Innovation and Competition in Standard-Based Industries: A Historical Analysis of the U.S. Home Video Game Market

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***Abstract*—This paper examines the competitive dynamics in a standard-based industry through a historical observation of the U.S. home video game industry. The paper focuses on the theoretical issues of switching costs, installed base, and complementary goods as critical factors of dominant designs and firm success in a network-based industry. Our analysis reveals multiple stages of technological innovations and changes of market leadership and industry standards during a relatively short history of the industry. The industry exhibits six generations of technological changes in video game consoles and complementary products, with each generation represented by a new set of competitors, dominant designs, and market leaders out-competing the leaders of the prior generation. Our analysis confirms the efficacy of traditional tenets of successful strategic management in a network-based industry, such as the importance of technological innovation, building entry barriers, protecting firm-specific assets, competitive pricing, brand recognition, and effective channel management. These traditional strategies, however, should be geared to achieve new strategic goals, such as building installed base and a network of complementary products, that are critical success factors in competing in a network-based industry.**

***Index Terms*—Innovation, network effects, standard based industries, video games.**

I. Introduction

In many markets, the decisions of some consumers can affect the utility that other consumers receive from a product [9], [10]. These so-called network externalities are common in markets where products need to be connected together into a network (e.g., a telephone) or ancillary products are needed to fully benefit from a good (e.g., compact disks for a CD player). Standards are often created in order to facilitate the development of these markets [12]. However, the basis for competition in these standard based industries is often different from traditional markets because, with network externalities, market share itself becomes a potentially valuable resource for firms [8]. Building on the work of economists and technological innovation researchers, analysis of how firms should compete in these markets has started to attract attention [1]–[5], [15], [17].

Traditional strategic frameworks explain discrepancies in levels of firm performance as an interaction between the external environment (e.g., industrial forces) and the resources and capabilities that are developed and deployed by firms [25], [45]. Competition in standard based industries does not overturn any existing frameworks. However, since the existing installed base of products is a potential competitive advantage, firms now have greater motivation to compete for market share. Therefore, strategy concepts that center around developing market share and mass acceptance of products, such as economies of scale, first mover advantage, and technological innovation, feature greater prominence in the analysis of these industries than they do for others. This study presents a historical analysis of the U.S. home video game industry to explore what roles these strategic issues play in a standard-based industry and to understand how they might be different from competing in traditional manufacturing industries. In particular, we focus on technological innovations, switching costs, installed base, and complementary products as determinants of *de facto* standards and firm success across multiple generations of standards in the U.S. home video game industry. The paper then attempts to draw a comprehensive conceptual model that explains firm success in a network-based industry.

The U.S. home video game market is an important example of a standard based industry because customers purchase or rent software to use with their console. The complementarity between software and hardware in this industry thus creates a need for an industry standard to lower transaction costs and to increase buyer-switching costs. The home video game market is a significant sector of the home electronics industry, with 1999 sales of $6.9 billion in the U.S. [19]. In addition, this industry is also of potential interest to scholars because it presents a dynamic and intensely competitive environment for firms. It has already experienced several stages of industry revolution and changes of market standards in a relatively short time period. Since the first emergence of a dominant design based on a cartridge system in 1976 [20], there have been at least five stages of technological innovations based on video graphics capability. A sixth round of innovation is presently underway. Even more remarkable is that there have been dramatic changes of market leadership along with these waves of technological innovation. This frequent change of market leadership stands in stark contrast to changes in other recently emergent industries, such as the personal computer industry, which has received considerable

Manuscript received July 23, 2000; revised May 2001. Review of this manuscript was arranged by Department Editor B. V. Dean. This work was supported in part by the Center for Technology Management, Rutgers University, New Brunswick, NJ. This work was presented in part at the 1999 Academy of Management Meetings in Chicago.

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Publisher Item Identifier S 0018-9391(02)01597-0.

attention from scholars examining innovation issues [21], [22]. For example, the personal computer industry saw the rapid imposition of standards upon IBM's entry in 1981 and has strong backward compatibility; the introduction of Pentium chips or Windows 95 did not preclude the use of software that had been written for DOS on the new machines [23], [24]. In contrast, backward compatibility has been rare in the home video game industry, with each generation effectively "resetting the clock" of competition between firms [13]. Therefore, firms in the home video game industry fought what could be viewed as a full-blown standards war about every five years. Therefore, we think that this industry is ideally suited for a systematic study of the relevant concepts and key considerations surrounding competition in standard based industries. An in-depth industry case analysis is an appropriate research method to explore competitive dynamics in standard based industries. It is a daunting task to conduct a large-scale empirical analysis on the issue because of the need for historical observations of multiple industries. Moreover, the diversity in technology across industries also requires different strategic approaches toward building and managing industry dominance in different industries [31], [43], [44].

The paper begins with a brief overview of theoretical concepts applied in our study, including dominant designs, switching costs, installed base, and *de facto* standards. This is then followed by a historical analysis of the U.S. home video game industry with a primary focus on these theoretical issues over multiple generations of industry standards. The paper concludes with a discussion of theoretical and practical implications of managing competition in standard-based industries according to the historical findings of the U.S. home video game industry. We then present an inductively driven theoretical framework for firm success in network markets that combines traditional competitive strategies with the strategic goals of building installed base and a network of complementary products.

II. Theoretical Overview

When competing in standard-based industries, managers cannot check all the extant precepts of strategic management at the door (e.g., [25]). Issues such as industry structure and differing resources and capabilities of competing firms remain important for gaining and sustaining a competitive advantage. However, of primary interest for this paper is the potential importance for many of the additional issues that have been proposed as significant for standard based industries. While the full array of relevant variables for competition in these industries remain open for discussion, this paper focuses on three issues in relation to standards and innovation:

1) the role of the dominant design, a single architecture that embodies all of the key features and elements of a product;
2) the role of customer switching costs, which are the costs incurred by customers and rival suppliers for moving between standards;
3) the important role of installed base, the current number of adherents to a standard.

As we focus on these issues specific to standard-based industries, the paper attempts to address three important theoretical issues. First, what are the roles of standards versus traditional sources of competitive advantage to establish market leadership in network-based industries? Second, what are the economic and competitive processes in within versus between standards competition? Lastly, what are the direct sources of success in establishing an industry standard in a network-based industry, i.e., superior technology, switching costs, installed base, backward compatibility, or complementary products? As we address these issues through a historical observation of the U.S. home video game industry, we also attempt to draw a comprehensive conceptual model that explains firm success in network markets.

1) Dominant Designs: While definitions vary slightly [26, p. 24], [27, p. 613], [20, p. 417], there is considerable consensus in the innovation literature that product designs (or production processes) in markets enter periods of punctuated equilibrium referred to as dominant designs. A dominant design is the product architecture that first embodies all the primary characteristics of later products [21]. For example, a typewriter that allows the typing of upper and lower case letters that can be seen as they are typed is a dominant design [26]. All typewriters that followed, even if from different makers, had those features. The emergence of the initial dominant design is usually what allows a well-defined market to take shape [27], [28]. A study of the U.S. personal computer industry showed that adopting the dominant design was important once it had emerged, but there was little performance difference between firms that developed the dominant design and those that quickly adopted it [21]. For this paper, we define a dominant design as the aspects of the video game consoles that are technically distinguishable to consumers, such as storage media and interface.

However, even after a dominant design emerges, technical improvement of products and/or production processes continues in industries. Early views were that it is generally difficult for incumbents to survive shifts in the underlying technologies of their industry [29]. Later models recognized that these innovative processes could be either competence enhancing or competence destroying for firms [28]. It is generally assumed that the emergence of dominant design depends on the nature and extent of technological innovation. The paper examines this assumption through a historical observation of the home video game industry that experienced multiple generations of dominant designs. The paper also explores other potential sources of dominant designs, including traditional competitive strategies and new strategic emphases in network-based industries such as installed base and complementary products.

2) Switching Costs: Switching costs are costs customers incur moving from one product to another. Once a dominant design emerges, creating switching costs becomes a central feature of competition in standard based industries [3]. Switching costs are facilitated, and mutually reinforced, by two things—complementary products and network effects. Complementary products have already been referred to and are simply those products that are needed to maximize the utility of the core product. Complementary products can be physical, e.g., razor blades for razors, or intangible, e.g., touch typing skills for QWERTY keyboard layouts [6]. Since investments by consumers in either raises their switching costs, the provision of these complements is critical for firms competing

in standard based industries [1], [14]. Switching costs can also arise out of the need for interconnectedness (i.e., network effects) where customers become relatively more "locked in" to a standard, as more customers are likely to spend on these complements. Therefore, in order to enter a standard based industry a competitor must offer a product that is significantly more technologically advanced than existing products. In our historical analysis, we explore the roles and sources of switching costs in the U.S. video game industry before and after a dominant player has emerged in a market. Beside traditional competitive strategies, we also focus on interconnectedness between hardware, i.e., video game consoles, and software, i.e., video games, to explain switching costs and the sustainability of dominant design in the industry.

