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# Why Blu-ray vs. HD-DVD is not VHS vs. Betamax: The Co-evolution of Standard-setting Consortia

by

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# WHY BLU-RAY VS. HD-DVD IS NOT VHS VS. BETAMAX: THE CO-EVOLUTION OF STANDARD-SETTING CONSORTIA

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Extensive research has been conducted on the economics of standards in the last three decades. To date, standard-setting studies emphasize a superior role of demand-side-driven technology diffusion; these contributions assume the evolution of a user-driven momentum and network externalities. We find that consumers wait for a dominant standard if they are unable to evaluate technological supremacy. Thus, supply-side driven activities necessarily need to address an absence of demand-side technology adoption.

Our paper focuses on Blu-ray vs. HD-DVD as an illustrative case of consortia standard wars. One central role of consortia is to coordinate strategic behavior between heterogeneous agents, e.g. incumbents, complementors (content providers) and others, but also to form a coalition against other standard candidates. More precisely, we argue for signalizing activities through consortia events. We depict the essential role of consortia structures for the recently determined standard war between the High-Definition disc specifications Blu-ray and HD-DVD. Therefore, the paper suggests that unique supply-side dynamics from consortia structures, consortia announcements and exclusive backing decisions of firms determined the standard-setting process in the Blu-ray vs. HD-DVD standard war.

This study is based on the following data: movie releases and sales numbers, membership affiliation for structural consortia analysis, and an in-depth event study. A detailed comparison of the technological specifications of both standard specifications supports our argument that there was no technological supremacy of one standard candidate from a consumer-oriented use-case perspective. We furthermore clarify that content providers (complementors) such as movie studios and movie rental services feature a gate-keeping position in the Blu-ray vs. HD-DVD standard war. In the case of Blu-ray, film studios decided the standard war because the availability of movie releases, but not technological supremacy, made the standard attractive to consumers.

Finally, we find that there is a co-evolution of the consortia in terms of membership dynamics. Particularly, firm allegiance of heterogeneous agents plays a crucial role.

JEL: B52, D84, L15, O33

Key words: Blu-ray, HD-DVD, standard wars, co-evolution, consortia, event study

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# 1 Introduction

Several studies on standard diffusion in consumer technologies have been conducted in the last three decades, for instance, VHS vs. BETAMAX (Arthur, 1990; Arthur, 1997; Liebowitz and Margolis, 1995; Park, 2004), DVD-RW vs. DVD+RW/DVD-RAM (Van Wegberg, 2004), and DIVX vs. DVD (Dranove and Gandal, 2003). Blu-ray and HD-DVD represent standard candidates developed to replace the 1995 DVD-standard. Blu-ray (Blu-ray Disc Association) was initiated by Sony. HD-DVD (HD-DVD Promotion Group) was originally developed by Toshiba and NEC; the HD-DVD specification was then approved by the DVD Forum.[1] The two formats increase storage capacity so that a disc can store an entire film at HDTV resolution. High definition television (HDTV) increases the maximal 16:9-screen resolution up to 720p, 1080i or 1080p ('p' for progressive, not interlaced resolution), which supports large plasma displays and LCD screens. For comparison, the existing DVD standard is limited to 480p (DVD Enhanced Definition format) and is thus not sufficient for recent technological developments in consumer electronics. Until today, HDTV mainly dominates the Japanese and US market; in some countries of Asia and in Europe it is rather in an early diffusion stage.

Shapiro and Varian (1999, p. 8) describe standard wars as "battle for market dominance between incompatible technologies." Such war takes place between firms (e.g., Microsoft against Netscape on internet browsers, or Matsushita against Sony on VHS/Betamax). It may be a battle of single technologies, but also a battle of product systems (cf. Shapiro and Varian, 1999). Furthermore, there is a well established body of literature on path dependency and technological lock-in by historical events (increasing returns, positive feedbacks, and ergodic systems; particularly cf. Arthur, 1989, 1990). Farrell and Saloner (1985) discuss lock-ins related to technology life-cycle. Markets with network effects and thus positive returns (cf. Katz and Shapiro, 1986, 1992; Shy, 1996; van Wegberg, 2004) are characterized by path-dependent processes of technology adoption; these authors also address the means of compatibility for the consumer. Furthermore, Liebowitz and Margolis (1995) argue that not only a superior technology, but also inefficient technologies may become a standard. Although most studies on standard-setting processes are empirically based on information and consumer technologies such as internet technologies or mobile phone technology (e.g., Andriew, 2008; de Vries et al., 2008; or Leiponen, 2008), contemporary research also looks at standard-setting processes in more traditional industries (e.g., Gerybadze, 2008; Gerybadze and Slowak, 2008; Schweikle, 2009). Standards within this paper shall be defined as the specification of technology with the purpose to integrate knowledge into products. Standardization shall describe the outcome of that standard-setting process, that is, dominant design within the industry or unification of different technological approaches between co-operating agents.

More recently, some studies have looked at the arrangement of agents who are involved in a particular standard war. For instance, Economides and Skrzypacz (2003) argue for a two-stage game: firms bargain to form consortia ("coalitions") until equilibrium is reached so that a specific profit equation holds and until the division of surplus is clearly specified.[2] Contemporary innovation studies provide evidence for a rise of collaborations among firms, e.g.

research and development alliances, standard-setting consortia or other kinds of inter-firm co-operation. Nonetheless, there is little research on how consortia's collaborative behavior is unfold and how the activities of one consortium in standard wars shape or relate to the activities of competing and complementary consortia. Our in depth case study on Blu-ray vs. HD-DVD demonstrates how recent standard wars occur between coalitions, respectively consortia, rather than between single firms, and what drives consortia dynamics. Standard wars today are underpinned by evolutional structural dynamics and events which (re)shape the value of standard technology in the course of time. Furthermore, we show that the interplay between complementors (content providers) and incumbents drives supply-side standard-setting dynamics. In our view, the supply-side is characterized by a population of generally competing, only temporally co-operating consortia. The demand-side is characterized by waiting consumers; more precisely, we assume that a 'sit-and-wait-strategy' is optimal in the face of technological non-supremacy and incompatibility of both standard candidates. Note that technological non-supremacy is paired with uncertainty about demand-side network effects. We conceptualize co-evolution among consortia as competition for limited assets, strategic positions, and crucial market access (e.g. movie studios, video game industry), where we find intra-system cooperation and inter-system aggression (for a formalized model see Albornoz and Parravano, 2009). In this respect, we analyze activities of firms/consortia in historical time and assume that agents exploit their experience from past standard wars.

Given that contemporary standard wars take place between consortia and not between single firms, the paper addresses the issue whether recent standard wars (in consumer electronics) are decided by technological supremacy, which would then lead to a quick adoption rate by consumers. If not, we ask what kinds of mechanisms and events essentially determine technology adoption.

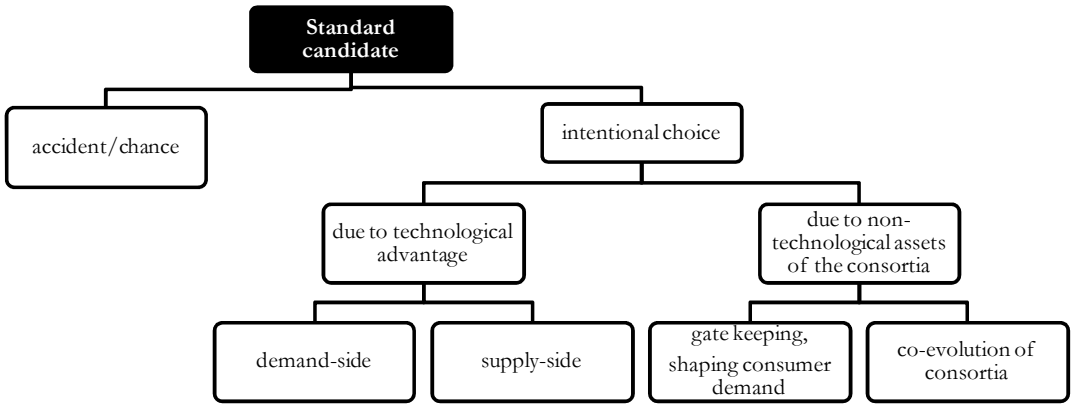
The structure of this paper is as follows. Chapter two gives a brief literature survey on standard wars and technology adoption, including an overview on consortia literature related to standard-setting. Moreover, we conceptualize the structure of a typical standard-setting consortium in consumer electronics. Chapter three then highlights the peculiarities of the recently determined Blu-ray vs. HD-DVD standard war by means of market share analysis, in-depth analysis of technological specifications and the structure of both HD-consortia. Chapter four then introduces our analysis of consortia dynamics, crucial announcements and firm or consortia decisions that seem to be important for a detailed understanding of the case; it also provides a social network illustration and contributes with an in-depth event study. Chapter five concludes this study.

## 2 The Role of Standard-Setting Consortia

Consumers face a coordination problem when choosing a standard as they do not know whether expected network benefits will be realized (Gandal, 2002, p. 81). Nonetheless, complementors may expect consumers to join the network first, while consumers' adoption decisions depend on available complementary goods such as software for hardware systems (referred to as "chicken-and-egg" problem, e.g. cf. Gandal, 2002). This is particularly true when

competing standard candidates are similar in technology, when they address a similar use case and features provided do not differentiate them. Gandal (2002) also asks how standards should be set – by competition/de facto, by voluntary industry consensus or, as mandatory. Concerning optimal economic selection choice of standards, we need to account for rates of technological change, antitrust issues, but also the role of intellectual property in standard negotiation. Figure 1 illustrates the different streams of research on standard wars, whereas intentional members' choice of consortia due to non-technological assets is a new field of study.

*Figure 1: Research on Standards Wars*




Although there are some studies which stress the rise of consortia for setting de-facto standards ("consortia movement"), there is little in-depth research on how consortia interact or, on their evolution in terms of social networks in the course of time.

Diffusion of technologies, essentially by standard wars between incompatible technologies in the Entertainment industry, has been extensively studied in terms of competition driven by either technological superiority or demand-side network effects. Technological superiority of the Video Home System (VHS) in some attributes particularly determined the BETAMAX decline. Members of the BETAMAX consortium were Sony, NEC, Toshiba, Sanyo, Fisher, and Wega. VHS was developed by Victor Company of Japan (JVC) which is part of Matsushita Electric. ). The use case of both standard candidates was about to offer films on a media which consumer could take along. In order to compensate the BETAMAX one year first mover advantage, JVC made early licensing agreements with General Electric, Philips, NEC, Toshiba, RCA and Sanyo. However, literature does not refer in detail to the dynamics of the VHS versus BETAMAX-consortia structure. According to Liebowitz and Margolis (1995) and opposed to Arthur (1990), the VHS-BETAMAX standard war (1973-1984, won by VHS) represents neither an inefficient outcome nor supremacy by chance. Furthermore, even though the tiny tape size of BETAMAX was designed by SONY to satisfy a 'to-go' attribute to consumers, the technology failed to sweep along a critical mass in the long run, although the format initially kept a majority of market share (Park, 2004). Every year, from 1978 on, BETAMAX was outsold by VHS. VHS speeded their product development to provide 4 hours, respectively 6 hours of recording time, whereas Sony's BETAMAX could only provide half of it (finally 5 hours in the late 1980s). In the 1980s, consumers used VCRs mainly to record TV programs. However, many programs

such as sport events and movies required more than 2 hours of play time. Although SONY increased efforts to enhance playtime after an initial inferiority compared to JVC's VHS tape length,[3] markets anticipated play time as a disadvantage of the BETAMAX format throughout the entire standard war. Even though the VHS-BETAMAX war was also influenced by strategic behavior (licensing, cooperation and pricing strategies), technological supremacy determined its outcome (Liebowitz and Margolis, 1995). Note that technological supremacy of VHS was possibly not only achieved by tape length, but also other – technological – factors. Some authors particularly argue for superior image quality of VHS (Park, 2004; Katz and Shapiro, 1994). In contrast to well-established studies on standard wars, but in line with recent research on collaborative R&D consortia, we look for strategic behavior of co-operating firms rather than for technological supremacy or for the single firm's strategic behavior at product markets. The case of Blu-ray/HD-DVD differs from well-established literature on network effects and standard wars because contrary to VHS/BETAMAX, the HD-standards diffusion was not determined by the demand-side, and it is not a case of obvious technological supremacy of one standard candidate. Particularly, complementary goods create a comparative advantage, for instance:

*"What is most important to consumers is how much they are paying, and HD DVD is simply less expensive. […] Focusing on one format will also allow us to provide better content because we're not splitting our attention." (Rob Moore, Paramount Pictures, 21.08.2007)*

