Winners-Take-Some Dynamics in Digital Platform Markets:

A Reexamination of the Video Game Console Wars

Chris F. Kemerer*

Brian Kimball Dunn**

Shadi Janansefat*

*University of Pittsburgh

**University of Oklahoma

February 2017

Helpful comments from C. Liu and research assistance from A. Linn and G. Moody are gratefully acknowledged.

Winners-Take-Some Dynamics within Digital Technology Markets:

A Reexamination of the Video Game Console Wars

Abstract

Platform markets are often expected to yield a Winner-Takes-All outcome, but the recent competitions in some IT platform markets have seen multiple standards prevail, resulting in a *Winners-Take-Some* (*WTS*) outcome. We empirically test the hypothesis that multi-homing of the most-popular complements is an influential factor in the market outcome in platform markets. We use the video game console market as an appropriate context, given that its generational nature allows us to observe multiple changes in the market and in multi-homing over time. We propose an objective schema for video game console classification that addresses conflicts in existing classifications, and also enables us to confidently identify the market leader(s) in each class of video game console. Applying this objective schema shows that, for the first time in the history of video game consoles, the most recently completed competition, (what we term the Internet Class competition) resulted in a *WTS* outcome. Following recent empirical economics research in the mobile operating systems market, we empirically evaluate the pattern of change in the degree of multi-homing among the most-popular videogames in each class. We find that 65% of the most-popular games in the Internet Class are multi-homing, a distinct increase from prior competitions. This finding of the increase in multi-homing is robust across three sets of data and to various sensitivity analyses. We argue that this increase is likely due to changes in the cost structure of software game development, as well as the increasingly downloadable nature of the games. Implications for management are discussed.

Managerial Relevance Statement

Platform markets, where an intermediary facilitates transactions among two or more types of agents (e.g., complementors and consumers), have historically been competitive battlefields among platform owners. Typically these competitions have yielded a single dominant market leader who captures significantly more than 50% of the market share. Managers have taken note of this process and have sought to position their own products to become the winning standard in emerging platform markets, often through subsidizing adoption. In this study of the videogame console platform market we empirically validate a movement toward a Winners-Take-Some (WTS) outcome, and suggest that the changing digital economics of multi-homing have contributed to this outcome. Future analogous markets that demonstrate this trend will require managers to employ significantly different strategies than those that were successful in the past.

***Index Terms**- Platform markets, winner-takes-all, winners-take-some, multi-homing, video game consoles, videogames.*

I. Introduction

Platform markets, where an intermediary facilitates transactions among two or more types of agents (e.g., complementors and consumers), have historically been competitive battlefields among platform owners. Typically, these competitions have yielded a dominant market leader who captures significantly more than 50% of the market share. In such markets the eventual winner typically enjoys increasing returns to scale and high profitability. Thus, at the inception of such a market, platform owners attempt to rapidly expand the network on each side of the market, often at great cost (e.g., due to price subsidies). Managers have taken note of this process and are motivated to position their own products to become the winning standard in emerging platform markets [1].

However, the expected outcome of a single platform owner achieving market dominance, the so-called "Winner-Takes-All" (hereafter "WTA") result, has been challenged in recent platform market competitions. Instances of a different pattern of competition where no single winner emerges include the markets for digital flash memory cards, digital media files, digital image files and mobile operating systems [2], [3]. In these markets the competitions have not resulted in a single dominant winner, but rather a "Winners-Take-Some" (hereafter "WTS") outcome, in which multiple platform owners survive the competition and each win a substantial, but non-dominant, share of the market.

Are these WTS results indicative of a change in the prevailing dynamics for platform markets such that WTA is no longer the expectation? Understanding whether a fundamental shift has occurred is of particular interest to managers involved in such markets. If WTA is not to be expected, then the dominant strategy may call for less up-front subsidization and other costs associated with the attempt to win early market share. If WTS is now more likely to be the prevailing outcome for platform markets, then such technology platforms may need to be positioned to fight *in* the market (as with traditional products), rather than fighting *for* the market as managers of WTA products have been encouraged to do [4].

This research seeks to aid our understanding of whether fundamental changes in platform market dynamics are occurring. To that end, we empirically re-examine an oft-studied context that has resulted in numerous competitions over time: home video game console competitions. This market has followed a generational pattern, with new technology and new platform introductions resulting in numerous successive competitions. Further, these competitions, when consistently classified and analyzed, had, prior to the most recently concluded competition, yielded a single winner with dominant market share in each generational classification. Understanding why this most recent competition, unlike those that preceded it, yielded a WTS outcome illuminates our research problem, providing useful guidelines for adjusting expectations for both current and future platform markets.

The video game console market competitions are a useful context for study for other reasons as well. In addition to the clear economic value of the industry and its products — DFC Intelligence estimated the industry would surpass $100 billion in 2018 [5] — the industry has been shown to be a useful specimen for examining a number of digital business-related topics, including network effects and complementary goods, as well as platform markets [6]–[12]. In addition, the cyclical nature of the industry, brought on by the rapid technological obsolescence of its platforms, provides a number of natural experiments in a short period of time in which to study these phenomena.

In evaluating these competitions among video game consoles we observe an important change in complementors' multi-homing behavior (i.e., development for more than one platform) that may have led to this recent WTS outcome. Multi-homing among video game developers has increased substantially — in the most recently concluded competition 65% of the most popular games were available on competitive consoles, the first competition in which this number has ever exceeded half of the market. We argue that this has contributed to the emergence of a WTS outcome in the most recently concluded competition.

The remainder of the paper is structured as followed. Section II reviews the literature on platform markets, multi-homing and research on video game consoles. In Section III we propose an objective schema for an analysis of video game platform market, as well as for the analysis of multi-homing in the Internet Class. We present a summary of our findings and discussion in Section IV, and Section V summarizes and suggests future research directions.

II. Literature Review

A. Platform Markets

A *platform market* is a market in which an intermediary (the platform) enables interaction between two separate entities on at least two sides of the market[1] [1], [6], [9] (See Fig. 1). Examples of these markets include PC operating systems (enabling interaction between consumers and application developers), employment websites (enabling interaction between job-seekers and employers), and video game consoles (enabling interaction between video game players and game developers) [1]. These markets are further characterized by the presence of positive *cross-side network effects*, by which the net utility on one side of the market (e.g., consumers of video games) increases as the number of adopters on the other side of the market (e.g., complementors such as video game developers) increases [13]. This creates a chicken-and-egg problem for platform owners who need to be attentive to both sides of the market in order to make their network grow [9].

Fig. 1 A Platform Market with Two-Sides

In evaluating the competitions within technology platform markets over the last few decades both academic research and marketplace results have fostered an expectation for the emergence of a dominant standard [1], [6], [14], [15]. VHS, Microsoft Windows, eBay, PayPal, and Blu-Ray DVD are all examples of products that went on to dominate their respective platform markets. As has occurred in numerous networked markets, each example involved a season of conflict in which multiple, seemingly viable candidates contended for adopters before, finally, a single winner emerged with a dominant majority of the market share [16]. This trend of observing a WTA outcome, however, has been disrupted in some more recent competitions where no clear standard has arisen. Among flash memory cards, for instance, a number of formats initially competed, and

[1] There is a significant amount of literature that describes this as a "two-sided market". More current work identifies these as "platform markets", an umbrella term which include two-sided markets, and it is this current nomenclature that is used here.

multiple standards prevailed [2]. Similarly, on web pages, a number of image formats (e.g., .gif, .jpg, .png) can be found, with none of them holding a dominant share, and hence the emergence of a WTS outcome.

B. Multi-homing

Another key attribute of platform market competitions is the decision of adopters whether or not to multi-home, meaning they adopt more than one of the platforms engaged in a competition [9]. In a two-sided platform market both sides of the market (i.e., consumer and complementor) can choose to either single-home (i.e., adopt one and only one platform) or to multi-home. In the video game console context a consumer can choose to adopt only one console within a given competition (single-homing) or might instead adopt multiple consoles (multi-homing; e.g., can buy and use both an Xbox 360 and a PlayStation 3). Similarly, complement providers may single-home (by creating platform-exclusive content) or multi-home (by developing content for more than one competing platform)[2]. This research shows that, where multi-homing costs are high, a single platform is more likely to win the market (WTA), and, where they are lower, a WTS outcome is more likely, all else being equal.

Prior economic literature has found multi-homing to be a significant factor in determining the price structure and dynamics of platform markets and their competitive outcomes. Rochet and Tirole (2003) found that when more buyers (i.e., consumers) multi-home, the result is a more favorable price structure for the sellers (i.e., complement providers) [9]. Armstrong (2006) argued that the decision of agents in a platform market to either single-home or multi-home is one of the determinant factors influencing the structures of prices offered to both sides of the market [11]. Doganoglu and Wright argue that multi-homing makes firms less likely to make their network compatible, even when it is efficient to do so. Furthermore, although multi-homing can make compatibility more socially desirable, it makes it less likely for firms to choose network compatibility [17]. Rysman found that when measured as holding credit cards from different networks (as opposed to using credit cards from different networks), multi-homing is more prevalent [18]. Farrell and Klemperer describe how multi-

[2] Some studies use *software exclusivity* or *software incompatibility* to refer to the opposite of multi-homing on the complementor side (i.e. here termed single-homing) [25], [28], [71]

homing practices weaken the network effects in different industries with two-sided markets, such as the market for video recordings, sound recordings and telecommunications [19].

Another factor that can weaken the network effects and make a WTS outcome more likely is the presence of low-cost conversion technologies [2]. In the market of digital flash memory cards, no tipping to one format or standard was observed. This WTS outcome is attributed to wide adoption of converters acting as "gateway technologies" between multiple formats [20]. The provision of converters reduces consumer perception of the value of network effects by allowing them to choose a flash memory card format with a smaller installed base without worrying about compatibility costs [2].

