominant standard in the digital format home video market (Dranove and Gandal, 2003).

Third generation: high-definition DVD formats

After the common DVD standard was set in 1995, Sony and Toshiba started to work on the next generation of home video technology. The standards competition was between Sony's Blu-ray and Toshiba's high-definition digital versatile disc (HD-DVD). The new technologies were intended to deliver high-definition video to television sets by providing more capacity than the DVD. In 2000, Sony developed its alternative format using new, blue lasers in optical disc systems. Blue lasers expand capacity by providing a more detailed high-definition picture because of the shorter wavelength of blue light relative to the red lasers used in DVD technology. A consortium of nine hardware firms (Sony, Philips, Samsung, Sharp, Pioneer, Matsushita, Hitachi, Thomson, and LG) supported the Blu-ray format, and many Hollywood studios also backed Sony's Blu-ray because of its larger capacity (see Appendix A).

In 2001, Toshiba unveiled its HD-DVD player at the computer electronic show. The HD-DVD technology was based on DVD technology (but with a blue laser), and DVD production facilities could easily and economically convert to HD-DVD disc facilities. However, data encoding differed in two ways. Since the Blu-ray disc has a tighter track pitch, it can hold more information on the same size disc as HD-DVD. In addition, the surface layer has a different thickness; while HD-DVD uses a 0.6 mm-thick surface layer, Blu-ray has a 0.1 mm surface layer. Because of the thinner surface layer, it is more costly to make Blu-ray discs in that their manufacture requires new production facilities and new coating technology. However, Blu-ray holds more information and extra layers can be added.

Toshiba launched the HD-DVD player for US$936 in 2006 in response to the Blu-ray player introduced in 2003 for US$3815. With the help of a lower price, more HD-DVD players were sold than Blu-ray players; however, Sony incorporated a Blu-ray drive in the PlayStation 3 without increasing the console price. Thus, as of 2008, Blu-ray players outsold HD-DVD players by two to one. In terms of standalone players, however, HD-DVD outsold Blu-ray (400,000 to 300,000) because of lower prices (US$499 against US$299). It is argued that Sony's Blu-ray technology is superior to Toshiba's HD-DVD. Table 1 summarizes the features of each technology; although both formats have the same level of resolution and audio soundtrack, Blu-ray has a larger disc capacity.

Hollywood movie studios were very influential in setting a new standard of high-definition video. Most studios backed Blu-ray technology, favoring its larger capacity. In August 2007, however, Paramount Pictures and DreamWorks Animation announced that their DVD titles would be released exclusively on HD-DVD. But, as of October 2007, Blu-ray titles outsold HD-DVD titles by almost two to

Table 1. Blu-ray and HD-DVD comparison

Feature	DVD	HD-DVD	Blu-ray
Maximum native resolutions supported via HDMI	EDTV (480p)	HDTV (720p, 1080i, 1080p)	HDTV (720p, 1080i, 1080p)
Maximum image-constrained native resolutions supported via component video	EDTV (480p)	EDTV+ (960×540)	EDTV+ (960×540)
Disc capacity	4.7GB (single layer)	15GB (single layer)	25GB (single layer)
	8.5GB (dual layer)	30GB (dual layer)	50GB (dual layer)
		51GB (prototype triple layer)	100GB (prototype quad layer)
Video capacity (per dual-layer disc)	SD: approximately 3 hours	SD: approximately 13 hours	SD: approximately 23 hours
	HD: n/a	HD: 5.1 or 3.3 hours, depending on encoding method	HD: 8.5 or 5.6 hours, depending on encoding method
Audio soundtracks	Dolby Digital EX, DTS-ES	Uncompressed linear PCM, Dolby TrueHD, DTS-HD Master Audio, Dolby Digital Plus, DTS-HD High Resolution, Dolby Digital, DTS	Uncompressed linear PCM, Dolby TrueHD, DTS-HD Master Audio, Dolby Digital Plus, DTS-HD High Resolution, Dolby Digital, DTS
Manufacturer support (home theater)	All	Toshiba, LG, Thomson/RCA, Onkyo, Samsung	Hitachi, Mitsubishi, LG, Sharp, Sony, Panasonic, Samsung, Philips, Thomson/RCA
Manufacturer support (PC storage)	All	Microsoft, Intel, HP, NEC, Toshiba	Apple, Dell, BenQ, HP, LG, Panasonic, Philips, Pioneer, Samsung, Sony, TDK
Studio support	All	Paramount, Studio Canal, Universal, Warner (until end of May 2008), the Weinstein Company, DreamWorks Animation	Sony Pictures (including MGM/Columbia TriStar), Disney (including Touchstone, Miramax), Fox, Warner, Lions Gate
Compatible video game consoles	PlayStation 2, PlayStation 3, Xbox, Xbox 360	Xbox 360 (via external HD-DVD accessory, sold separately)	PlayStation 3
Player prices	US$99 and less	US$130 (Xbox 360 accessory); US$150 and more (stand-alone players); US$999 for combo player	US$399 (PlayStation 3); US$499 and more (stand-alone players); US$999 for combo player
Movie prices	US$6 and more (retail)	US$20–28 (retail)	US$20–28 (retail)