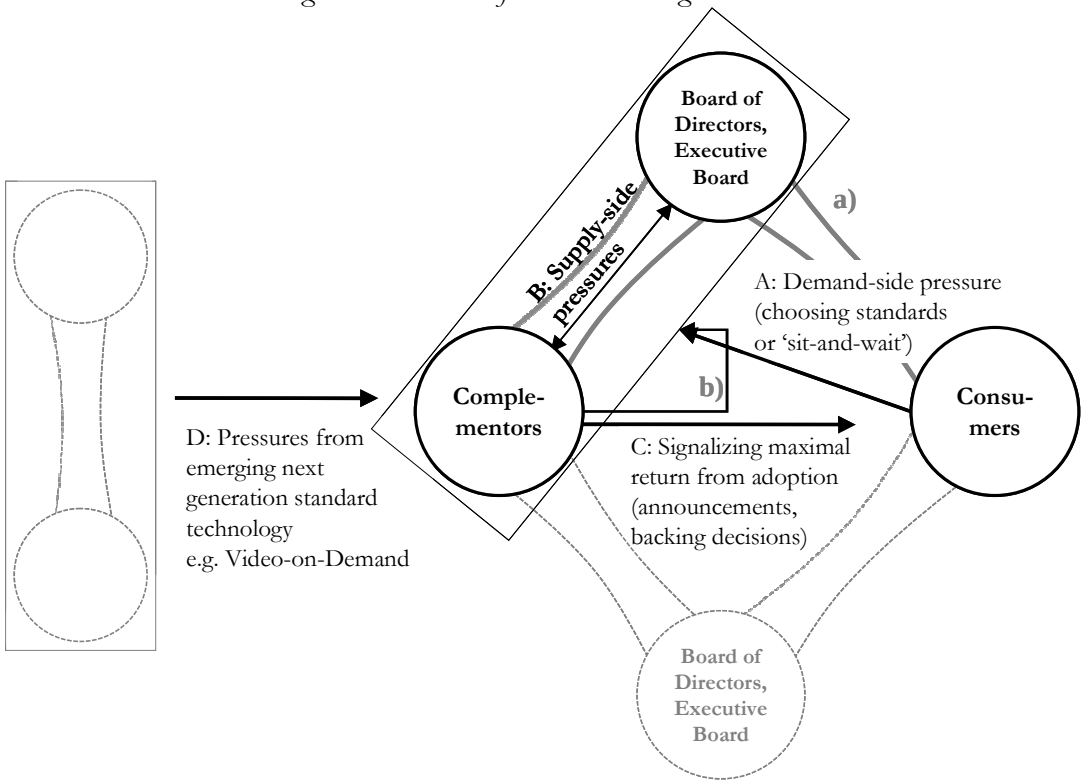
More precisely, our paper extends the literature on standard wars in two directions. First, we show how firms behave strategically as consortium members (via consortia decisions and announcements). Second, we develop an evolutionary view on standard wars driven by consortia. In line with Consoli (2008), we argue for a "co-evolution of capabilities" and, derived from that idea, for a co-evolution of consortia, respectively their agents who behave strategic and deploy coalitions (e.g., formalized as consortia, or reached by bilateral contracts) at all market arenas. Few studies explicitly deal with inter-firm consortia standard wars (e.g., Lim, 2008); however, they do not sufficiently take an evolutionary perspective rooted in learning and market expectations which emerge from a series of events. Furthermore, we demonstrate that recent standard wars may not be decided by technological supremacy, but are driven by strategic behavior of consortia member firms. The case of Blu-ray against HD-DVD represents such a standard-setting case. Table 1 spells out the various meanings of 'standard-setting consortia'.

*Table 1: Standard-setting Consortia*

| | |
|---|---|
| Alliances for Developing and Sponsoring Standards | "A firm sponsors de facto standards either by promoting its own proprietary methods as a standard or by entering into an alliance to develop and promote standards favored by a coalition of firms." (Axelrod et al., 1995). |
| Consortia | "[Consortia are] a collection of like-minded interests that participate in the development of what may be a market accepted solution to what is perceived to be a user problem." (Weiss and Cargill, 1992, p. 560).<br>"Lying somewhere roughly equidistant between the unilateral de facto standard impositions of Microsoft and the broad, participatory process leading to the development of de jure standards by bodies such as the ISO are a plethora of groupings of companies that have come together to address, most typically, a single discrete technical need. The common goals of these groupings may be as narrow as setting a consensus-based interface standard for music hardware and software (i.e., the MIDI Manufacturer's Consortium), or as wide as promoting standards perceived as being necessary to enable the effective development of a new type of programming (i.e., the Object Management Group, or OMG, formed to promote and facilitate object-oriented programming techniques). These groupings, variously formal and informal, are usually referred to as consortia." (Updegrove, 1995). |
| Networks as regulators | "[…] networks – institutions that facilitate interconnection between users of a good or service exhibiting network effects, and thus enable the realization of the network effects. Networks appear in many forms: trade associations, commodity exchanges, electricity grids, Internet auction sites, Peer-to-Peer and Business-to-Business exchanges, etc. In certain circumstances, networks are better regulators than the parties to the transaction or other third parties (such as the government)." (Aviram, 2003, p. 7). |

Weiss and Cargill (1992) distinguish between implementation consortia, application consortia, and proof-of-technology consortia. The case we present shares some characteristics with proof-of-technology consortia but it differs in the objectives of the consortium's biggest, most influential firms (hereafter referred to as incumbents). The Blu-ray and HD-DVD consortia do "work out the concepts of the technology prior to making major investments that will run counter to one another" but competition on concepts takes place between and not within the consortia; also note that competition is not fought between single firms. We will thus demonstrate what constitutes a new category of standard-setting consortia, namely belief-building consortia. Such consortia pursue an early diffusion momentum in the face of a finite standards life cycle and the maximization of innovation rents through signalizing high utility to an undecided consumer.

*Figure 2: The Role of Standard-setting Consortia*




*a) Network effects from lead markets? E.g., game consoles' installed-base.*
*b) Network effects from retail and rental channels?*

Why does strategic behavior matter? Our concept of dynamics around a standard candidate and the means of consortia are illustrated in figure 2. The concept of consortia wars departs from standard wars-theory in two respects. First, consortia as groups of firms may have better information on emerging next generation of standard technology than single firms do have (see mark D in figure 2). Second, complementors (content providers) take a crucial role in the process of shaping demand and initializing demand-side network effects. Our concept is in line with evolutionary theory because we find that dynamics of consortia structures (in historical time) are crucial for understanding standard-setting processes and finally, crucial for standard-setting success. Furthermore, the history of standard wars lets us assume that agents have learnt from previous standard wars (e.g. Sony was involved in VHS vs. Betamax, DVD-R vs. +R, Blu-ray vs. HD-DVD). Third, most important, the war gaming between consortia brings increased costs in comparison to single firm standard wars; it may also delay an industry standard through a long-term stalemate between the leading consortia. Note that it is then important for a consortium to attract content-providers respective complementors, but also to convince the uncertain consumer to adopt the own standard candidate. Dedicated activities such as search, evaluation, selection and adoption of a standard candidate, but also backing decisions are subject to the variety of consortia members and possibly rival interests, which evolve and change in the course of time.

In the case of Blu-ray vs. HD-DVD, consumers do not unfold network effects; they are waiting to see a superior standard candidate (dominant design) as they are uncertain about the intensity

and direction of future technology adoption dynamics (mark A in figure 2). Furthermore, we suggest that supply-side agents put pressure on each other, e.g., in terms of switching between consortia, announcements on the future technology diffusion at trade fairs, or by negotiating long-term backing agreements (see mark B in figure 2). Complementary goods and asset providers (hereafter referred to as complementors) and incumbents (here, big firms in the Board of Directors/the Executive Board) function as gatekeepers in lead markets for a standard. Their activities – backing decisions and announcements – influence the reputation of the consortium, but they also shape consumer demand, e.g. via media and retail channels (see mark C in figure 2). Furthermore note that strategic behavior of the firms anticipates the limited time span between standardization (the emergence of a dominant design) and the end of the standard lifecycle: new proposals worked out by other consortia or even from other overlapping markets emerge to replace the Blu-ray or HD-DVD standard (see mark D in figure 2). It is worth noting that complementors and vendors worry about long-lasting standard wars, which requires a quick development of stable standard platforms (cf. Weiss and Cargill, 1992). The delay of standard adoption and the delay of complementary goods provided is a serious constraint to innovation rents which are captured from implementing a new standard. In the case of the successor Blu-ray, we find press evidence on that the standard may be challenged by download business models in the near future. Moreover, the DVD-Forum has recently approved a high-definition download standard. The focus of this paper is on what is labeled as 'mark C' in figure 2. Agents try to signalize that a commitment for their favored standard-setting consortia will be an advantage in the near future; and they take several paths to convince and force the consumer adapting to their standard candidate (e.g., via game console markets). If consumers and even complementors are cautious and wait for a winning standard, such signalizing turns out to be an important standard-setting capability.[4]

If there is only one standard candidate, the intra-consortia process of standard-specification is mainly depending on the formation of coalitions (Van Wegberg, 2004). We distinguish several trade-offs to be considered by the agents when choosing consortia design and technical scope. Such trade-offs concern consortia decisions on the one, and firm decisions related to the consortium's standards on the other hand. Note that Warner Bros. used different paths to establish a standard (van Wegberg, 2004; Farrell and Saloner, 1988): via market mechanisms, and via negotiations within and between consortia.

*Table 2: Trade-offs in Standard Wars*

| | |
|---|---|
| Consortium decisions | Size (bandwagon-effect)/time-to-specification (derived from Weiss/Cargill, 1992); and degree of compatibility/speed of standardization (van Wegberg, 2004) |
| | Value created (disruption)/value captured (evolution) |
| Firm decisions | Backing consortia, backing exclusively |
| | Value created/value captured (Simcoe, 2006) |

As argued by Weiss/Cargill (1992: 563), *"an incentive exists to get as many firms as possible into the consortium so that the size of the network will be as high as possible"*. The larger the consortium, the more

markets adopt to the standard candidate. At the same time, such inclusive consortia delay standards specification and decrease the effectiveness of consortia; bandwagon-effects become stronger but time-to-specification increases. Although the momentum for the finite specification proposal should be stronger for inclusive than for small consortia, those positive externalities are postponed. Note that the standards' lifecycle is finite and thus the delay of specification means a loss of value capture for incumbents and complementors. The same applies to consumers: product lifetime becomes shorter but at constant switching costs. Van Wegberg (2004, p. 20) argues that "*a grand coalition [that is, an inclusive consortium] has a better chance of ensuring compatibility between the technologies used in an industry than competing coalitions*", but it "*may also take more time to arrive at a decision than competing coalitions. It has more opposite interests to accommodate. This delay represents an intra-coalition coordination failure.*"

Simcoe (2006) argues for a trade-off between value created in terms of providing open standards and value captured respecting innovation rents from appropriation by closed standards. Open standards create more value, e.g. through increased compatibility, increased quality, lower product prices for users, and 'restrictions on taxes by technology licensors'. Therefore, firms should collaborate on standards (create maximum value) but compete on implementation. Slowak (2008) suggests solving this trade-off by "a virtuous cycle of exploration and exploitation". If simplified, that is, the collaborative advancement from standards' vintage to vintage by the consortium so that there is more value created for the entire population of affiliated consortium agents at constant fraction of each firm's rents from proprietary activities interrelated with the standard. In absolute numbers, innovation rents thus increase.

There is also a trade-off concerning value created (utility) in terms of disruption versus value captured in terms of evolution. Disruptive standard candidates may embed more novel functionality, they may also be advanced in their basic design but they may lack backward compatibility. Evolutionary standards rather assure backward compatibility as they incrementally advance technology; thus they maintain the installed base but may be less innovative. In our case study the question arises if creating an evolutional standard based on the DVD-format (e.g., download supplements standards) could have been a better strategy than creating a new type of high definition disk. Evolution versus disruption in standards specification in the course of different releases or between interrelated standards poses two different problems: An evolution of DVD in terms of HD-DVD devices which also play DVD disks places DVD and HD-DVD media in indirect competition, it turns HD-DVD "readiness" into an optional feature until film supplements transcend DVD storage capacity, or until a critical mass of households own HDTV-screens. A revolution of DVD in terms of incompatible Blu-ray rather places DVD and Blu-ray into direct competition, consumers need to switch the installed base in order to watch Blu-ray disks.

We conclude that all agents disagree with time-consuming decision processes and standard candidate-postponing alignments within or between consortia. Thus, "*speeding up standardization will be valuable if the benefits from the standard are time-dependent.*" (van Wegberg, 2004, p. 28).

## 3 Blu-ray versus HD-DVD: Technology and Market Shares

Based on our event study, we identify several critical events for the Blu-ray diffusion. Besides the exclusive backing of various Hollywood studios (e.g. Warner Bros., FOX, Universal, Paramount), the format was also exclusively chosen by movie rentals (e.g. Blockbuster, Netflix). However, the study also shows exclusive backing of HD-DVD by global players, e.g. Dreamworks, Paramount Pictures still in the year 2008; we additionally analyzed the release date of HD-movies, which do not at all reflect an obvious Blu-ray victory until February 2008 (cf. figure 3). We first analyze if the Blu-ray/HD-DVD standard war has been decided by technological superiority as well.