Most recently Bresnahan *et al*. show that in the two-sided market of mobile operating system platforms, the multi-homing of more attractive and highly demanded apps can cause a fragmented market structure, in other words, a WTS equilibrium [3] . Their model proposes that the non-tipping structure of the market can be explained by allowing for heterogeneity of app attractiveness to customers. The authors suggest that app demand is highly concentrated, and that a small subset of highly attractive apps will be in higher demand by customers, regardless of the platform. Due to high demand, such app developers find it profitable to supply to both (or all) platforms and to multi-home across platforms. The model suggests that, if an adequate number of attractive apps multi-home, then the stable market structure will be in a fragmented equilibrium, i.e., a WTS outcome. The model is tested empirically with data collected on developers' platform choices and app and developer characteristics, as well as from commercial data on app usage. The empirical data supports this model, showing that since more attractive and highly demanded apps multi-home, the fragmented structure of the mobile app platform market is stable and no tipping will occur [3][3].

---

[3] Bresnahan *et al*.'s observations about mobile applications' multi-homing behavior is further supported by recent work highlighting the software tools available to reduce the cost of this practice [35].

C. Video Game Consoles

The video game console industry is a popular context for academic study (see Table I for a chronologically-ordered summary of video game console research), starting at least with Gallagher and Park's highly cited 2002 survey of video game console market dynamics in *IEEE Transactions on Engineering Management* [12][4]. Other research has utilized the home video game console market context to investigate the platform success dynamics based on complement sales [21], complement number and variety [22], [23], complement quality [24]–[26], customer expectations regarding future complement availability and quality [24], [27], complement exclusivity [23], [28], market concentration among complements [28], customer heterogeneity [26], [29], and technical qualities of the platform itself [30], [31]. In addition, the market has been used to assess the importance of platform technical qualities in determining complementor market entry [26][5].

Prior studies have examined how the characteristics of the video games themselves (quality, popularity, and exclusivity) affect the market for video game consoles and its dynamics [25], [28], [32], [33]. Historically, in the video game market multi-homing had not been a common practice since developing for multiple platforms meant re-programming games to work on those platforms, as well as incurring costs to manufacture and warehouse game cartridges. However, the composition of game development costs has changed, which can be hypothesized to increase the relative attractiveness for game developers to multi-home their games. Middleware "engines", which enable developers to more easily and inexpensively replicate graphic rendering and game behavior across platforms, have become more common [34], [35].

[4] We note that some earlier research (e.g., Dermer 1992) also uses video game consoles as examples.

[5] The home video game console market has existed since the early 1970s when various companies released home video game consoles (e.g., the Magnavox Odyssey). While the earliest consoles were limited to pre-loaded game content hard-wired into the console itself, in the mid- to late-1970s console platforms, such as the Atari 2600 (VCS) began to appear. The functionality of these newer platforms could be extended through the purchase of additional complementary content (i.e., video game cartridges). Since then, video game consoles have formed a platform market, where manufacturers build and sell the console, while primarily third parties develop and sell games that can be played on that console [9].

Table I Video Game Console Markets Literature Review

				Platform Market Factors			
				Network Effects			
Author(s)	**Title**	**Journal**	**Dependent Variable(s)**	**Buyer-Side**	**Seller-Side**	**Pricing/Subsidy**	**Other Concepts**
Gallagher and Park (2002)	Innovation and Competition in Standard-Based Industries: A Historical Analysis of the US Home Video Game Market	IEEE Transactions on Engineering Management	Market Winners (Anecdotal)	*Discussed, Not Measured*	Anecdotal	Price Cuts (Anecdotal)	Improvement in Graphics, Switching Cost
Shankar and Bayus (2003)	Network Effects and Competition: An Empirical Analysis of the Home Video Game Industry	Strategic Management Journal	Sales (in Dollars)		Sales of Top 10 Game Titles, Impact of Network Size		
Venkatraman and Lee (2004)	Preferential Linkage and Network Evolution: A Conceptual Model and Empirical Test in the US Video Game Sector	Academy of Management Journal	Complementor Decision to Develop for a Platform		(DV)		
Clements and Ohashi (2005)	Indirect Network Effects and the Product Cycle: Video Games in the US, 1994-2002	Journal of Industrial Economics	Units Sold	Cumulative Unit Sales (Prior to 1994)	Complementor Decision to Adopt Platform (Modeled)	Mean Console Price	
Zhu and Iansiti (2007)	Dynamics of Platform Competition: Exploring the Role of Installed Base, Platform Quality, and Consumer Expectation	Working Paper	Indirect Network Effects, Console Quality	Cumulative Unit Sales	Titles Available, Avail. of Future Titles, Gamespot Ratings	Mean Console Price	
Corts and Lederman (2009)	Software Exclusivity and the Scope of Indirect Network Effects in the US Home Video Game Market	International Journal of Industrial Organization	Number of Titles, Market Share	Cumulative Unit Sales	Titles Available, Number of "Hit Games"	Mean Console Price	Title exclusivity has increased over time and has weakened and changed the scope of indirect network effects
Chintagunta, Nair and Sukumar (2009)	Measuring Marketing Mix Effects in the 32/64 Bit Video Game Console Market	Journal of Applied Economics	Units Sold		Titles Available	Mean Console Price	
Dube, Hitsch and Chintagunta (2010)	Tipping and Concentration in Markets with Indirect Network Effects	Marketing Science	Market Share	Customer Valuation of Variety	Titles Available, Avail. of Future Titles	Console Price, Estimated Mfr. Royalty Fees	
Gretz (2010)	Hardware Quality vs. Network Size in the Home Video Game Industry	Journal of Economic Behavior & Organization	Market Share (Categorical), Available Titles	Market Share			Word Length, Processor Speed, RAM
Gretz (2010)	Console Price and Software Availability in the Home Video Game Industry	Atlantic Economic Journal	Console Price		Titles Available		
Liu (2010)	Dynamics of Pricing in the Video Game Console Market: Skimming or Penetration?	Journal of Marketing Research	Units Sold, Prices	Unit Sales	Titles Available	Mean Console Price	Consumer Heterogeneity (Modeled)
Srinivasan and Venkatraman (2010)	Indirect Network Effects and Platform Dominance in the Video Game Industry: A Network Perspectiv	IEEE Transactions on Engineering Management	Market Share	Cumulative Unit Sales	Titles Available, Title Genres Available	Mean Console Price	Game Title Exclusivity
Zhou (2011)	Bayesian Estimation of a Dynamic Equilibrium Model of Pricing and Entry in Two-Sided Markets: Application to Video Games	Working Paper	Console Units Sold, Software Units Sold, Market Entry		Online Software Ratings	Mean Console Price, Software Price	High- and Low-Type Consumers
Prieger and Hu(2012)	Applications barrier to entry and exclusive vertical contracts in platform markets	Economic Inquiry	Market Share	Market Share	Titles Available	Mean Console Price	Game Title Exclusivity and its impact on rivals' console demand
Lee (2013)	Vertical Integration and Exclusivity in Platform and Two-Sided Markets	The American Economic Review	Predicted Unit Sales, Consumer Welfare		Concentration of Sales ("Hit Titles " measured as being a Top 10 best-selling game)	Mean Console Price, Mean Complement Price	Prohibiting game title exclusivity contracts favors the incumbant
Kim, Prince and Qiu (2014)	Indirect network effects and the quality dimension: A look at the gaming industry	International Journal of Industrial Organization	size of installed base	Unit Sales	Quality-differentiated titles	Price cuts (Anecdotal)	Variety in Game Quality
Derdenger (2014)	Technological Tying and the Intensity of Competition: An Empirical Analysis of the Video Game Industry	Quantitative Marketing and Economics	Units Sold	Households with Units	Unit Sales and Revenue, Units per Household, Genre	Static Prices (Modeled)	Technical Features, Console as Game Producer

The video game console market is of particular interest in evaluating changing market dynamics. Since video game consoles are subject to rapid obsolescence due, in part, to their limited extensibility, a series of discrete platform competitions has emerged as new technology has been developed and brought to market. Thus each new competition begins with the rise of a new technology and ends with the onset of succeeding technologies [12]. The resulting competitions have clear beginnings and ends, and each has a limited number of participants. Thus, the competitions themselves can be directly compared to each other to enable drawing inferences regarding the factors driving differences in competition dynamics.