(*Continued*)

Table 1. (*Continued*)

Feature	DVD	HD-DVD	Blu-ray
Number of titles available at the end of 2007	50,000-plus	about 330	about 360
Players are backward compatible with existing DVD videos	Yes	Yes	Yes
Set-top recorders available now	Yes	No	No
'Managed copy' option	No	Yes	Yes
Copy protection/ digital rights management	Macrovision, CSS	AACS, ICT	AACS, ICT, BD+, BD-ROM Mark
Region-coded discs and players	Yes	No (currently; could change in future)	Yes

Source: HD-DVD Promotion Group (2007) and Blu-ray Disc Association (2008).

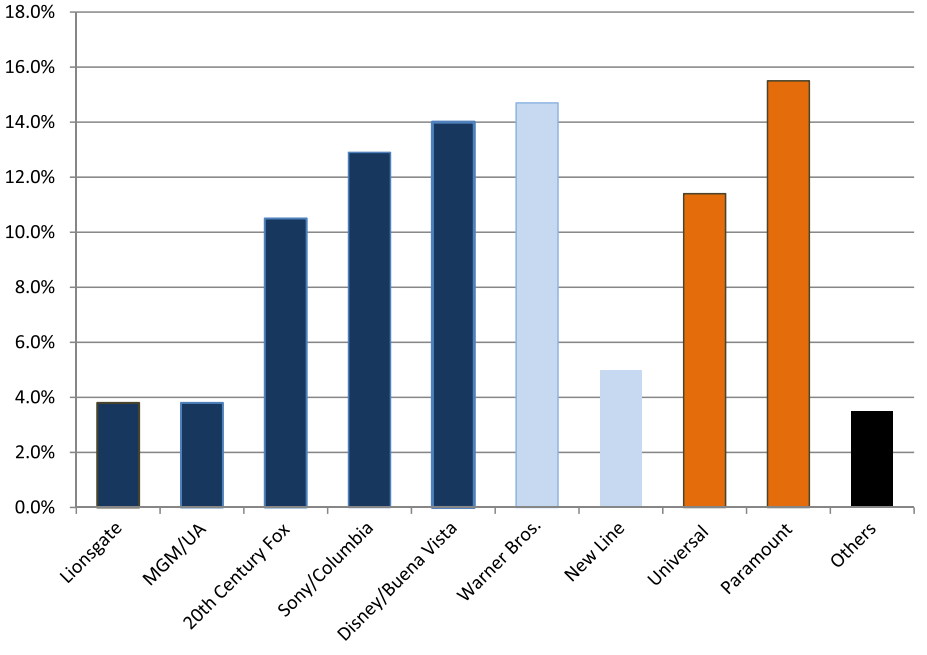

Figure 2. High-definition format alliance by studio (2007)
Notes: Dark gray=only Blu-ray; light gray=Blu-ray + HD-DVD; mid-gray=only HD-DVD.
Source: Box Office Mojo (2008) (boxofficemojo.com). (Available in color online).

one (2.6 million against 1.4 million). Movie studio support was balanced between the two formats until 2007. Figure 2 shows that about 45% of movie studios exclusively supported the Blu-ray format, 20% supported both formats, and only

27% exclusively supported HD-DVD. Then, in January 2008, the balance tipped towards Blu-ray after Warner Brothers, which initially supported both formats, announced exclusive support for Blu-ray. In February 2008, Toshiba halted production of HD-DVD players, ending the standards competition. Though the discs are slightly more expensive to produce and the players cost more, Blu-ray technology won the competition mainly because of the support of four of the largest Hollywood movie studios.