*Proposition 1: 'Image quality' and 'tape length' or technological attributes from similar importance to the consumer have been crucial arguments for Blu-ray to win over HD-DVD. Alternatively, the Blu-ray/HD-DVD standard war could have been decided just by chance.*

Note that the anticipated use case could also lead to superior value of one standard candidate to the consumer. Table 3 gives a technical overview of both standard candidates.

*Table 3: Blu-ray versus HD-DVD Technology*

| Technology characteristics [a)] | Concerned agent | Blu-ray | HD-DVD |
|---|---|---|---|
| *Copy protection* | film industry, consumer (anti-consumer technology BD+ and BD-Rom) | AACS[5] , BD+, BD-Rom (BD+ = dynamic encryption coding; BD Rom = digital watermark) | AACS |
| *Disc capacity* | consumer, PC industry [a)] | 1-layer: up to 20GB (2005)<br>2-layer: up to 50GB (Oct 2006)<br>R&D announcements:<br>4-layer: 100GB; -layer: 200GB; 16-layer: 400GB (announced Jul 2008) | 1-layer: up to 15GB<br>2-layer: up to 30GB (2006)<br>3-layer: up to 45GB (Oct 2005)<br>3-layer: up to 51GB (Nov 2007) |
| *Interactive platform/software* | Gaming and film industries | BD-J (Java based; SUN Microsystems) | iHD (HDi; Microsoft) |
| *Video codec [b)]* | film industry, consumer | MPEG2, H.264 (MPEG4, AVC) and VC-1; 1080i, 1080p; transfer rate 36-54 MBps; video bit rate: 28,0 MBps | MPEG2, H.264 (MPEG4, AVC) and VC-1; 1080i, 1080p; transfer rate 36,55 MBps; video bit rate: 40,0 MBps |
| *Region coding* | Film industry, game industry | 3 country groups (less then DVD)[6] | not until 2007 [c)] |
| *Audio codec* | Film industry, game industry | Dolby Digital, PCM, Dolby True HD, DTS, DTS-HD | Dolby Digital, PCM, Dolby True HD, DTS, DTS-HD |

*a) For costs of player and disk manufacturing see Appendix. Costs of purchase are one crucial decision criterion in consumers' choice of a standard*

*b) The amount of high definition content that can be stored on a HD-disc is entirely dependent upon the codec used for encoding. Using the standard MPEG-2 DVD compression, a single-layer Blu-Ray disc (25GB) could hold two hours of HD programming, and doubling with MPEG-4 or VC-1 compression.*

*c) At the very beginning, several HD-movies were exclusively launched on Blu-ray by Hollywood studios due to the missing region coding on HD-DVD.*

Image quality of both HD-formats is already specified via the 1080p HD standard. Within this paper, technological superiority is defined as superior functionality of one standard candidate to the consumer at equal costs compared to other candidates. Thus, does "storage capacity" as functionality make Blu-ray a superior technology from consumer perspective? If we assume that 25GB storage capacity equals ca 135 minutes of compressed High-Definition MPEG2 Video, then run times are rather similar. In addition, MPEG4 compression offers even more playtime for both standard candidates. Consequently, blockbuster movies could be stored on both media without abdication. We conclude that storage capacity did not significantly vary between Blu-ray and HD-DVD until Warner's crucial decision of backing Blu-ray exclusively (cf. Appendix A). The announcement of 100GB and 200GB Blu-ray multi-layer discs is not related to Blu-ray's supremacy; these announcements were made after Toshiba's final decision to stop HD-DVD R&D.

Brookey (2007) argues that "*tech-savvy consumers are sure to recognize this difference, and are likely to resist any new format that does not appear to have a long shelf-life"* (Brookey, 2007, p. 203); he continues, *"In spite of this disadvantage, the HD-DVD has some advantages of its own. Because its numerical aperture is smaller than Bluray, HD-DVD drives are backward compatible; in other words, when HD-DVD players hit the market they were able to play old DVDs with an upgraded image quality. Blu-ray on the other hand is not backward compatible, and its players will most likely have to include a separate drive for the legacy DVD format."* (Brookey, 2007, p. 203). Furthermore, different revisions for each HD-format constrain vertical compatibility and imply search costs/information asymmetries to the consumer, as theoretically discussed by e.g. Shy (1996) and van Wegberg (2004).

The value added of additional Blu-ray disc capacity comes with serious disadvantages in compatibility, while HD-DVD provides enough capacity to store recent firms in HD-resolution quality. All in all, technology of the two standard candidates is quite similar in terms of consumer utility (this excludes from network effects, complementarity to other standards, and all kinds of systemic standard-setting characteristics or systemic innovation). Both formats, at least their latest revisions, provided a storage capacity up to 51GB, which is sufficient for crystal-clear 1080p video and uncompressed audio blockbuster movies and add-ons.[7]

*"Though similar in design, the specification papers of the two formats do show a few technical differences. One of the significant differences between the two mediums is that the laser's aperture is different, with Blu-ray having a thinner protective layer (0.1nm) than both the HD-DVD and the DVD (who both share the same thickness of 0.6nm, reducing costs for HD-DVDs to be produced). This allows Blu-ray to have a higher capacity than HD DVD, but at a higher cost to the manufacturer and ultimately the consumer." (Zardis, 2007).*

TDK's announcements of potential Blu-ray storage capacity of 100GB and future 200GB, if intended in timing and effect, express strategic behavior. Agents also may have learned from the VHS-BETAMAX format war that technological attributes matter; especially if such attributes are aggressively brought to consumer markets via backing/backing exclusively decisions and announcements of consortia. More precisely, we argue that technology did not decide the Blu-ray/HD-DVD standard war in autopoiesis. If technological superiority was important to population dynamics and expectations of success, then this superiority was artificially created by

events and the strengthening of ties between application segments, technology providers, complementors and the consortia's incumbents.

Given similarity in the two standard candidates' utility to the consumer, Blu-ray format victory could be due to chance. Note that if assumed that only HD-DVD is compatible to DVD-hardware, the entrant Blu-ray should suffer from an already installed base of the recent incumbent HD-DVD Promotion Group (backed by the DVD Forum). Assuming a critical mass necessary in technology diffusion, a substantial increase in market share could determine the standard war in an early phase. Therefore, we first focus on the content providers as in table 4. For each agent we assume a particular strategic behavior with respect to the standard-setting arena and each agent's role determined by both technological competencies and standard-setting experience gained through learning from previous consortia projects. Therefore, we propose that agents as members of consortia leverage their market position but also advance the business environment in favor of their standard candidate: lead user-segments for HD-standards are home entertainment (movie studios, movie rental service providers, movie retail industry; including adult industry) and video (console) games.

*Table 4: Film Industry Market Shares and Allegiance*

| Studio | market shares, 2005 | market shares, 2006 | market shares, 2007 | market shares, 2008 | Allegiance 2007 | |
|---|---|---|---|---|---|---|
| | | | | | *HD-DVD* | *Blu-ray* |
| Warner Bros | 21,2[1)] | 18,1[1)] | 18,8 [1)] | 20,7 [1)] | X | X |
| Paramount | 10,5 | 9,7 | 13,4 [2)] | 13,3 [2)] | X | |
| Disney/Buena Vista | 15,8 [7)] | 15,4 | 13,1 | 12,2 | | X |
| Sony (incl. Columbia) | 12,5 | 12,6 | 13,5 | 11 | | X |
| Universal | 14 [6)] | 11,3 | 10,7 | 11,1 | X | |
| 20th Century Fox | 14 | 13,7 | 15,3 [3)] | 14,7 [3)] | | X |
| Lionsgate | 4,2 | 5,2 | 5,3 | 6,7 | | X |
| Dreamworks | - | 3,2 [5)] | - | - | X | |
| MGM | 1,9 | 2,2 [4)] | - | - | X | X |
| Other | 5,9 | 14 | 9,9 | 10,4 | | |
| *Cumulated market share* | *$23.8 billion* | *$23.6 billion* | *$22.9 billion* | *$21.7 billion* | *42.9%* | *66,0%* |

*Source: Video Business (2009), Quarterly Market Data and The Economist (2008), Box Office Mojo, by box office revenue; 2005-2008 year-end total overall consumer spending, including year-end total sell through market share and year-end total rental market share.*

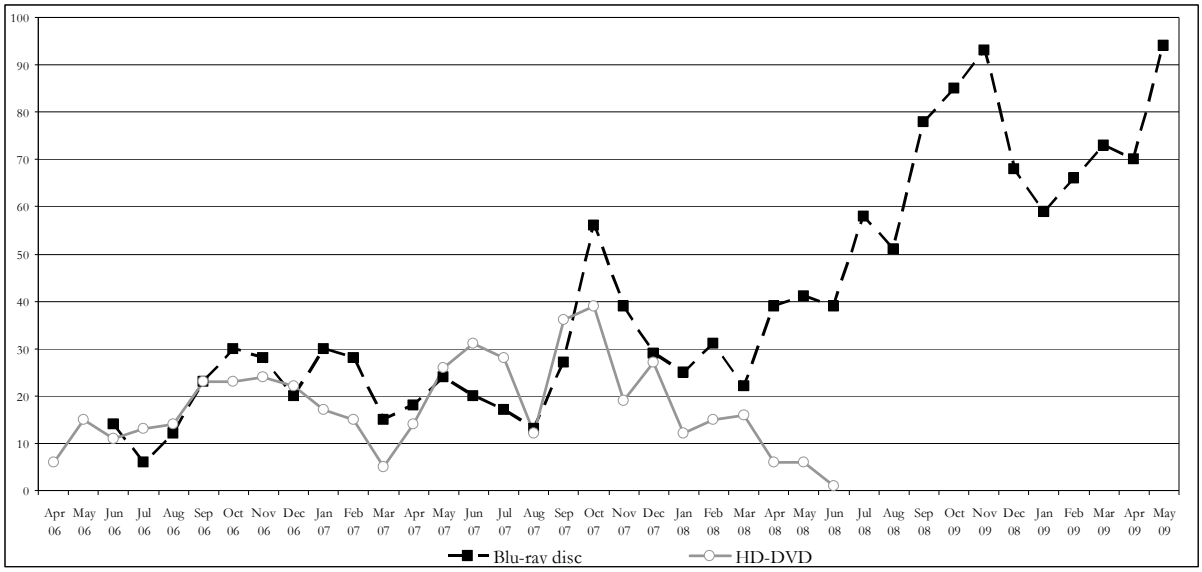
*1) Warner includes HBO and NewLine; 2) Paramount includes Dreamworks; 3) FOX includes MGM; 4) MGM belongs to SONY in Q1/Q2 and to FOX in Q3/Q4; 5) owned by Paramount but distributed by Universal for several months; 6)Universal includes Dreamworks; 7) includes Miramax Dimensions*

*http://www.videobusiness.com/info/CA6630875.html*

In 2007, film studios merely support Blu-ray (see table 4). Besides Paramount, also Warner and Disney showed some attitude to back the HD-DVD format. Consequently, the unexpected turn of Warner Bros. towards Blu-ray was an absolute surprise for both, the HD-DVD Promotion Group and the other agents in consumer markets. Note that most shifts towards the Blu-ray format happened in Q4/2006, 2007 and Q1/2008 (cf. Appendix A; also figures 10 and 11).

In addition to table 4, figure 3 gives some indication in terms of HD movie releases on both HD-technologies from Q2/2006 until Q1/2009.

*Figure 3: Blu-ray vs. HD-DVD Movie Releases April 2006 until May 2009*

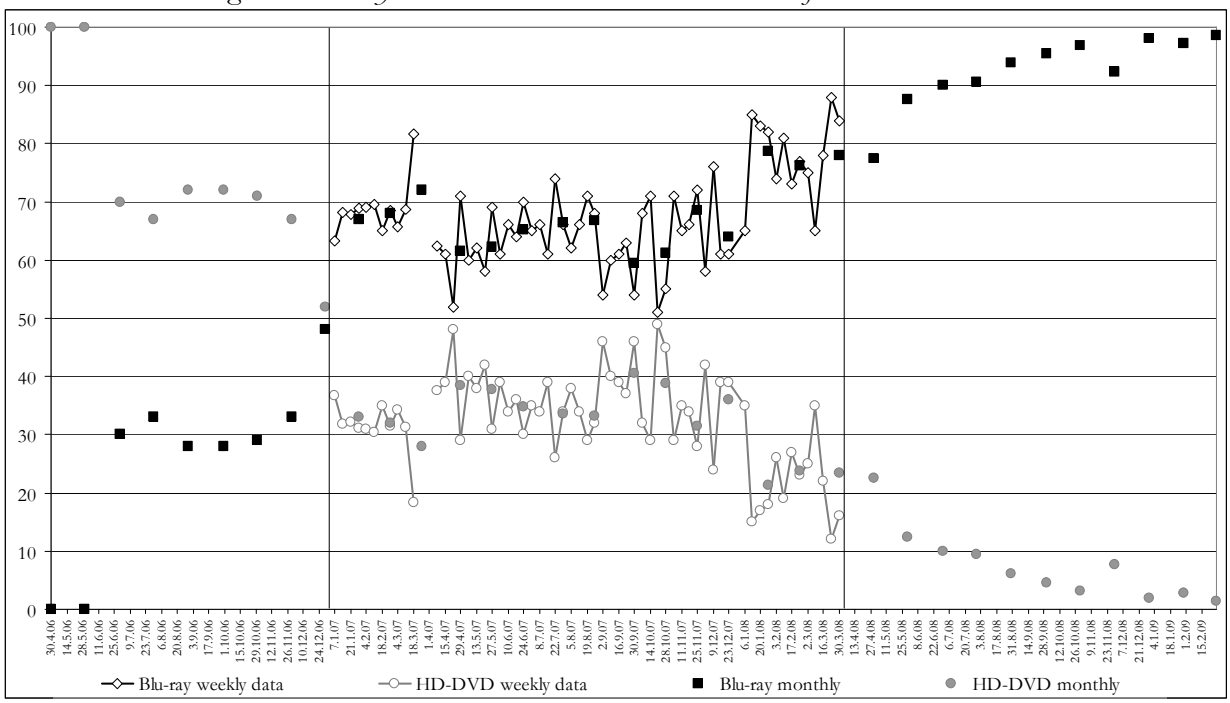



*Source: own illustration and calculations of movie releases based upon studio announcements and press releases on http://bluray.highdefdigest.com/releasedates.html; http://www.blu-ray.com/ and http://www.hddvd.com/*

We identified no clear supremacy of Blu-ray in terms of movie releases until Warner's announcement to back Blu-ray exclusively (Q1/2008). HD-DVD movie releases then continued until June 2008, however decreasing. It is also clearly visible that the majority of content providers waited until a final restructuring of both consortia in terms of backing decisions has happened in Q1/2008; early market takeoff can be dated to winter 2008/2009. Similar to the VHS/BETAMAX standard war, analysts assigned a strategic role to the adult movie industry and movie rental service providers in the HD case. Indeed, our event study identifies several events within the adult movie industry (backing standard candidates) that contribute to consortia structure dynamics (cf. Appendix A).