III. ANALYSIS

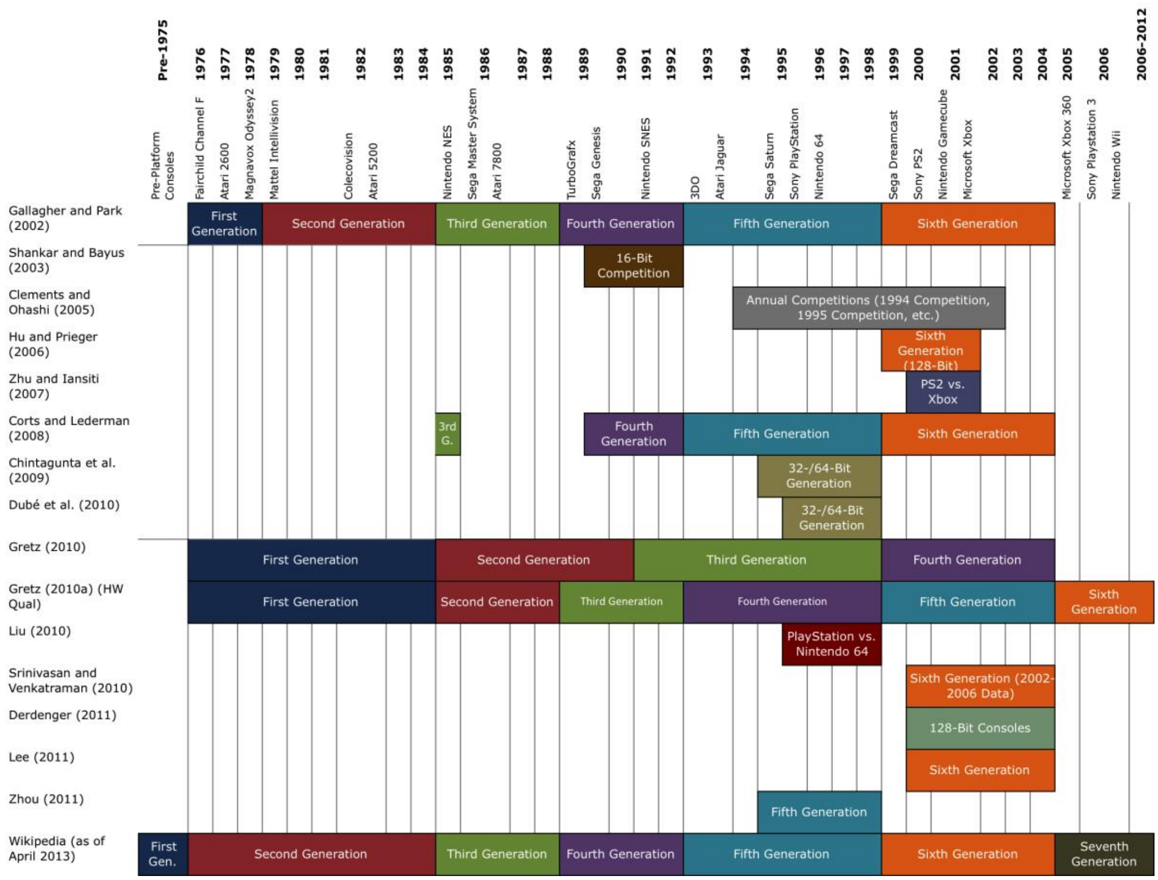
A. *Defining Video Game Platform Competitions*

While these successive competitions have proven useful to researchers, the establishment of a consistently applied scheme by which to classify the generations of competitions has proven problematic. Although Gallagher and Park set out an initial classification scheme in 2002, many researchers have opted to draw from only a selected slice of market data, often without respect to boundaries around discrete competitions [12]. Still others have invoked the concept of generations, without clearly citing the source of those categorizations. This is problematic in that understanding potential changes in dynamics among the various competitions will be less useful where there is not an agreed-upon set of competitors within any given competition.

Adding to the significant variation in competition classification schemes is the existence of a separate classification scheme on the widely-cited website Wikipedia, a scheme that neither coincides with classifications used in the academic literature nor presents the criteria used for determining its own classification. As a result, between Wikipedia's popular classification and those conveyed by the academic literature, researchers and managers are left with a wide, inconsistent, and undocumented variety of ways by which the various video game consoles have been separated into discrete competitions (see Fig. 2).

For example, the TurboGrafx console introduced in 1989 is characterized as "fourth-generation" by Wikipedia, but considered as "second generation" (along with earlier consoles, such as the 1985 Nintendo NES) in Gretz [36], as "third generation" in Gretz [30], and omitted entirely by Corts and Lederman [25]. Similarly, the 1995 Sony PlayStation is considered as "fifth generation" by both Wikipedia and Corts and Lederman, but as "third generation" and "fourth generation" respectively in Gretz [30] and Gretz [36], and as "32-/64-bit generation” by both Chintagunta *et al*. and Dubé *et al*. [27], [37]. In addition, the Wikipedia classification scheme considers video game systems released prior to 1976 as the “first generation”, whereas these non-platform devices (i.e., their functionality could not be extended through game cartridges, see Footnote 5) are disregarded by academic researchers.

Fig. 2 Comparison of Video Game Console Competition Classification Schemes (IN COLOR)



All of this raises the question as to which scheme is the most appropriate or suitable for research. These various existing categorization schemes are also problematic in that they can be difficult to replicate in terms of the criteria used to establish the boundaries. For example, the earliest of these studies, Gallagher and Park [12], recounts the historical competitions in the video game console industry, identifying along the way six generations, with the onset of each new generation defined by the single requirement of a “100% improvement in graphics capability” (p. 70). This classification scheme has two limitations. First, there is no specific argument proposed as to why improvement in graphics capability is a sufficient and appropriate single criterion. Second, even if graphics capability is assumed to be the best single criterion, the measurement used to categorize a new generation is not specified, i.e., the concept of “100% improvement” in graphics capability is not defined in a manner that would allow independent replication.

A second problem with these competing classifications is that their results, in many cases, appear to be in sharp contrast to what has been observed in other network market outcomes, further undermining the trust that might otherwise be placed in them. In particular, two such contradictions stand out. The first is that prior theory in the evolution of technology markets and the importance of network effects and complementary goods suggests that markets such as the home video game console market should be expected to have WTA outcomes in which a single dominant standard emerges from amongst a field of competitors [6], [38], [39]. However, the Wikipedia generational classification, as a recent instance of these discordant prior classifications, fails to yield this expected result. For example, Wikipedia’s fourth generation does not end with a single competitor having over 50% of the market. This anomalous result would have the potential to be of significant interest to management of technology scholars and to practice if there could be greater confidence in the underlying classification scheme, which is, unfortunately, undocumented.

Another anomaly from these schemes arises from the considerable research and empirical evidence from Christensen and others, which indicates that true generational shifts are the result of disruptive technologies, and that a winning vendor in one generation is very rarely the winning vendor in the succeeding generation [40], [41]. For example, as technology progressed over time, the rigid disk drive industry was able to build ever-smaller hard disk drives, establishing a number of standards along the way. With the onset of each new generation of hard disks (i.e., a new size standard), however, Christensen found that the dominant firm in one generation did not come to dominate the succeeding generation (due to focusing too acutely on the highly profitable generation in which it dominated). Similar histories have been attributed to the computer and PC industry [41] and to the photolithography industry [40].

The Wikipedia classification scheme contradicts this prior Christensen and related research as it includes the Sony PlayStation in its fifth “generation” and the Sony PlayStation 2 in its sixth, which results in the same competitor winning successive competitions. Again, like the anomalous fourth generation result cited above, this outcome also has the potential to be a managerially interesting finding, if it were only based on a reliable, rigorously established, and well-documented categorization.

B. A Rationalized Classification Scheme

The lack of a coherent classification scheme and the anomalous conclusions resulting from the Wikipedia generation summary and others suggest the need for an improved classification scheme that is unambiguously described and can be consistently applied to past, present, and future home video game console competitions. We propose a scheme that meets these criteria. Further, we note that when looking at past competitions, our scheme rectifies the discord between existing approaches to classification and theoretical expectations for competitive outcomes in past competitions.

Our scheme is based on both a primary and a secondary classifier. The primary classifier is processor word length and, within this, the second classifier is time between world-wide release dates. The logic behind this approach is two-fold. First, processor word length has been a widely used technical metric to define computing power [42]. Processors with longer word lengths, all else being equal, will have superior operational performance relative to shorter word length machines [25], and these benefits have resulted in a monotonic growth path for processor word length. Growth in processor word lengths is also a potentially disruptive force in that systems software (e.g., operating systems) often requires significant modification in order to take advantage of the new longer word length offered by the hardware. Therefore, an incremental increase in processor word lengths is a natural technical break point between what we term *classes* of consoles[6].

Second, we recognize that word length, although a useful metric, may not capture all of the technical advancements that take place, particularly in periods where improvements in word length happen more slowly. Therefore, we add a second dimension to the classification criteria that is based on the time between world-wide release dates. The passage of time as a criterion should capture the "residual", i.e. the incremental technical improvements that naturally occur over time and that would not be fully captured by processor word length. It

---

[6] We have adopted the terminology of "class" rather than "generation" to convey the notion of improvement from one group to the next, and to avoid the confusion with prior work that could result from adding one more discordant set of "generations" to the literature.

also has the advantage that it is likely to continue to be a useful metric in analyses of future consoles, unlike, perhaps, a more locally technology-specific metric, such as a measure of display technology that which may become outdated.

Specifically, we consider a new class to begin when a system is introduced with a processor with a longer word length (e.g., 64-bit consoles are considered a different class from 32-bit consoles), and then additionally where there has been a gap of at least two years between the world-wide releases of major consoles[7]. This second criterion results in splitting each of the original 8- and 16-bit sets of consoles into multiple classes. The resulting full classification of consoles and data regarding sales and class dominance can be found in Fig. 3 and Table II[8].

Fig. 3 Authors' Proposed Classification Scheme

		Authors' Scheme
Pre-1975	Pre-Platform Consoles	Proto-Class
1976	Fairchild Channel F	Early 8-Bit Class
1977	Atari 2600	
1978	Magnavox Odyssey2	
1979	Mattel Intellivision	
1980		
1981		
1982	Colecovision, Atari 5200	Middle 8-Bit Class
1983		
1984		
1985	Nintendo NES	Late 8-Bit Class
1986	Sega Master System, Atari 7800	
1987		
1988		
1989	TurboGrafx, Sega Genesis	Early 16-Bit Class
1990		
1991	Nintendo SNES	Late 16-Bit Class
1992		
1993	3DO, Atari Jaguar	32-Bit Class
1994		
1995	Sega Saturn, Sony PlayStation	
1996	Nintendo 64	64-Bit Class
1997		
1998		
1999	Sega Dreamcast	128-Bit Class
2000	Sony PS2	
2001	Nintendo Gamecube, Microsoft Xbox	
2002		
2003		
2004		
2005	Microsoft Xbox 360	Internet Class
2006	Sony Playstation 3, Nintendo Wii	
Post-2006		

This new classification scheme results in nine measurable classes of consoles (excluding the earliest pre-platform consoles) that cover the entire period from the 1970s to the consoles of the most recently completed competition.