Historical significance at Sony

Table 2 is a snapshot of the three standards wars in terms of Sony's sales. In 1976, Sony introduced Betamax and in 1977 VHS was introduced. The ensuing standards war lasted until 1985, when VHS obtained a 90% market share. We see from the table that, although Sony lost the standards war in 1985, video sales represented a 981% increase over 1976. In 1990, two different disc standards were announced: MMCD (Sony and Philips) and SDD. By 1995, a new format – DVD – was adopted by all. Although, the DVD outcome cannot be called a war *per se*, it appears as though Sony lost a battle as their 1995 video sales dropped 20% from 1990. This fact is borne out by a comment made by Sony president Koichi Tsujino: 'With DVDs, we invested a huge amount in development and competitors walked away with the profits' (Nakamoto and Burt, 2003). A different story emerges when we look at the birth of Blu-ray in 2003 and the explosion of video sales in 2008, representing a 62% increase over 2003 (PlayStation 3 includes a Blu-ray player). If we examine the last two columns in Table 2, we see that Sony's total net sales jumped 207% from 1976 to 1985, by 24% from 1990 to 1995 and by only 3% from 2003 to 2008. However, Kunii (2002) states that analysts were expecting a 40% reduction in operating profits, while Sony's market capitalization fell from about US$130 billion in 2000 to US$42.4 billion in 2002. Clearly, the pictures for Sony's growth, profitability and market capitalization have been questionable for some time. A major issue facing the company is that hardware innovations are easy to copy in a digital environment. Game consoles and music are the most profitable divisions in Sony, while profit in electronics is slim or non-existent (Kunii, 2002). Thus, building market share in consumer electronics is difficult, especially when competitors can copy new products easily and cheaply (Kunii, 2002; Nakamoto and Pilling, 2003).

Table 2. Sony sales of video and related equipment and total net sales for selected years

Timeframe	Year	Video sales	Change	Total net sales	Change
Betamax introduction	1976	47,692		463,528	
Standard war winner (VHS)	1985	515,531	981%	1,420,785	207%
MMCD and SDD announced	1990	908,399		3,695,508	
DVD common format	1995	731,097	–20%	4,592,565	24%
First Blu-ray sold	2003	949,261		7,496,391	
Standard war winner (Blu-ray)	2008	1,540,561*	62%	7,729,993	3%

Note: *Includes video and game console sales.
Source: www.sony.net.

Strategic options in standards competition

First-mover advantage

First-mover advantage is defined as the ability of pioneering firms to earn positive economic rents (Lieberman and Montgomery, 1988). With its initial resources and learning through production, the first mover can maintain cumulative advantages (or increasing returns) over later movers and establish market dominance. Several sources of first-mover advantage exist. Lieberman and Montgomery (1988) group them into three broad categories: technological leadership, pre-emption of assets, and consumers' switching cost.

A first mover can gain technological leadership through learning by doing, lead time over later entrants, and patents from R&D races. It can also gain advantage by pre-empting rivals in the acquisition of scarce assets, such as physical resources, process inputs, and geographical space. As consumers accumulate experience with the first mover's products, they are less willing to switch to other technologies, and late entrants have to invest extra resources to lure customers away from the first mover (Makadok, 1998). Although switching costs are low in some internet-based markets where consumers can easily click away from the first mover's products (Porter, 2001), they may be quite high for markets with experience goods, such as home video players (Agarwal and Gort, 2001).

On the other hand, late entrants may benefit from the first mover's experience (second-mover advantage) because late movers can free-ride on the first mover's investments in R&D, buyer education, and infrastructure development. They can glean better information about buyer preferences and have more time to plan for manufacturing, distribution, licensing, or the use of complementary products and services (Cusumano *et al*., 1992). If the market is new and uncertain, the first mover faces a high degree of risk, and early introduction can entail compromises in quality and a greater incidence of bugs. The weakness of the first-mover advantage is often enhanced by what is called 'incumbent inertia'. If a firm is locked into a specific set of fixed assets, the firm may be reluctant to expand product lines or it may become organizationally inflexible (Lieberman and Montgomery, 1988).

VCR market

In the VCR standards competition, Sony aggressively pursued a first-mover advantage by introducing its Betamax format first. Its rival, Matsushita, entered later with a focus on its manufacturing and marketing capabilities by investing in manufacturing capacity to capitalize on rapid market rapid growth (Cusumano *et al*., 1992). Lieberman and Montgomery (1988) argue that early entry is likely to be a desirable strategy for firms whose relative skills are in new product development, whereas firms with relative strengths in marketing and manufacturing may prefer to enter later. The strategies of the two rivals in the VCR standards competition conform to this argument.