In addition to the share of movie releases on HD-discs, figure 4 highlights the calculated market shares of Blu-ray and HD-DVD movie sales in the US market for the time period April 2006 until May 2009 (weekly and monthly data). It is highly visible, when comparing figure 4 with table 4 and Appendix A, that the standard candidates' market share of HD movie sales fluctuates proportionally with the market share of HD-technology backing/backing exclusively movie studios. This may mean that the share of weekly/monthly unit sales follows with a certain lag the market share of backing/backing exclusively decisions of movie studios. Consequently, we value the sales development as an outcome of *ex ante* strategic 'backing/backing exclusively' decisions of content providers (complementors). According to figures 3 and 4, the main standard war began around Q3/2006 and lasted eighteen months (Q1/2008).

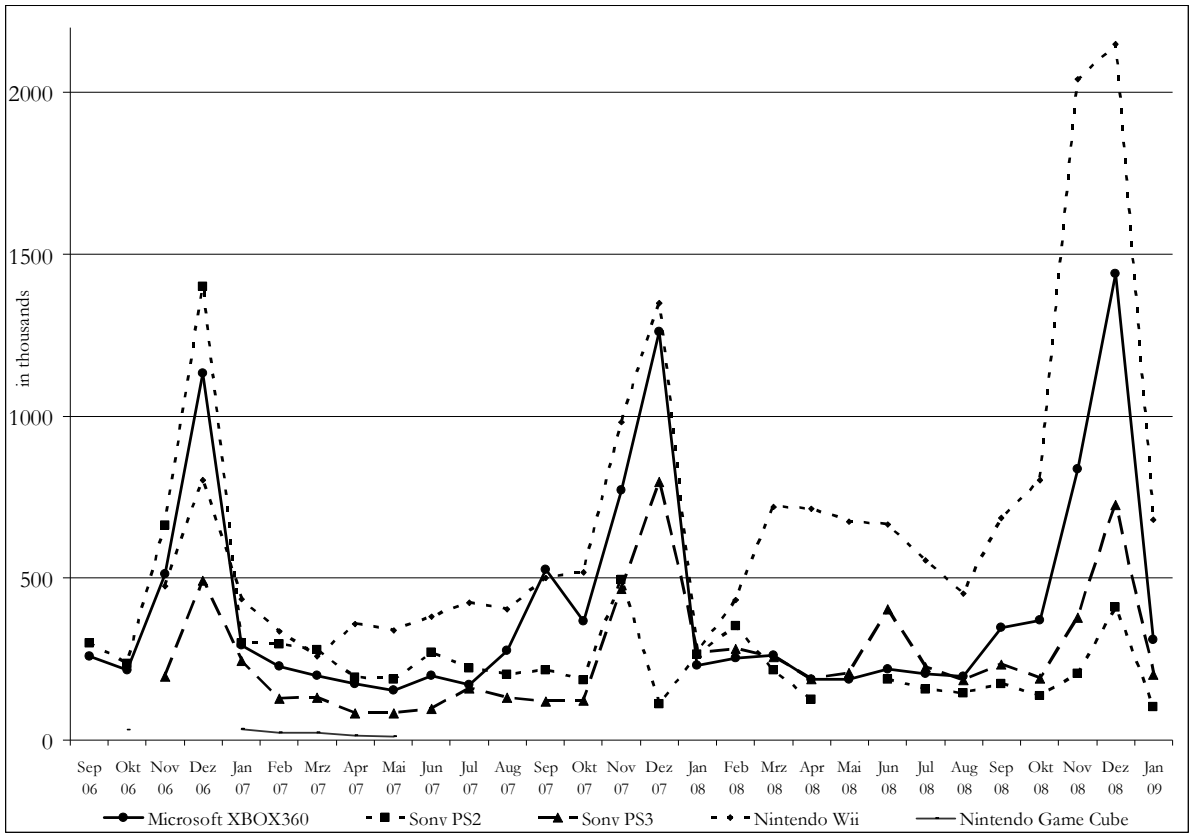
*Figure 4: Blu-ray vs. HD-DVD - US-Market Share of HD-Disc Sales*




*Source: own illustration and calculations; data on market shares are related to US-market High-definition disc sales as reported by Nielsen Videoscan first alert data (weekly US sales data reported by the Home Media Magazine; http://www.engadgethd.com/ and http://www.blu-raystats.com) and sales statistics from DVD-Empire (http://www.dvdempire.com); sub-periods contain different data: monthly data from Apr 2006 until Dec 2006 (Nielsen Video Scan) and Mar 2008 until Apr 2009 (DVD Empire); weekly data from Jan 2007 until Mar 2008 (Nielsen Video Scan); monthly data between Jan 07 and Mar 08 are calculated as average mean from weekly sales data.*

New digital video formats such as Blu-ray and HD-DVD additionally allow for watching high-definition videos on video game consoles. In the case of Blu-ray/HD-DVD the use-case of both standard candidates does not differ. Both standard candidates are designed to allow watching high-definition videos stored on disks, and both refer to game consoles as a lead market (Japan, USA) for relevant video codices, but also at the strength of their installed base of Blu-ray/HD-DVD players. Thus, further effort has been made by both HD-consortia in attracting agents from the game development industries, e.g. Electronic Arts (see also figure 11). Game consoles nowadays essentially contribute to the diffusion speed of high-definition storage media, as games are in need of additional storage capacity which is limited by the previous DVD technology. We conclude that the introduction of Sony's PS3 and Microsoft's XBOX 360 in lead markets for game industry such as USA and Japan was of strategic importance for both consortia; game consoles may include HD-players and thus increase a standard candidate's installed base which in consequence creates predictions of success. Figure 5 highlights the evolution of US game console sales between Sept Q4/2007 and Q4/2008. Notice, that the time path of each console technology is different, although Q4 always peaks for each console during Christmas time.

*Figure 5: US Game Console Sales*




*Source: own illustration; data from Shilov, A.: Video Game Console Market Continues Its Formidable Growth in the U.S. – NPD Group, Feb 12, 2009 (http://www.xbitlabs.com/news/multimedia/display/20090212170954_Video_Game_Console_Market_Continues_to_Grow_in_the_U_S__NPD_Group.html).*

We complementarily analyzed the Japanese market: consoles sales in year 2008 for Japan are as follows (in units sold), Nintendo DS (4,029,804), Sony PlayStation Portable (3,543,171), Nintendo Wii (2,908,342), Sony Play Station 3 (991,303), and Microsoft Xbox 360 (317,859).[8] However, it is essential to note that the HD-DVD player for the XBOX 360 was an external device, whereas the PS3 has a built-in technology. However, a detailed analysis of installed-base lacks consistent data: neither are all PS3 used for HD movies, nor are all XBOX 360 on the market equipped with an HD-DVD player. Technological comparison as in table 3, the late take-off of movie releases on Blu-ray in autumn 2008 (see figure 3), and the dynamics in market shares in the year 2007 (see figure 4) indicate that both standard candidates were perceived as equivalent by the market. Proposition 1 (see p. 9) does not hold and thus, the case of Blu-ray vs. HD-DVD is different from the case of VHS/Betamax. We propose:

*Proposition 2: Strategic behavior which leads to dynamics in bargaining power of agents and uncertainty in standards specification (including the pace of innovation by standards releases) shifts competition on implementation of standards from a technology to a market arena. Standard-setting capabilities and given opportunities from market structure matter, not only technological competence or innovation performance of the firm.*

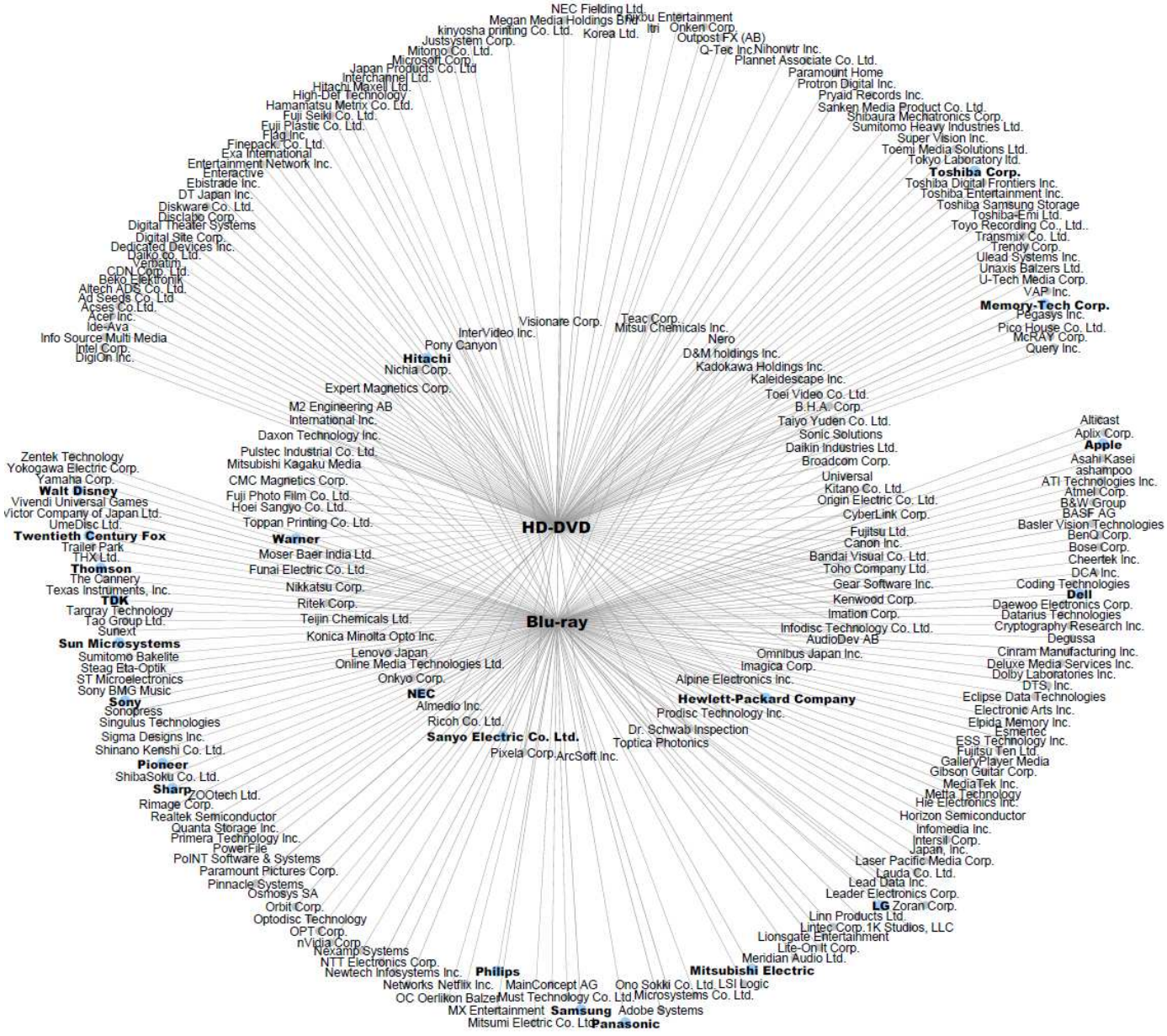
In an interview conducted to Ars Technica by Microsoft Director for Platform Strategies, Scott Henson, he stated that the Xbox 360 HD-DVD drive would likely never be internalized into Microsoft's game console because *"[we] don't want to charge customers $200 extra for something that may be the next Betamax."* (Ars Technica, 2007, Interview from January 2007). Above statement either indicates that the means of predictions is not understood by consortia members or that Microsoft has lost its belief in HD-DVD success in Q1/2007. Cooperation, coordination and timing of events and announcements appear to be crucial for a successful diffusion of standard candidates, particularly in respect to internalization of predictions of lead users and markets for complementary goods. However, consortia members not always behave fully allegiant towards their associates. We identified some interesting suspiciousness between several HD-DVD Promotion group members, which appear crucial in an ongoing standard war. We also find strategic payments by promotion groups to critical consortia members as an essential instrument in diffusing the own standard candidate. Chapter four shall provide evidence for our proposition two.