C. Past Competitions and WTA Outcomes

In contrast with earlier proposals, the classification scheme presented in Fig. 3 is consistent, clearly explicated, and more easily replicable. It is also applicable to the entire video game console history, rather than being limited to a subset of years like most of the schemes shown in Fig. 2. Beyond these desirable

---

[7] By "major" we include consoles that sell at least one million units; the million-unit sales figure has been a traditional threshold, e.g., Crossley, Rob. 2013, February 19. "Timeline: The Towering Triumph of PlayStation 2", *Computer and Video Games*. http://www.computerandvideogames.com/391986/features/timeline-the-towering-triumph-of-playstation-2/).

[8] Sales figures given are current world-wide unit sales as of Sep 2016. Sources: Wikipedia (Fairchild Channel F, Magnavox Odyssey2); http://images.businessweek.com/ss/06/10/game_consoles/source/3.htm (Atari 2600) http://www.intellivisiongames.com/history.php (Intellivision) http://www.colecovision.dk/history.htm (Colecovision); http://www.mashpedia.com/Atari_5200 (Atari 5200); http://retro.ign.com/articles/965/965032p1.html (Sega Master System) http://www.gamasutra.com/blogs/MattMatthews/20090526/1521/Atari_7800_Sales_Figures_1986__1990.php (Atari 7800); http://www.gamepro.com/gamepro/domestic/games/features/111822.shtml (TurboGrafx-16); http://segatastic.blogspot.com/2009/12/mega-drive-sales-figures-update.html (Sega Genesis); and vgchartz.com (Nintendo NES, Late 16-Bit, 32-Bit, 64-Bit, 128-Bit and Internet Classes).

measurement characteristics, it also produces a different set of dominant consoles ("winners") than would be yielded by some earlier classification systems.

Table II Classification of Video Game Console Competition Classes

Note: WTA dominant console for each class denoted in ***bold.***

Class	Console	Word Length or Elapsed Time	Release Date	Sales (M)	% of Class
Early 8-Bit	Fairchild Channel F	8 Bits	Aug-76	0.8	2.2%
	Atari 2600	**8 Bits**	**Oct-77**	**30**	**83.8%**
	Magnavox Odyssey2	8 Bits	1978	2	5.6%
	Mattel Intellivision	10 Bits[9]	1979	3	8.4%
Middle 8-Bit	**Colecovision**	**8 Bits**	**Aug-82**	**6**	**85.7%**
	Atari 5200	8 Bits	Nov-82	1	14.3%
Late 8-Bit	**Nintendo NES**	**8 Bits**	**Oct-85**	**61.9**	**78.7%**
	Sega Master System	8 Bits	Jun-86	13	16.5%
	Atari 7800	8 Bits	Jun-86	3.8	4.8%
Early 16-Bit	NEC TurboGrafx-16	16 Bits	Sep-89	10	20.1%
	Sega Genesis	**16 Bits**	**Sep-89**	**39.7**	**79.9%**
Late 16-Bit	**Nintendo SNES**	**16 Bits**	**Aug-91**	**49.1**	**100.0%**
32-Bit	3D0	32 Bits	Oct-93	2	1.7%
	Atari Jaguar	32 Bits	Nov-93	0.5	0.4%
	Sega Saturn	32 Bits	May-95	8.8	7.6%
	Sony PlayStation	**32 Bits**	**Sep-95**	**104.3**	**90.2%**
64-Bit	**Nintendo 64**	**64 Bits**	**Sep-96**	**32.9**	**100.0%**
128-Bit	Sega Dreamcast	128 Bits	Sep-99	8.2	3.9%
	Sony PlayStation 2	**128 Bits**	**Oct-00**	**157.7**	**74.3%**
	Nintendo GameCube	128 Bits	Nov-01	21.7	10.2%
	Microsoft Xbox	128 Bits	Nov-01	24.7	11.6%
Internet Class	Microsoft Xbox 360	4 years[10]	Nov-05	85. 6	31.3%
	Sony PlayStation 3	6 years	Nov-06	86.6	31.7%
	Nintendo Wii	5 years	Nov-06	101.2	37.0%

Two important findings emerge from applying this classification scheme to earlier video game console competitions. First, the results of this approach make evident that a single, dominant console emerges in each class, as highlighted by bold text in Table II. This is consistent with much prior widely accepted research on technological market evolution, which predicts single winners [43]. Second, this classification scheme yields results in which winners do not repeat from one competition to the next, which, again, is predicted by existing literature [39]–[41]. Finally, we note a significantly different finding for the most recently concluded

[9] This oddity has been confirmed at the manufacturer's website: http://www.intellivisionworld.com/English/FAQ/. Including this unique console configuration with its contemporary peers in the Early 8-bit Class, despite the disparity in word length, does not materially affect the results, given its low sales.

[10] This class is designated through Rule 2 (i.e., the number of years between major releases).

competition, the Internet Class competition, wherein a single winner did not arise. This new result will be explored in greater detail in the data analysis section below.

D. The transition to WTS

We term the most recently completed competition the “Internet Class” competition. It began with the release of the Microsoft Xbox 360 in November 2005. Its competitors, the Nintendo Wii and Sony PlayStation 3, were both released worldwide in November 2006. Industry expectations were that this competition would end with a single winner as had previous competitions, with many industry pundits predicting an eventual victory for one or another of the platforms. For example, in 2007, the research firm *Research and Markets* predicted that the PlayStation 3 would be the eventual winner [44], whereas *Wired* magazine projected a victory for Nintendo’s Wii [45]. In 2008 Don Reisinger at *CNet* claimed that Microsoft’s Xbox 360 would win [46][11].

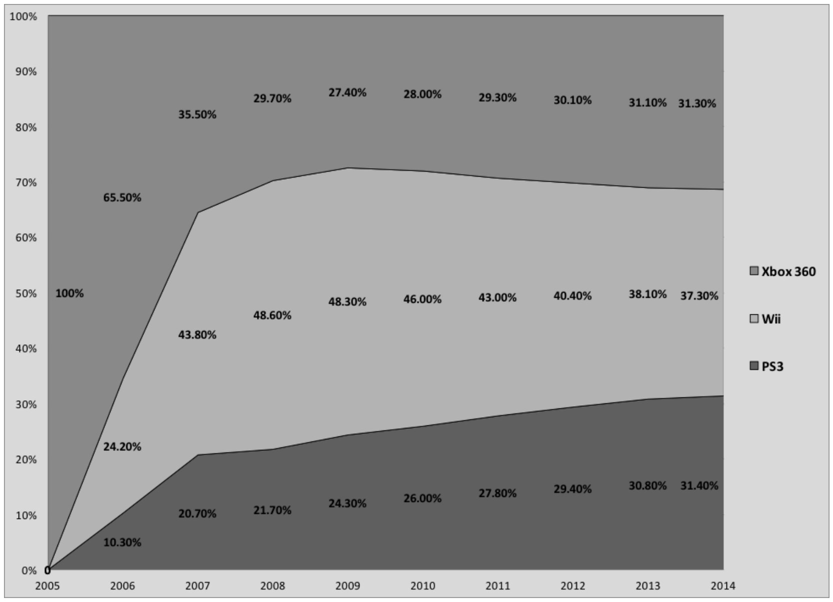
Based on their chosen strategies the manufacturers of these consoles also appeared to believe that the Internet Class competition would yield a WTA result. Microsoft, for instance, hoped to gain an edge by being the first to release their platform, blaming their failure to dominate the previous, 128-bit class in part on conceding a full year of sales to the eventual winner, PlayStation 2 [47]. In the third year of the competition, Microsoft seemed to continue to believe that a WTA result would occur, pointing out in a press release that it had been the first to reach 10 million unit sales in the United States and that, according to one senior vice president, “History has shown us that the first company to reach 10 million in console sales wins the generation battle” [48]. However, despite this head-start, and an early lead in sales, by the end of 2007 (the first full year in which all three consoles were available) the Xbox 360 had lost its lead in worldwide sales (see Fig. 4 [42].

In fact, at the end of 2008 it looked as though the Internet Class competition might instead tip toward Nintendo, as at that point the Wii installed base share had grown to 48.6%. This trajectory, together with the expectation of strong network effects as had been witnessed in past competitions, bolstered the idea that the Wii would become the competition’s dominant platform.

---

[11] Note that industry observers predicted a WTA outcome, although was no general agreement on which console would win.

Fig. 4 Percentage of Worldwide Installed Base by Platform by Year, Internet Class



That dominance, however, never occurred. Despite its lead in installed base, Wii's market share fell every year after 2008. In 2011, more units of each of the PlayStation 3 and Xbox 360 were sold than of the Wii. By the end of 2012, while Nintendo's console retained a larger installed base than its two competitors, none of the three could claim 50% of the market (see Fig. 4).

Given that this competition is now over, we note that, unlike those that preceded it, it did *not* result in a WTA outcome but rather a three-way WTS outcome. In the next section we discuss this anomalous result and evaluate multi-homing's contribution to this outcome.

E. Influence of Multi-homing

i. Multi-homing measurement

Given the findings of recent work within the mobile phone app context [3], where multi-homing behavior of the most popular apps was seen to influence competition outcomes, we now examine whether multi-homing behavior by complementary products contributed to the historically anomalous WTS outcome seen in the most recently concluded competition.

In particular, Bresnahan argues that it is the multi-homing decisions of those complements deemed *most valuable to the user*[12] that are instrumental in determining a platform competition's result. Their model allows for the heterogeneity of the value to the user among complements, and assumes that the higher value apps make a larger contribution to the attractiveness of the platform to the user, all else being equal. The decision by such high value complements to multi-home can sustain a WTS market outcome. Given that video game platform complements are primarily video game content, we focus on the video games that can be seen as the high value complements. In the video game industry game critique websites, such as IGN.com, GameSpot.com, GameCritics.com, and GameRankings.com publish reviews, rankings and scores for games, giving a measure of the value for the investment the users will make when buying a game [49]. These professional video game critics are found to have a greater influence on buyers' decisions than other consumers' opinions, and higher review scores are found to lead to higher sales [50]. Therefore, consistent with this prior work, we believe that it is appropriate to treat these ratings as a useful measure of user value.