In terms of technological leadership, it is argued that the technological differences between Betamax and VHS formats were minor because both technologies derived from the common u-matic technology (Cusumano *et al*., 1992). By introducing a premature technology with a short playing time and high price, Sony could not gain a technological advantage in design and manufacturing as a first mover. The follower (Matsushita) could quickly neutralize Sony's technological

advantage by providing a more consumer-oriented product with a longer play time.

Consumer switching costs could have favored Sony's early introduction of Betamax if the installed base had increased rapidly. However, that did not occur. Though Matsushita quickly dominated the market and captured more than half of the market share in 1978, a year after it introduced VHS, Sony's sale of Betamax-format product steadily increased until the early 1980s. The increased market of the VHS format was mainly driven by new consumers, rather than switching of existing consumers. Overall, the first-mover advantage does not explain the dominance of the VHS format in the VCR market competition. Sony could not capitalize on its first-mover advantages, such as technological leadership, pre-emption of scarce resources, or switching costs. The standards competition in the VCR market must be explained by factors other than first-mover advantage.

High-definition video market

Sony was again the first mover, ahead of Toshiba, in the high-definition home video competition. As in the VCR format competition, Sony was known for innovation and entrepreneurial vision, with many new products (the transistor radio, Walkman, Trinitron TV). Toshiba's relative advantage was in manufacturing and marketing. Table 3 demonstrates Sony's consistent patent filing activity since 2001, while Toshiba is not among the top five patent filing firms for HD-DVD. It is interesting to note that Samsung was the top patent filer from 2000 to 2007 in both formats. Why did Samsung not take advantage of their lead in patents to lead the standards war?[1] The reason, as far as we can tell, is related to core patents. While one could argue that Samsung had already caught up with Sony in terms of the number and quality of patents in 2003 (Joo and Lee, 2010), the firm did not invent Blu-ray or HD-DVD. Thus, the patents held by Sony for Blu-ray and Toshiba for HD-DVD pertained to the core technologies of both formats. Furthermore, in the DVD format competition, Toshiba developed the SD format and Sony developed the MMCD format. The DVD standard was something of a compromise in that it used some technology from MMCD, but was primarily based on Toshiba's SD format (Economist, 2004). So, as a newcomer to the Blu-ray–HD-DVD format war, Samsung was intent on being on the winning team. The company played on both sides, while awaiting the outcome. The proof of this assertion is that Samsung had the greatest number of Blu-ray (61) *and* HD-DVD (79) patents.[2] (Appendix B provides a detailed discussion of how patent statistics were compiled.)

The two technologies (Blu-ray and HD-DVD) were significantly different. As mentioned, one main difference was storage capacity (Table 1). A higher capacity disc enables software firms to create higher quality home video on disc, and provides some room for innovative software (not limited to director or actor interviews, deleted scenes, etc.). Therefore, storage capacity could be seen as a potential leading factor in the high-definition standards competition. The first mover may attempt to deter entry of late entrants through strategies of pre-emption. Sony was better positioned to establish geographic entry and/or shelf space dominance with an early introduction of the Blu-ray player. However, its high price (US$3815 at its introduction in 2003) limited the adoption of its technology and Sony could not pre-empt easily. The high price also limited switching behavior. When consumers perceive technological uncertainty on experience goods, such as Blu-ray or HD-DVD

Table 3. Top five firms filing Blu-ray and HD-DVD patents in United States by year

	Year								
Blu-ray	2000	2001	2002	2003	2004 (patent count)	2005	2006	2007	Total
Koninklijke Philips Electronics N.V.	1	2	3	10	3	1			20
LG Electronics Inc.				13	11	1			25
Matsushita Electric Industrial Co., Ltd			1	20	23	4	8		56
Samsung Electronics Co., Ltd				16	14	12	13	6	61
Sony Corporation		3	2	4	11	13	9	1	43
Total	*1*	*5*	*6*	*63*	*62*	*31*	*30*	*7*	*205*
HD-DVD									
General Electric Company		1	1	3	3				8
LG Electronics Inc.	2	3	4	4	1		1		15
Matsushita Electric Industrial Co., Ltd	1	2	2	2	3	1	3		14
Samsung Electronics Co., Ltd	14	12	11	10	11	5	11	5	79
Target Technology Company, LLC					2	3	3		8
Total	*17*	*18*	*18*	*19*	*20*	*9*	*18*	*5*	*124*

Source: United States Patent and Trademark Office (2008).

players, they resist adoption (Kalish and Lilien, 1986; Carpenter and Nakamoto, 1989). In sum, Sony did not win the standards war because of first-mover advantage. Technological leadership through learning by doing or pre-emption of scarce resources was not observed, and switching costs were prohibitive. Other factors played a role (see below) in Sony's success in the standards competition.