3) Installed Base: Once customers start to incur switching costs, then (and only then) installed base starts to become a valuable resource for firms [3]. Installed base is the existing number of users of a product. Therefore, the most direct way to build a firm's installed base is to be an early seller in a market. Early entry into a market often provides a lasting source of competitive advantage if the entrant can preempt assets, control technological leadership, or create customer switching costs [16]. The preemption of assets refers to the benefits a firm gains by accessing valuable resources before their value is known, e.g., a corner location on a highway that is about to be expanded. Contrary to many other markets, in a standard-based industry, market share may be a preempted asset. Technological leadership could result from legal protections like patents or learning-based cost advantages [25]. Empirical findings, however, have been mixed about first mover advantage, with many cases of first mover failures [31]. This suggests that there are strategic opportunities, such as penetration pricing and investments in complements, along with the entry order that determine a firm's installed base. In standard based industries the management of expectations of future installed base, such as pre-announcement of new product development, is also described as a useful strategy for firms [14]. Our analysis will delineate whether each of these forces are present and the roles they play in competing for installed base in the U.S. home video game industry. This would also be able to provide some insights whether competing for installed base, and dominant design, requires a shift in strategic focus from the traditional tenets of strategic management.

4) De Facto Standards: If a firm selects the eventual dominant design, exploits network effects by building switching costs, and increases its installed base and complementary products, it has a good chance to set a formal or a *de facto* standard in an industry. Formal standards are usually set through negotiations between most, if not all, of the potential vendors of a technology. However, of more interest here are *de facto* standards that emerge through market competition. *De facto* standards arise simply as a result of consumer choice. The triumph of Matsushita's video home system (VHS) format over Sony's Betamax is a classic example of the imposition of a *de facto* standard [32]. Matsushita's victory has been attributed to the presence of complementary products, i.e., videotape rentals, and its ability to ramp up production to build installed base [32]. This success led to a rapid disappearance of Sony's Betamax, as the installed base of VHS rapidly expanded [32].

The tendency for markets to pick one standard over the other is referred to as tipping. Standard tipping often causes "orphaning" of earlier standards as late adopters choose a platform that becomes incompatible with the earlier one and vendors of complementary products stop supporting the earlier standard [90]. Once a standard is adopted, competition between firms moves from between standards (e.g., Mac versus PC) to a battle within them (e.g., Compaq versus Dell). Continuing our VCR example, the battle turned into a more conventional within standards rivalry as Sony began to produce VHS devices.

Our study illustrates frequent changes and emergence of new standards in the U.S. home video game industry. In particular, we identify six distinctive generations of standards in this industry. We explore below the competitive processes of within and between standards competition in the U.S. home video game industry. The three theoretical issues, dominant design, switching costs, and installed base, are examined in each of these technological generations in terms of their roles toward building and tipping the industry standard. Multiple views, including these three issues, that are often overlapping, have been presented in the literature to explain the success and failure of a standard. Although it is not our intent to test each one of these views, the analysis below provides some historical evidence to draw insightful conclusions about the relative efficacy of these alternative views of success in standard-based competition. Some of these alternative views considered in our analysis include technological innovation (product superiority), switching costs, installed base, backward compatibility, and availability of complementary products, along with traditional competitive strategies. Based the historical findings, the paper presents an inductively drawn conceptual model that explains firm success in network-based industries.

III. Historical Analysis of the Home Video Game Market

1) Method: Our historical analysis attempts to illustrate characteristics surrounding dominant designs, switching costs, and installed base for each generation of technological changes, and eventually identify the drivers of success, in the U.S. home video game industry. Rather than mixing and matching examples to examine the relative strengths and issues surrounding competition in these industries we attempt a historical analysis. This however presents an important methodological challenge—how can the reader be assured that we are not cherry picking the history of the market while at the same time not being bored with a complete recitation of it? This is not a new problem and has been recognized most eloquently by Miles and Huberman, "We do not really see how the researcher got from 3600 pages of field notes to the final conclusions . . ." [33].

Our approach for this difficult problem is as follows. First, we attempt to limit our discussion of the industry to only its most dramatic events focusing on the issues surrounding dominant design, creation of switching costs, and building of installed base that we identified as being theoretically important. Second, since we are limiting ourselves to a historical study, our sources, books, newspaper articles, annual reports, etc., are publicly available and accessible. Third, we make every effort to aid the reader's interpretation of our analysis through the use

of tables that highlight differences in the key aspects of this industry across generations. Finally, by examining this dynamic industry we are able to see if patterns repeat across generations or remain stable. This allows for a limited amount of rigor to be applied since we must be consistent in applying our constructs and expected patterns across generations.

While our attempt is to draw an inductive theoretical framework that explains the success in a network market, based on the current literature, we expect a few patterns would emerge in the home video game industry.

a) Early adoption by a firm of what retrospectively turns out to be the dominant design will enhance its performance (in terms of survival and market share) in the industry [27].
b) Firms will challenge existing market leaders by introducing technically more advanced platforms to overcome existing customer switching costs [34].
c) Early movers will do better at building installed base (i.e., market share) than later movers.
d) Firms exhibiting the greatest control over complementary products will be able to persist in the market.
e) If a de facto standard is set, we expect to see tipping and a shift to within standard competition by market participants.
f) Despite the new competitive rules emerging in network-based industries, we expect that traditional tenets of competitive strategy are similarly important to explain market dominance and firm success in this type of industry.

2) Industry Overview: The emergence of the home video game market is attributed to the introduction and reduction in cost of two technologies—the transistor and microprocessor. Pioneers in these two fields, especially microprocessors, sought applications for their remarkable new products. Two companies, Magnavox (in the home) and Atari (in the video arcade), quickly adopted the promise of these new technologies to invent the electronic video game as a new form of entertainment [35]. However, the first home systems could play only a limited number of games that were hardwired into consoles. In 1976, Fairchild first introduced a central console with removable cartridges. This architecture, i.e., console and cartridges, and the consumer's TV became the first dominant design. This is where our historical analysis of the video game industry begins.

As noted above, there have been five distinct generations in the evolution of home video game consoles with a sixth generation underway as we write. Although each generation has unique aspects, there are a few general themes in the home video game market that are consistent across generations.

a) Profit margins on software, historically cartridges, but more recently CD-ROMs, have been higher than on the hardware, i.e., game consoles.
b) All hardware companies, with one exception (3DO), produced their own software titles. These in-house titles have been supplemented by varying numbers of third party software developers.
c) There has been a correlation between popular arcade hits, such as Pac Man, Donkey Kong, and Mortal Kombat, and successful home versions of the same games, making both creating and licensing these games valuable. Some of these games came to be referred to as a "killer app," software that was so good that it motivated consumers to buy not only the game but a compatible hardware platform as well [23].
d) Starting with the third generation, most video game players were first introduced in Japan about a year earlier than in the U.S. market. However, success in Japan does not appear to have influenced the outcome in the U.S. market. For example, NEC had tremendous success in Japan with its Turbo Grafix-16 but it failed in the U.S. [35].
e) Especially during the later generations, new systems were announced long before they became available in the market. For example, the Nintendo-64 was announced in August 1993 for shipment in the fourth quarter of 1995, but didn't appear on the market until the fourth quarter of 1996 [36].
f) Since they are popular Christmas presents, most sales of home video games in the U.S. occur in November and December. Accordingly, introduction of new products occurs mostly during the fourth quarter of the year.

Table I summarizes the six generations of video game technologies according to rival platforms and their respective manufacturers, introduction date, and graphics processing power (CPU, bits, and ROM). The difference between generations of platforms in graphics capability is exponential (i.e., a minimum of 100% improvement between generations) and they are similar in magnitude to technological discontinuities that have been identified in other studies [26]–[28]. The first platform (core hardware product and associated software) and manufacturer listed in each generation indicates the first mover of that generation. The platform in bold indicates the most popular platform in each generation. However, the most popular platform did not always embody a new dominant design. These are indicated with a superscript-$^{\mathrm{DD}}$. This summary shows the technological change that reoccurs every four to five years, creating a constantly evolving and dynamic industry. Time period indicates the period from the first introduction of a system to its final phase-out in a generation. Therefore, the periods are not consecutive and sometimes overlap across generations; for example, the second-generation Intellivision was introduced when the sales of the first generation VCS were booming. In addition, there are also gaps, e.g., 1985, due to negligible industry activity. We present a brief history of unique elements of each generation in the home video game industry. In particular, our discussion focuses on the sequence of market entry by competitors and the different designs they offered. We hope to draw out insights on the evolution of dominant design, first-mover advantages and switching costs, complementary products, *de facto* standards, and tipping in standard-based industries.