Given our ultimate research focus on the relative success of console platforms, we need to specify what qualifies as multi-homing for the purpose of our analysis. Each game may have been released on only one platform (i.e. single-homing) or on more than one platform (potentially multi-homing). Within the context of this analysis, *we consider a multi-homing game one that was released on multiple platforms in the same class*. Our definition of multi-homing is therefore more specific than prior videogame research where an exclusive game has been defined as one that has never been released on any other platform, regardless of class [25]. Under our definition if a game is released on only one platform in a given class competition then it is single-homing within that competition, regardless of whether it is also released for a platform (or platforms) engaged in a different class competition. Again, we take this measure since we are concerned only with the outcomes of discrete competitions defined by classes; therefore, the fact that a game may also later be released on a platform in a future class cannot affect the outcome of the current class in question. In order to restrict the analysis of

[12] Bresnahan *et al*. use *popularity*, *attractiveness* and *value to the user* somewhat interchangeably. To avoid confusion with other specific popularity measures in use we will generally refer to this concept as "value to the user".

multi-homing to a given competitive class we exclude the games that are released after the competition in a given class is settled. We use a consistent cutoff date of December 31st of the year in which the first video game console of the next class is in the market. This is to ensure that a multi-homing game is, in fact, influencing the market outcome before the competition of the current class ends.

In addition, our study, following Bresnahan *et al*., also differentiates between *multi-homing* (at the time of a complementary good's introduction) and *late multi-homing* [3]. *Late multi-homing* is described as an instance where a complement is ported to a second platform, but, due to the delay in availability on multiple platforms, it can no longer be influential on whether the market tips [3]. Given the relatively short cycle times for each class in the video game context, we consider it an instance of late multi-homing *when it takes more than six months for a complement to become available on a second platform*. In analyzing the impact of multi-homing on platform success it is appropriate to restrict the analysis of multi-homing to a given competitive class[13].

Previous video game studies which looked at software exclusivity considered them retrospectively and cross-sectionally, such that if a given piece of software (e.g., video game, mobile app, etc.) had ever been available on more than one platform, it is considered multi-homing [25], [28]. However, in the economics multi-homing literature there are documented instances where a delay in multi-homing has made it uninfluential on the market outcome [3] [19]. Therefore, we specify that for a multi-homing game to be relevant the gap between release dates on the first platform and the second platform must be less than six months[14]. This differentiation is important in the context of video game consoles due to the generational pattern of this market. If a game is ported to a second console long after the dynamics of competition in that class have taken shape, such a delay means that multi-homing cannot influence the market outcome.

[13] We also conducted a sensitivity analysis using a longer lag time, and the main results were unchanged. See section III.E.v.

[14] This is unless the second platform has entered the market more than six months after the release of the game. In that case, the gap between the release date of the *game* on the second platform and the market entry of the second *platform* needs to be less than six months. It should be noted that sensitivity analysis was also done using an alternative one year gap size, and those results are consistent with the six month gap.

ii. Multi-homing Behavior of the Top *MobyRank* Games

MobyGames[15] is a comprehensive source for video game data that has been used previously in academic studies (e.g., Corts & Lederman 2009). Its content includes video game ratings offered from professional critics and other respected reviewers whose work appears in various media outlets (e.g., online, television, print) [51]. Based on its assembly of third-party reviews, MobyGames assigns each game a "MobyRank", which is a measure of collective critical opinion and critical success. This rank is based on a weighted average of normalized rankings from the various reviews collected, and requires the availability of a minimum number of critical ratings. In prior research meta critic scores similar to MobyRank are found to be a determinant of sales performance, e.g. high scores were found to be a determinant of a game becoming a blockbuster, and a proxy for the utility derived by the player [52]. We therefore use MobyRank as a measure for video game user value.

Fig. 5 Critic Reviews for a Sample Game on MobyGames (Source: MobyGames.com[16])

Review Source	Review Date	Rating	Normalized Rating
Game Over Online	Nov 22, 2010	80 out of 100	80
Hey Poor Player	Dec 08, 2010		80
Gamers Daily News	Nov 24, 2010	7.5 out of 10	75
GamePro (US)	Nov 19, 2010		70
Softpedia	Dec 20, 2010	7 out of 10	70
Gamereactor (Sweden)	Nov 22, 2010	7 out of 10	70
IGN	Nov 19, 2010	6 out of 10	60
videogamer.com	Nov 26, 2010	6 out of 10	60
Eurogamer.net (UK)	Nov 26, 2010	3 out of 10	30
1UP	Nov 26, 2010	D	25

Fig. 5 depicts a sample of critic reviews for a game with multiple sources of critics. MobyGames also presents a list of the "most popular" games for each platform. We use the MobyRank measure of games within this most popular set to identify the highly valued games. Appendix A provides a detailed list of the games

[15] http://www.mobygames.com/

[16] http://www.mobygames.com/game/xbox360/crazy-taxi

considered. We collected data on the highest MobyRanked games for each platform in the following classes: Early 16-bit class, 32-bit class, 128-bit Class, Internet Class (See Table III).[17] We collected the game title and MobyRank for these most popular games for each console.

Table III Video Game Consoles and Classes Included in the Most Popular Games Dataset

Class	Video Console	# of games with release dates
Early 16-bit class	TurboGrafx	151
	Sega Genesis	158
32-bit class	3DO	113
	Atari Jaguar	59
	Sega Saturn	144
	Sony PlayStation	183
128-bit Class	Sega Dreamcast	171
	Sony PS2	202
	Nintendo GameCube	193
	Microsoft Xbox	189
Internet Class	Microsoft Xbox 360	169
	Sony PlayStation 3	137

Next, we rely on *Gamewise* for data on the release dates for the popular games. *Gamewise* contains data on more than 45,000 games and offers a searchable database[18]. *Gamewise* contains release data of videogames on the different platforms for which each game has been released. From this source we were able to collect release dates for 80% of MobyGames-rated most popular games[19] (Table III). In the event that a game on a platform is released on different dates in different regions, we collect the first release date on that platform. The

[17] We do not include Late 16-bit class and 64-bit class in this analysis as there is only one platform in each of these classes and therefore it would not be possible to examine multi-homing across platforms. In addition, in the Internet Class, we exclude Wii since compared to PS3 and Xbox 360, Wii is lacking in technical and graphical capabilities [73]. Given the introduction of the Wii remote, Wii differs from Xbox 360 and PlayStation 3 in the audience it attracts and its most popular genres [74]. Wii does not support HD and its hardware is not on a par with either the PS3 or Xbox360. Xbox 360 and PS3 both have CPUs working at 3.2 GHz, while the microprocessor of a Wii console operates at 729 MHz. The Wii has significantly less main system RAM (64 MB compared to Xbox 360's 512 MB shared RAM and PS3's 256 GB). PS3 and Xbox360 are also superior and faster to Wii when it comes to GPU: the GPU clock speed for Xbox 360, PS3 and Wii are 500 MHz, 550 MHz and 243 MHz respectively. Xbox 360 has 512 MB of shared video RAM and PS3 benefits from 256 MB of video RAM, while the Wii uses 24 MB of video RAM [75]. These technical differences make it essentially technically infeasible and therefore very unlikely for PS3 and Xbox 360 games to be available on Wii, and vice versa. For the same reason, other studies have also excluded Wii when analyzing the competition in this class [76].

[18] See http://gamewise.co/ and http://gamewise.co/about/

[19] Twenty percent of the games do not appear in the Gamewise.co database of the games, or the database lacks complete data on their release dates. However, these games are less likely to appear in the top-ten or top-20 games, and therefore their omission is unlikely to affect the results.

collected data set from these two sources contains, for each game, the platform(s) for which the game was released, the release date on each platform, and its MobyRank.

Using these data we present the results for the top-ten popular games with the highest MobyRank for each platform in each class[20]. For example, in the Early 16-bit class we find the ten games with the highest MobyRank on TurboGrafx and on Sega Genesis. We label each of these games as either multi-homing or single-homing. The results (Table IV) show that only ten percent of these twenty games (top-ten on two platforms) are multi-homing (i.e. only two highly ranked games in the Early 16-bit class are available on multiple platforms).

Table IV Level of Multi-homing among top-ten highly MobyRanked games

Class	% of multi-homing games
Early 16-bit class	10%
32-bit class	20%
128-bit Class	43%
Internet Class	65%

Table IV shows that the percentage of games that are multi-homing increases from this mere 10% level to 65% in the Internet Class competition, or more than half of the games. In prior studies regarding dominant design emergence, a dominant design has been defined as when 50% or more of products all share the design [53]. Analogously, we propose that when the level of multi-homing among the most highly valued complements exceeds the 50% threshold, that this leads to a WTS platform market.

iii. Multi-homing Behavior of the Top *GameRankings* Games

To increase our confidence in the results and allow us to focus further on the change in multi-homing between the 128-bit and Internet Classes, we next collect an alternative set of ranking data from a different source, *GameRankings*. Similar to MobyGames, *GameRankings* aggregates review scores for games from both online and offline sources[21]. Using these sources they compile lists of all-time top-ten best games for each

[20] Note that the result shown also holds if a different threshold is used, e.g. top-20 games, rather than the traditional top-10 [28].
[21] See http://www.gamerankings.com/ and http://www.gamerankings.com/help.html

platform in the 128-bit and the Internet Classes[22]. We follow the same procedure to identify the multi-homing games in each class and observe the change in the levels of multi-homing between two classes (Table V).