Indirect network effects and software provision

In such industries as information and consumer electronics, a firm's success in introducing a new product depends on the network effect. Katz and Shapiro (1985) distinguish between direct and indirect network effects. Direct network effects arise where the number of purchasers helps determine the value of the product. A typical example is a telephone network in which the value of a telephone directly depends on the number of other consumers (size of installed base) who have joined the network. For indirect network effects, the value of a product does not depend directly on the physical effect, but indirectly on the availability of complementary products, such as movies or software.

Indirect network effects are pervasive in the computer and home video market because of the interdependence between hardware and software. Church and Gandal (1992) claim that software availability needs to achieve a critical mass for hardware sales to escalate. Furthermore, the size of the network associated with exclusive hardware often influences the outcome of standards competitions (Ohashi, 2003). Indirect network effects give rise to a chicken and egg paradox in which consumers wait to adopt the hardware until enough software is available, and software manufacturers delay releasing software until sufficient consumers have adopted the hardware (Gupta *et al*., 1999; Caillaud and Jullien, 2003). Hardware firms and software firms need to invest in market creation and break the deadlock, but coordination among firms often proves difficult (Katz and Shapiro, 1994; Gupta *et al*., 1999).

VCR market

The main objective of early VCR adopters was time-shifting for TV programs or sports (to view programs at a later time). In the United States in the late 1970s, three-quarters of all VCR owners bought no pre-recorded tapes (Cusumano *et al*., 1992). In 1978, RCA formed an alliance with Magnetic Video Corporation of America and gave each VCR purchaser two free pre-recorded MV programs. Sony matched this move in 1979 by linking with Video Corporation of America. Video rental shops began to expand in the early 1980s, and sales and rentals of movie titles grew rapidly, doubling each year from 1982 to 1986 (Park, 2004). The standards war between VHS and Betamax was already over by 1981–1982, and by the time Sony realized it was falling behind, it was too late to overcome the disadvantage (Ohashi, 2003).

Given this trend in pre-recorded movies, the indirect network effect through the provision of complementary products does not fully explain the dominance of the VHS format, at least not in the early stage of distribution in the 1970s. Since the 1980s, there has been almost no significant difference between the two formats in performance, features, or price. The widespread availability of pre-recorded programs in VHS format since the mid-1980s may have increased the sales of VHS players; in fact, Ohashi (2003) shows a significant indirect network effect during

this period. However, the market dominance of the VHS format started in 1978, before pre-recorded movies were widely available. The VHS format overtook the Betamax format in market share in 1978 (57% against 43%), and the gap had widened by 1981 (72% against 28%). Thus, we can argue that the role of an indirect network effect was not significant in the early adoption of the VHS format.

High-definition video market

In an analysis of the standards competition in the high-definition home video market, it is important to examine the behavior of software firms and Hollywood movie studios. Instead of recording, the main use of high-definition video is to play pre-recorded movies. Table 4 shows Hollywood studio market share by year. In 2004, Blu-ray support (from Buena Vista, Sony Pictures, and 20th Century Fox) amounted to 37% of the market, while HD-DVD support (from Paramount Pictures, Warner Brothers, Universal and New Line) was 34%. The studios' decision to support either format wavered because it was easy for them to use a new format. Consequently, the studios changed their decision several times up to 2008, when a decisive move was made. In January 2008, Warner Brothers announced that it would stop issuing HD-DVD movies, essentially ending the standards competition. After the Warner Brothers announcement, only two major movie studios (Paramount and Universal) exclusively supported HD-DVD, and their combined share in the studio market at the end of 2007 was only 27%. A few days after the Warner Brothers announcement, Wal-Mart announced that it would phase out HD-DVD. When making an adoption decision, consumers form expectations about the availability of software in each format. Movie studio support is critical to the decision, and it is argued that the indirect network effect played a critical role in the high-definition standards competition.