3) First and Second Generations: The Atari Years: The first generation of cartridge-based home video games was an outgrowth of the first successful coin-operated video game, Pong. Pong, an electronic version of tennis, was invented by Atari in 1972 and became wildly popular and widely copied by hosts of other small companies. Atari had trouble meeting demand for Pong and produced only 10% of the 100 000 "Pong-type" games produced in the industry [37]. Magnavox was the first of many companies to introduce a home version of "Pong,"

TABLE I
TECHNOLOGICAL EVOLUTION IN THE U.S. HOME VIDEO GAME INDUSTRY

Generation (Time Period)	Rival Platforms (Manufacturers)	Introduction Date	Operating Performance		
			CPU	Bit	ROM
1st (1976-1982)	Channel F[DD] (Fairchild)*	Aug. 1976	2 MHz	8	
	VCS[DD]** (Atari)	Oct. 1977	1.19MHz	8	4K
	RCA (Studio)	Jan. 1977		8	2K
	Odyssey^2 (Magnavox)	1978	1.78	8	
	Gamevision (Texas Instruments)				
	Home Arcade (Bally)	Feb. 1978	3.58MHz	8	
2nd (1980-1984)	Intellivision (Mattel)*	1980	.5MHz	16	16K
	Atari 5200 (Atari)	1982	1.79MHz	8	
	Colecovision**(Coleco)	Sep. 1982	3.58MHz	8	8-32K
	Arcadia 2001 (Emerson)	1982	3.58MHz	8	8K
3rd (1986-1990)	**NES****(Nintendo)*	Oct. 1985	1.79MHz	8	24-32K
	Master System (Sega)	Jun. 1986	3.6MHz	8	32-131K
	Atari 7800 (Atari)	Jun. 1986	1.79MHz	8	52K
4th (1989-1996)	**Sega Genesis****(Sega)*	Aug. 1989	7.6MHz	16	64K
	Turbo Grafix16 (NEC)	Sep. 1991	3.6MHz	8/16	250K
	Super NES (Nintendo)	Sep. 1991	3.58MHz	16	
5th (1995-present)	Interactive Multiplayer (3DO)*	Oct. 1993	12.5MHz	32	660Mb
	Jaguar (Atari)	Oct. 1993	26.6MHz	32	660Mb
	Saturn (Sega)	May 1995	28MHz	32	660Mb
	Playstation**[DD] (Sony)	Sep. 1995	33.9MHz	32	660Mb
	Nintendo 64 (Nintendo)	Oct. 1996	93.75MHz	64	100Mb
6th (1999-present)	Dreamcast (Sega)	Sep. 1999	200MHz	128	1.1Gb
	Playstation 2 (Sony)	Oct. 2000	294MHz	128	5.6Gb
	GameCube (Nintendo)	Nov. 2001	485MHz	128	1.5Gb
	Xbox (Microsoft)	Nov. 2001	733MHz	128	5.6Gb

* indicates the first mover.
** indicates the most popular platform.
[DD] indicates early adaptor and dominant design.

which became very popular [35]. However, consumers soon got tired of these simplistic games and desired more variety. In late 1976, Fairchild Instrument and Camera introduced the Channel F game system to meet this market opportunity. This system used replaceable cartridges, which offered consumers a theoretically inexhaustible variety of games.

Atari quickly followed with a cartridge-based system of its own, called the Video Computer System (VCS, later renamed the 2600). Learning from its Pong experience, Atari wanted to make sure that it could produce enough VCSs to meet demand. Therefore, it sought a partner with significant financial resources and found one in Warner Communications. Warner bought Atari for $28 million in 1976 [38]. With a capital infusion from Warner, Atari built 400 000 VCSs in order to be able to fully meet the expected demand for Christmas in 1977 [37]. However, the expected Christmas orders for home video games did not occur, and Atari was stuck with its inventory. Fairchild, also reeling from a tremendous drop in digital watch prices, exited the market.

The transition year in home video game market was 1978. Atari built on an earlier supplier relationship of its "Home-Pong" game with Sears to sell its VCS under the Sears name, "Telegames," while focusing primarily on the coin-operated arcade side of its business. This resulted in better sales in the fourth quarter of 1978 and along with increased marketing, considerable hope for its VCS in 1979. Magnavox also adopted the dominant design when it introduced its own cartridge-based Odessy^2 (called Odyssey Two) system.

Licensed by Midway from Tatio, Space Invaders arrived from Japan in late 1978 as the first major arcade game hit since Pong [35]. Space Invaders is credited with starting the video game craze in the U.S. In 1979, Atari purchased a license for a home version of Space Invaders and developed a home version of its own popular Asteroids arcade game. On the strength of these titles, Atari's VCS sales exploded and it easily became the most popular home video game platform with an 80%–90% market share between 1979 and 1981 [35]. Since Atari produced both arcade and home video games, its economies of scope allowed it to preempt rivals, such as Magnavox, from obtaining successful game designs that had been proven in the video arcades. Atari's influence over these key complementary products allowed it to dominate in the hardware market.

Atari's dominance with VCS began to slip as the market competition shifted to the software business. In 1980, Activision was started by four former Atari programmers to make VCS compatible cartridges [35]. Making a cartridge cost about $5 while its retail price ranged from $20 to $30 [39]. Given these economics, it is no surprise that Activision, with start-up capital of less than $1 million, was able to generate over $50 million in revenue within 18 mos [39]. While Atari sued Activision, other companies started to monitor the VCS cartridge market carefully. While the provision of these additional complementary products did add to Atari's VCS appeal, they cut into Atari's own profitable cartridge sales.

The entry of the first second-generation system, Mattel's Intellivision, also came in 1980. Coming from a well-known toy company, the Intellivision's sound and graphics were clearly superior to the VCS. However, without the power of any big name arcade hit cartridges, such as Space Invaders or Asteroids, sales of the Intellivision never approached those of Atari's VCS.

TABLE II
MARKET SHARES FOR HARDWARE AND VCS SOFTWARE IN 1982*

Company	Hardware Share	VCS Cartridge Share
Atari	2600 System (VCS) - 58 % 5200 System – 6%	58 %
Coleco	Colecovision – 17%	9 %
Mattel	Intellivision – 8 %	N/A
Imagic	N/A	5 %
Activision	N/A	20%
Others	11 %	8 %

* Market shares are in units.
Source: [37, 41].

TABLE III
CHANGES IN RETAIL PRICES OF VIDEO GAME AND HOME COMPUTER

Manufacturer	Model	Price		Price Change
		1/1/1983	5/31/1983	
Video Games				
Atari	VCS/2600	$139.00	$99.00	29%
Coleco	ColecoVision	$199.00	$139.95	30%
Mattel	Intellivision	$199.00	$139.95	30%
Home Computers				
Atari	Model 400	$299.00	$79.95	73%
Commodore	VIC-20	$199.95	$99.00	50%
Commodore	Commodore 64	$595.00	$289.00	51%
Tandy	TRS-80 Color	$299.00	$199.00	33%
Texas Inst.	TI 99 4A	$350.00	$99.00	72%
Timex	TS-1000 - Sinclair	$69.95	$45.00	36%

Sources: [40, 82]

The next two years show how rapidly things could change in this market. The pinnacle year for Atari was 1981. In fact, its main problem was to keep up with the demand for its VCS and related games. However, 1982 was the beginning of the end for Atari in the home video game industry for two reasons. First, another toy maker, Coleco, entered the market in early 1982 with its own second-generation system called the Colecovision. Unlike Mattel, Coleco had licensed a hit arcade game called Donkey Kong from a Japanese playing card, toy, and video game company named Nintendo. A copy of Donkey Kong was included with every Colecovision.[1] Coleco also marketed an adapter that allowed the Colecovision to play Atari's VCS games. While adapter sales were never brisk, its availability helped nullify the advantage of VCS having a larger software library in consumers' minds. By buying a Colecovision, consumers could theoretically have the best of both worlds. In addition, Coleco was very serious about winning the license deals that Atari had historically had to itself. Arnold Greenberg, president of Coleco, was quoted saying, "we will pay whatever we have to pay" [40, p. 110]. This focus on complementary products paid off; Colecovision was an instant hit, grabbing 17% of the hardware market, compared to only 8% for the Intellivision introduced in 1980, or 6% for the more recently introduced Atari 5200 [37]. Table II gives market shares in unit volume for competing hardware systems in 1982.

Atari's second problem is also shown in Table II. By 1982, serious competition had emerged in VCS software. Having set the *de facto* standard, Atari was now facing within-standard competition in the lucrative software market. Bensen and Farrell refer this type of challenge to a *de facto* standard holder as "pesky little brother [14, pp. 126–127]." Atari opened the floodgates for this type of competition when it settled its suit against Activision in early 1982 and allowed firms to produce VCS cartridges in exchange for a small licensing fee [35]. With the legal threat gone, 28 companies eventually entered the market for Atari's VCS cartridges [35]. The strongest of these new entrants was another company of ex-Atari programmers called Imagic, whose colorful and action oriented games grabbed 5% of the VCS compatible market [37]. Adding software injury to hardware insult, Coleco's Donkey Kong grabbed 9% of the software VCS software market [41]. All this emerging competition cut into sales of Atari's products and caused distributors to renege on their earlier orders, leading to an inventory crisis for Atari.