Table V Level of Multi-homing among all-time best games

Class	% of multi-homing games
128-bit Class	33%
Internet Class	50%

We see here a result similar to that offered using the MobyGames data, thus confirming an increase in multi-homing from the 128-bit to the Internet Class among the highest rated games available in each of those classes. This corroborates the idea that a shift in multi-homing behavior among the highest valued complements has helped drive the WTS result in this most recently completed competition.

iv. Multi-homing Behavior of the Top *VGChartz*-selling Games

Additionally, we also consider actual complement sales as a proxy for user value, a measure that determines which complementary goods' multi-homing decisions might influence a competition's outcome. Data were collected on the top-ten best-selling games for all consoles in the 128-bit and Internet Classes from *VGChartz.com*, an industry research firm that publishes data and estimates related to game hardware and software sales[23]. Using release date data from Gamewise, and using our same multi-homing criteria, we identify multi-homing games and measure the percentage of multi-homing among the top-ten best-selling games in each class (Table VI).

Table VI Level of Multi-homing among top-ten best-selling games

Class	% of multi-homing games
128-bit Class	18%
Internet Class	60%

We observe here an even greater increase in the levels of multi-homing between the 128-bit and the Internet Classes when complement value, as measured by sales, is considered. These results show that 60% of

[22] Historical data on *GameRankings* is not available for all platforms in the early 16-bit and the 32-bit classes

[23] http://www.vgchartz.com/about.php. Historical data for classes earlier than these two were not available on this site. A sensitivity analysis shows that these results also hold true for alternative thresholds, e.g. top-20 games.

the top-ten best-selling games for the platforms in the Internet Class are multi-homing, as opposed to only 18% of such games multi-homing in the prior 128-bit class.

v. Additional Sensitivity Analyses

In identifying the most highly valued games we followed the prior literature that has relied on a top-ten list [28]. Here, we test the robustness of our results using an alternative criterion, i.e. the top-20 games. Table VII shows the result of analyzing the data on the top-20 most popular games with the highest MobyRank and the top-20 best-selling games per *VGChartz*. The pattern of change in the levels of multi-homing is consistent with the previous results on the top-ten games[24].

Table VII Level of Multi-homing among Top-20 MobyRanked and VGChartz Games

Class	Top-20 MobyRanked Games	Top-20 VGChartz Games
Early 16-bit Class	7%	N/A
32-bit Class	15%	N/A
128-bit Class	51%	23%
Internet Class	62%	55%

As a second sensitivity analysis, and to further explore the observed increase in multi-homing in the Internet Class, we performed an analysis using an alternative gap size of one year between the release dates to tag a game as multi-homing (as opposed to the six-month gap used to differentiate late multi-homing in the previous analyses). Applying this new specification across all three data sources yielded the results shown in Table VIII for the ten games with (a) the highest *MobyGames* ranking, (b) the highest *GameRankings* rankings, and (c) the best-selling games per *VGChartz.com*.

Even with this more generous definition of concurrent multi-homing the observed patterns of change remain consistent with previous results and show a meaningful increase in the level of multi-homing in the Internet Class compared to previous video game console classes.

---

[24] Similar sensitivity analysis is not possible using the GameRankings data since GameRankings compiles lists of all-time top-ten best games only.

Table VIII Level of Multi-homing among top-ten games with one year gap size, across game-ranking sites.

Class	Top-ten MobyRanked Games	Top-ten GameRanking Games	Top-ten VGChartz Games
Early 16-bit Class	10%	N/A	N/A
32-bit Class	25%	N/A	N/A
128-bit Class	48%	43%	20%
Internet Class	65%	55%	60%

Third and finally, we test for the sensitivity of our results using an alternative, stricter measure of multi-homing. This alternative measure adds a stricter criterion for labeling a game as multi-homing by examining the specific platforms the game is available on. In this analysis a game is labeled as multi-homing if it meets the previously described criteria and is also released on the dominant video game console of that class. For example, the game "Flashback: The Quest for Identity" released on the Atari Jaguar in the 32-bit class is also available on the 3DO console, but not on the Sony PlayStation, which was the market winner of this class. Therefore, under this alternative stricter measure it would not be considered multi-homing. The results of the analysis using the stricter measure are shown in Table IX. We observe that, consistent with prior results, the level of multi-homing has been steadily increasing over time.

Table IX Level of Multi-homing among top-ten MobyRanked games using stricter measure of multi-homing

Class	% of multi-homing games
Early 16-bit class	10%
32-bit class	13%
128-bit class	38%
Internet class	N/A[25]

All of these sensitivity analyses support the initial results of an increasing level of multi-homing of video games over time. In the next section we discuss the implications of this observed change and how it supports a WTS outcome for the Internet Class video game market.

[25] The level of multi-homing using the alternative measure based on a dominant platform cannot be computed for the Internet Class because there is no single winner in this class.

IV. Discussion

A. Summary of results

The emergence of a dominant leader with a substantial majority of the market share has typically been the observed outcome in platform markets. But, in more recent competitions, there have been occurrences of an alternative outcome in which there are multiple winners, each with some relevant market portion [2]. Understanding the underlying mechanism that results in such a change in the dynamics of market should be useful to managers as it helps to guide appropriate strategies for firms to better position their products and services. To better compare the classes of video game consoles and to address the conflicts between different classifications of consoles, we proposed a new, objective classification scheme to define the discrete platform competitions. The scheme is based on two classifiers: processor word length and time between world-wide release dates. Using the new, objective scheme enabled us to appropriately determine the results of the competitions in each class, which shows an unprecedented, "no-tipping" WTS outcome in the Internet Class.

Prior literature has emphasized the importance of multi-homing, especially among highly valued complementors, and how multi-homing can influence whether or not a market tips toward any one platform. We collected and analyzed three sets of data to examine whether developers of the most highly valued video games in the Internet Class are releasing their games on multiple platforms at a higher rate than they did in previous classes. We started by analyzing the data on highest MobyRanked games for each console in four consecutive classes and found that multi-homing rose from 10% to 65% from the Early 16-bit Class to the Internet Class. Using an alternative data source we performed a similar analysis to compare multi-homing behavior among the highest rated games of both the 128-bit and Internet Classes, which confirmed our original finding. We also considered game sales as a measure and again witnessed the same outcome, where the games with the highest sales multi-homed substantially more in the Internet Class competition than the 128-bit class, up to 60% of the top-ten most popular games (from 18%). We also confirmed the robustness of our results by testing with different samples (e.g. top-20 rather than top-10) and varying the gap size (from 6 months to one year).

B. Implications

The increase in the level of multi-homing among the highest quality and most popular games is associated with the emergence of an unprecedented WTS outcome in the Internet Class of video game consoles. Reports from industry show the prevalence of multi-homing among the most popular games in the Internet Class even in 2013, which was the last year the Internet Class consoles competed against each other. According to a report from the *Wall Street Journal* (*WSJ*) at the end of the Internet Class in 2013, the three games that revitalized the video game industry before the release of the next-class consoles were “Grand Theft Auto V”, ”Madden NFL 2015” and “NBA 2K14” [54]. Looking at the data available on these games it is interesting (but now not surprising) to see that all of these games are multi-homing in the Internet Class, consistent with the results of our study.

While the presence of a single dominant platform has the potential to benefit all members of a market, it is also the case that complement providers (e.g., video game developers) have a counter-incentive to actively promote the survival of multiple platforms. Intuitively, in a market with a monopolistic platform, that platform has considerable leverage in negotiating the licensing fees it receives from game sales, while with multiple platforms this is diminished, all else being equal. When there are multiple viable, successful-enough platforms, game developers have a stronger negotiating position and may opt to develop for all, a subset, or only one of the competitors. In earlier competitions this preference may have been offset by significant costs; developing for multiple platforms means re-programming games to work on those platforms as well as, in the pre-digital downloads days, incurring costs to manufacture and warehouse products. However, technology and practices have changed such that more of the initial costs incurred when writing a game for its first platform are now avoidable in making the game available on a second platform. The *WSJ* reported that new software tools have reduced the amount of repetitive work needed to make games, and this new layer of automation saves both time and money for game developers [34]. For instance, in the past decade game publisher Electronic Arts has been devoted to enhancing the game engines that are described as “dynamic workhorses”. The game engines provide tools to game developers, making game development more efficient and enabling more cost-effective cross platform development [55][26]. In addition, past versions of Xbox and PlayStation consoles used very different hardware chips, which increased development time to create two sets of software. However, in the Internet Class, they used the same chip.

Additionally, given the incentives to do so, including reduced porting costs, much of the economic rent in the videogame industry may have shifted from the platform owners to the game developers [56]. Sales of "blockbuster" games suggest that game makers are indeed reaping the benefits of this shift[27]. Further evidence was admitted by Nintendo president Satoru Iwata, who said that widening games' availability threatened the existence of Nintendo, which has relied on its exclusive access to its games to sell its consoles [57].

In the Internet Class competition reduction in the cost of game development may have also been a function of downloadable content, which provides revenue opportunities to help offset multi-homing costs. The in-game purchases of downloadable content are a source of revenue for both downloadable games and games purchased in physical format. This enables the game developers to realize further income from the same general game and code base, thus helping to offset multi-homing costs in the Internet Class. Further, information regarding the downloadable content is easily obtained via the Internet and it facilitates a consumer's decision-making on purchasing such content [58].The transition to making games Internet-compatible and the consoles Internet-ready started with consoles in the 128-bit class, although these were limited in the age of relatively slow dial-up modems [59]. In fact, the chance of success for the Internet connectivity feature was questioned by contemporaneous observers partly because the fulfillment of transactions required a high-speed broadband infrastructure that could support widespread Internet access and high-volume information transmission, which took time to develop [60]. Therefore, despite the fact that consoles like the PlayStation 2 were capable of connecting to the Internet, it was speculated that Sony had to wait until its next class of consoles (i.e., PlayStation 3) before its online ambitions could be realized [61]. However, with advances in networking

[26] Similar to the middleware engines used in video game development, cross-platform development tools for smartphone applications can also reduce the required effort for application development. These tools allow for creating apps for different operating systems using the same base code [77]

[27] "In Video Game Market, Blockbusters' Dominance Grows", *New York Times* BITS, September 30, 2013

technology and the widespread availability of faster Internet services, Internet-enablement became standard for consoles in the Internet Class, and games and game content can be downloaded onto consoles without the use of physical media. Both PlayStation 3 and Xbox 360 included far more extensive connections with the Internet than their predecessors [62].