# 4 Structural Dynamics in the Case of Blu-ray vs. HD-DVD

*"[Blu-ray] is an extremely complex animal. Small supporters could have a big impact if they judge their work for the format to be strategically important, while big company bureaucracy could make their support for a format irrelevant. Since data on small and private company supporters is less accessible, we'll just have to wait and see how the game plays out." (HDBlu.com, In the War of Supporters, Blu-Ray Has a Big Lead, Nov 6, 2006, http://www.hdblu.com/reviews/supporters.htm).*

As we argued, there is no obvious technological supremacy in favor of the winning standard Blu-ray. Thus, cause and effect are not rooted in technology only, but driven by either market structure or psychology. As follows we show that the structure of consortia and the activities of complementors made the DVD successor. Although each agent acts according to a particular set of strategies in the sense of economic game theory, it is the dynamics unfold by the interaction within the population of agents which leads to consumer's adoption or backing decisions of supply-side agents. One method to account for complex consortia structures is a social network analysis. Figure 6 highlight the consortia structures of Bluray Disc Association and the HD-DVD Promotion Group as of the year 2006.

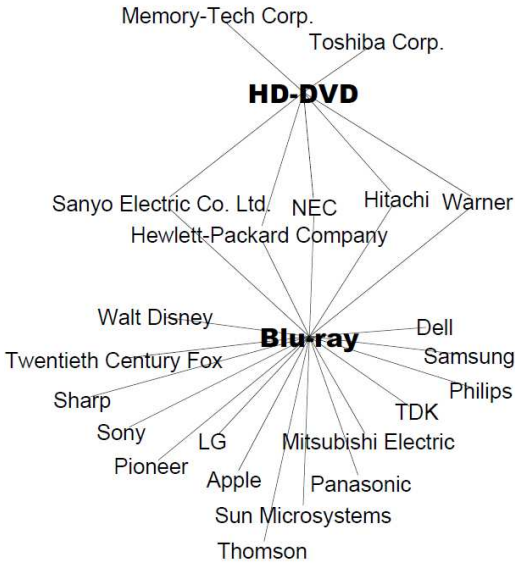
*Figure 6: The Consortia Networks behind Blu-ray and HD-DVD (year 2006)*




*Source: own illustration; data from www.mediabiz.de and from event study (Appendix A)*

A separate network graph for the executive board members as shown in figure 7 makes clear that Blu-ray holds a structural advantage: it has more executive members than HD-DVD; furthermore, several HD-DVD executive members are committed to both consortia.

*Figure 7: The Incumbents behind Blu-ray and HD-DVD (year 2006)*




*Source: own illustration; data from www.mediabiz.de and from event study (Appendix A).*

In line with evolutionary theory we find (a) an interaction between heterogeneous agents: big technology firms (incumbents), complementors (content providers) and specialized technology providers (hardware/ software manufacturers); (b) heterogeneity with respect to firm size and innovativeness; and (c), we assume that there are learning effects from previous standard wars.
Figures 8 and 9 illustrate how attention to each standard candidate varies in the course of time. We argue that the diffusion of a standard in modern times comes with information search activities of consumers which are conducted via internet search engines and information at the standard-setting consortia web pages. Thus, events which shape consumers' demand for a standard candidate also initialize active search activities of potential consumers. They attract undecided consumers who wait until the end of standard war. The search engine indices provided in figures 8 and 9 shall represent a proxy for the consumers' attention to each standard candidate within a five year period.

*Figure 8: Search Statistics for "Blu-ray" versus "HD DVD" on the Search Engine Google*

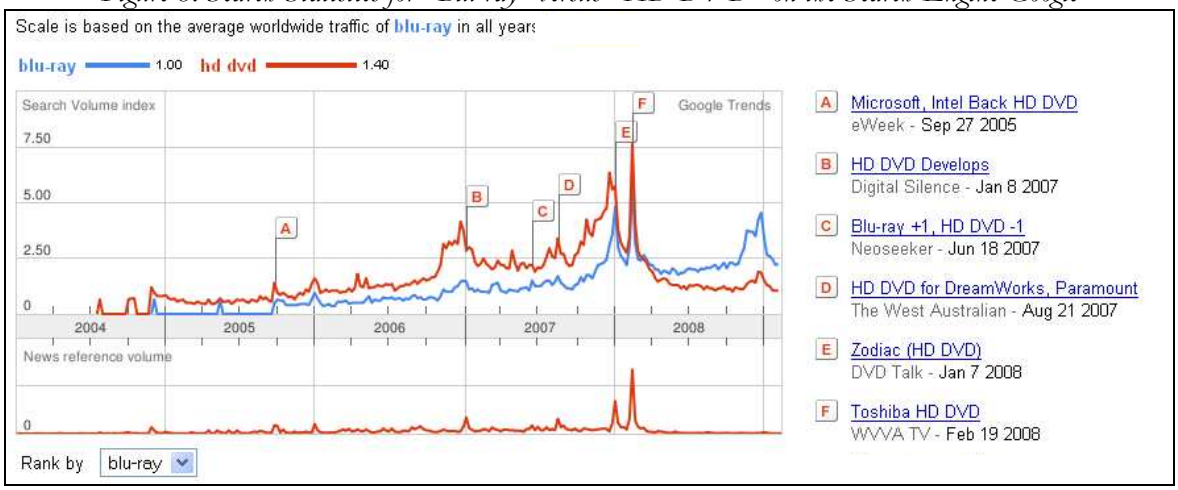
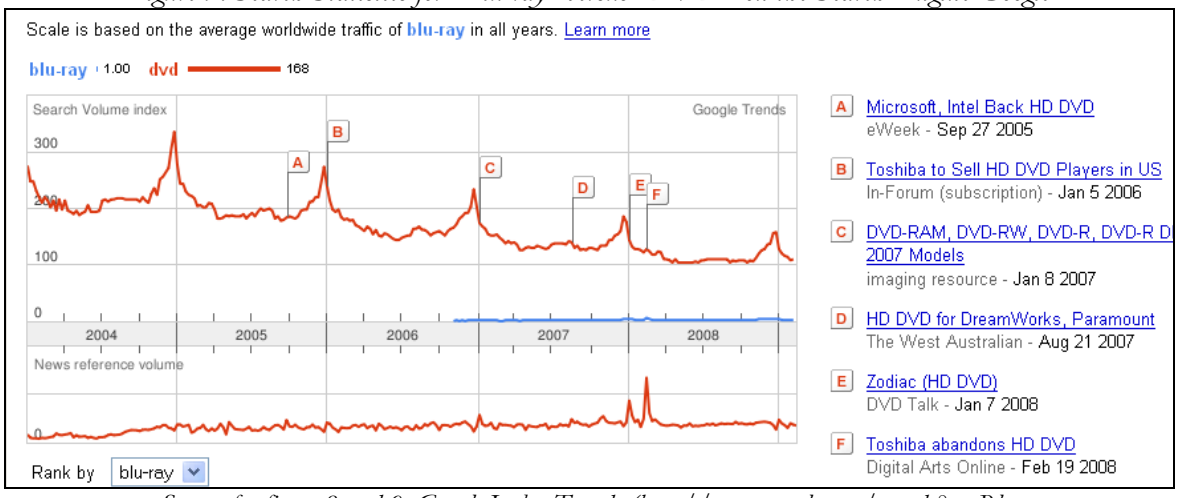


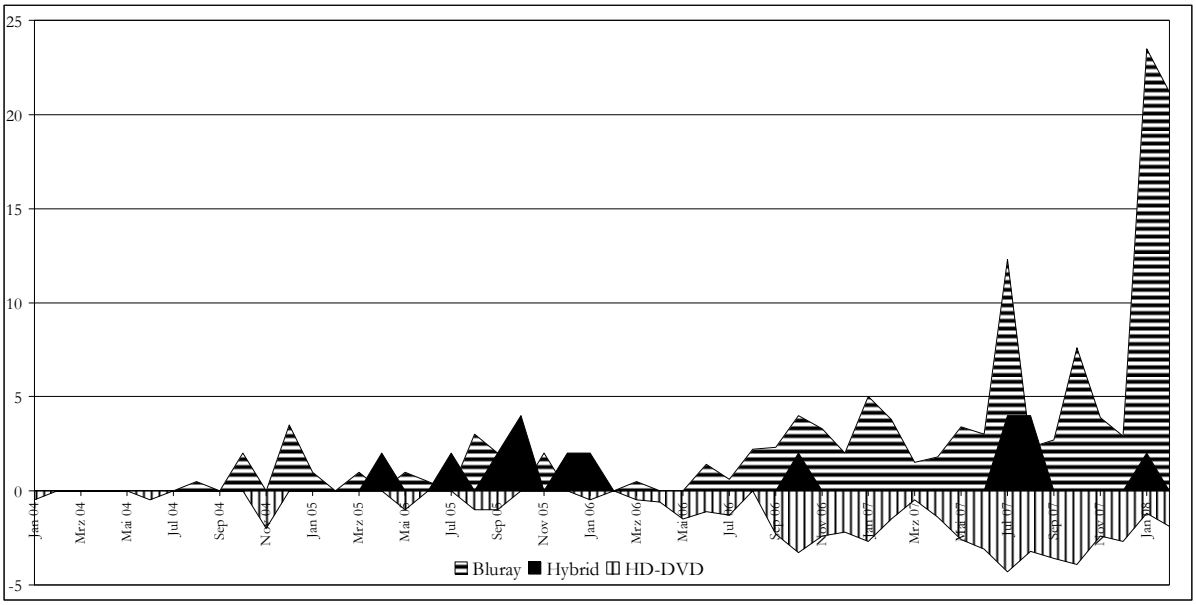

*Figure 9: Search Statistics for "Blu-ray" versus "DVD" on the Search Engine Google*




*Source for figure 8 and 9: Google Labs, Trends (http://www.google.com/trends?q=Blu-ray%2C+HD+DVD&ctab=0&geo=all&date=all&sort=1) as to February 21, 2009.*
*"Google Trends analyzes a portion of Google web searches to compute how many searches have been done for the terms you enter, relative to the total number of searches done on Google over time. ... The data Trends produces may contain inaccuracies for a number of reasons, including data-sampling issues and a variety of approximations that are used to compute results." (http://www.google.com/intl/en/trends/about.html, About Google Trends).*
*Data has been normalized; 1.0 represents the average search traffic for "Blu-ray" during the selected time period (all years).*
*Note that only English-language headlines can be displayed by the application (here marked A-F).*

We conduct an event study on the standard war between the Blu-ray and HD-DVD. We assume that each agent committed to High-definition technology has an explicit strategy how to back or to take an opposition against each of the two consortia (see figure 10 and figure 11). Previously, we have elaborated technological advantages and commitment to one standard candidate – either Blu-ray or HD-DVD. Nonetheless, we also see activities which are neutral between both standard candidates. As follows, activities which aim to back both standard candidates and which create products compatible with both standard candidates are referred to as activities for a hybrid standard. We use essential outcomes of our event study to elaborate the evolution of standard candidates in the course of time. As illustrated in figure 10, there was a tendency toward a hybrid HD standard which combines specifications from both competing consortia.