1983 was a bust year for the video game industry. Of special concern to Atari was its large inventory after significant portions of the 1982 orders were returned. However, of considerable concern to all participants was the meltdown in the home computer industry. Texas Instruments precipitated this meltdown when it dumped its entire inventory, equivalent to 9% of the market, of the ill-fated 99/4A home computer. Massive price-cutting ensued, which erased the $100–$200 price premium for home computers over home video game systems. As a result, consumers did not trade up from a 2600 to a 5200 or a Colecovision as expected; instead, they bought a home computer. Table III shows the price change between Jan. 1 and May 31, 1983.

This combination of new entry and substitutes in the video game industry led to tremendous industry-wide losses and exit of several major competitors. While unit sales in 1983 remained flat, Atari suffered a 50% reduction in revenue and an operating loss of $539 million due to the intense price-cutting [38]. By 1984, industry losses had totaled up to $3 billion [42] and firms were rapidly exiting the market. Mattel, whose losses over six mos had eliminated the entire net worth of the company, exited the market in July 1983 [43]. In May 1984, Atari was split into two parts and sold by Warner to Jack Tramiel (Atari Corporation) and Namco (Atari Games), a Japanese coin-op video game maker [44].

This closes out the first two generations of the home video game market in the U.S. Despite its early successes, Atari Corporation was now a minor player. Coleco, which sold a majority of the second-generation type systems, had exited the market by the end of 1984, along with most of the smaller software companies.

[1]This was standard practice. The included game was referred to as a "pack-in." Atari bundled Combat! with the VCS and later Pac Man with the 2600 and its own second-generation 5200 system.

While at first blush the story of the first two generations of this market may appear to be a classic five forces case of entry and substitutes [45], there are several other competitive issues present. Consistent with innovation theory, Atari was a successful early adopter of the dominant design. Due to the capital infusion from Warner, Atari was able to remain in the industry and exploit traditional first mover advantages. It could preempt assets, such as programmers and game ideas, and had little competition for arcade licenses (e.g., Space Invaders, Pac Man) that were critical for success in the home video game market. However, new entrants eroded this advantage by bidding up these costs. Atari did have legally protected technological leadership until its settlement with Activision opened up its profitable cartridge market. This reduced its control over complementary products and, therefore, its customers' switching costs. Atari's VCS set the standard for third-party complementary products and had an installed base of over 65% of all consoles sold by the end of the period [35]. Therefore, Atari's experience illustrates that setting the standard and building installed base alone does not always result in sustained competitive advantage for firms.

4) Third Generation: The Rise of Nintendo: Despite the collapse of the U.S. market, 1986 saw a nation-wide rollout of the Nintendo Entertainment System (NES). The NES had more realistic graphics than the earlier systems and had been a great success in Japan. More importantly, Nintendo designed a much more rationalized approach to the market than the earlier U.S. firms had taken.

Unlike Atari's VCS, the NES was designed from the outset to ensure Nintendo could control its complementary products. First, Nintendo produced cartridges for the NES that contained a "lock out" chip that prevented unauthorized licensees from making NES compatible cartridges [35]. Second, Nintendo limited the number of licensees that could create games for its system to 16 firms, of which four were U.S.-based. In addition, although it had licensees, Nintendo maintained its own in-house programming ability and routinely obtained licensing rights to most current arcade coin-operated titles. For example, Nintendo bundled Super Mario Brothers, a game based on characters from its earlier arcade hit Donkey Kong, with the NES [46]. Third, Nintendo insisted on exclusive deals from the software makers; anyone who received a Nintendo license for a game would be prohibited from making the game available on any other competing systems for two years. This discouraged the emergence of rival networks and allowed Nintendo a limited form of monopoly power [47]. Additionally, a licensee was limited to producing only five game titles per year, which prevented companies from flooding the market with "copy-cat" games and insured they released only what they thought were their best games. These actions stood in stark contrast to Atari in late 1983, which allowed an unlimited number of licensees to produce an unlimited number of titles in exchange for a small fee. Finally, while Nintendo manufactured all the cartridges for the NES, it was incumbent on the licensee to sell them. This reduced Nintendo's risk of a game being a flop and being returned by retailers, as had happened to Atari. These restrictions allowed Nintendo to strongly rationalize and control what had been a wide open market. Licensees were agreeable to these terms because, at the moment, they had no other outlet for their games. Therefore, this highly restrictive licensing system made it possible for Nintendo to preempt programming resources and tightly control complementary products.

Nintendo's plan worked flawlessly and the NES became wildly popular. U.S. sales were increased from 1.5 million units in 1986 to 9 million units in 1989 [35]. Exploiting its control over the cartridge manufacturing process, Nintendo often engineered shortages of some popular game titles, which further added to the "craze" nature of the business. It is unclear if this did, in fact, increase demand and sales of Nintendo cartridges, but it certainly increased awareness of the NES and frustrated its distributors and retailers. In addition, Nintendo broadened its name awareness. It gained exposure in a broad range of marketing channels, including a breakfast cereal, Saturday morning Mario cartoons, a feature length movie called The Wizard, and the largest circulation teenage magazine in the U.S., "Nintendo Power."

Nintendo's two main competitors during this time were Atari Co. and Sega. The now independent and weakened Atari Co. attempted to cash in on the new craze with its 7800 system introduced in May, 1986. However, the 7800 never really caught on despite Atari's purchase of Federated Superstores, an electronics chain, in order to carry Atari's products [48]. The Atari 7800, unlike most other consoles before or since, was also backward compatible with the earlier VCS games. However, since they were so dated and offered relatively poor graphics quality, this was not as strong a selling point as it would have been for a second-generation machine. Sega had a system similar to the NES, called Master System. Unfortunately, Sega suffered from two main problems. First, like Atari's 7800, most of the best potential home video game titles were now in exclusive deals with Nintendo. Second, Sega had trouble accessing the distribution network; even a distribution contract with Tonka Co. could not fully overcome this problem. Relative sales figures show the discrepancy in the market; while in 1986, Atari and Sega sold 100 000 7800s and 125 000 Master Systems, respectively, Nintendo sold over 1 million NES consoles [35].

The third generation illustrates the potential for a first mover with a well-structured network to harness the benefits of setting a market standard. Nintendo successfully preempted the game design, licensed assets, and held onto its technological leadership. Unlike the first two generations, programmers could not leave to set up a rival company because it would not have been allowed a NES license, lock out chips, or NES cartridge production facilities. In addition, software was no longer as profitable for companies because Nintendo controlled the manufacturing process and received large royalties on any game title released for the NES. Nintendo had fully exploited the conceptual advantages of being the first mover by establishing the standard (over 80% market share), preempting scarce assets (e.g., programmers), and being synonymous with home video game technology in consumers' minds.

5) Fourth Generation: New Challenges: Just like Atari's competitors, Nintendo's competitors looked to technological innovation to help them gain inroads on the market leader. In late 1989, Sega and NEC introduced the Sega Genesis system and the Turbo Grafix-16 system, respectively. These two new entrants

hoped to leapfrog Nintendo's 8-bit NES with their 16-bit graphic processors that provided much better colors, 512 versus 52 colors of the NES, and digital sound [49]. However, just like Intellivision in 1980, these two new platforms suffered from the lack of any proven software. During the Christmas season of 1989, there were 265 NES titles available against about 20 Sega Genesis games and a dozen Turbo Grafix-16 games [49]. Accordingly, in 1989 sales of these competitor systems, 600 000 for Genesis and 200 000 for Turbo Grafix-16, did not approach the nine million unit sales of Nintendo's NES system [50], [51]. Nintendo had a record profit of $725 million in 1990 [50].

During 1990 and 1991, however, Sega was able to substantially increase its sales based on aggressive advertising, sports-based game cartridges, and the popular game character, Sonic the Hedgehog. Sega harnessed the few software firms that had not already signed on with Nintendo into its own licensing network. In addition, as Sega emerged as a serious contender, Nintendo licensees created Genesis games, although they could not offer the exact same titles as they did for Nintendo [46]. Sega's sales momentum built up and carried over into the critical Christmas season in 1991. Nintendo waited until September 1991 to introduce its 16-bit system, the Super NES (SNES), but was unable to match the strength of the Genesis, either in number of software titles available or unit sales being outsold 1.4 million Genesis machines to 1.2 million SNES machines for the fourth quarter of 1991 [46].

The rise of Sega was only one of the many problems facing Nintendo during this period. Nintendo came under increasing pressure from its licensees, which had grown to 65 companies, to loosen their restrictions. As a result, Nintendo started to allow its licensees to manufacture their own cartridges [49]. In addition, under threat of antitrust investigation, Nintendo also removed the prohibition on licensees making their games available on competing platforms [46]. Software companies were now able to make the same games available for multiple platforms. This freed current Nintendo licensees to release games for the Genesis which had a higher installed base than the SNES. Naturally, Sega benefited greatly from these changes. On the other hand, NEC's Turbo Grafix-16 exited the market in 1992. This platform had sales of about one million units, but failed to attract strong software support [51]. NEC later attempted to return to the market with a multimedia platform, which was also unsuccessful.