Sony and Microsoft are also changing their focus to achieve increases in service revenues such as subscription and downloadable games [63]. This follows the change in consumers' habits to increasingly buy and download video games over the Internet [64]. Electronic Arts, for example, announced in 2014 that sales and game downloads over the Internet made up 45% of the company's revenue, and this was expected to reach 50% in 2015 [65]. Earlier in 2013 the president of Nintendo also stated that Nintendo was under pressure to change its console-focused business strategy due to the prevalence of downloadable games that can move seamlessly between platforms [57].

In addition to the increased availability of downloadable games, the video game console market has witnessed a surge in the supply of free-to-play games. Free games offered on websites have been a source of revenue since the 1990s, when advertisers incorporated products directly into games [66]. In the video game console market the free-to-play games are available without an initial purchase, but the in-game purchases make these games a source of revenue. The increase in market revenue of the free-to-play games that are offered as downloadable game started in the Internet Class, and it has been on the rise since 2010. The expansion of downloadable games and the proliferation of free-to-play games allow game developers to benefit from the same code base on multiple platforms and from gaining revenue from in-app purchases [67]. These additional revenue opportunities make multi-homing more feasible for game developers.

A change in the generational nature of the video game console market may also be reflecting the observed change in dynamics of the market and the high potential for emergence of a WTS outcome. Recently the *WSJ* reported that, instead of introducing a new generation of consoles after several years, Sony and Microsoft will be releasing modest hardware upgrades more frequently [63]. Sony released a hardware-upgraded successor to the PlayStation 4 in November 2016; this successor is still branded as a PlayStation 4 and is compatible with the earlier version. The *WSJ* further reported that Microsoft is expected to follow suit in late 2017. Neither of these two new releases is considered a next-generation console, but rather consoles that are compatible with the PS4 and the Xbox One, but with faster Graphic Processing Units (GPUs) [68]. This is in contrast to the industry-wide pattern for console makers to release their next console about every five years [69]. Since there does not seem to be a large technological leap from the current class of consoles to their successors, this sort of backward compatibility can help console makers to take advantage of their already existing installed base [70]. Given the prevalence of multi-homing among the most popular games, the backward compatibility can intensify the impact of such games on the market outcome.

C. Conclusions and Future Research

In this research we have reexamined the platform market for videogame consoles and their complementary videogames. Using a new objective measurement scheme we identify a series of classes of videogame platforms, for which all but the last exhibit classic Winner-Takes-All (WTA) outcomes and all exhibit the Christensen-like propensity for incumbents in one class to be replaced by a new entrant in the succeeding class. In the last completed class, the Internet Class, a Winners-Take-Some (WTS) outcome has been observed, and, as suggested by recent economics research, this is also the class where a high level of multi-homing of its complements was observed. Contemporaneous news accounts point to declining multi-homing costs in this environment related to software engines and downloadable media, and these can reasonably be assumed to have contributed to the multi-homing outcome.

While the differences between the Internet Class video game console competition and earlier competitions are clear, they lead to the more broadly interesting question of whether these differences represent a more general shift in digital goods markets. Prior research in flash memory, graphics formats, and apps for mobile operating systems have shown that all of these are also demonstrating a tendency towards WTS equilibria. Future empirical research could be usefully devoted to other platform markets that may exhibit similar changes, such as application software in non-mobile operating system environments and streamed or otherwise downloadable digital consumer media that have supplanted fixed physical format complements.

Similar changes in these environments would suggest that managers re-consider market strategies that have been honed based on the WTA outcomes of past market competitions.

REFERENCES

[1] T. Eisenmann, G. Parker, and M. W. Van Alstyne, "Strategies for two-sided markets," *Harv. Bus. Rev.*, vol. 84, no. 10, p. 92, 2006.

[2] C. Z. Liu, C. F. Kemerer, S. A. Slaughter, and M. D. Smith, "Standards competition in the presence of digital conversion technology: An empirical analysis of the flash memory card market," *MIS Q.*, vol. 36, no. 3, pp. 921–942, 2012.

[3] T. Bresnahan, J. Orsini, and P. Yin, "Demand heterogeneity, inframarginal multihoming , and platform market stability: mobile apps," *Unpublished*, 2015. [Online]. Available: http://idei.fr/sites/default/files/IDEI/documents/conf/Internet_2016/Articles/yin.pdf.

[4] C. Kemerer, C. Z. Liu, and D. Smith, "Strategies for tomorrow's digital goods markets," *Commun. ACM*, vol. 56, no. 5, pp. 76–82, 2013.

[5] DFC Intelligence, "DFC intelligence releases new forecasts for global video game industry," 2016. [Online]. Available: http://www.dfcint.com/wp/new-video-game-industry-forecasts/.

[6] M. L. Katz and C. Shapiro, "Network externalities, competition, and compatibility," *Am. Econ. Rev.*, vol. 75, no. 3, pp. 424–440, 1985.

[7] J. Farrell and G. Saloner, "Competition, compatability and standards: the economics of horses, penguins and lemmings," *Dep. Econ. UCB*, 1986.

[8] N. Economides, "The economics of networks," *Int. J. Ind. Organ.*, vol. 14, no. 6, pp. 673–699, 1996.

[9] J. Rochet and J. Tirole, "Platform competition in two-sided markets," *J. Eur. Econ. Assoc.*, vol. 1, no. 4, pp. 990–1029, 2003.

[10] B. Caillaud and B. Jullien, "Chicken-and-egg: competition among intermediation service providers.," *RAND J. Econ.*, vol. 34, no. 2, pp. 309–328, 2003.

[11] M. Armstrong, "Competition in two-sided markets," *RAND J. Econ.*, vol. 37, no. 3, pp. 668–691, 2006.

[12] S. Gallagher and S. H. Park, "Innovation and competition in standard-based industries: a historical analysis of the US home video game market," *IEEE Trans. Eng. Manag.*, vol. 49, no. 1, pp. 67–82, 2002.

[13] J. Rochet and J. Tirole, "Two-sided markets: a progress report," *RAND J. Econ.*, vol. 37, no. 3, pp. 645–667, 2006.

[14] C. Shapiro and H. R. Varian, "The art of standards wars," *Calif. Manage. Rev.*, vol. 41, no. 2, pp. 8–32, 1999.

[15] A. Gawer and M. A. Cusumano, *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation*. Harvard Business School Press Boston, 2002.

[16] H. R. Varian and C. Shapiro, "Information rules: a strategic guide to the network economy," *Harvard Bus. Sch. Press. Cambridge*, pp. 1–352, 1999.

[17] T. Doganoglu and J. Wright, "Multihoming and compatibility," *Int. J. Ind. Organ.*, vol. 24, no. 1, pp. 45–67, 2006.

[18] M. Rysman, "An empirical analysis of payment card usage," *J. Ind. Econ.*, vol. 55, no. 1, pp. 1–26, 2007.

[19] J. Farrell and P. Klemperer, "Chapter 31 Coordination and Lock-In: competition with switching costs and network effects," *Handb. Ind. Organ.*, vol. 3, no. 6, pp. 1967–2072, 2007.

[20] P. A. David and J. A. Bunn, "The economics of gateway technologies and network evolution: Lessons from electricity supply history," *Inf. Econ. Policy*, vol. 3, no. 2, pp. 165–202, 1988.

[21] V. Shankar and B. L. Bayus, "Network effects and competition: An empirical analysis of the home video game industry," *Strateg. Manag. J.*, vol. 24, no. 4, pp. 375–384, 2003.

[22] M. T. Clements and H. Ohashi, "Indirect network effects and the product cycle: video games in the US, 1994–2002," *J. Ind. Econ.*, vol. 53, no. 4, pp. 515–542, 2005.

[23] A. Srinivasan and N. Venkatraman, "Indirect network effects and platform dominance in the video game industry: A network perspective," *IEEE Trans. Eng. Manag.*, vol. 57, no. 4, pp. 661–673, 2010.

[24] M. Iansiti and F. Zhu, "Dynamics of platform competition: Exploring the role of installed base, platform quality and consumer expectations," in *ICIS 2007 Proceedings*, 2007, p. 38.