*Figure 10: Convergence/Divergence towards a Hybrid Standard in the HD market*




*Source: own illustration; events are based upon Appendix A and scored according to Appendix B.*

However, first, after first official press releases and meetings of the two consortia in Q2/2005, negotiations were stopped and a convergence of the standard candidates' technological specifications failed in Q3/2005 (cf. Appendix A). Secondly, we identified two additional tendencies towards a hybrid technology: the development of a HD hybrid disc, called "Total HD Warner Bros." and hybrid HD players, which were officially announced between Q4/2006 and Q1/2007 (by Samsung, LG and Warner Bros). Warner values the development of Total HD as follows:

*"The Total Hi Def disc is about giving consumers complete choice, providing creators and artists the greatest possible distribution of their work, and helping retailers thrive in the marketplace. By eliminating potential apprehension over formats, we believe this new disc could help consumers fully embrace the greatest home entertainment experience available." (Kevin Tsujihara, President of Warner Bros. Home Entertainment Group, Jan 09, 2007)*

However, Warner Bros. finally stopped the introduction of their Total HD and backed Blu-ray exclusively in Q1/2008 (cf. Appendix A):

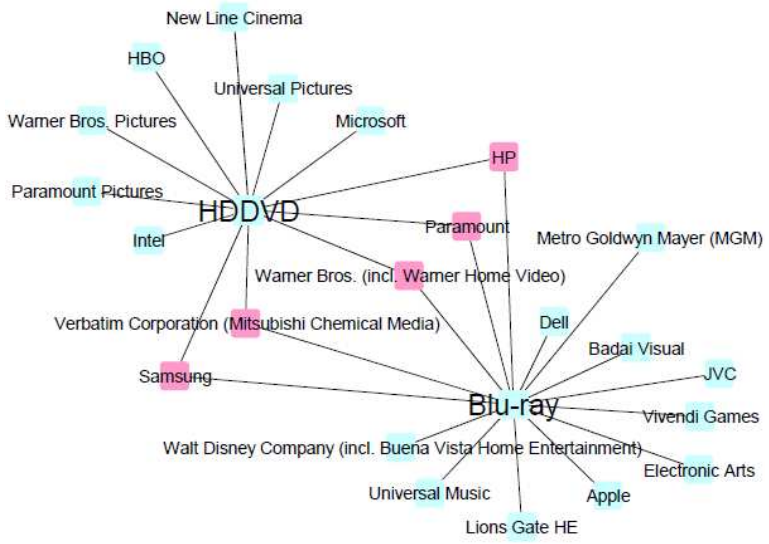
*"Warner Bros. has produced in both high-definition formats in an effort to provide consumer choice, foster mainstream adoption and drive down hardware prices. […] Today's decision by Warner Bros. to distribute in a single format comes at the right time and is the best decision both for consumers and Time Warner. […] Warner Bros.' move to exclusively release in the Blu-ray disc format is a strategic decision focused on the long term and the most direct way to give consumers what they want. […] The window of opportunity for high-definition DVD could be missed if format confusion continues to linger. We believe that exclusively distributing in Blu-ray will further the potential for mass market success and ultimately benefit retailers, producers, and most importantly, consumers. […] A two-format landscape has led to consumer confusion and indifference toward high definition, which has kept the technology from reaching mass adoption and becoming the important revenue stream that it can be for the industry," (Barry Meyer, Chairman & CEO, Warner Bros. and Kevin Tsujihara, President, Warner Bros. Home Entertainment Group, January 4, 2008 – Burbank, CA)*

We find that strategic behavior emerged in the course of time; agents substitute technological arguments for their favorite standard candidate by media-effective backing/backing exclusively decisions and consortia announcements. Given that consumption of standard candidates in the early phase of the technology life-cycle is highly dependent on consumer's capabilities, skills and the underlying knowledge (Loasby, 2000, p. 306), then, the purchasing process is characterized by uncertainty, heterogeneous needs and thus different use-cases of technology (cf. Loasby, 2000, p. 307; Consoli, 2008, p. 413). If either there is no functional or technological differentiation in standard technology and design or if information asymmetries hide the differences, then demand-side agents cannot develop explicit preferences. Indeed, Blu-ray and HD-DVD provide similar quality to the consumer:

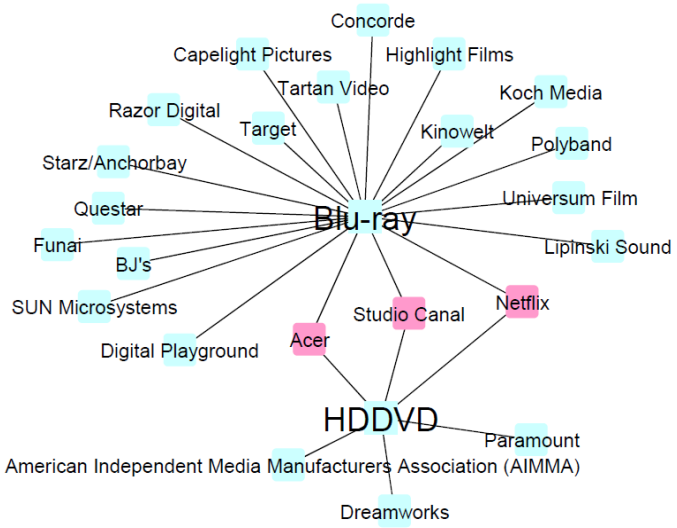
*"There is no real difference in quality based on what I've seen between HD DVD and Blu-ray. I don't know how quickly these two competing formats will catch on, but when it comes to image quality, they both look great." (Kuchera, 2007, Ars Technica)*

Figure 11 then shows a structural disadvantage of the HD-DVD standard candidate (in terms of firm affiliation to the HD-DVD consortium) increasing in the course of time. More and more executive members (with strategic positions) who initially were committed to both consortia later switched to back Blu-ray exclusively. This finding is in line with our event study.

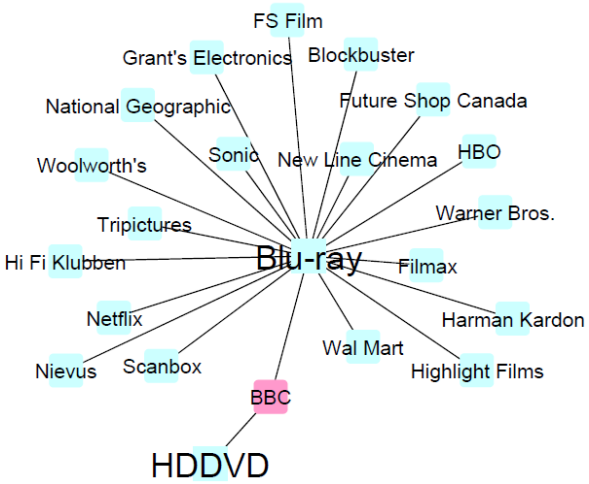
*Figure 11: Consortia Dynamics - Backing/ backing both/ backing exclusively decisions of hardware/ software manufacturer, content providers, retailers and rental service providers*
*Period 2004-2005: Backing/ backing both/ backing exclusively decisions*




*Period 2006-2007: Backing/ backing both/ backing exclusively decisions*




*Period 2008: Backing/ backing both/ backing exclusively decisions*




*Source: own illustration, based upon Appendix A*

# 5 Conclusions

The existing literature on technology diffusion provides several case studies and models on standard adoption. Research particularly illustrates the means of network size and positive externalities, technological supremacy, compatibility in systemic markets, or path dependency. As HD-DVD and Blu-ray are similar in their technological specification, the demand-side faced high risk of choosing the wrong standard candidate. We exposed a case where strategic behavior of consortia has caused the success of one standard candidate, namely Blu-ray. We also unfold non-linear dynamics: for instance, although HD-DVD dominated Google search index statistics opposed to Blu-ray until Q1/2008, the standard war suddenly shifted in favor of Blu-ray in the year 2008. Before that, several activities (and alternatives) to unify both technologies and to establish a hybrid HD-standard failed. Note that the number of movie releases during standard war did not differ systematically. In opposition to the HD case, the often cited VHS/BETAMAX standard war has been clearly decided by technological supremacy of VHS and thus emphasizes sovereign adoption choice of the consumer.

The economic problem in consortia-driven standards wars on similar technologies is as follows. Neither supply-side agents nor consumers want to exclusively commit to back a standard which could turn out as the 'underdog' in the end of the standards war. Both supply-side and demand-side agents share the interest to reach one industry-standard only. Reasons are the need for economies of scale in production, and positive network effects by increasing the installed base. Furthermore, there are incentives to maximize revenue streams from standard implementation within its finite life time. The chicken-and-egg-problem describes the fact that each agent is waiting for the mass of other agents to lock into a standard and thus to decrease uncertainty on future network effects. That said, the more the majority of agents and in particular the consumer is unable to objectively identify and evaluate technological advantages, the more a lack of standards adoption arises. Given a finite standards life cycle, the supply-side in the case of Blu-ray vs. HD-DVD thus unfolds activities to alter the value of standard candidates by backing/backing exclusively decisions and by announcements in favor of the own candidate's 'expected market success'. Such announcements shall substitute the crucial demand-side adoption and thus lacking positive consumption externalities from a dominant design. The accumulated 'backing exclusively' announcements of content providers (e.g. movie studios) in Q1/2008 decided the standard war.

Our main argument is that supply-side activities in consortia-driven standard wars may address a lack of adoption momentum by strategic behavior. Such behavior *inter alia* concerns the design and collaboration rules (institutions) of consortia, but also an economical design of standards specifications. We outline crucial economic trade-offs to be considered by agents when disclosing knowledge to consortia or dedicating competitive assets. First, there is a critical size of consortia needed to reach a standard-setting momentum. Consortia structures in the HD-case were highly dynamic due to announcements and co-evolution of backing decisions. Second, incumbents and specialized technology provide need to open up technology in order to attract complementors and finally consumers but at the same time they try to profit from appropriated

inputs in terms of subsequent licensing (e.g. proprietary video codices included by Microsoft). Third, each consortia needs to balance between evolution in standards design for momentum from installed-base (here, e.g. backward-compatibility to DVD) versus giving consumers incentives to switch (disruptive functionality). Our social network analysis demonstrates that both standard candidates are supported by a large number of firms. However, in terms of executive board memberships and backing exclusively decisions, Blu-ray could increase its structural advantage in the course of time. Finally, HD-DVD lost the standard war because it was seldom backed exclusively by agents (e.g. content providers) in the crucial time frame.

Finally, the paper demonstrates how events can be used to analyze convergence/divergence between competing standard candidates and that the interplay between consortia, not only between firms, may create non-linear dynamics. We provide a behavioral approach based on the deployment of non-technological assets of the consortia. Rooted in heterogeneous consortia structures, we assume that agents' activities reflect current activities within and between consortia. These activities also consider knowledge from past standard wars experience (e.g. Sony). Accordingly, we suggest that consortia in terms of social networks are a fruitful level of analysis and, increasingly, the locus of strategizing.

## References


Albornoz, J. M. and Parravano, A. (2009), Coevolution of Competing Systems: Cooperation and Inhibition, Working Paper, Universidad de Los Andes (http://arxiv.org/PS_cache/arxiv/pdf/0904/0904.2741v1.pdf, arXiv at Cornell University Library).

Arthur, W. B. (1989), Competing Technologies, Increasing Returns and Lock-in by Historical Events, *Economic Journal*, 99, pp. 116-131.

Arthur, W. B. (1990), Positive Feedbacks in the Economy, *Scientific American*, pp. 92-99.

Arthur, W. B. (1997), Competing Technologies, Increasing Returns, and Lock-In by Historical Small Events, in: Brian W. Arthur (ed.), *Increasing Returns and Path Dependence in the Economy*, Michigan, Michigan University Press, pp. 13-32.

Aviram, A. (2003), Regulation by Networks, *John M. Olin Program in Law & Economics Working Papers*, No. 181, (http://www.law.uchicago.edu/Lawecon/WkngPprs_176-200/181.aa.regulation.pdf).

Axelrod, R., Mitchell, W., Thomas, R. E., Bennett, D. S., Bruderer, E. (1995), Coalition Formation in Standard-setting Alliances, *Management Science*, 41 (9), pp. 1493-1508.

Brookey, R. A. (2007), The Format Wars Drawing the Battle Lines for the Next DVD, *Convergence: The International Journal of Research into New Media Technologies*, 13 (2), pp. 199-211.

Consoli, D. (2008), Co-evolution of Capabilities and Preferences in the Adoption of New Technologies, *Technology Analysis and Strategic Management*, 20 (4), pp. 409-425.

De Vries, Huibert, de Vries, Henk, Oshri, I. (2008), *Standards Battles in Open Source Software: The Case of Firefox*, Palgrave Macmillan.

Dranove, D. and Gandal, N. (2003), The Dvd-vs.-Divx Standard War: Empirical Evidence of Network Effects and Preannouncement Effects, *Journal of Economics & Management Strategy*, 12 (3), pp. 363-386.

Economides, N., Skrzypacz, A. (2003), Standards Coalitions Formation and Market Structure in Network Industries, Working Paper No. EC-03-08, Stern School of Business (http://www.stern.nyu.edu/networks/Standards.pdf).

Farrell and Saloner (1985), Standardization, Compatibility, and Innovation, *Rand Journal of Economics*, 16, pp. 70-83.

Gandal, N. 2002. Compatibility, Standardization, and Network Effects: Some Policy Implications, *Oxford Review of Economic Policy*, 18 (1), pp. 80-91.

Gerybadze, A. (2008), Einsatz von Klugheit im Innovationsprozess: Intelligente neue Formen der Durchsetzung von Standards. In A. Scherzberg (Ed.), *Klugheit: Begriff - Konzepte – Anwendungen*, Mohr Siebeck, Tübingen, pp. 113-128.

Gerybadze, A and Slowak, A. P. (2008), Standard-setting Competition and Open Innovation in Non-HT Industries: Mechanical Engineering and Machinery. In H. Hirsch-Kreinsen, D. Jacobsen (Eds.), *Innovation in Low-Tech Firms and Industries*, Edward Elgar, Cheltenham, pp. 43-63.

Greenstein, S. and Stango, V. (2007), Standards and Public Policy, Cambridge (UK), Cambridge University Press.