After NEC's departure, the duel between Sega and Nintendo continued with considerable intensity. Sega upped the ante in November, 1992 when it introduced the Sega CD [52].[2] Compact disks (CDs) were heralded as a boon to the game industry because they could store tremendous amount of data (i.e., 500 times the capacity of a cartridge), which would enable realistic game play and movie type games [49].[3] However, the Sega CD did not have any immediate impact on its sales because of the steep price of the CD add-on, about $300, and game play that was still constrained by the Genesis' video processors. Sales in 1992 were similar to those in 1991, with Sega and Nintendo in a dead heat.

Little change was seen in 1993 as the two Japanese giants continued the battle with more games and add-ons. By the end of 1993, Sega and Nintendo had sold worldwide over 40 million fourth-generation consoles, with Sega leading in the U.S. market [53]. Considering its past dominance in this industry, this was a disappointing result for Nintendo.

The fourth generation was marked by Sega's successful challenge to Nintendo's dominance. This was the first generation that had seen two major rivals both with well-developed networks for complementary products. Third-party games were often released simultaneously for both platforms. Not surprisingly, the legacy of Nintendo's strength coupled with Sega's successful innovation resulted in a draw. On the other hand, NEC was unable to marshal a good field of complementary products for the TurboGrafix-16 and was compelled to exit the market. Also, since neither the SNES nor the Sega Genesis were backward compatible with earlier devices, it was critical to build franchises around game characters, such as NEC's Mario Brothers and Sega's Sonic, in order to translate past success into future advantage.

6) The Fifth Generation: A startup company, 3DO, initiated the fifth generation of home video games by introducing a 32-bit system, called the Interactive Multiplayer (IM), in March 1994. 3DO, taking note of Nintendo's approach, assembled a huge network of licensees for its platform, including a whopping 302 software companies and three hardware vendors [54]. This network was critical because 3DO principally profited by licensing the right to use its video game technology, not producing the game players or cartridges. Investors found this approach attractive; before a single IM had been sold, 3DO had raised $48 million from its inital public offering (IPO) [54]. However, in stores, enthusiasm was more muted. While a small number of game titles was a typical problem for a new platform in this industry, unlike other early entrants in prior generations, 3DO's game player, produced by licensee Panasonic, was expensive, $699, compared to $150–$200 for the Genesis or the Super NES systems [35]. These problems led to slow initial sales, only 50 000 units by November, 1994 [55].

Recalling its early mover success in the fourth generation, in May, 1995, Sega introduced a 32-bit fifth-generation machine, called the Sega Saturn. Sega also introduced the Sega Channel and an internet add-on for the Saturn to pursue opportunities in online game play. However, like the IM, the Saturn was priced at the high end of the market—$399. Sega's interest in other businesses, such as video theme parks, might also have hampered the Saturn by distracting firm management [56].

While Sega was considering theme parks, Sony entered the industry in late 1995 with its own video game player, called the Playstation. We believe that the Playstation was the second dominant design to appear in the industry. Like the IM and Saturn, it utilized CDs for its games. However, Sony went beyond these platforms by offering optional memory cards that let players save their games in progress.[4] We believe these two features, CDs that allowed a dramatic increase in the complexity of games and the new memory capability, distinguished the Playstation in consumers' minds sufficiently and helped it become a dominant

[2]The Turbo Grafix 16 had also had a CD expansion module.

[3]CDs' primary advantages over cartridges were in lower production costs and higher memory capacity, but at the expense of longer game loading times.

[4]Earlier versions of console games had used different codes to allow players an approximate save capability.

design. Priced at $299, the Playstation outsold the Saturn by 60 000 to 25 000 during the 1995 Christmas season [57]. On the strength of a strong marketing campaign and a plethora of action game titles, Sony sold over one million Playstations in six months [58].

Despite the entry of fifth-generation platforms, 16-bit machines continued to be popular. While Sega was focusing on the Saturn, Nintendo continued to turn out popular software titles for the SNES by incorporating additional graphics ability into cartridges rather than the console. As a result, the SNES was outselling the more advanced fifth-generation machines as late as Christmas, 1996. As a whole, 16-bit machines and related software accounted for 63% of home video game sales in 1995 [59].

However, in 1996, Sony was able to gain a tremendous ground in the market based on its price cut from $299 to $199 on the Playstation system. Sega's advantage in the U.S. market in early 1996—38% share versus 30% for Nintendo and 24% for Sony—began to slip as the Saturn sales lagged far behind Sony's Playstation and Nintendo's just-arrived Nintendo 64 [53]. Although Sega matched Sony's price cuts, Sony continued to dominate the 32-bit segment, outselling Sega two to one in 1996, while 16-bit sales dried up for all firms [60].

However, the big winner in 1996 was latecomer, Nintendo. Nintendo introduced its Nintendo 64 in October, 1996, with great success. Unlike other fifth-generation machines, the Nintendo 64 was introduced at the currently prevailing price for hardware, $199. Based on the strength of this low price and the appeal of its bundled Super Mario game, the Nintendo 64 matched the sales of Sony's Playstation over the crucial 1996 Christmas season, i.e., 1.3 versus 1.4 million units, respectively [60]. It also gained ground on Sony's advantage in installed base of 2.8 million versus 1.7 million for the Nintendo 64 [60]. The success of the Nintendo 64 was achieved despite the traditional bane of new systems, i.e., limited software; it had only six titles. Furthermore, it did not fully conform to the new dominant design. It had memory cards but still utilized cartridges for its games.

The later generations of players present something of an enigma. Innovation, via increasingly better graphics capabilities, continued to provide a gateway for new challengers in the industry. Yet, early mover advantages were not routinely decisive; NEC and 3DO both entered the market earlier than the prior incumbents but failed. However, the success of challengers, such as Sega against Nintendo and Sony against 3DO and Sega, illustrates the importance of complementary products and installed base. Sega succeeded through its provision of complementary products, especially games centered on its popular Sonic character. Sony's winning strategy was to expand installed base by lowering the price of core products. Since 3DO's hardware partners could profit only from the hardware product side, they were not willing to cut costs for the IM, and their product failed.

7) The Sixth Generation: A sixth generation of consoles was initiated by Sega's introduction of its 128-bit Dreamcast system on September 9, 1999 [61]. With the support of a $100 million promotional budget [62], the Dreamcast easily exceeded its early sales targets [63]. On the strength of Deamcast's sales, Sega surged from less than 1% of the market to about 15% in the fourth calendar quarter of 1999 and all of 2000 [64], [65]. Sega did not ignore complementary products offering 16 Dreamcast software titles at its introduction [61].

TABLE IV
DISTRIBUTION OF TOP 20 SOFTWARE TITLES PER PLATFORM BETWEEN 1999–2001

Month	Playstation	Nintendo 64	Dream Cast	Playstation 2
Aug-99	14	6	0	0
Sep-99	13	3	4	0
Oct-99	13	5	2	0
Nov-99	15	4	1	0
Dec-99	14	6	0	0
Jan-00	17	3	0	0
Feb-00	14	4	2	0
Mar-00	12	5	3	0
Apr-00	15	4	1	0
May-00	15	4	1	0
Jun-00	15	4	1	0
Jul-00	13	5	2	0
Aug-00	15	4	1	0
Sep-00	14	4	2	0
Oct-00	14	2	1	3
Nov-00	10	6	3	1
Dec-00	12	6	1	1
Jan-01	11	5	1	3
Feb-01	9	4	2	5

Source: [73]

Nintendo and Sony offered the standard responses to Sega's newest threat, they cut prices on their fifth-generation systems to $129 and $99, respectively [66], while promising new sixth-generation systems of their own for Fall 2000 [63], [67]. Sony previewed its own sixth-generation system, the PlayStation 2, one week after the Dreamcast's debut [68].

Consistent with past practice, the Dreamcast was a significant technological advance over the systems already on the market (see Table I). It also conformed to the dominant design parameters of Sony's PlayStation featuring a high capacity CD drive, memory cards, and similar controllers. One area where the Dreamcast differed significantly from earlier products, however, was that it included a modem that was designed to facilitate games over Sega's network [69] and used a variant Windows CE from Microsoft as its operating systems [70].

The sixth-generation competition for the Dreamcast picked up slowly. Sony got its highly anticipated PlayStation 2 into stores on October 26, 2000, over a year after the Dreamcast's debut [71]. The PlayStation 2 was a formidable competitor selling 1.4 million units by the end of the year [65]. Although it was technically similar to the Dreamcast, it offered two significant advantages. First, it was capable of playing consumer digital video disks (DVDs) making it a substitute for a DVD player. This was cited as a factor in making the machine so successful in Japan [72]. Second, and more importantly from the perspective of standard based industries, it was backward compatible with several hundred existing PlayStation games.