Strategic alliances with hardware firms

While hardware firms in a standards competition strive to capitalize on the indirect network effect by attracting a large network of software providers, they also establish strategic alliances with other hardware firms to gain a larger installed base in the hardware market. This incentive can be explained by the direct network effects in which a firm tries to establish a larger network in the early stage of systems

Table 4. Top seven Hollywood studio market share by year

Distributor	2000	2001	2002	2003	2004	2005	2006	2007
Paramount Pictures	10.57	11.00	7.46	7.09	6.73	9.28	10.21	15.67
Warner Brothers	11.45	14.85	11.70	12.60	13.16	16.26	12.70	14.77
Buena Vista	14.94	10.93	12.78	16.76	12.47	10.38	16.00	13.99
Universal	14.62	11.48	9.74	11.78	9.77	11.20	8.69	11.41
Sony Pictures	11.69	8.87	16.80	12.84	14.27	8.53	16.69	10.72
20th Century Fox	9.82	10.55	10.69	8.88	9.87	15.27	14.99	10.53
New Line	5.03	7.15	9.77	10.04	4.25	4.72	2.71	5.06
Other	21.88	25.17	21.06	20.01	29.48	24.36	18.01	17.85
Total	100	100	100	100	100	100	100	100

Source: Nash Information Services (2008).

competition. In addition to strategic alliances, heavy promotional spending and deep discount offers were also crucial in creating positive feedback in the home video market.

Competition in network markets is likely to lead to standardization on a single technology because a small initial advantage will influence consumer expectations about the adoption of a particular standard (Arthur, 1989; Gandal, 2002). Consumer expectations are self-fulfilling, and an early lead can be transformed into an advantage that is difficult to overcome. Penetration pricing is a common tactic to build an installed base quickly.

VCR market

One of Sony's Betamax mistakes was not securing hardware company support, which is akin to 'family' support (Morita, 1986). Sony independently introduced the Betamax format player without collaborating with other firms, and it was reluctant to build Betamax VCRs for its licensees to distribute under their own labels. Believing in its own superiority in technology, Sony was unwilling to compromise on the Betamax standard or to support potential licensees with original equipment manufacturer (OEM) shipments (Cusumano *et al*., 1992). In addition, Sony was slow in licensing its technology to other firms.

On the other hand, Matsushita followed a strategy aimed at forming a large family by aggressively pursuing both licensees and OEM shipments. In 1976 and 1977, the VHS format was supported by Hitachi, Mitsubishi and Sharp in Japan, several small firms in Europe, and RCA in the United States. This allowed partners to share in the development of improved VHS technology in ways that JVC might not have pursued itself. The outcome of collaborative development with other firms provided a model with two hours of play time, in contrast to Sony's one hour. Strategic alliances enabled low-cost manufacturing and mass distribution capacity, thus supplying lower-priced VHS machines. The aggressive marketing of less expensive VHS machines led to the rapid development of hardware products, contributing to positive feedback with network effects.

High-definition video market

A decade ago, Sony's new President, Kunitake Ando, was a strong proponent of alliances (Kunii, 2002). Bremner (2005) praised the company for forming alliances with Samsung, Panasonic, Dell, and Disney, stating that 'partnerships speed up product development'. Sony learned from its mistake of not having an alliance of firms supporting its technology, and took a different approach with Blu-ray. Blu-ray and HD-DVD technologies are similar in function, but they are technically different in terms of manufacturing processes. Hardware firms had to make irreversible capital investments in one technology. HD-DVD players could be made in existing DVD player production facilities, and it was therefore attractive for hardware firms to commit to HD-DVD. Initially, LG, Matsushita, Philips, Pioneer, Samsung, and Sony committed to Blu-ray, and Intel, Microsoft, NEC, and Toshiba committed to HD-DVD. Sony actively formed alliances with hardware firms by providing attractive licensing terms. Since the manufacturing hardware firms assumed significant risk in this standards war, they had an incentive to delay their capital investment. Some firms used a hedging strategy; two manufacturing firms (LG and Samsung)

developed a player that offered both Blu-ray and HD-DVD formats. In addition to establishing strategic alliances with hardware firms, Sony included a Blu-ray drive in its PlayStation 3 gaming console, thus rapidly increasing the installed base. By the end of 2007, 400,000 HD-DVD and 300,000 Blu-ray standalone machines had been sold. PlayStation3, however, had sales of 1.8 million units.

Conclusion

Price and quality are the primary strategies in a traditional competitive environment (Porter, 1980). The addition of industry standards and complementary networks significantly complicates matters. Cusumano *et al*. (1992) shows how competitive strategies can control the dynamic power of the mass-consumer market to the advantage of a second-mover with extensive technological skills, but with a weak starting position in manufacturing and distribution capabilities. This paper presents an historical analysis of the US high-definition home video industry. The paper focuses on first-mover advantages and network effects. The high-definition home video industry and the home video game industry studied in Gallagher and Park (2002) offer great potential for theoretical development and validation of existing theoretical claims. There are clear market leaders and followers, and rapid technological change in the industry. The complex interaction of factors means that there is no easy way to predict the outcome of standards wars.