Katz, M. and Shapiro, C. (1986), Technology Adoption in the Presence of Network Externalities, *Journal of Political Economy*, 94 (4), pp. 822-841.

Katz, M. and Shapiro, C. (1992), Product Introduction with Network Externalities, *Journal of Industrial Economics*, 40 (1), pp. 55-83.

Katz, M. and Shapiro, C. (1994), Systems Competition and Network Effects, *Journal of Economic Perspectives*, 8 (2), pp. 93-115.

Leiponen, A. E. (2008), Competing through Cooperation: The Organization of Standard setting in Wireless Telecommunications, *Management Science*, 54 (11), pp. 1904-1919.

Liebowitz, S. J. and Margolis, S. E. (1995), Path Dependence, Lock-in, and History, *Journal of Law, Economics and Organization*, Oxford University Press, 11 (1), pp. 205-26.

Lim, A. S. (2008), Inter-Consortia Battles in Mobile Payments Standardisation, *Electronic Commerce Research and Applications*, 7 (2), pp. 202-213.

Loasby, B. J. (2000), Market Institutions and Economic Evolution, *Journal of Evolutionary Economics*, 10 (3), pp. 297–309.

Menon, A. G. (2008), Revisiting Dynamic Capability, *IIMB Management Review*, pp. 22-33.

Park, S. (2004), Quantitative Analysis of Network Externalities in Competing Technologies: The VCR Case, *The Review of Economics and Statistics*, MIT Press, 86 (4), pp. 937-945.

Schweikle, R. (2009), *Innovationsstrategien und Determinanten des Wettbewerbserfolges: Eine vergleichende Analyse japanischer und deutscher Unternehmen*, Gabler.

Shapiro, C. and Varian, H. R. (1999), The Art of Standard Wars, *California Management Review*, 41 (2), pp. 8-32.

Shy, O. (1996), Technology Revolutions in the Presence of Network Externalities, *International Journal of Industrial Organization*, 14 (6), pp. 785-800.

Simcoe, T. (2006), Open Standards and Intellectual Property Rights. In H. Chesbrough, W. Vanhaverbeke and J. West (Eds.), *Open Innovation: Researching a New Paradigm*, pp. 161-183. Oxford & New York. Oxford University Press.

Slowak, A. P. (2008), Standard-setting Capabilities in Industrial Automation: A Collaborative Process, *Journal of Innovation Economics*, 2008 (2), pp. 147-169.

Updegrove, A. (1995), Standard setting and consortium structures, *StandardView* (Association for Computing Machinery), 3 (4), pp. 143-147.

Van Wegberg, M. (2004), Standardization and Competing Consortia: The Trade-Off between Speed and Compatibility, *International Journal of IT Standards and Standardization Research*, 2 (2), pp. 18-33.

Weiss, M., and Cargill, C. (1992), Consortia in the Standards Development Process, in: *Journal of the American Society for Information Science*, 43 (8), pp. 559-565.

## Appendix A

The original consortia information web page is only still available for Blu-ray, but not for HD-DVD. Thus, our event analysis is based on a key word search at the search engine Google. A consortia-independent key word search also better represents the markets' perception of the standards war in the course of time.

| Date | Agent | Standard Candidate | Score | Description |
|---|---|---|---|---|
| Jan-95 | DVD Forum | | - | Consortium founded by Hitachi, Matsushita, Mitsubishi, Pioneer, Philips, Sony, Thomson, Time Warner, Toshiba, Victor Company of Japan (JVC) |
| Oct-00 | Sony, Pioneer | BD | 0,5 | DVR Blue presented at Ceatec, Japan (later on first Blu-ray Disc revision, BD-RE) |
| Jan-02 | Toshiba | HDDVD | - | Specification proposal HD-DVD at DVD Forum |
| Feb-02 | Sony | BD | - | Blu-ray Disc plans are unveiled |
| Feb-02 | Blu-ray Disc Association | BD | - | Consortium formed by Hitachi, LG, Panasonic, Pioneer, Philips, Samsung, Sharp, Matsushita, Sony, and Thomson |
| Feb-02 | Hitachi, LG, Panasonic, Pioneer, Philips, Samsung, Matsushita, Sharp, Sony, Thomson | BD | 0,5 | Announcement of basic specifications |
| Mar-02 | DVD Forum, Warner Bros. | HDDVD | 0,5 | DVD forum approves the dual-layer DVD-9 disc (HD-DVD) |
| Aug-02 | NEC, Toshiba | HDDVD | - | HD-DVD (Advanced Optical Disc, AOD) proposed to be the next successor standard of DVD |
| Feb-03 | Sony | BD | - | Licensing of Blu-ray Disc begins. |
| Apr-03 | Sony | BD | - | First devices in stores (Sony BDZ-S77, Japan) |
| Jan-04 | Dell, HP | BD | 1 | Backing |
| Mar-04 | DVD-Forum, Microsoft | HDDVD | 0,5 | Microsoft's Windows Media 9 (VC-9) codec is selected by the DVD Forum; the codec will be required for all players in addition to MPEG-2 and H.264; condition: MS must modify license terms and propose the codec as open standard at Society of Motion Picture and Television Engineers |
| Jun-04 | Panasonic (Matsushita Electric) | BD | | Second manufacturer after Sony who launches devices (player???) in Japanese stores |
| Jun-04 | DVD-Forum | HDDVD | 0,5 | HD-DVD format approved |
| Aug-04 | Sony | BD | 0,5 | Physical specifications are finished |
| Sep-04 | BDA, Microsoft | BD | - | Blu-ray Disc will use several codices: MPEG-2, H.264 and Microsoft's VC-1. As VC-1 becomes included in both standards, Blu-ray and HD-DVD, Microsoft will gain royalties despite the fact which of both standard candidates will win the HD disc format war. |

| | | | | |
|---|---|---|---|---|
| Oct-04 | 20th Century Fox | BD | 1 | Backing, and on July 29, 2005 the studio officially announced its support for Blu-ray Disc. Twentieth Century Fox formally announced its support of the Blu-ray Disc format as a next-generation optical standard and joined the now 14-member board of Blu-ray Disc Association (BDA). Fox is the second movie studio to announce support for Blu-ray Disc. |
| Oct-04 | Blu-ray Disc Association | BD | - | Blu-Ray Disc Association (BDA) launches with more than 70 companies: growth from 13 to 73 companies over the last three months. |
| Oct-04 | JVC | BD | 1 | Backing |
| Nov-04 | Paramount Pictures, Universal Pictures, Warner Bros. Pictures, HBO, New Line Cinema | HDDVD | 1 | Backing |
| Nov-04 | Universal Pictures | HDDVD | 1 | Backing |
| Dec-04 | Blu-ray Disc Association | BD | 0,5 | Announcement of additional software specifications; allows linking games to movies on BD |
| Dec-04 | Walt Disney Company (incl. Buena Vista Home Entertainment) | BD | 2 | Backing, exclusively |
| Dec-04 | HD-DVD Consortium | HDDVD | | Consortium is formed by Toshiba |
| Dec-04 | Badai Visual | BD | 1 | Backing |
| Jan-05 | Vivendi Games, Electronic Arts | BD | 1 | Backing |
| Feb-05 | BDA | BD | | BDA surpasses 100 Members |
| Mar-05 | Apple | BD | 1 | Backing |
| Mar-05 | Apple | | - | Apples new QuickTime Version 7 will support the H.264 Advanced Video Codec (AVC) |
| Apr-05 | Sony | BD/HDDVD | 2 | Sony open to HD DVD/Blu-ray convergence |
| May-05 | Toshiba | BD/HDDVD | 1/1 | Toshiba refuses convergence of the two formats |
| May-05 | TDK | BD | - | BD Prototype developed with 100GB. [Not said, if ready for mass production] |
| Jun-05 | BDA, SUN | BD | 0,5 | SUN announces that BDA has chosen Java-based BD-J interactivity layer instead of Microsoft's HDi |
| Jul-05 | Verbatim Corporation (Mitsubishi Chemical Media) | BD/HDDVD | 2 | Backing both |
| Aug-05 | Lions Gate HE | BD | 1 | Backing |
| Aug-05 | Universal Music | BD | 1 | Backing |
| Aug-05 | DVD-Forum, HD-DVD Promotion Group, BDA | BD/HDDVD | 1/1 | Negotiations to unify standards has failed |
| Sep-05 | Sony | BD | 1 | Sony expects Blu-ray victory within 12 months |

| | | | | |
|---|---|---|---|---|
| Sep-05 | Samsung | BD/HDDVD | 2 | Backing both |
| Sep-05 | Microsoft, Intel | HDDVD | 1 | Backing |
| Sep-05 | Aplix | BD | 1 | Backing; aims to accelerate the integration of Java in BD |
| Oct-05 | BDA | BD | - | BDA surpasses 150 members |
| Oct-05 | Paramount | BD/HDDVD | 2 | Backing both |
| Oct-05 | Warner Bros. (incl. Warner Home Video) | BD/HDDVD | 2 | Backing both |
| Oct-05 | Microsoft, Intel, HP | BD | - | After demands of modifications of the Blu-ray disc standard by Microsoft and Intel, also Hewlett-Packard requests consortia negotiations related to technical possibilities of protected copies on home-based servers. |
| Nov-05 | Metro Goldwyn Mayer | BD | 1 | Backing |
| Nov-05 | MGM | BD | 1 | Backing |
| Dec-05 | HP | BD/HDDVD | 2 | Backing both |
| Jan-06 | Digital Playground | BD | 1 | Backing |
| Jan-06 | Pioneer | BD | - | Pioneer places a premium on high-definition Blu-ray media players |
| Jan-06 | Netflix | BD/HDDVD | 2 | Backing both |
| Jan-06 | Microsoft | HDDVD | 0,5 | Xbox 360 to get external HD DVD player |
| Mar-06 | LG | BD/HDDVD | 0,5/0,5 | LG Electronics to produce HD DVD drives in addition to Blu-ray |
| Mar-06 | Toshiba | HDDVD | - | First devices in stores (HD-A1 player) |
| Apr-06 | HD-DVD | HDDVD | 0,6 | 6 movies |
| May-06 | HD-DVD | HDDVD | 1,5 | 15 movies |
| Jun-06 | BD | BD | 1,4 | 14 movies |
| Jun-06 | HD-DVD | HDDVD | 1,1 | 11 movies |
| Jul-06 | BD | BD | 0,6 | 6 movies |
| Jul-06 | HD-DVD | HDDVD | 1,3 | 13 movies |
| Aug-06 | BD | BD | 1,2 | 12 movies |
| Aug-06 | SUN Microsystems | BD | 1 | Backing |
| Aug-06 | HD-DVD | HDDVD | 1,4 | 14 movies |
| Aug-06 | 20th Century Fox, Warner Bros. | | - | 20th Century-Fox will finally join Warner, releasing Blu-ray titles |
| Sep-06 | BD | BD | 2,3 | 23 movies |
| Sep-06 | HD-DVD | HDDVD | 2,3 | 23 movies |
| Oct-06 | BD | BD | 3,0 | 30 movies |

| | | | | |
|---|---|---|---|---|
| Oct-06 | American Independent Media Manufacturers Association (AIMMA) | HDDVD | 1 | Backing |
| Oct-06 | HD-DVD | HDDVD | 2,3 | 23 movies |
| Oct-06 | NEC | BD/HDDVD | 2 | NEC unveils chip to bridge Blu-ray/HD DVD divide |
| Nov-06 | BD | BD | 2,8 | 28 movies |
| Nov-06 | Sony | BD | 0,5 | Sony's PlayStation 3, which packs a Blu-ray Disc drive, goes on sale in Japan |
| Nov-06 | HD-DVD | HDDVD | 2,4 | 24 movies |
| Nov-06 | Universal Studios | HDDVD | - | Universal Studios claims to have the first true HD movie on HD DVD |
| Dec-06 | BD | BD | 2,0 | 20 movies |
| Dec-06 | HD-DVD | HDDVD | 2,2 | 22 movies |
| Dec-06 | HD-DVD Promotion Group | HDDVD | - | Encryption cracked |
| Jan-07 | BD | BD | 3,0 | 30 movies |
| Jan-07 | Hitachi | BD | 0,5 | 100 GB Blu-ray Disc presented (four layers) |
| Jan-07 | LG | BD/HDDVD | 0,5/0,5 | Dual-format Blu-ray/HD DVD player announced |
| Jan-07 | Warner Bros. | BD/HDDVD | 0,5/0,5 | HD DVD - Blu-ray combo disc (Total HD) announced |
| Jan-07 | HD-DVD | HDDVD | 1,7 | 17 movies |
| Jan-07 | Toshiba | HDDVD | - | Player for $600 announced |
| Jan-07 | Microsoft, Broadcom | | - | Microsoft, Broadcom aim to lower cost of HD DVD players |
| Jan-07 | TDK | BD | 0,5 | 200-GB-Blu-Ray-Discs and Mini Blu-Ray Discs for Camcorder/7,5 GB presented at CES 2007 |
| Feb-07 | BD | BD | 2,8 | 28 movies |
| Feb-07 | HD-DVD | HDDVD | 1,5 | 15 movies |
| Feb-07 | Spielberg Movie???? | HDDVD | - | Spielberg denies to release movies on HD-DVD |
| Feb-07 | Sony | BD | 1 | Sony claims victory of BD over HD-DVD towards the magazine Video Business; according to Nielsen VideoScan US sales analysis; marketing campaign in the US market is planned |
| Mar-07 | BD | BD | 1,5 | 15 movies |
| Mar-07 | HD-DVD | HDDVD | 0,5 | 5 movies |
| Apr-07 | BD | BD | 1,8 | 18 movies |
| Apr-07 | HD-DVD | HDDVD | 1,4 | 14 movies |
| Apr-07 | Toshiba | | - | The HD-A20 carries a suggested retail price of $500, while the MSRP of the HD-A2 has been dropped to $400 |
| May-07 | BD | BD | 2,4 | 24 movies |
| May-07 | Funai | BD | 1 | Backing |