In the battle for complements, despite its late and limited introduction, the PlayStation 2 quickly overcame the Dreamcast. This is highlighted by the success PlayStation 2 titles had breaking into the top 20 sales lists for software. Table IV shows the distribution of top 20 software titles per platform between

1999–2001. Sony's success was also mirrored in sales figures of each firm's in-house titles, with 14.1% accounted by for Sony, 3.5% by Sega, 20.7% by Nintendo, and the remaining shares by third party developers [65]. However, the PlayStation 2 does appear to have one issue that plagued the Atari Jaguar and Sega Saturn; it is very hard to program games for it [74].

At present, the most interesting aspect of the sixth generation is the entry of U.S. software giant Microsoft into the market [75]. Microsoft's X-Box is based on technology from the personal computer industry [70]. For the X-Box Microsoft has undertaken aggressive efforts to encourage developers by seeding development tools and offering a nonpreferential licensing scheme as well as developing software titles in house [74], [76]. Microsoft has also received a possible assist from Sony, who kept the PlayStation 2 priced at $299, the same as the newer X-Box. These actions suggest that the X-Box has an exceptionally good chance to the overtake the PlayStation 2.

While it is unclear if tipping will occur in this generation, it is clear that being an early mover did not confer benefits to Sega. In January 2001, after continuous losses generated through aggressive price-cutting and numerous failed promotions including free Dreamcasts [77], Sega announced it would cease manufacturing of the Dreamcast [74].

IV. Theoretical Implications

The history of the video game industry offers insights on technological innovation which culminated in dominant designs, controls over complementary products to nurture switching costs, early mover advantages and competitive strategies to build installed base, and competition in standard-based industries. In this section, we examine some of the relevant theoretical issues in these areas in the context of this historical information.

1) Role of the Dominant Design: The video game industry evolved as firms engaged in continuous technological innovation. Each innovation shifted the industry into a new generation, resulting in new platforms, a new set of competitors, and different competitive moves. Two clear dominant designs emerged; one based on cartridges (Channel F and VCS/2600) and the other based on CDs and memory cards (Playstation). How important is adopting the dominant design?

The issue of a dominant design does not appear to have been as significant here as it has been in other industries. Most products in the first, second, and third generations of the industry uniformly adopted the console, cartridge, and consumer's TV design.[5] Given this homogeneity, it is difficult to argue that adopting the dominant design offered an advantage or not. While an early adopter (Atari) of the dominant design was successful, it offered little lasting advantage. In the fifth generation, Sony did much better with the second dominant design of CD game media coupled with memory cards. The fact that Sony continued to do well against established video game rivals who did not initially adopt its design (e.g., Nintendo) offers some support for the idea that initiating the dominant design can be a source of competitive advantage. Of course, dominant designs can only be recognized retrospectively [28, p. 443]. Therefore, we have to acknowledge that our labeling the Playstation as a dominant design may be premature. However, we are encouraged that the recently announced specifications for sixth generation video games generally include CD or DVD as game media and some memory capability.

2) Switching Costs and Technological Innovation: How important were switching costs and how were they overcome? Prior to the emergence of a dominant player in a generation, it is most of the traditional competitive strategies, involving firm capabilities, entry barriers, channel management, brand awareness, pricing, and entry order, that contributed to building switching costs. Once the market is settled with a dominant design, it is reinforced primarily through two sources: customer's sunk costs in a console player and its associated game library, and the tacit knowledge of how to play games. However, both of these were rather low. Companies generally priced their consoles low in order to gain users. However, this had the effect of lowering a customer's sunk costs. At the same time, while the games themselves were often complex, there was not that much tacit knowledge lost in switching from one player to another.

Therefore, it is no surprise that successful entry was possible. While some new entrants were more successful (Coleco, Sega, and Sony) than others (Mattel, NEC, and 3DO), they all were able to enter with a technologically superior platform. Therefore, we explain successful challengers as not only bringing to bear superior technology, but also duplicating the nonproduct advantages of the incumbent. For example, Coleco entered with a proven arcade hit, Donkey Kong, tied to its second-generation system while Intellivision did not. Sega developed a character franchise around its Sonic the Hedgehog character to match Nintendo's Mario Brothers. Superior technology was merely a necessary but not sufficient condition to challenge the leading firms in the industry. Also of interest, and consistent with innovation theory, is that no prior winner ever initiated a new generation.

3) Entry Timing: The history of this industry provides an ideal venue to examine first mover advantages for several reasons. First, it is an emerging industry that did not exist before 1976. Second, the history reveals a rapid turnover in leadership, which facilitates the examination of several cases of market leadership over a relatively short time period. This rapid turnover was primarily due to ongoing opportunity of technological innovations as illustrated above. A company may succeed, only to see its dominance quickly threatened as technology advances. Finally, because of ongoing entry and exit of firms in each generation, we can examine firm performance simply using survival as an indicator of success.

Tables I and V show that first mover advantage alone was not enough to ensure success in this emerging market. While Nintendo and Sega succeed as first movers in the third and the fourth generations, Fairchild, Mattel, and 3DO did not establish market leadership as first movers in the first, second, and fifth generations. Table V presents for each generation the early movers, their platforms, their lead until the next competing platform within the same generation, and the lead until the beginning of the next generation. Again, it does not appear that lead-time in order to build installed base was decisive. It should be noted that the lead for Atari is somewhat inflated because there was little or no market in 1976–1978 and 1984–1985 for it to exploit.

[5]There was only one exception to this, the Vetrix, which used vector graphics. Since TVs do not do well displaying vector graphics, the Vetrix's screen was built into the platform. It garnered little market share.

TABLE V
EARLY MOVERS AND MARKET LEADERSHIP IN THE VIDEO GAME INDUSTRY

Early Mover (Entry Year)	Platform	Generation	Lead within Generation	Lead before New Generation
Fairchild (1976)	Channel F	1st	0	Withdrawn (1977)
Atari (1976)	VCS/2600	1st	0	4 years
Mattel (1980)	Intellivision	2nd	2 years	6 years
Nintendo (1986)	NES	3rd	1 year	3 years
Sega (1989)	Genesis	4th	0	5 years
NEC (1989)	TG-16	4th	0	Withdrawn (1991)
3D0 (1994)	Interactive Multiplayer	5th	1 year	6 years

In the first generation, Atari was successful in obtaining typical first mover advantages with solid technological leadership, preemption of assets, while generating some level of customer switching costs. However, as discussed, it failed to hold on to these benefits. Its technological leadership was rapidly weakened as its programmers went off to start their own firms. Despite Atari's active use of the courts, it failed to prevent other companies from making cartridges for its VCS, adapters for rival hardware for VCS games, and close copies of popular VCS games. New entrants eroded Atari's preemption of assets by bidding up the price of arcade licenses, movie tie-ins, and programming talent. Customer switching costs were not a large factor since Atari and its rivals purposely set console prices low to increase the sale of cartridges.

Other early movers, such as Fairchild, Mattel, NEC, and 3DO, did not benefit from any of these drivers of early mover advantages. Fairchild did not persist in the market long enough to realize any benefits that it might have captured. Mattel's technological leadership was not inimitable and it did not benefit from the complements that Atari could offer (see Table VI). NEC was also a competent early mover but it did not develop sufficient complements to expand the basis of its platform. As we will discuss later, 3DO was not a successful early mover because its structure undermined its ability to conform to the industry norm of subsidizing hardware with software sales.

Nintendo's success as an early mover in the third generation was even more dramatic than Atari's in the first. Its effective lead is much greater than it appears within the third generation because it virtually shut out other competitors through network arrangement for complementary products. Given lock out chips and contractual safeguards, it became the only firm that was able to gain ironclad preemption of assets and cement technological leadership for an entire generation. Nintendo's tremendous success in the third generation reflected its ability to secure these advantages. Sega was also a first mover winner in the fourth generation. Although it never achieved the same level of market share that Nintendo garnered in the third generation (more than 80%), it did manage to break Nintendo's strangle hold on the market.

During the history of the video game industry, three of the early movers became the dominant players in their generation: Atari, Nintendo, and Sega. Their success was possible based on the utilization of typical first mover advantages, such as the preemption of assets, technological leadership, and switching costs. These findings offer some support for early movers emerging as dominant players in the market. However, as illustrated by the failure of other early movers, early mover advantages are not sufficient to establish sustainable market leadership, especially in this type of standard-based industry. This is consistent with surveys of prior work on first mover advantages [30]. However, we believe that unlike prior examples of first mover advantage, the potential rewards of success are greatly enhanced in standard based industries. For example, at its peak, Nintendo's profit was as large as Sony's on only a quarter of Sony's sales [46]. We will now discuss some of the other important competitive issues that are specific to a standard-based industry and examine their practice and effectiveness in the home video game industry.