Our key assertion is that success in the high-definition home video industry required more than just technological innovation or being a first mover. Technological innovation is essential, and a first-mover advantage is helpful, but not sufficient, in establishing a dominant market position. Once a new format standards war begins, the strategic focus shifts from technological innovation to traditional competitive strategies in order to build a network of complementary products and an installed base. Historical evidence shows that Sony created a winning alignment of Blu-ray producers from the beginning because of the way its managers established alliances, which differed from the first home video competition, when Sony pressed commitment and reputation. This alliance resulted in significant added benefits in addition to the network alliance of complementary firms for Blu-ray. Consequently, an effective winning strategy in a standards war appears to be building a network of complementary products and subsequently an installed base.

Our argument partially supports the traditional notion of first-mover advantage, but this is important only until first movers develop a network of complementary products. We conclude that building a network of complementary products and an installed base should be the primary goal. For R&D, network effects were also important in gathering major hardware firms to invest in one technology. Sony began licensing Blu-ray technology earlier than HD-DVD, and the patents filed for Blu-ray were clustered in Japan, where the technology originated. This may have yielded advantages for Blu-ray technology in terms of knowledge spillover. In the final contest, the Warner Brothers decision provided direct evidence to draw conclusions about standards competition. The alliances that Sony formed for production and distribution proved to be the decisive factors in the triumph of Blu-ray over HD-DVD.

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Notes

1. We are grateful to an anonymous referee for asking this question.
2. Samsung may have held most patents, but this does not mean that all the patents were valuable. The value of patents is highly skewed, with about 90% being worth little (*cf.* Scherer *et al*., 2000).

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Appendix A. Blu-ray and HD-DVD chronology 2000–2008

Table A1. Blu-ray and HD-DVD chronology 2000–2008

Year	Date	Description
2000	5 October	DVR Blue unveiled at Japan's Ceatec show by Sony and Pioneer. Format goes on to form basis for first-generation Blu-ray disc BD-RE.
	1 November	Sony announces development of ultra density optical.
2002	19 February	Led by Sony, nine of world's largest electronics companies unveil plans for Blu-ray.
	29 August	Toshiba and NEC propose HD-DVD to DVD forum.
	1 October	Prototypes of both formats unveiled at Japan's Ceatec exhibition.
2003	13 February	Licensing of Blu-ray disc begins. Producers pay US$20,000 to license Blu-ray while content-protection system license carries US $120,000 annual fee and additional charge of US$0.10 per player. Media makers pay US$8000 annually and US$0.02 per disc for the copy protection system.
	7 April	Sony announces its Blu-ray disc-based professional disc format for data archiving applications.
	10 April	Sony markets world's first Blu-ray disc recorder, the BDZ-S77, based on 23GB cartridge version of BD-RE disc costing 450,000 yen.
	28 May	Mitsubishi Electric joins the Blu-ray disc group.

(*Continued*)

Table A1. (*Continued*)

Year	Date	Description
2004	7 January	Toshiba unveils first prototype HD-DVD player at CES (backwards compatible with DVD).
	12 January	Hewlett-Packard and Dell put their support behind Blu-ray disc.
	10 June	The first commercial version of HD-DVD-ROM is approved by the DVD forum.
	21 September	Sony announces that PlayStation 3 will use Blu-ray disc.
	29 November	Paramount Pictures, Universal Pictures, Warner Brothers Pictures, HBO, and New Line Cinema announce support for HD-DVD.
	9 December	Disney announces support for Blu-ray disc.
2005	7 January	Backers of both formats promise players and movies in North America by the end of the year. Did not happen.
	21 April	Sony and Toshiba begin discussions on the possibility of a single format. Talks fail.
	18 August	Lions Gate Home Entertainment and Universal Music Group decide to back Blu-ray disc.
	27 September	Microsoft Corp. and Intel Corp. support HD-DVD.
	3 October	Paramount Home Entertainment says it will offer movies on both HD-DVD and Blu-ray disc.
	16 December	Hewlett Packard decides to drop exclusive support for Blu-ray disc and back both formats.
2006	4 January	At CES, Bill Gates announces Microsoft will offer add-on HD-DVD drive for Xbox 360 console.
	10 March	Blu-ray disc-supporter LG Electronics shocks industry with development of HD-DVD drive.
	31 March	Toshiba launches the world's first HD-DVD player, the HD-XA1. It cost 110,000 yen (US$936 at the time) in Japan.
	11 November	Sony's PlayStation 3, containing a Blu-ray disc drive, goes on sale in Japan.
	29 December	Hackers break through part of the AACS copy protection on both HD-DVD and Blu-ray disc.
2007	7 January	Seeking to end the battle, LG Electronics unveils a dual-format player, while Warner Brothers shows a prototype disc that holds both an HD-DVD and Blu-ray disc layer compatible with players for both formats.
	17 April	Sales of HD-DVD players in North America hit 100,000 since launch.
	1 August	Microsoft cuts the price of its HD-DVD player for the Xbox 360 from US$199 to US$179 and starts offering five free movies.
	20 August	Paramount and Dreamworks Animation both drop Blu-ray disc in favor of HD-DVD.
	13 September	Sony says it will use Blu-ray disc in all high-definition video recorders in Japan.
	7 November	Price of Toshiba HD-DVD players drops to US$100 with rebates as Christmas season begins.
	11 November	Sony begins selling a lower cost version of the PlayStation 3.
2008	4 January	Warner Brothers to stop issuing HD-DVD movies and rely exclusively on Blu-ray disc. In response, the HD-DVD Promotion Group cancels its CES news conference.
	14 Jnauary	Toshiba cuts the price of HD-DVD players. Retail price of HD-A3 US$150.
	11 February	NetFlix and BestBuy say they will phase out HD-DVD.
	15 February	Wal-Mart, the world's largest retailer, says it will phase out HD-DVD by June.