| | | | | |
|---|---|---|---|---|
| May-07 | LFP (adult Industry) | BD | - | Adult movie plans announced |
| May-07 | HP | BD/HDDVD | - | Plans for hybrid player/writer announced |
| May-07 | HD-DVD | HDDVD | 2,6 | 26 movies |
| May-07 | Toshiba | HDDVD | - | Player hits sub-$300 mark |
| Jun-07 | BD | BD | 2,0 | 20 movies |
| Jun-07 | BDA | BD | - | Consumers who buy any Blu-ray player from July to September will get five movies from various labels including Sony, Disney, Fox, MGM, Paramount, Lionsgate and Warner Brothers. |
| Jun-07 | Sony | BD | - | Player hits sub-$500 mark |
| Jun-07 | Starz/Anchorbay | BD | 1 | Backing |
| Jun-07 | Warner Bros. | BD/HDDVD | - | Blu-ray-HD DVD combo disc plans cancelled |
| Jun-07 | HD-DVD | HDDVD | 3,1 | 31 movies |
| Jul-07 | BD | BD | 1,7 | 17 movies |
| Jul-07 | BJ's | BD | 2 | Backing exclusively |
| Jul-07 | European Commission | BD | - | European Commission is to investigate suggested anti-competitive business moves of BDA |
| Jul-07 | Questar | BD | 2 | Backing exclusively |
| Jul-07 | Razor Digital | BD | 2 | Backing exclusively |
| Jul-07 | Target | BD | 2 | Backing exclusively |
| Jul-07 | Tartan Video | BD | 2 | Backing exclusively |
| Jul-07 | Samsung | BD/HDDVD | 0,5/0,5 | hybrid player announced |
| Jul-07 | Target | BD/HDDVD | 2 | Backing both |
| Jul-07 | Tartan Video | BD/HDDVD | 2 | Backing both |
| Jul-07 | HD-DVD | HDDVD | 2,8 | 28 movies |
| Jul-07 | HD-DVD Promotion Group | HDDVD | 1 | HD-DVD group claims victory against Blu-ray in Q2 |
| Jul-07 | Microsoft | HDDVD | - | Xbox 360 HD DVD player hits $179 mark |
| Jul-07 | Toshiba | HDDVD | - | Player hits $113 mark |
| Jul-07 | Toshiba | HDDVD | - | Player hits $299 mark |
| Aug-07 | BD | BD | 1,3 | 13 movies |
| Aug-07 | Samsung | BD | - | Player hits $425 mark |
| Aug-07 | Acer | BD/HDDVD | 2 | Backing both |
| Aug-07 | Studio Canal | BD/HDDVD | 2 | Backing both |
| Aug-07 | HD-DVD | HDDVD | 1,2 | 12 movies |
| Aug-07 | Paramount, Dreamworks | HDDVD | 2 | Backing exclusively (for 18 months); New York Times reports that 150 Mio US $ have been paid for abandoning Blu-ray |

| | | | | |
|---|---|---|---|---|
| Aug-07 | Kinowelt, Capelight Pictures, Polyband, Concorde, Highlight, Kinowelt, Universum Film, Koch Media | BD | 1 | Backing |
| Sep-07 | BD | BD | 2,7 | 27 movies |
| Sep-07 | HD-DVD | HDDVD | 3,6 | 36 movies |
| Oct-07 | BD | BD | 5,6 | 56 movies |
| Oct-07 | BDA | BD | - | The specifications of the BD+ virtual machine are available only to licensed device manufacturers. A list of licensed commercial adopters is available from the BD+ website. The first titles using BD+ were released in October 2007. Versions of the BD+ protection have been circumvented by various versions of the AnyDVD HD program, including a new version of BD+ released in November 2008, and later cracked by AnyDVD on December 29, 2008. |
| Oct-07 | Lipinski Sound | BD | 2 | Backing exclusively |
| Oct-07 | HD-DVD | HDDVD | 3,9 | 39 movies |
| Oct-07 | Microsoft, Toshiba | HDDVD | - | Advanced Interactivity Consortium (AIC) is founded |
| Nov-07 | BD | BD | 3,9 | 39 movies |
| Nov-07 | Bestbuy | HDDVD | - | Players hit 100$ mark |
| Nov-07 | HD-DVD | HDDVD | 1,9 | 19 movies |
| Nov-07 | Wal Mart | HDDVD | - | Players hit 100$ mark |
| Nov-07 | Sony | BD | - | Sony begins selling a lower cost version of the PlayStation 3. |
| Nov-07 | HD-DVD Promotion Group | HDDVD | 0,5 | Triple-layer specification is approved by DVD Forum |
| Dec-07 | BD | BD | 2,9 | 29 movies |
| Dec-07 | LG | BD/HDDVD | - | Hybrid player in stores |
| Dec-07 | HD-DVD | HDDVD | 2,7 | 27 movies |
| Dec-07 | BDA, HD-DVD Promotion Group | BD/HDDVD | - | Up scaling DVD players cut into sales for both HD formats |
| Jan-08 | Apple | BD | 1 | Apple claims Blu-ray victory |
| Jan-08 | BD | BD | 2,5 | 25 movies |
| Jan-08 | Blockbuster | BD | 2 | Backing exclusively |
| Jan-08 | FS Film | BD | 2 | Backing exclusively |
| Jan-08 | Future Shop Canada | BD | 2 | Backing exclusively |
| Jan-08 | Grant's Electronics | BD | 2 | Backing exclusively |
| Jan-08 | HBO | BD | 2 | Backing exclusively |
| Jan-08 | National Geographic | BD | 2 | Backing exclusively |

| | | | | |
|---|---|---|---|---|
| Jan-08 | New Line Cinema | BD | 2 | Backing exclusively |
| Jan-08 | Sonic | BD | 2 | Backing exclusively |
| Jan-08 | Sony, Sharp | BD | - | Free Sony player for every new Sharp TV Set |
| Jan-08 | Warner Bros. | BD | 2 | Backing exclusively |
| Jan-08 | Woolworth´s | BD | 2 | Backing exclusively |
| Jan-08 | BBC | BD/HDDVD | 2 | Backing both |
| Jan-08 | HD-DVD | HDDVD | 1,2 | 12 movies |
| Jan-08 | Toshiba | HDDVD | - | HD-A3 player hits US$150 mark |
| Jan-08 | US Super Bowl Event | HDDVD | - | HD DVD commercial exclusively |
| Feb-08 | BD | BD | 2,2 | 22 movies |
| Feb-08 | Best Buy | BD | 1 | Claims Blu-ray victory |
| Feb-08 | Harman Kardon | BD | 2 | Backing exclusively |
| Feb-08 | Hi Fi Klubben | BD | 2 | Backing exclusively |
| Feb-08 | Highlight Films | BD | 2 | Backing exclusively |
| Feb-08 | Netflix | BD | 2 | Backing exclusively |
| Feb-08 | Paramount | BD | - | Paramount Pictures announced it would be releasing movies on Blu-ray Disc format. |
| Feb-08 | Scanbox | BD | 2 | Backing exclusively |
| Feb-08 | Tripictures | BD | 2 | Backing exclusively |
| Feb-08 | Universal Studios | BD | - | Universal Studios announced it would be releasing movies on Blu-ray Disc format. |
| Feb-08 | Circuit City | HDDVD | - | Players hit $112 mark |
| Feb-08 | HD-DVD | HDDVD | 1,9 | 19 movies |
| Feb-08 | Microsoft | HDDVD | - | Microsoft drops price of Xbox 360 HD DVD add-on |
| Feb-08 | Microsoft | HDDVD | - | Microsoft stops making external HD DVD drives for its Xbox 360 game console |
| Feb-08 | Filmax, Tripictures | BD | 2 | Backing exclusively |
| Feb-08 | Nievus | BD | 2 | Backing exclusively |
| Feb-08 | Amazon | HDDVD | - | HDDVD discs discount by 50% |
| Feb-08 | Wal Mart | BD | 2 | Backing exclusively |
| Feb-08 | Toshiba | HDDVD | - | Toshiba's announcement on February 19, 2008 that it would no longer develop or manufacture HD DVD players and drives. |
| Mar-08 | Microsoft | HD Downloads | - | Microsoft claims that physical discs will disappear in favor of download standards and announces Microsoft XBOX Live |

| | | | | |
|---|---|---|---|---|
| Mar-08 | HD-DVD Promotion Group | HDDVD | - | Promotion group officially dissolved on March 28, 2008 |
| Jun-08 | DVD Forum | HD Downloads | - | Approval of the mark for Download/DL technology |
| Feb-09 | DVD Forum | HD Downloads | - | Download/DL licensing specifications revealed |

*Source: own illustration; events are collected by applying the following search runs: key words include the consortia names "Blu-ray Disc Founder Group" OR "Blu-ray Disc Association" OR "HD DVD Promotion Group" and exclude Wikipedia pages. Search queries have been separated for each year from 2001 to 2008. For instance, our query for year 2008 is: "Blu-ray Disc Founder Group" OR "Blu-ray Disc Association" OR "HD DVD Promotion Group" "2002" -Wikipedia. We furthermore conduct a search on the term 'standard war', e.g. Blu-ray HD DVD standard war "2008" -Wikipedia. Finally, the list of events is completed as to our best knowledge from secondary analysis such as technology reports or documents and press releases issued by leading consortia members.*

## Appendix B

Movie releases in Appendix A are scored and used in figure 10 according to the following index: (releases per month/10); this index is essential to control for crucial cyclical movie releases on both standard candidates. Secondly, this method is applied to assure that each released movie is included in our analysis without giving their sum an unreasonable weight against other events. Other types of events (see Appendix A) are excluded from figure 10.

| **Kind of events** | **Scores for BD or HD-DVD** | **Scores for hybrid** (thus in favor of both standard candidates or a common standard instead) |
|---|---|---|
| Backing exclusively | 2 | - |
| Backing | 1 | - |
| Claiming victory | 1 | - |
| Presentation at trade fairs (not both standard candidates), or announcements of basic specifications (not proposals only) | 0,5 | - |
| Backing both (by products) | 0,5/0,5 | - |
| Backing both (commitment) | - | 2 |

## Notes

[1] We provide an in depth case of a specific standard war (Blu-ray against HD-DVD) and thus do not take other emerging standard candidates into account (e.g., Taiwan's Forward Versatile Disc, China's Enhanced Versatile Disc, Japan's Holographic Versatile Disc, or upcoming download format standards).

[2] "In the first stage, firms choose whether to affiliate with other firms so as to share a technical standard (platform). The result of the first stage game is a partition of the set of firms into associations (coalitions), where the same technical standard prevails within each coalition, and different standards prevail across coalitions. ... Each firm can only choose one such platform." (Economides and Skrzypacz, 2003, pp. 2-4).

[3] BETAII: more than one hour play time.

[4] Dynamic capabilities can be taken for "abilities to", more precisely, as "identifiable processes" or "second order capabilities constituted of strategically important core capabilities which in turn are comprised of functional capabilities" (Menon, 2008, p. 25). They are "fungible" and they represent, particularly "routines". Core processes, upon which dynamic capabilities are based, particularly concern learning, competence & resources-reconfiguration, but also the coordination and integration of resources into the organization.

[5] AACS is a copy protection layer which is supported and developed by a consortium that includes Disney, Microsoft, Matsushita (Panasonic), Warner Bros., IBM, Toshiba and Sony. Thus AACS Licensing Administrator consortium consists of several companies of BLURAY and HD-DVD adherents.

[6] The first generations of BD blockbuster releases were compatible with almost all players around the world.

[7] Ritek says that its multi-layer extension process can be applied to both HD DVD and Blu-ray formats. At base specifications, 10 layers on an HD DVD would yield 150GB, assuming 15GB per layer. For Blu-ray, the total over 10 layers jumps to 250GB, assuming the base 25GB per layer.

[8] Data source: Famitsu: As for 2008 domestic game market scale approximately 582,610,000,000 Yen, Jan 5, 2009 (http://www.famitsu.com/game/news/1221045_1124.html, Enterbrain Inc., translated from Japanese to English by http://babelfish.yahoo.com/, Yahoo Inc.).