4) Complementary Products and Installed Base: What distinguishes competition in standard-based industries from other industries is the presence of potential network effects. With different software and hardware competing for market dominance, network effects were present in the home video game industry. What was the role of complementary products and installed base in this market?

To what extent was the success of a video game console dependant on its complementary products, i.e., software? At first, most software was produced in house for each platform by the parent company. By licensing Hangman and Yahtzee from Milton Bradley, Texas Instruments was the first to use nonvideo game licensing for programs. However, during the first two generations, the competitive focus was specifically on obtaining popular arcade hits for a company's own platform [40]. Based on its in-house arcade unit and first mover status, Atari had an early advantage here. As other firms entered the VCS software market, however, Atari began to lose cartridge sales. While Atari acted unconcerned, its public claim that the increase in software for the VCS resulted in higher demand for the VCS was certainly true [78]. Atari was harmed because it was in the practice of selling platforms at cost in order to profit from cartridge sales. Atari's weakness accelerated when it agreed to a small license fee for VCS compatible cartridges. Unlike Atari, Nintendo and other followers handled this problem by continuing to sell platforms at near cost while strictly licensing who could make games for them, imposing higher licensing fees, and actively enforcing their contracts. Table VI maps out platforms, early mover status,

TABLE VI
MAJOR PLATFORMS AND COMPLEMENTARY PRODUCTS IN THE HOME VIDEO GAME INDUSTRY

Generation	Competitor	Platform	Early Mover	Complements	Outcome
1st	Atari	VCS/2600	Yes	Strong	Winner
2nd	Atrari	5200	No	Avg.	Also Ran
	Mattel	Intellivision	Yes	Weak	Also Ran
	Coleco	Colecovision	No	Strong	Winner
3rd	Atari	7800	No	Weak	Also Ran
	Nintendo	NES	Yes	Strong	Big Winner
4th	Nintendo	Super NES	No	Strong	Tie with Genesis
	Sega	Genesis	Yes	Strong	Tie with SNES
	NEC	TGrafix-16	Yes	Weak	Also Ran
5th	Atari	Jaguar	No	Weak	Also Ran
	Nintendo	Nintendo 64	No	Average	Tie with Sony
	Sega	Saturn	Yes	Average	Also Ran
	3DO	Interactive Multiplayer	Yes	Average	Also Ran
	Sony	PlayStation	No	Strong	Winner

complementary products, and outcome (by platform) of the major competitors across generations.

From Table VI, Atari's VCS had a lot of uncontrolled support that resulted in a large number of complements for its platform. Nintendo had an unusually strong network support in the third generation. Table VI also indicates that there is a tight correlation between complements and firm performance. The firms and platforms with strong complementary support, such as Atari's VCS, Coleco's Colecovision, Nintendo's NES and SNES, Sega's Genesis, and Sony's Playstation, emerged as winners in their own generations. The outcome also seems to be more closely tied with complements than early mover status; that is, many of the early movers did not become winners, but every platform with strong complementary support did.

In Table VI, of special interest is 3DO in the fifth generation. 3DO entered the market with what appeared to be a powerful network of three hardware licensees and 302 software licensees. 3DO's technically superior system with a strong network behind it was theoretically a formidable challenge to Nintendo and Sega. However, 3DO never met with much success. 3DO's failure can be partially attributed to a high price, $699, that was twice as much as 16-bit systems and far beyond the mass market price for consumer electronics of about $200–$300. Combined with the customary lack of software for new hardware platforms, this was enough to keep 3DO's system from reaching a critical mass to incur further support in the industry.

However, we believe that the primary source of 3DO's failure was more than its high price. 3DO had a broad base of support, but it was not deep. 3DO's 302 software licensees only produced about 35 games for the Interactive Multiplayer, and only one hardware licensee, Panasonic, actually built IM. Although it is critical to develop a broad network of suppliers and users to succeed in standard-based industries, this also carries a danger of becoming too dependent on outsiders for critical resources. Powell, Koput, and Smith-Doer [79] emphasize the importance of retaining a hand in the research process and in house capabilities in managing alliance strategy. 3DO presents a classic example of the perils of relying too much on the network for a firm's strategic success and key resources. Gomes-Casseres [80] illustrates the risk of losing competitive basis by relying too much on the network in a case study of the RISC chip industry. We believe 3DO's failure in the fifth generation of the video game industry presents another illustration of this risk. 3DO attempted to profit by licensing the rights to make hardware or software, which required broad market penetration to further encourage software development. However, unlike other companies in this industry, 3DO also relied on a licensee to make the hardware platform. Therefore, the platform could not be sold at cost or a loss because the hardware licensee, i.e., Panasonic, had no incentive to subsidize the software licensees. The software licensees, in turn, had no incentive to write for the IM and pay royalties to 3DO until it gained wide acceptance. Other firms had overcome this problem by selling their consoles at low prices, which helped sell more systems and garner more external support for their platform. A variation of this theory can also explain Atari's fall. While its network helped entrench its platform as a standard, the network itself came at the expense of Atari's own in-house staff who left to form new game companies. In other words, Atari's critical internal resources were traded for platform support.

Overall, the firms with strong emphasis on the provision of complementary products, i.e., Atari, Nintendo, Sega/Nintendo, and Sony/Nintendo, did well in four of the five generations of the home video game industry. Three of these four winners were also first movers (Atari, Nintendo, and Sega) suggesting a potential interaction effect between these two factors, i.e., early movers are successful if they develop a strong network of complementary products, rather than just focusing on installed base. However, Coleco, the second-generation winner, was an exception. While it was able to overcome an early mover, Intellivision, its complementary network was clearly not better than Atari's.

Although securing complementary products was critical, even having a successful platform and "setting the standard" was no guarantee of firm success in this industry. Much like IBM in the PC industry, Atari was able to set the standard in the first generation, but the potential gains from it went to other firms. Clearly there is more to gaining sustainable competitive advantage than simply setting the standard. Despite large installed bases for Atari and Nintendo in the first and the third generations, respectively, competitors in later generations were successful in challenging their dominance. This also appears to reduce the chances for "lock out," the idea that an extant standard precludes later, and intrinsically better, products from entering the market [10].

We believe there were three main reasons for the lack of lock out in this industry:

a) no backward compatibility between core products;
b) subsidized costs of core products;
c) very low intangible customer switching costs.

There were few systems in this industry that had backward compatibility with earlier ones. The lack of backward compatibility limited the value of earlier dominant designs in the market. It is notable that the only "new" system with backward compatibility, i.e., Atari's 7800, was successful primarily on the grounds of this feature [35]. If Nintendo's fourth- or fifth-generation systems had been backward compatible, this history would have been very different since 1991. Of course, maintaining backward compatibility is expensive, and it is critical to keep the hardware's cost low to compete in this industry. On the other hand, intentionally depressing the cost of core products also serves to lower switching costs and, therefore, the chances for lock out. A potential reason for the weak backward compatibility in this industry can be found in the customer profile, which includes mostly children. Unlike adult customers in other industries, such as the Wintel system in the PC industry, children may play video games at a particular developmental stage and then go onto other things when they lose interests in video games. Given the discontinuity in the customer group, there is little incentive for platform manufacturers to stick to the old standard as they attempt to leapfrog the current competition with a new design.

Lock out would also be less likely if it costs only a small marginal amount to buy an alternate platform, compared to a piece of software. For example, current fifth-generation players cost $129 but software for them costs $50–$70. This is a much lower core to complement product ratio than other typical standard-based industries, such as the VCR to tape rentals or the PC to software. Finally, compared to other standard-based industries, e.g., typewriter keyboards, intangible switching costs are minimal for home video games. The consoles are easy to handle; they generally consist of a power switch and a slot to insert a cartridge. The challenge lies in the game itself and, while they can be quite demanding on eye-hand coordination, the objectives of the games are usually simple, e.g., shoot the bad guys. Also, since video games are a youth-oriented industry, fads and fashion are much more salient in this industry, which helps overcome intangible switching costs.

In the video game industry, setting the standard was helpful only when a company was positioned to reap the advantage of it because lock out alone could not be counted on for long term dominance. As discussed above, Nintendo is a good example of this. In the third generation, Nintendo tried to build dominance with exclusive licenses and lock out chips. However, Nintendo did not build trust within its network. In fact, its conduct bordered on being exploitative, such as limiting quantities of cartridges for licensees and always demanding payments in advance. Such enforcement enabled Nintendo to build further advantages for its current product but at the cost of undermining long-term support for its network. In short, Nintendo's success during the third generation was based on its closed system standard. However, this advantage came at the expense of tying the network to its third-generation platform, the NES, not to Nintendo. Later when the opportunity came, Nintendo's NES allies were happy to desert it for Sega's Genesis and Sony's Playstation.