[25] K. S. Corts and M. Lederman, "Software exclusivity and the scope of indirect network effects in the U.S. home video game market," *Int. J. Ind. Organ.*, vol. 27, no. 2, pp. 121–136, 2009.
[26] Y. Zhou, "Bayesian estimation of a dynamic equilibrium model of pricing and entry in two-sided markets: application to video games," *Unpublished*, 2011. [Online]. Available: https://econ.tepper.cmu.edu/seminars/docs/Paper_Yiyi.pdf.
[27] J.-P. H. Dubé, G. J. Hitsch, and P. K. Chintagunta, "Tipping and concentration in markets with indirect network effects," *Mark. Sci.*, vol. 29, no. 2, pp. 216–249, 2010.
[28] R. S. Lee, "Vertical integration and exclusivity in two-sided markets," *Am. Econ. Rev.*, vol. 103, no. 7, pp. 2960–3000, 2013.
[29] I. L. B. Liu, C. M. K. Cheung, and M. K. O. Lee, "Understanding Twitter usage : What drive people continue to tweet," *Proc. Pacific Asia Conf. Inf. Syst.*, pp. 927–939, 2010.
[30] R. T. Gretz, "Hardware quality vs. network size in the home video game industry," *J. Econ. Behav. Organ.*, vol. 76, no. 2, pp. 168–183, 2010.
[31] T. Derdenger, "Technological tying and the intensity of price competition: An empirical analysis of the video game industry," *Quant. Mark. Econ.*, vol. 12, no. 2, pp. 127–165, 2014.
[32] J. H. Kim, J. Prince, and C. Qiu, "Indirect network effects and the quality dimension: A look at the gaming industry," *Int. J. Ind. Organ.*, vol. 37, pp. 99–108, 2014.
[33] J. E. Prieger and W. M. Hu, "Applications barrier to entry and exclusive vertical contracts in platform markets," *Econ. Inq.*, vol. 50, no. 2, pp. 435–452, 2012.
[34] I. Sherr, "Software developers trim costs on new games," *Wall Street Journal*, 2013. [Online]. Available: http://www.wsj.com/articles/SB10001424127887324904004578537341148291184.
[35] S. Jiang, "Comparison of native, cross-platform and hyper mobile development tools approaches for iOS and Android mobile applications," University of Gothenburg, 2016.
[36] R. T. Gretz, "Console price and software availability in the home video game industry," *Atl. Econ. J.*, vol. 38, no. 1, pp. 81–94, 2010.
[37] P. K. Chintagunta, H. S. Nair, and R. Sukumar, "Measuring marketing-mix effects in the 32/64 bit video-game console market," *J. Appl. Econom.*, vol. 24, no. 3, pp. 421–445, 2009.
[38] W. B. Arthur, "Competing technologies, increasing returns, and lock-in by historical events," *Econ. J.*, vol. 99, no. 394, pp. 116–131, 1989.
[39] J. M. Utterback, *Mastering the dynamics of innovation (2nd ed)*. Harvard Business Review Press, 1996.
[40] R. M. Henderson and K. B. Clark, "Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms," *Adm. Sci. Q.*, pp. 9–30, 1990.
[41] C. M. Christensen, *The innovator's dilemma: the revolutionary book that will change the way you do business (2nd Edition)*. HarperBusiness, 2011.
[42] J. Babb and N. Terry, "Comparing video game sales by gaming platform," *Southwest. Econ. Rev.*, vol. 40, no. 1, pp. 25–46, 2013.
[43] M. L. Katz and C. Shapiro, "Technology adoption in the presence of network externalities," *J. Polit. Econ.*, pp. 822–841, 1986.
[44] C. A. Berardini, "Analyst: PS3 will win the console war in the long term," 2007. [Online]. Available: http://news.teamxbox.com/xbox/12500/Analyst-PS3-Will-Win-The-Console-War-In-The-Long-Term/.
[45] R. Beschizza, "Wii wins next-gen battle," 2007. [Online]. Available: http://www.wired.com/gadgetlab/2007/04/wii_wins_nextge/.
[46] D. Reisinger, "The Xbox 360 should win this console war," *CNET.com*, 2008. [Online]. Available: http://news.cnet.com/8301-13506_3-10039408-17.html.
[47] C. Morris, "Xbox 360 makes its debut," *CNN.com*, 2005.
[48] M. Mcwhertor, "MS Still thinks it can win the console war, Xbox 360 pushes past 10 million in U.S.," 2008. [Online]. Available: http://kotaku.com/5009041/ms-still-thinks-it-can-win-the-console-war-xbox-360-pushes-past-10-million-in-us.
[49] K. Stuart, "Has video game reviewing become an impossible task?," *The Guardian*, 25-Nov-2015.

[Online]. Available: https://www.theguardian.com/technology/2015/nov/25/video-game-reviewing-critics-industry.
[50] J. Cox and D. Kaimann, "How do reviews from professional critics interact with other signals of product quality? Evidence from the video game industry," *J. Consum. Behav.*, vol. 14, no. 6, pp. 366–377, 2015.
[51] "MobyGames FAQ," 2014. [Online]. Available: http://www.mobygames.com/info/faq.
[52] J. Cox, "What makes a blockbuster video game? An empirical analysis of US sales data," *Manag. Decis. Econ.*, vol. 35, no. 3, pp. 189–198, 2014.
[53] M. J. Benner and M. Tripsas, "The influence of prior industry affiliation on framing in nascent industries: the evolution of digital cameras," *Strateg. Manag. J.*, vol. 33, no. 3, pp. 277–302, 2012.
[54] I. Sherr, "Retail videogame sales soar in september with 'Grand Theft Auto V,'" *Wall Street Journal*, Oct-2013. [Online]. Available: http://www.wsj.com/articles/SB10001424052702304864504579142141433823508.
[55] S. E. Needleman, "'Engine' software fuels growth for videogame industry," *Wall Street Journal*, Oct-2016. [Online]. Available: http://www.wsj.com/articles/videogame-industry-adapts-to-running-on-engines-1476123424.
[56] V. T. Dao and B. Zmud, "The Influence of Technology-Related, Market-Related, and Standards-Related Strategic Signaling during a Standards War," *IEEE Trans. Eng. Manag.*, vol. 62, no. 3, pp. 300–310, 2015.
[57] M. Negishi, "Nintendo's losses mount," *Wall Street Journal*, Oct-2013. [Online]. Available: http://www.wsj.com/articles/SB10001424052702304655104579166691934077798.
[58] J. Lim, V. Grover, and R. L. Purvis, "The consumer choice of E-channels as a purchasing avenue: An empirical investigation of the communicative aspects of information quality," *IEEE Trans. Eng. Manag.*, vol. 59, no. 3, pp. 348–363, 2012.
[59] T. Collins, "Playing hardball," *Pittsburgh Post-Gazette*, p. 42, 25-Aug-2000.
[60] D. Takahashi, "Sega will give Away dreamcasts To lure subscribers to the Web," *Wall Street Journal*, Apr-2000. [Online]. Available: http://www.wsj.com/articles/SB954796769165121570.
[61] C. Dawson, "Sony plays to win," *Far East. Econ. Rev.*, vol. 163, no. 9, pp. 10–12, Mar. 2000.
[62] R. A. Guth, N. Wingfield, and P. Dvorak, "It's Xbox 360 vs. PlayStation 3, and war is about to begin," *Wall Street Journal*, 09-May-2005. [Online]. Available: http://www.wsj.com/articles/SB111559165779427687.
[63] S. E. Needleman and T. Mochizuki, "PlayStation and Xbox consoles get upgrades at faster clip," *Wall Street Journal*, Sep-2016. [Online]. Available: http://www.wsj.com/articles/videogame-consoles-get-upgrades-more-often-1473176586.
[64] I. Sherr, "Microsoft has sold more than 5 million Xbox Ones," *Wall Street Journal*, Apr-2014. [Online]. Available: http://www.wsj.com/articles/SB10001424052702304626304579508240364266268.
[65] I. Sherr, "Video game makers are optimistic about the holiday season," *Wall Street Journal*, May-2014. [Online]. Available: http://www.wsj.com/articles/SB10001424052702304831304579545993254350928.
[66] B. Barnes, "Play Time," *Wall Street Journal*, 05-Mar-2002. [Online]. Available: http://www.wsj.com/articles/SB1015030297351722 40.
[67] M. Negishi, "A Truce in the Videogame Wars," *Wall Street Journal*, Oct-2013. [Online]. Available: http://www.wsj.com/articles/SB10001424052702304500404579126814129050396.
[68] C. Baker, "What do the PS4 Pro and Xbox's Project Scorpio mean for the game industry?," *Gamasutra*, Sep-2016. [Online]. Available: http://www.gamasutra.com/view/news/282317/What_do_the_PS4_Pro_and_Xboxs_Project_Scorpio_mean_for_the_game_industry.php.
[69] "No Laughing Matter," *The Economist Technology Quarterly*, 06-Dec-2001. [Online]. Available: http://www.economist.com/node/884973.
[70] J. Claussen, T. Kretschmer, and T. Spengler, "Backward compatibility to sustain market dominance–evidence from the US handheld video game industry," *Unpublished*, 2010. [Online]. Available: https://epub.ub.uni-muenchen.de/11499/2/ClaussenKretschmerSpengler-

Backward_Compatibility_as_Entry_Deterrence.pdf.
[71] R. Mantena Sankaranarayanan, R. and Viswanathan, S., "Exclusive licensing in complementary network industries," *NET Institute, New York, NY.*, vol. NET Instit, no. December, 2007.
[72] J. Dermer, "Traps in technology management," *IEEE Trans. Eng. Manag.*, vol. 39, no. 4, pp. 412–416, 1992.
[73] J. Bakalar, "Xbox 360 vs. PlayStation 3 vs. Wii: Updated," *CNET*, 2009. [Online]. Available: https://www.cnet.com/news/xbox-360-vs-playstation-3-vs-wii-updated/.
[74] A. Marchand and T. Hennig-Thurau, "Value creation in the video game industry: Industry economics, consumer benefits, and research opportunities," *J. Interact. Mark.*, vol. 27, no. 3, pp. 141–157, 2013.
[75] P. Thurrott, "Xbox 360 vs. PlayStation 3 vs. Wii: A technical comparison," 2010. [Online]. Available: http://winsupersite.com/product-review/xbox-360-vs-playstation-3-vs-wii-technical-comparison.
[76] J. Rietveld, M. A. Schilling, and C. Bellavitis, "Reload and relaunch: strategic governance of platform ecosystems," *Unpublished*, 2016. .
[77] J. Ohrt and V. Turau, "Cross-platform development tools for smartphone applications," *Computer (Long. Beach. Calif).*, vol. 45, no. 9, pp. 72–79, 2012.