(*Continued*)

Table A1. (*Continued*)

Year	Date	Description
	16 February	Public broadcaster NHK reports Toshiba halts production of HD-DVD players. *Nikkei Business Daily* says Toshiba to stop developing the format any further.

Source: Adapted from Williams (2008).

Appendix B. Extraction of patent data

Patent data used in this study were extracted from the US patent and trademark office webpage. The patent data available on the website contain detailed technological information which is important for engineers. The website provides sufficient technological and performance specifications of each patent developed by each assignee. Moreover, it also contains some straightforward, helpful information for the purpose of this study. The data were extracted using three fields – title, abstract, and description – available from the advanced patent search query webpage. Typically, Blu-ray technology is classed under five main patent names, representing its evolution: Blu-ray, BD-RE, UDO, BDZ and dvr-blue. Patent data were extracted if any of the five names of Blu-ray were included in the three fields mentioned above (Table B1). It is a remarkably complete dataset for the industry; not a sample of firms, but complete high-definition home video market patent information. HD-DVD is primarily known by two different names: HD-DVD and AOD. Similarly, the same method used for Blu-ray was used to extract patent data for HD-DVD.

Table B1. Patent search queries

Blu-ray	HD-DVD
((TTL/((((blu-ray OR bd-re) OR udo) OR bdz) OR dvr-blue) OR ABST/((((blu-ray OR bd-re) OR udo) OR bdz) OR dvr-blue)) OR SPEC/((((blu-ray OR bd-re) OR udo) OR bdz) OR dvr-blue)	((TTL/(AOD OR hd-dvd) OR ABST/(AOD OR hd-dvd)) OR SPEC/hd-dvd)

Blu-ray patent terms, such as UDO (Ultra Density Optical) and BDZ, have applications in areas other than Blu-ray. For instance, 'Udo' is a person's name in German, a type of plant, and it also can stand for User Device Operation. Likewise, BDZ can mean an abbreviation for benzodiazepines in chemistry, or it can be used in finance as differentials.

Similarly, the HD-DVD term, AOD (Advanced Optical Disc), has meanings other than HD-DVD. Specifically, AOD is an abbreviation for Argon Oxygen Decarburization in chemistry. Subsequently, any patents unrelated to HD-DVD *per se* were removed. Since Blu-ray is a subset of the HD-DVD term, some patent data extracted for HD-DVD included Blu-ray in the patent information. Hence, patents with the Blu-ray term in title or abstract were queried, manually inspected, and removed if they did not satisfy the criteria. Ultimately, the entire patent dataset for our study was individually inspected for inclusion. Inspecting the title and abstract of each patent allowed irrelevant Blu-ray or HD-DVD patent data to be removed. Where patent data were insufficient to determine eligibility, claim and description of the patent were followed up. We decided if the patent data included any of the following terms then they were retained in our study: data, optical, medium, conductor, motion picture, signal, music, video; otherwise, the patent was removed. Patents that were included in both Blu-ray and HD-DVD were re-inspected for eligibility of being included in both datasets, and irrelevant ones were removed.