Atari and Nintendo applied another strategy to reap the benefit of setting the standard, which was to build complementary resources in addition to products. These resources were helpful beyond simply establishing the standard. Based on its early success, Atari had a large library of popular software titles to draw upon. Atari released versions of Asteroids, Pac Man, and Space Invaders for all its platforms in all the generations. Similarly, Nintendo used its early lead-time to build another strong resource, what we call its "Donkey Kong franchise." This set of related games, over ten in all, are all based on the characters that first appeared in Donkey Kong 20 years ago. For Nintendo, this game character franchise has supplanted the importance of arcade game hits that were critical for Atari's early success.[6] After all, the recent success of the Nintendo 64 is largely credited to the high game play value of the included cartridge, i.e., Super Mario 64, that is a direct descendant of Donkey Kong. The rapid technological change over generations has strengthened this advantage. Technological advances allow even more realistic and entertaining exploitation of this franchise, often providing a potential in-house "killer app." Nintendo used this strategy with its fourth- and fifth-generation entries.

5) Tipping: Finally, we also discuss "tipping," a tendency in this type of industry to rapidly adopt a single dominant standard [81]. Examples would include IBM compatible PC's and VHS format videocassette recorders [32]. However, probably for reasons similar to why lock out did not occur, tipping was not common in this industry. Although the industry has been highly dynamic, there are some firms that have persisted for some time. Atari (1976–1997) and Nintendo (1986–present) were dominant players in their respective generations and actively competed in the market for several years. However, there were several

[6]Today, the ubiquitous Pokemon might be another example of this type of franchise for Nintendo.

other companies that dominated in various generations, such as Coleco in the second and Sega in the fourth, that did not persist. There were also a number of challengers present in each generation that obtained significant market shares with nondominant designs. Thus, we can conclude that tipping was rare in this industry. Compared to the orphaning of CP/M by DOS in the PC industry, there is a much lower level of user-based network effect, i.e., intangible switching costs, in the video game industry, allowing multiple formats to exist at the same time.

V. Conclusion

Success in a standard-based industry requires new competitive rules in addition to traditional tenets of strategic management. Working around industry standards and complementary networks require much more than dealing with price and quality that were the primary elements in traditional generic competitive strategies [45]. Recently, there have been significant efforts to bridge this gap. However, it is a daunting task to study firm strategy in a standard-based industry because of limited empirical observations, i.e., the need for longitudinal data at the industry level.

This paper presents a historical analysis of the U.S. home video game industry. The history reveals quite rapid changes of technologies, competitors, and firm strategies over a relatively short time period. This industry offers much potential for theoretical development and validation of existing theoretical claims especially because of its emergent status, the existence of clear market leaders and followers, and its rapid technological change. Furthermore, it operates in a nice juncture of the real and information economy. Video games are very real products that also embody many aspects of information goods [3].

We focused on three important strategic issues:

1) technological innovation and dominant designs;
2) early mover advantages (and switching costs);
3) competition in standard-based industries, especially the role of complementary products and installed base.

The key finding in this study is that success in a standard-based industry requires much more than just technological innovation or being a first-mover in a market. Technological innovation was essential and being a first-mover helpful, but not sufficient, toward building a dominant position in the market. An effective strategy to become a winner in each generation appears to be building a network of complementary products and subsequently installed base, which depend on each firm's competitive strategies toward building switching costs. Although innovation did not guarantee eventual success in the market, it was a mandatory strategic weapon for challengers. The industry experienced several quantum changes because of technological innovations, leading to different competitive landscapes with a new set of competitors. Even the most successful firms in this industry, with strong complementary networks, were not able to sustain their dominance for more than one generation. The history of this industry presents a typical Schumpeterian regime, but in a much more dynamic sense. This finding is in line with the resource-based view, which relates a firm's sustained competitive advantage with its internal innovation and learning capabilities.

Our findings also offer partial support to traditional argument on first mover advantages; they were important only to the extent that first movers used their time to develop a network of complementary products. This study also validates that installed base alone is not sufficient to develop sustained competitive advantages [3]. This study focused on some of the new competitive dimensions, such as complementary products and installed base, in a standard-based industry. However, it should be noted that most traditional tenets of strategic management, such as technological innovation, building entry barriers, protection of firm-specific key resources, building name brands, pricing, etc., still play critical roles to succeed in a network-based industry. This study illustrates that building a network of complementary products and installed base should be the primary goal to compete in this type of industry. However, competing for such goals depends on traditional competitive strategies. For example, the history of the video game industry shows that attracting independent software vendors into the network of a platform requires the following:

1) superior technology;
2) early entry through innovation;
3) proper pricing;
4) name brand;
5) channel management;
6) entry barriers.

These competitive strategies provide higher switching costs and a broader network of complementary products, which further increases the installed base. Success in building complementary products and installed base then reinforces switching costs. We thus conclude that the new competitive rule in a network-based industry reflects the change of strategic goals, but not necessarily the change of competitive strategies. Explaining the success in a standard-based industry thus requires multiple perspectives including traditional competitive strategies, technological superiority, and building a network of complementary products and installed base. According to these findings, we suggest a conceptual framework that explains firm success in network markets. The model emphasizes firm (innovation and managerial) capabilities as the founding and necessary block to sustain a firm's advantage within and across generations of standards. Strong capabilities and absorptive capacity allow early entry or adoption of a new design and effective competitive strategies, creating a higher level of switching costs toward the firm's platform. These are critical forces toward meeting the strategic goals of installed base and complementary products. Fig. 1 summarizes these findings into a conceptual model for competitive success in network markets.

Due to the lack of tipping and lock out of competing standards, this study does not provide direct evidence to draw conclusions about between and within standard competition. However, since each generation of platforms reflects a distinctive set of technological combinations that is often incompatible with earlier generations, we believe comparing across and within generations allows implications similar to the within and between standards competition to be drawn. A clear pattern emerging from our historical observation about the generational shifts in industry standards is that it is a typical Schumpeterian compe-

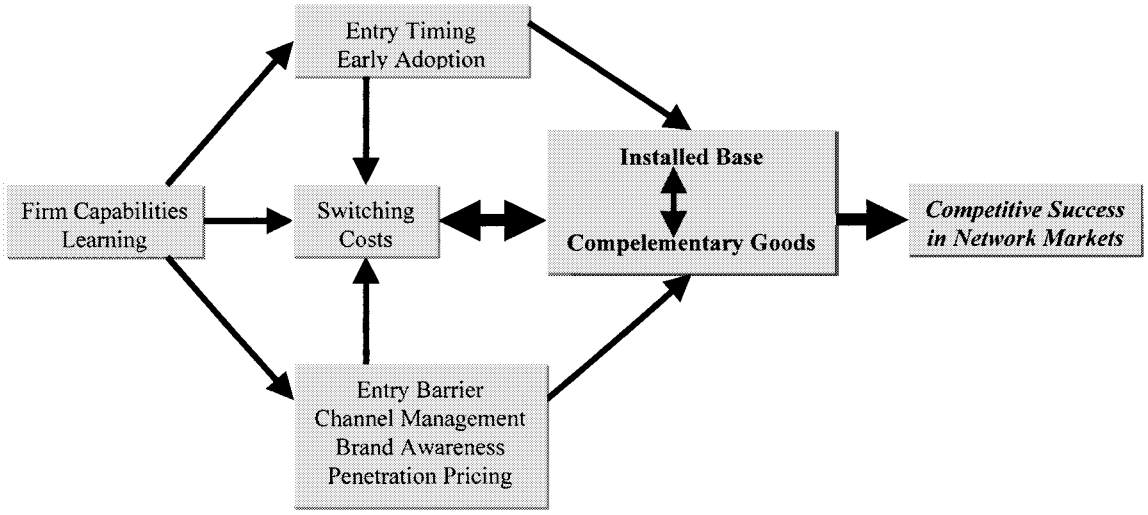

Fig. 1. A conceptual framework of competitive success in network-based industries.

tition with new generation, rising only through technological innovation. Our study also exhibits that a generational shift requires far more than incremental changes in operating performance of the platform. Technological innovation, however, is limited in within generation competition as firms operate within a similar technological configuration. As a new generation starts, the strategic focus shifts from technological innovation into traditional competitive strategies to build a network of complementary products and installed base.

The ongoing confusion on how to compete in this new type of industry leaves many opportunities for future work in the area. Similar case studies for other standard-based industries, e.g., the PC industry, could be used to add further insights to some of the theoretical issues discussed in this study and to explore other unique features of competing in these industries. There also remain several aspects of the video game industry itself that could be explored. Even some of the current theoretical arguments on competing in standard-based industries need to be refined in future studies. It would be of special interest to strategy scholars to explore the linkage between setting a standard and subsequent performance of the firm.

Finally, given the lack of theoretical frameworks and normative suggestions, we hope that this historical analysis will offer valuable insights to practicing managers. In particular, it is critical that managers understand the unique natures and new competitive rules in this type of industry before attempting to develop new strategies for them. It is worthwhile to note that the firms with good understanding of prior history, change, and market development performed well in this industry.

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